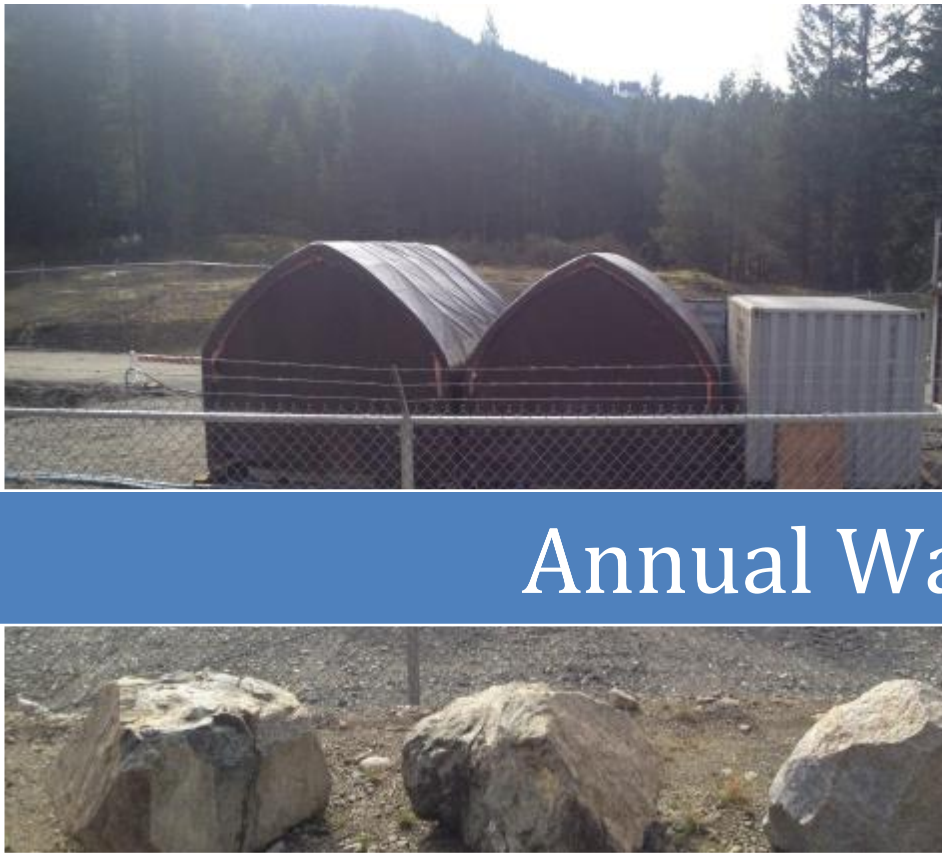

2018

Annual Water Report

Prepared by:

Town of Ladysmith

Infrastructure Services

Department

LADYSMITH

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1. Introduction

The 2018 Annual Water Report provides an overview of the Town of Ladysmith water system (water sources, maintenance programs & capital improvements) and summarizes the annual water quality and production data. All water suppliers, under their Operating Permit, are required to provide an annual water report to the Vancouver Island Health Authority. This report is also posted on the municipal web site at www.ladysmith.ca.

2. Service Area & Sources

The Town of Ladysmith's water is drawn from two sources, which provide water through separate facilities at the mid/north and south ends of Town. The community is supplied in part by the Holland Lake and Holland Creek watershed, which enters the water supply system at a diversion point at the Chicken Ladder Intake, a small stilling basin located approximately 2.5 km. from the Public Works yard, as well as from Stocking Lake, located south of the Town. Both of these supplies are now piped directly to the enclosed Arbutus Reservoir, where it is chlorinated and distributed by gravity to the entire Ladysmith service area, the Diamond Improvement District and Stz'uminus IR 13.

Holland Lake

The Holland Lake reservoir was constructed in 1979 at the location of two original lakes approximately 5 km west of the Town in a 'regulated access' watershed – it consists of two earth filled embankments, providing 1,600,000 cm of live storage. The reservoir currently discharges through a 450mm dia. steel pipe located 6.0 meters (19.7 feet) below the spillway elevation. There is a small remotely operated valve that controls discharge into Holland Creek, which augments base flows in Holland Creek, and enters the Town's water system at Chicken Ladder, located approximately 1 km west of the Arbutus reservoir. The dam is in good condition, and receives regular maintenance in accordance with current Provincial Dam Safety Standards. The dam is rated a high-risk structure in accordance with the Provincial Dam Classification system. Staff carry out annual dam inspections; no issues were identified in 2018.

The Holland Lake reservoir is located predominately in active forestry lands owned by TimberWest Forest Corporation (TimberWest). The majority of lands contributing to the lower reaches of Holland Creek upstream of Chicken Ladder Intake is crown land managed forest. The Town owns the Holland Lake perimeter, while TimberWest owns the lands contributory to the Lake.

Logging Roads exist throughout the area, but are gated and signed to restrict public access to the Town's Lakes and Intakes. The public use the watershed for walking, and other related recreational activities, however, camping and water use at Holland and Stocking Lakes is restricted.

Chicken Ladder Intake (Holland Creek)

The Chicken Ladder Intake was constructed on Holland Creek in the 1960's, when the lower Holland Dam water intake that was originally constructed by the Ladysmith Water Company was relocated due to the need for higher operating pressures in the system. At that time, an earthen open reservoir was constructed adjacent to Holland Creek under the Power Lines, and a chlorination building was constructed at the same time. The earthen open reservoir was subsequently filled in and replaced with a 5,700 cm concrete covered reservoir in 2008, and the replacement of the chlorination building was completed in 2014, which is located on the site of the old open reservoir. The Chicken Ladder Intake is located next to a well-used trail, and is considered to represent a moderately high risk for public access due to poor site security and constrained site access due to topography. The site has signage and is marked restricting public access, but the remoteness of the location results in less than ideal site security.

Stocking Lake

Stocking Lake was built in the 1920's, by the Ladysmith Water Company, which was subsequently taken over by the Town. The Lake serves both the Town, as well as the Saltair area (Cowichan Valley Regional District). The Intake, shared by both water jurisdictions, is a 900mm dia. steel pipe located 5.0 meters (16.4 feet) below the spillway elevation. The dam is in 'fair' general condition, but has a documented seepage issue that dates back to the 1980's. The amount of seepage does not appear to change from year to year, however, discussions have commenced between the CVRD and the Town to repair the leak by adding additional embankment and enhance the stability of the structure. The dam rating is a low risk structure in accordance with the Provincial Dam Classification system.

ATV users and occasional campers also frequent the Stocking Lake area, as there is evidence of vandalism in the area. A trail system travels the length of the Lake. TimberWest, the Crown, the CVRD, and the Town own the contributing areas of the watershed.

Arbutus Reservoir

The Arbutus reservoir, 5,700 cu meters in capacity, currently provides daily peaking for the Town. As of the fall of 2012, Arbutus Reservoir serves both the North as well as the South portions of Ladysmith.

Figure 1 shows the general layout of the Watersheds and major storage and intake structures.

2.1. Ladysmith Water System - Distribution

The topography of the Town of Ladysmith slopes steeply towards the waterfront, resulting in a large range in the water pressures within the Town's water system. With the completion of the covered Arbutus Reservoir in 2008 and subsequent increase in distribution pressure (32psi), the Town introduced two specific pressure zones within the system with the installation of four pressure-reducing stations. Future development above the 130 meters geodetic will require the construction of additional reservoirs and pumping facilitates.

The distribution system for the Town consists of over 61 km of water main of varying sizes from 100mm to 250mm. The mains are made of cast iron piping, asbestos cement piping or PVC piping. The cast iron and the asbestos cement piping (approximately 21 km) are located mainly in the older section of Town and within the area amalgamated from Saltair in 1985. The majority of the asbestos cement piping is 100 mm in diameter and requires replacement to allow for adequate flows throughout the system.

The Town has been actively working on a replacement program since 2000. Throughout the distribution system, fire hydrants situated at a spacing offer adequate fire flows for all properties.

The Town has had access to computer modelling software for monitoring static and dynamic water pressures within the system.

The Town recently replaced the existing gas chlorination system with a new gas system, with provision of possibly manufacturing chlorine in the future. The project is part of a multi-phase project to improve water treatment for the Town. This is discussed later in the Report.

2.2. Water Filtration Facility

In 2008, Municipalities on Vancouver Island received notice by Island Health (VIHA) that they would have to meet the microbiological treatment objectives commonly known as the "4-3-2-1 rule", which require that surface water sources include adequate treatment for viruses, Cryptosporidium parvum and Giardia lamblia, typically in the form of filtration followed by disinfection.

It was hoped that the quality of the Town's raw water supplies would qualify for filtration deferral from VIHA. If so, the Town would be able to avoid or delay the implementation of full filtration, and instead limit short-term upgrades to UV disinfection. Unfortunately detailed water quality testing demonstrated that the raw water sources at time exceeded 5 NTU and Escherichia coli virus counts regularly exceeded 20 counts/100ml.

As a result, the Town made plans to move forward with development of a Water Filtration facility. A pilot testing program commenced to determine if membrane filtration was effective at removing turbidity and microbiological contamination when combined with chlorination. However, even chemically enhanced membrane filtration was inadequate in the following ways:

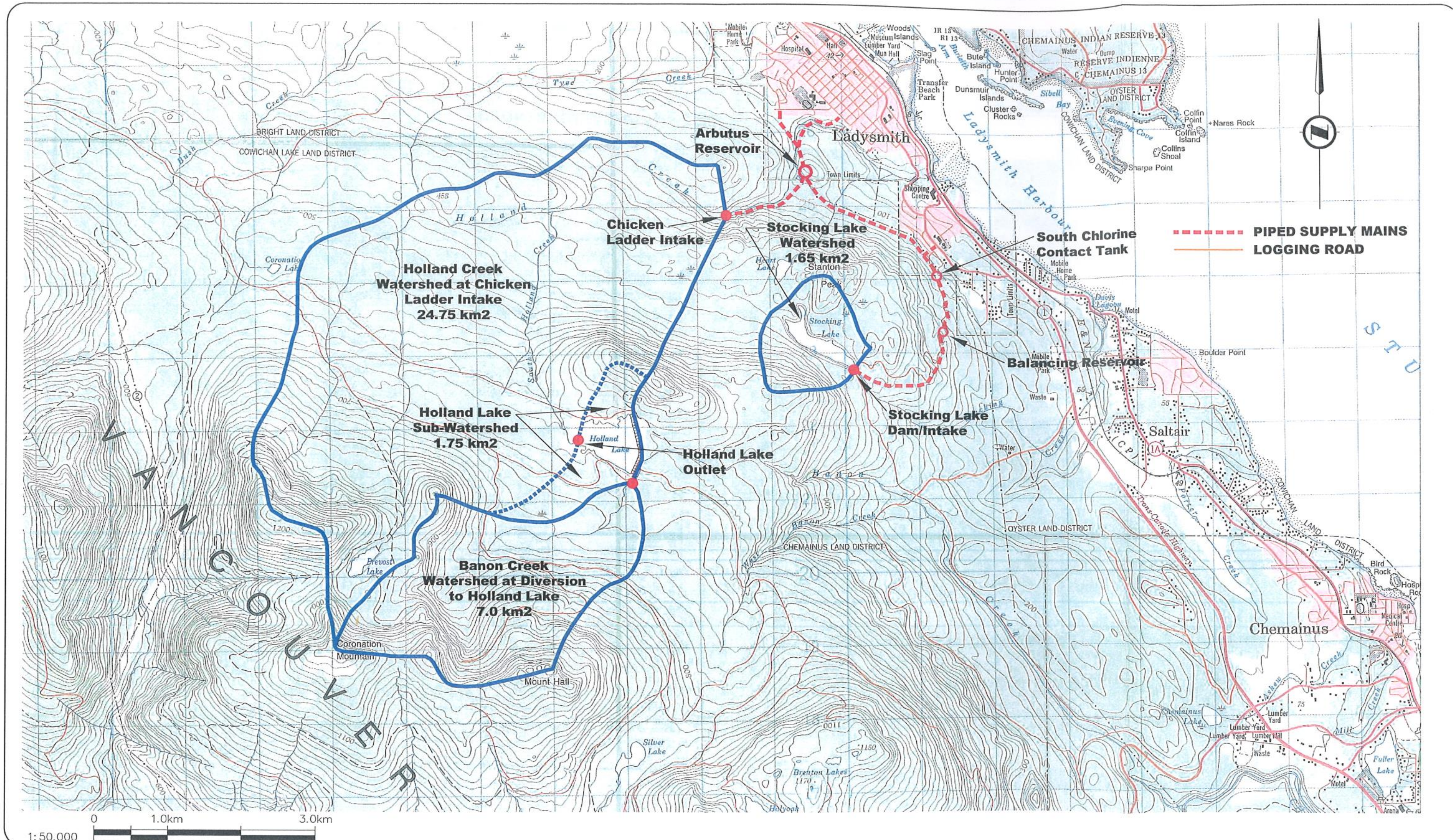
- Membranes could not remove enough colour to meet the aesthetic objectives.
- Removal of organic material was relatively poor, which could result in significant concentrations of Haloacetic acids (HAA) (a disinfection by-product), forming in the distribution system.
- The membranes fouled relatively rapidly, indicating that a full-scale implementation would require frequent cleaning, higher consumption of cleaning chemicals, and increased downtime.

The piloting program confirmed DAF and membrane filtration combined would provide the treatment required and this was the recommended option.

In 2016, CWWF awarded the Town $8.8 million for implementation of DAF and membrane filtration at the Arbutus WTP. Subsequent to this grant funding, the town awarded the design and construction services contract to Associated Engineering, with an overall completion goal of March 2019.

Design of the facility has continued through 2017. The Town tendered the membrane portion of the plant and this was awarded to GE, with a pressure membrane configuration. Preliminary design was completed and submitted to Island Health for comment. The final design was completed in March of 2018 and the project was issued for tender on March 20, 2018.

Figure 1 System Overview



3. Water Licensing

The Town currently holds the following water licenses:

Table 1 - Town Water Licences

License	Type	Annual Storage (cm, or Diversion (cm/yr)	Max Day Flow (Cu m)	Location	Date of Original Issuance	Comments
CL 017746	Diversion	995,000		Holland Creek (Chicken Ladder)	1946	Whole Year
CL 029821	Storage	123,348		Holland Creek (Chicken Ladder)	1962	Original earth reservoir (Now replaced with Arbutus Reservoir)
CL 125167	Diversion		3,640 cm/ day	Banon Creek	1977	Replaces 112813 Diversion
CL 125167	Storage	1,820,000		Holland Lake	1977	Replaces 112813 Storage, updated to allow Holland to Stocking Pipeline
CL 112812	Storage	246,700		Holland Lake	1952	Replaces 21164
CL 005333	Diversion	Either: 829,000, or 454,000*		Stocking Lake	1902	Max 2,273 cm/ day

**Under review by TOL staff*

Of relevance to the Town, the Cowichan Valley Regional District (CVRD) also holds water licenses on Stocking Lake as follows:

Table 2 - CVRD Water Licenses

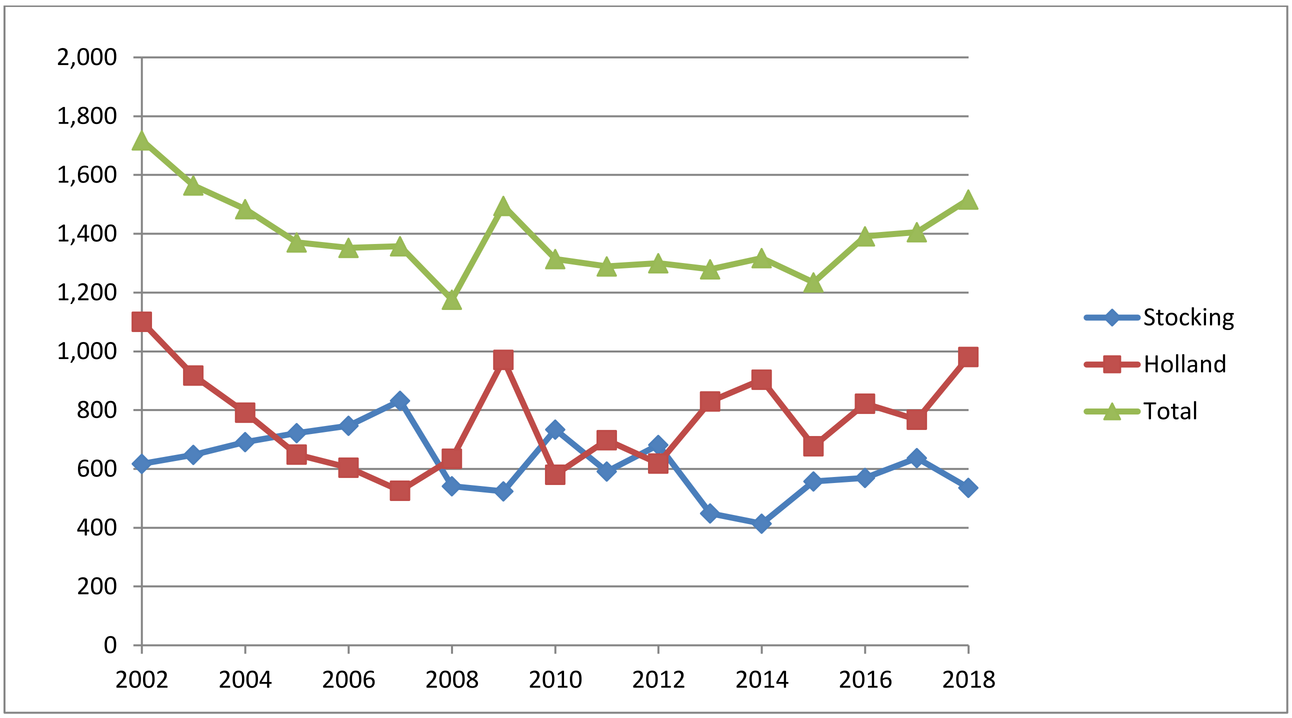
License	Type	Annual Storage (cm, or Diversion (cm/yr)	Max Day Flow (Cu m)	Location	Date of Original Issuance	Comments
CL 67482	Diversion	476,000		Stocking Lake	1984	All year, replaces 61318
CL 67481	Diversion	447,000		Stocking Lake	1955	All year, replaces 28487
Cl 67484	Storage	542,000		Stocking Lake	1984	

4. Water Consumption

The Town used 1,517,798 cubic meters of water in 2018, an increase of 7.5% over 2017, and considerably less than the consumption in 2002 (1.7M cu m). This reflects a trend that has been occurring at the Town since the introduction of residential water metering in 2006. The Town is using approximately 17% less water now than 15 years ago (2002 annual consumption was 1,700,000 cu m). During the same period, the Town has grown over 24.6%, resulting in a net reduction of per capita water consumption in the order of 36%.

A summary of water consumption by month, including the flow splits between Stocking Lake and Chicken Ladder Intake (Holland Creek) follows on the next page, illustrated as follows:

Figure 2
Ladysmith Total Consumption and Flow Source – 2002-2018
(In Thousands of cubic meters)



The general downward trend in water consumption is likely the result of the Town's decision to install residential water meters in 2006, as well as its progressive block pricing rate structure for single family residential water accounts. The Town has also been encouraging water conservation through programs such as a toilet rebate program, which would also have a downward impact on consumption.

Flow Split between Holland and Stocking Lakes

Over the last 12 years, the Town has used roughly equal amounts of water from Holland and Stocking watersheds. This has occurred primarily for two reasons: Firstly, until the fall of 2012, portions of South Ladysmith were incapable of feeding the Holland Watershed due to piping and chlorination equipment considerations. In 2012, installation of a two-way interconnecting pipe system connected the Stocking Lake supply line directly to the Arbutus Reservoir. Upon completion of this project, the old chlorination facility servicing South Ladysmith was taken out of service, and all chlorination is now taking place near the Arbutus Reservoir. This has had the effect of allowing an additional 100,000 cubic meters of Holland Creek water to be able to serve South Ladysmith during times when Holland Creek has acceptable turbidity levels.

Table 3 Town of Ladysmith Water Consumption, 2002-2018

(In thousands of cubic meters)

Year	Totals (thou cm)			Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec		
	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total
2002	617	1,101	1,718	112	2	114	100	1	102	78	34	112	63	48	110	18	126	144	21	176	198	22	196	218	22	207	230	15	148	163	9	113	122	80	22	102	77	27	104
2003	647	917	1,565	101	7	108	90	15	105	84	24	108	91	11	102	11	121	132	20	186	206	23	194	217	15	155	170	8	103	112	54	47	101	49	52	101	101	2	103
2004	691	792	1,484	112	3	115	103	2	105	103	1	104	36	80	116	13	140	153	14	142	157	21	150	171	14	138	153	25	84	109	53	49	102	97	3	100	98	0	98
2005	722	649	1,371	113	0	113	99	0	99	101	0	101	90	8	98	46	77	123	11	117	128	15	134	149	20	152	173	16	118	134	45	43	88	75	0	75	92	0	92
2006	747	605	1,352	103	0	103	76	1	77	90	0	90	85	0	85	122	11	133	50	84	134	22	162	183	21	155	176	25	108	133	17	84	102	77	0	77	60	0	60
2007	832	526	1,358	109	2	111	98	0	98	102	0	102	99	4	102	66	61	127	22	126	148	28	141	168	25	61	86	17	102	119	87	11	97	73	19	92	106	1	107
2008	541	635	1,176	76	0	76	35	0	35	62	0	62	33	0	33	61	51	112	20	118	139	34	163	197	22	128	150	23	86	109	79	8	86	64	18	82	32	63	95
2009	524	971	1,495	52	43	96	30	56	86	42	48	90	39	80	119	30	134	164	36	160	196	31	158	189	26	126	151	24	82	107	61	35	96	99	2	102	54	45	100
2010	734	580	1,314	94	1	95	67	19	85	54	51	105	58	29	86	54	48	102	37	74	112	26	144	170	23	127	150	43	65	108	85	8	94	95	3	98	98	11	109
2011	591	698	1,290	99	0	99	49	34	84	78	18	96	53	37	90	67	31	98	15	115	130	19	135	154	20	140	160	29	89	118	78	13	91	49	36	84	36	51	87
2012	682	619	1,300	74	15	88	80	0	80	91	0	91	86	0	86	32	80	112	14	103	117	20	137	157	23	142	165	19	105	124	65	36	101	88	0	88	92	0	92
2013	449	830	1,279	90	0	90	86	0	86	93	3	96	46	38	85	15	93	108	24	95	118	2	169	171	1	149	150	12	94	106	20	70	90	53	30	83	7	89	97
2014	414	903	1,317	32	68	100	52	35	88	81	14	95	18	65	83	0	107	107	3	142	145	5	165	171	1	144	145	1	113	114	62	27	89	66	23	89	93	0	93
2015	557	677	1,235	92	0	92	85	0	85	92	0	92	50	40	91	1	120	121	3	149	152	0	122	123	0	108	108	0	91	91	64	27	92	71	18	88	98	1	99
2016	569	823	1,392	104	0	104	102	0	102	83	28	111	0	105	105	4	143	147	1	139	140	0	142	142	0	146	146	0	104	104	78	17	95	93	0	93	103	0	103
2017	638	768	1,405	103	0	103	94	0	94	106	0	106	94	20	115	0	106	106	0	137	137	0	171	171	0	166	166	7	103	109	44	45	89	82	21	103	108	0	108
2018	536	981	1517	109	0	109	99	0	99	68	41	109	44	60	104	0	204	204	0	169	169	0	204	204	0	166	166	12	98	110	19	77	96	87	0	87	95	0	95

5. Drinking Water Regulations

In Canada, the Provincial and Local Governments regulate drinking water. While the Federal Government, Health Canada, performs research and publishes recommendations for safe drinking water, each Province has the responsibility to regulate drinking water (in British Columbia [BC], the Ministry of Health has this responsibility). Locally, each water supplier also complies with the local Health Authority requirements (The Town of Ladysmith is under the jurisdiction of Island Health [VIHA]).

This section presents the Federal recommendations, as well as the BC regulations and requirements from the VIHA.

5.1. Canadian Drinking Water Quality Guidelines

The Federal-Provincial-Territorial Committee on Drinking Water establishes the Guidelines for Canadian Drinking Water Quality and are published by Health Canada (Ref. 8). They are regularly revised, based on the latest research results. The Guidelines are intended to be used as benchmarks for the Provinces.

The Guidelines consider more than 100 parameters that potentially can be found in Canadian drinking water sources: bacteriological pathogens; physical and chemical contaminants, including metals, inorganics, pesticides, and other organics; as well as radionuclides. The Guidelines establish two types of limits for these contaminants. The Maximum Acceptable Concentration (MAC) is based on health considerations, while the Aesthetic Objective (AO) is based on aesthetic considerations.

Appendix A provides the latest revision (June 2012) of the Canadian Drinking Water Guidelines.

5.2. BC Regulations

In BC, the British Columbia Drinking Water Protection Regulation (2003) and the Drinking Water Protection Act (2001) regulate drinking water (Refs. 1 and 2, respectively).

The BC Ministry of Health is primarily concerned with bacteria. Escherichia coli and fecal coliforms must not be detected. Total coliforms must not be detected 90 percent of the time, and if detected, they must be less than 10 counts per 100 mL.

The regulations also provide monitoring frequency requirements. They vary with the number of served population. For a water supply system that serves between 5,000 and 90,000 people, it is required that one sample per 1,000 people be collected per month. For Ladysmith, which currently serves 8,000 people, eight samples per month are required. Moreover, the bacteriological analyses must be performed by a laboratory approved by the BC Ministry of Health.

Other requirements include reporting. The water supplier must make public an annual report showing the results of the monitoring. In addition, if the standards are not met, the laboratory must immediately inform the health officer and the water supplier. The water supplier must then give a public notice of non-potable water.

The regulations also require certification for water systems operators. This will be discussed in Section 8.0 of the report.

5.3. Island Health Authority Requirements

The Town must also comply with the local Health Authority requirements. VIHA officers evaluate and assess new sources of water for public use, make recommendations for operating permits, review water quality monitoring data, and inspect water systems.

VIHA has issued two policies regarding drinking water quality. The *Guidelines for the Approval of Water Supply Systems* were issued in 2006 and provides treatment requirements and recommendations on water quality testing before the approval of any new water supply system.

The *Drinking Water Treatment for Surface Water Supplies Policy*, or *4-3-2-1 Policy*, were issued at the end of 2007 and refers to treatment requirements for water systems supplied by surface water. Both are discussed below.

Guidelines for the Approval of Water Supply Systems

VIHA *Guidelines for the Approval of Water Supply Systems* require that before the submission for approval of new water supply system, raw water be characterized for the following parameters:

- Microbiological pathogens: total coliforms, non-coliform bacteria, Escherichia coli,
- heterotrophic plate count
- Physical parameters: colour, conductivity, pH, turbidity
- Chemical parameters: alkalinity, corrosiveness, hardness, organic nitrogen, total
- dissolved solids (TDS), total organic carbon (TOC), ammonia, chloride, fluoride, nitrate,
- nitrite, sulphate, arsenic, selenium, and other metals
- The guidelines also require treatment providing the following levels:
- 3 log inactivation or reduction for Cryptosporidium and 3 log inactivation or reduction for Giardia
- 4 log inactivation or reduction for viruses and bacteria
- Minimum CT factor of 12 min.mg/L and chlorine residual of 0.2 mg/L
- Disinfection by-products (trihalomethanes [THMs], haloacetic acids [HAAs], chlorite and bromate) at acceptable levels
- Acceptable colour, odour, and taste

Drinking Water Treatment for Surface Water Supplies Policy

More recently, VIHA issued the *Drinking Water Treatment for Surface Water Supplies Policy* that has stricter requirements on treatment for water systems supplied by surface water. Treatment goals for surface water systems are the following:

- 4 log inactivation or removal of viruses;
- 3 log inactivation or removal of *Cryptosporidium* and *Giardia;*
- 2 treatment processes (usually filtration and disinfection);
- 1 ntu turbidity maximum in the finished water;
- Filtration deferral may be permitted under the following conditions:
    - Turbidity be less than 1 ntu 95 percent of the time, and peak turbidity readings be less than 5 ntu for no more than 2 days in a 1-year period;
    - No more than 10 percent of raw water samples exceed 20 Escherichia coli/100 mL in any 6-month period;
    - Two primary disinfectants be used; the two together need to achieve the 4 log inactivation or reduction of viruses and 3 log inactivation or reduction of *Cryptosporidium* and *Giardia;*
    - Effective ongoing watershed protection;

As well, the VIHA may require additional treatment to address the following:

- High bacterial counts or risks of fecal contamination of source water;
- High organic matter that may result in unacceptable levels of disinfection by-products;
- Chemicals or other contaminants that may affect potability.

6. Water Quality Monitoring Program

The Town monitors and records water quality parameters in general compliance with the requirements of our Operational Permit issued by VIHA. In 2009, Koers and Associates issued a Water Quality Monitoring Program Report (Ref 4) that guides the collection of a number of water quality parameters for the Town, summarized as follows:

Table 4 Water Testing Frequencies

Parameter	Frequency by Location			
	Holland Lake	Chicken Ladder Intake (Holland Creek)	Balancing Reservoir (Stocking Lake)	Distribution System
Physical Parameters				
Turbidity	Weekly or Continuous*	Weekly or Continuous*	Weekly or Continuous*	-
Total Organic Carbon (TOC)	Monthly	Monthly	Monthly	-
Dissolved Organic carbon (DOC)	Monthly	Monthly	Monthly	-
True Color	Weekly	Weekly	Weekly	-
Apparent Color	Weekly	Weekly	Weekly	-
Temperature	Weekly	Weekly	Weekly	Along with regular health Sampling
Ultraviolet Transmissivity (UVT)	Semi-Monthly	Semi-Monthly	Semi-Monthly	-
Total Dissolved Solids (TDS)	Monthly	Monthly	Monthly	Monthly
Chemical Parameters				
Alkalinity	Monthly	Monthly	Monthly	Monthly
Physical Parameters	Monthly	Monthly	Monthly	Monthly
Calcium	Monthly	Monthly	Monthly	Monthly
Bromide	Monthly	Monthly	Monthly	-
Hardness	Semi-Annually	Semi-Annually	Semi-Annually	-
Total Metals	Semi-Annually	Semi-Annually	Semi-Annually	Semi-Annually
Microbiological Parameters				
E Coli	Semi-Annually	Semi-Annually	Semi-Annually	Semi-Annually
Total Coliforms	Semi-Annually	Semi-Annually	Semi-Annually	Semi-Annually
Regular Health Sampling	-	-	-	?
Miscellaneous Parameters				
Total Extractable Hydrocarbons (T.E.H.)	-	Following high turbidity events	-	-
THM Formation	Quarterly, or following high color events	Quarterly, or following high color events	Quarterly, or following high color events	Bi-Monthly
Chlorine Residual	-	-	-	Along with regular health Sampling
* Actual Turbidity Frequency	Continuous	Daily	Continuous	Continuous

Detailed in Appendix B are the results of the annual lab tests (excluding turbidity and health Bacteriological testing) for Holland Lake, Stocking Lake, and Chicken Ladder Intake.

6.1. Physical Parameters

a) Turbidity

The Town receives its source water from either Chicken Ladder Intake (on Holland Creek upstream of the Arbutus reservoir), or Stocking Lake. The Chicken Ladder Intake includes released water from Holland Lake, as well as additional catchment water collected downstream from Holland Dam through the Holland Creek watershed. The Town has the ability to 'switch' water supplies rapidly in response to turbidity events in either sources of supply, and hence has the ability to influence the water quality of delivered water to the system, subject to total annual flow and time of year limitations set out by our respective water licenses. The table below provides the blended turbidity values for water used for the Ladysmith system. See Section 4 for details on the flow splits between Stocking and Chicken Ladder (Holland Creek):

Table 5 Blended Water (Either Stocking Lake, or Chicken Ladder)

Month	Ave	High	Low	Days > 1 NTU	Days > 5 NTU	Percent Stocking Water	Percent Holland Water
January	0.12	0.18	0.11	0	0	100	0
February	0.17	0.24	0.09	0	0	100	0
March	0.08	0.10	0.05	0	0	58	42
April	0.15	0.25	0.06	0	0	43	57
May	0.23	0.48	0.11	0	0	0	100
June	0.16	0.28	0.10	0	0	0	100
July	0.16	0.41	0.08	0	0	0	100
August	0.09	0.15	0.05	0	0	0	100
Sept	0.17	0.51	0.08	0	0	10	90
Oct	0.26	0.22	0.09	0	0	22	78
Nov	0.29	0.44	0.17	0	0	100	0
Dec	0.23	0.37	0.16	0	0	100	0
Total				**0**	**0**	**45**	**55**
Average	**0.18**	**0.30**	**0.10**				
Max/Min		**0.51**	**0.05**				

Our blended water easily meets the VIHA Guidelines for Surface Water Supplies for turbidity in 2018.

In addition to measuring turbidity in our 'managed' water supply, the Town also collects turbidity data for all of our sources of supply, irrespective of whether the supply is being utilized at the moment. This includes the continuously monitored turbidity meter at Holland Lake and Stocking Lake, as well as 'manual' field turbidity samples that are taken weekly by staff at both Stocking Lake, as well as our Chicken Ladder (Holland Creek) Intake.

Holland Lake

During 2018 continued problems occurred with the turbidity metering system and the power generation system at Holland Lake that made the readings sporadic, for this reason there where gaps in the turbidity data this year. The results of our fifth full year of continuous Holland Lake turbidity monitoring are as follows:

Table 6 Holland Lake Turbidity Summary (NTU)

Month	Complete	Ave	High	Low	Days > 1 NTU	Days > 5 NTU
January		0.59	2.01	0.42	4	
February		0.47	0.58	0.33		
March		0.52	6.35	0.30	3	1
April		0.44	0.72	0.29		
May		0.56	0.86	0.36		
June		0.61	9.14	0.43	1	1
July		0.37	0.64	0.21		
August		0.31	0.49	0.17		
Sept						
Oct						
Nov						
Dec						
Summary						

Stocking Lake Turbidity

Stocking Lake generally produces water under 1.0 NTU during the entire year. The Town installed a continuous turbidity meter on the Stocking Lake system a number of years ago. The following are the results of the 2018 turbidity testing for Stocking Lake:

Table 7 Stocking Lake Continuous Turbidity Results

Month	Complete	Ave	High	Low	Days > 1 NTU	Days > 5 NTU
January	Yes	0.30	0.42	0.25	0	0
February	Yes	0.28	0.33	0.23	0	0
March	Yes	0.27	0.32	0.22	0	0
April	Yes	0.31	0.44	0.19	0	0
May	Yes	0.29	0.42	0.16	0	0
June	Yes	0.24	0.41	0.14	0	0
July	Yes	0.26	0.48	0.15	0	0
August	Yes	0.24	0.60	0.12	0	0
Sept	Yes	0.30	2.60	0.10	11	0
Oct	Yes	0.28	0.47	0.15	0	0
Nov	Yes	0.43	0.66	0.28	0	0
Dec	Yes	0.38	0.44	0.280	0	0
Summary		0.29	2.60	0.10	11	0

Chicken Ladder Intake (Lower Holland Creek)

Staff visit Chicken Ladder Intake on a daily basis, and collects a turbidity sample during that inspection. The summary is as follows:

Table 8 Holland Creek (at Chicken Ladder) Measured Turbidity Results

Month	Complete	Ave	High	Low	Days > 1 NTU	Days > 5 NTU
January		0.35	0.350	0.350	0	0
February		0.983	3.540	0.310	2	0
March		0.955	3.390	0.310	6	0
April		0.873	2.830	0.390	5	0
May		0.628	0.840	0.470	0	0
June		0.409	0.670	0.090	0	0
July		0.348	0.620	0.15	0	0
August		0.313	0.730	0.19	0	0
Sept		0.343	0.450	0.220	0	0
Oct		0.478	1.590	0.200	1	0
Nov		1.365	6.420	0.000	6	2
Dec		0.505	0.930	0.260	0	0
Summary		0.629	6.420	0.000	20	2

Staff monitor turbidity levels at Chicken Ladder on a regular basis, and are able to 'switch' water supplies rapidly when turbidity events occur (usually the result of high intensity rain events occurring in the upper Holland watershed). As a result, none of the high turbidity water from Chicken Ladder ended up in the water system in 2018.

b) Organic Carbon, Color, Temperature, Ultraviolet Transmissivity, Dissolved Solids

Results for Holland Lake, Stocking Lake, and Chicken Ladder are attached in Appendix B, and summarized as follows:

Table 9 Holland Lake – Other Physical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Total Dissolved Solids	8	Mg/L	15	23	<10	<500	OK
PH	21	PH Units	6.79	7.28	6.32	6.5-8.4	
True Color	31	Col Unit	12.03	23.9	5.6	<15 (AO)	OK
Apparent Color	31	Col Unit	12.1	20.0	5.0		
Dissolved organic Carbon	8	Mg/L	2.17	2.6	0.97	<5 (AO)	OK
Total Organic Carbon	8	Mg/L	2.66	3.0	2.1	n/a	
Ultraviolet Transmissivity	16	AU/cm	83.58	87.9	76.8	>80 (AO)	High

(AO) Aesthetic Objective

Table 10 Holland Creek (Chicken Ladder) – Other Physical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Total Dissolved Solids	8	Mg/L	19.75	28	<10.0	<500	OK
PH	26	PH Units	6.90	7.17	6.61	6.5-8.4	OK
True Color	37	Col Unit	14.89	30.1	5.5	<15 (AO)	High
Apparent Color	37	Col Unit	13.24	20	5		
Dissolved organic Carbon	9	Mg/L	2.26	4.21	0.75	<5 (AO)	OK
Total Organic Carbon	9	Mg/L	2.53	3.41	1.57	n/a	
Ultraviolet Transmissivity	19	AU/cm	81.84	89.6	69.2	>80 (AO)	High

(AO) Aesthetic Objective

Table 11 Stocking Lake – Other Physical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Total Dissolved Solids	8	Mg/L	24.0	32	<10	<500	OK
PH	25	PH Units	7.03	7.31	6.7	6.5-8.4	OK
True Color	36	Col Unit	10.58	23.8	<5.0	<15 (AO)	
Apparent Color	36	Col Unit	12.22	30	5		
Dissolved organic Carbon	9	Mg/L	2.5	2.5	1.4	<5 (AO)	OK
Total Organic Carbon	9	Mg/L	2.71	3.72	1.83	n/a	
Ultraviolet Transmissivity	18	AU/cm	84.41	86.1	81.0	>80 (AO)	

(AO) Aesthetic Objective

6.2. Chemical Parameters

The Town conducts bi-annual metals testing. Results for all three water sources are as follows in Table 12.

Table 12 Metals, Hardness Testing - June 28, 2018

Maxxam ID		RK1693	RK1694	RK1695		
Sampling Date		2017/06/28 14:30	2017/06/28 8:30	2017/06/28 11:00		
COC Number		519810-01-01	519810-01-01	519810-01-01		
	UNITS	**HOLLAND LAKE**	**STOCKING LAKE**	**CHICKEN LADDER**	**CDW/BC Guideline**	**Comments**
Calculated Parameters						
Total Hardness ($CaCO_3$)	mg/L	4.00	9.83	6.58	0.50	OK
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	67.2	28	53.9	100	OK
Total Antimony (Sb)	ug/L	<.50	<0.50	<0.50	6	OK
Total Arsenic (As)	ug/L	<0.10	<0.10	0.12	10	OK
Total Barium (Ba)	ug/L	4.5	3.1	3.5	1000	OK
Total Beryllium (Be)	ug/L	<0.10	<0.10	<0.10		
Total Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0		
Total Boron (B)	ug/L	<50	<50	<50	5000	OK
Total Cadmium (Cd)	ug/L	0.076	<0.010	0.585	5	OK
Total Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	50	OK
Total Cobalt (Co)	ug/L	<0.20	<0.20	<0.20		
Total Copper (Cu)	ug/L	1.19	<0.50	5.6	AO <1000	OK
Total Iron (Fe)	ug/L	135	45	53	300 AO	OK
Total Lead (Pb)	ug/L	<0.20	<0.20	0.21	10	OK

Total Lithium (Li)	ug/L	<2.0	<2.0	<2.0		
Total Manganese (Mn)	ug/L	6.6	4.0	2.6	50 AO	OK
Total Mercury (Hg)	ug/L	<0.01	<0.01	<0.01	1	OK
Total Molybdenum (Mo)	ug/L	<1.0	<1.0	<1.0	73	
Total Nickel (Ni)	ug/L	<1.0	<1.0	<1.0		
Total Selenium (Se)	ug/L	<0.10	<0.10	<0.10	50	OK
Total Silicon (Si)	ug/L	936	2190	2320		
Total Silver (Ag)	ug/L	<0.020	<0.020	<0.020		
Total Strontium (Sr)	ug/L	5.8	9.6	10.0	5Bq/L	
Total Thallium (Tl)	ug/L	<0.010	<0.010	<0.010		
Total Tin (Sn)	ug/L	<5.0	<5.0	<5.0		
Total Titanium (Ti)	ug/L	<5.0	<5.0	<5.0		
Total Uranium (U)	ug/L	<0.10	<0.10	<0.10		
Total Vanadium (V)	ug/L	<5.0	<5.0	<5.0		
Total Zinc (Zn)	ug/L	<5.0	<5.0	8.6	<5mg/L	OK
Total Zirconium (Zr)	ug/L	<0.10	<0.10	<0.10		
Total Calcium (Ca)	mg/L	1.23	3.17	2.01		
Total Magnesium (Mg)	mg/L	.227	.466	.379		
Total Potassium (K)	mg/L	0.153	.238	.255		
Total Sodium (Na)	mg/L	.637	1.03	1.09	< 200 AO	OK
Total Sulphur (S)	mg/L	<3.0	<3.0	<3.0		

6.3. Other Chemical Parameters

The Town also tests for Alkalinity, Calcium, Bromide, and Hardness. Results of these tests are as follows:

Table 13 Holland Lake - Other Chemical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Alkalinity	7	Mg/L	3.70	5.8	2.4	n/a	
Calcium	7	Mg/L	1.243	1.420	1.130	n/a	
Bromide	7	Mg/L	<0.01	<0.01	<0.01	n/a	

Table 14 Holland Creek (Chicken Ladder) - Other Chemical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Alkalinity	9	Mg/L	5.78	8.4	3.9	n/a	
Calcium	9	Mg/L	1.823	2.410	1.560	n/a	
Bromide	9	Mg/L	<0.010	<0.010	<0.010	n/a	

Table 15 Stocking Lake - Other Chemical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Alkalinity	8	Mg/L	7.69	9.9	3.5	n/a	
Calcium	8	Mg/L	3.237	3.540	2.830	n/a	
Bromide	8	Mg/L	<0.010	<0.010	<0.010	n/a	

6.3.1. Microbiological Parameters

The Town, through Island Health, conducts weekly tests for E-Coli and Total Coliforms of our distribution system (treated water). Tests are taken weekly, and are enclosed in Appendix E. The Town is required to meet the following standards set out by Island Health for our distribution system:

Parameter	Standard
Fecal Coliform Bacteria	No detectable fecal coliform bacteria per 100 ml
Escherichia Coli	No detectable Escherichia Coli per 100 ml
Total Coliform Bacteria	At least 90% of samples have no detectable total coliform bacteria per 100 ml and no sample has more than 10 total coliform

The Town also tests our raw water sources for E-Coli and Total Coliforms. Summarized results for 2018 are as follows:

Table 16 Source (Untreated) Water E-Coli and Total Coliform Results Holland Lake

Parameter	No of Samples	Units	Ave	High	Low	Samples > 20 (e-coli)	Comments
E-Coli	14	Cfu/100ml	2.8	29	<1	0.0% > 20 cfu/100ml	10% max
Total Coliforms	14	Cfu/100ml	1591	9000	60	84% > 100 cfu/100ml	

Table 17 Source Water E-Coli and Total Coliform Results Holland Creek (Chicken Ladder)

Parameter	No of Samples	Units	Ave	High	Low	Samples > 20 (e-coli)	Comments
E-Coli	17	Cfu/100ml	12.36	40	<1	5.2% > 20 cfu/100ml	10% max
Total Coliforms	17	Cfu/100ml	935	3800	21	84% >100 cfu/100ml	

Table 18 Source Water E-Coli and Total Coliform Results Stocking Lake

Parameter	No of Samples	Units	Ave	High	Low	Samples > 20 (e-coli)	Comments
E-Coli	18	Cfu/100ml	2.13	<10	<1	0% > 20 cfu/100ml	10% max
Total Coliforms	18	Cfu/100ml	7.35	2700	18	63% > 100 cfu/100ml	

For 2018, there were exceedances of E-Coli in raw water samples.

6.4. Miscellaneous Parameters

THM Formation

Trihalomethanes (THM's) and Haloacetic Acids (HAA's) are formed as products of conventional chlorination within a water system. They are commonly referred to disinfection by-products. The Canadian Drinking Water guideline is 0.1 mg/L for THM's and 0.08 mg/L for HAA's.

Eight tests total were conducted within the water system in 2018 for each, as follows:

Table 19 THM Formation in Water System, in mg/L

	558 Hooper	1280 Rocky Creek	CDW Guideline	Comments
Date	THM	THM		
Mar.07/18	0.079	0.070	0.100	Marginally meets CDWG
Jun.13/18	0.064	0.047	0.100	Meets CDWG
Sept.18/18	0.073	0.065	0.100	Meets CDWG
Dec. 05/18	0.071	0.066	0.100	Marginally meets CDWG

Table 20 Total HAA Formation in Water System, in mg/L

	558 Hooper	1280 Rocky Creek	CDW Guideline	Comments
Mar. 07/ 18	0.120	0.096	0.080	
Jun. 13/18	0.078	0.055	0.080	
Sep. 18/18	0.069	0.077	0.080	
Dec. 05/18	0.038	0.090	0.080	Marginally Meets CDWG

Table 21 THM Component Results, in mg/L

Test Date	Component	558 Hooper	1280 Rocky Creek
Mar 07, 2018	Chloriform	0.077	0.068
Mar 07, 2018	Chlorodibromomethane	<0.001	<0.001
Mar 07, 2018	Bromodichloromethane	.0022	0.0018
Mar 07, 2018	Bromoform	<0.001	<0.001
Mar 07, 2018	1,4-Difluorobenzene (sur.)	102%	101%
Mar 07, 2018	4-Bromofluorobenzene (sur.)	94%	91%
Mar 07, 2018	D4-1,2-Dichloroethane (sur.)	91%	98%
June 13, 2018	Chloriform	0.062	0.045
June 13, 2018	Chlorodibromomethane	<0.001	<0.001
June 13, 2018	Bromodichloromethane	0.0024	0.0019
June 13, 2018	Bromoform	<0.001	<0.001
June 13, 2018	1,4-Difluorobenzene (sur.)	100%	100%
June 13, 2018	4-Bromofluorobenzene (sur.)	93%	93%
June 13, 2018	D4-1,2-Dichloroethane (sur.)	93%	92%
Sept 18, 2018	Chloriform	0.069	0.062
Sept 18, 2018	Chlorodibromomethane	<0.001	<0.001
Sept 18, 2018	Bromodichloromethane	.0037	0.0029
Sept 18, 2018	Bromoform	<0.001	<0.001
Sept 18, 2018	1,4-Difluorobenzene (sur.)	100%	99%
Sept 18, 2018	4-Bromofluorobenzene (sur.)	89%	88%
Sept 18, 2018	D4-1,2-Dichloroethane (sur.)	94%	93%
Dec 05, 2018	Chloriform	0.069	0.064
Dec 05, 2018	Chlorodibromomethane	<0.001	<0.001
Dec 05, 2018	Bromodichloromethane	.0024	0.0023

Dec 05, 2018	Bromoform	<0.001	<0.001
Dec 05, 2018	1,4-Difluorobenzene (sur.)	98%	98%
Dec 05, 2018	4-Bromofluorobenzene (sur.)	84%	84%
Dec 05, 2018	D4-1,2-Dichloroethane (sur.)	94%	95%

Haloacetic Acids are referred to as "disinfection by-products", which are caused by the process of chlorination. In the Town's water supply, the principle cause of the higher HAA's is the requirement to provide enough chlorine dosage to effectively disinfect all of the dissolved organic carbon and turbidity, both in the Holland Lake source as well as the Stocking Lake source. This is a typical situation for surface water supplies on Vancouver Island, particularly related to soft water supplies (surface, rainwater based). Higher PH water sources will often have higher THM's, and lower HAA's.

Reducing the chlorine dosage will reduce the amount of disinfection by-products , but runs the risk of 'using up' all of the residual chlorine in the distribution system, which is not acceptable from a health perspective (domestic water distribution systems must retain a chlorine residual in all parts of the distribution system at all times). The most effective method of reducing disinfection by-products is to remove turbidity (dirt) and dissolved organic carbon (often colorless to the naked eye), so that the chlorine dosage can consequently be reduced. This will allow a reasonable chlorine residual to be maintained in the system while keeping HAA;'s (and THM's) low as well.

The most effective means for doing this is to filter the water before chlorination. The Town has made the commitment to proceed with filtration, which is expected to be in operation by 2018. When this improvement is in place, we expect HAA and THM concentrations to be reduced dramatically.

The table and chart on the following page shows the HAA and THM component test results for the Town, taken quarterly, over the previous five years.

Health Canada has published an extensive review of the effects of Haloacetic Acids in drinking water. The Review can be accessed at:

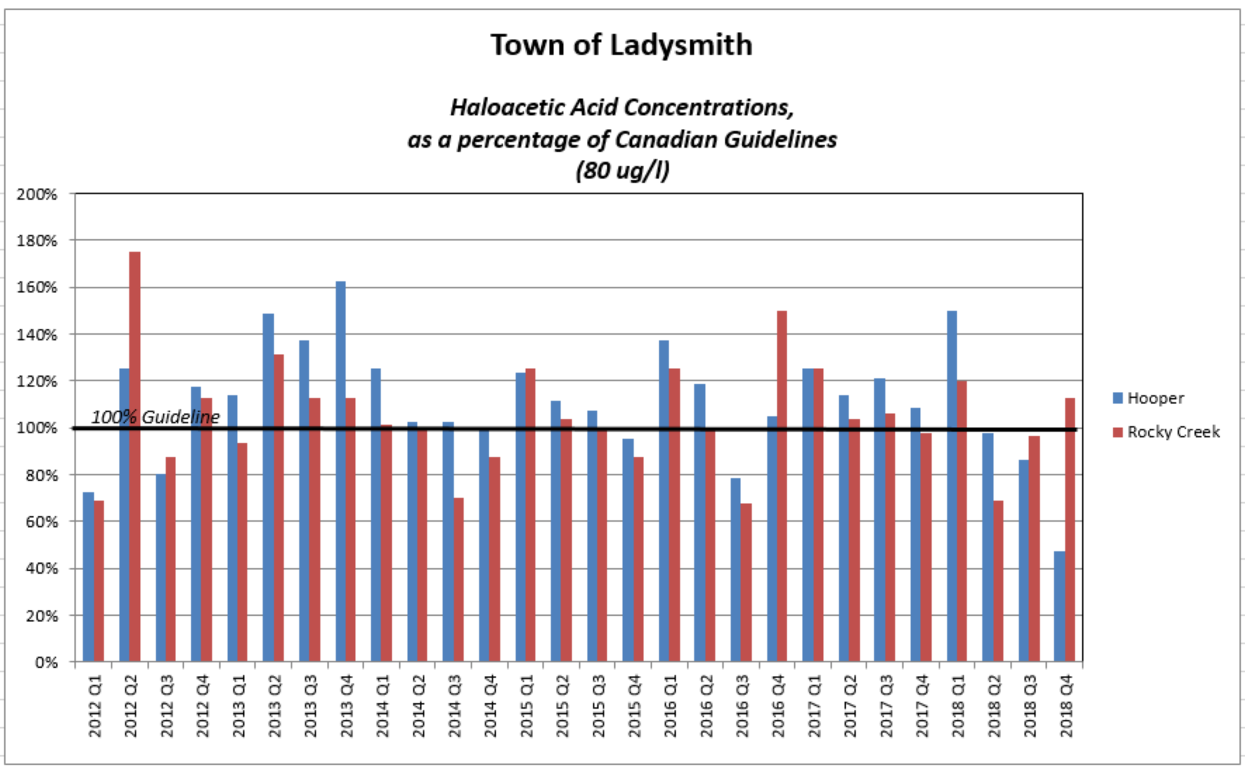
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/haloaceti/index-eng.php

A copy of Part One of the executive summary follows in Appendix D, and provides an overview of this issue.

Table 22 HAA Analysis: 2012 to 2018

Concentrations in micrograms per liter (ug/l)																	Total HAA's				Inferred DCAA*		Inferred TCAA**	
																	80 ug/l		60 ug/l		40 ug/l		30 ug/l	
			MCAA		MBAA		DCAA		TCAA		BCAA		DBAA		Total		% Can Guideline		% US Guideline		% Can Guideline		% Can Guideline	
			Location		Location		Location		Location		Location		Location		Location		Location		Location		Location		Location	
Year	Quarter	Seq	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky	Hooper	Rocky
2012	1	5	ND	ND	2	ND	19	20	36	36	1	ND	ND	ND	58	55	73%	69%	97%	92%	48%	50%	120%	120%
2012	2	6	ND	ND	ND	ND	34	60	68	83	ND	ND	ND	ND	100	140	125%	175%	167%	233%	85%	150%	227%	277%
2012	3	7	ND	ND	ND	ND	19	23	45	47	ND	ND	ND	ND	64	70	80%	88%	107%	117%	48%	58%	150%	157%
2012	4	8	ND	ND	ND	ND	29	30	65	60	ND	ND	ND	ND	94	90	118%	113%	157%	150%	73%	75%	217%	200%
2013	1	9	ND	ND	ND	ND	34	29	57	46	ND	ND	ND	ND	91	75	114%	94%	152%	125%	85%	73%	190%	153%
2013	2	10	ND	ND	ND	ND	56	49	63	56	ND	ND	ND	ND	119	105	149%	131%	198%	175%	140%	123%	210%	187%
2013	3	11	ND	ND	ND	ND	55	48	55	42	ND	ND	ND	ND	110	90	138%	113%	183%	150%	138%	120%	183%	140%
2013	4	12	ND	ND	ND	ND	53	37	77	52	ND	ND	ND	ND	130	90	163%	113%	217%	150%	133%	93%	257%	173%
2014	1	13	ND	ND	ND	ND	45	36	58	55	ND	ND	ND	ND	100	81	125%	101%	167%	135%	113%	90%	193%	183%
2014	2	14	ND	ND	ND	ND	47	42	35	37	ND	ND	ND	ND	82	79	103%	99%	137%	132%	118%	105%	117%	123%
2014	3	15	ND	ND	ND	ND	38	19	44	37	ND	ND	ND	ND	82	56	103%	70%	137%	93%	95%	48%	147%	123%
2014	4	16	ND	ND	ND	ND	22	27	58	43	ND	ND	ND	ND	79	70	99%	88%	132%	117%	55%	68%	193%	143%
2015	1	17	ND	ND	ND	ND	30	33	70	70	ND	ND	ND	ND	99	100	124%	125%	165%	167%	75%	83%	233%	233%
2015	2	18	ND	ND	ND	ND	35	34	53	50	ND	ND	ND	ND	89	83	111%	104%	148%	138%	88%	85%	177%	167%
2015	3	19	ND	ND	ND	ND	20	28	67	52	ND	ND	ND	ND	86	80	108%	100%	143%	133%	50%	70%	223%	173%
2015	4	20	ND	ND	ND	ND	21	25	55	45	ND	ND	ND	ND	76	70	95%	88%	127%	117%	53%	63%	183%	150%
2016	1	21	ND	ND	ND	ND	36	34	78	70	ND	ND	ND	ND	110	100	138%	125%	183%	167%	90%	85%	260%	233%
2016	2	22	ND	ND	ND	ND	30	32	65	48	ND	ND	ND	ND	95	80	119%	100%	158%	133%	75%	80%	217%	160%
2016	3	23	ND	ND	ND	ND	14	20	50	34	ND	ND	ND	ND	63	54	79%	68%	105%	90%	35%	50%	167%	113%
2016	4	24	ND	ND	ND	ND	9.4	39	75	77	ND	ND	ND	ND	84	120	105%	150%	140%	200%	24%	98%	250%	257%
2017	1	25	ND	ND	ND	ND	36	35	69	65	ND	ND	ND	ND	100	100	125%	125%	167%	167%	90%	88%	230%	217%
2017	2	26	<5.0	<5.0	<5.0	<5.0	34	32	57	51	<5.0	<5.0	<5.0	<5.0	91	83	114%	104%	152%	138%	85%	80%	190%	170%
2017	3	27	<5.0	<5.0	<5.0	<5.0	35	33	61	52	<5.0	<5.0	<5.0	<5.0	97	85	121%	106%	162%	142%	88%	83%	203%	173%
2017	4	28	<5.0	<5.0	<5.0	<5.0	9.4	39	61	48	<5.0	<5.0	<5.0	<5.0	87	78	109%	98%	145%	130%	24%	98%	203%	160%
2018	1	29	<5.0	<5.0	<5.0	<5.0	40	35	79	61	<5.0	<5.0	<5.0	<5.0	120	96	150%	120%	200%	160%	100%	88%	263%	203%
2018	2	30	ND	ND	ND	ND	25	24	53	31	ND	ND	ND	ND	78	55	98%	69%	130%	92%	63%	60%	177%	103%
2018	3	31	<5.0	<5.0	<5.0	<5.0	11	32	57	46	<5.0	<5.0	<5.0	<5.0	69	77	86%	96%	115%	128%	28%	80%	190%	153%
2018	4	32	<5.0	<5.0	<5.0	<5.0	5.6	32	32	58	<5.0	<5.0	<5.0	<5.0	38	90	48%	113%	63%	150%	14%	80%	107%	193%
5 Year Average							27.2	31.6	58.9	51.5					86.3	81.9	108%	102%	144%	136%	68%	79%	196%	172%
* Assumes that TCA's make up 50% of total HAA's in water										5 Year Average, both locations:					84.1					average	73%		184%	
		Actual Percentage of DCA's to HAA's					34.9%			Year (2017,2018) Average, both location					84.0					total HAA equiv	59		147	

** Canada: 30ug/l, US: 20ug/l and WHO: 200ug/l



7. Watershed Management

Both Holland and Stocking Lake watersheds are jointly used ‘semi-closed’ watersheds, owned and managed by a number of parties, including:

- Town of Ladysmith;
- Ministry of Forests, Lands and Natural Resource Operations (MFNRO);
- TimberWest Forest Corporation (TimberWest);
- Cowichan Valley Regional District (CVRD).

MFNRO leases some of the lands to private third parties and First Nations principally for forestry use.

There are not any public roads within the watershed area, but are predominately private forest access roads that are jointly used by the parties.

The public is encouraged to use a recreational trail system within the watershed, and includes trails that are adjacent to both Holland and Stocking Lakes. The Town maintains a well-used trail system that includes the above noted trail routes. Posted signs at a number of strategic locations prohibit vehicle access to the Lakes, and prohibit recreational lake use such as boating, swimming, and fishing.

7.1. Security

The Town jointly manages a number of gates within the Holland and Stocking Lakes Watersheds that control access into Holland and Stocking Lakes. Normally these gates are left in a locked state, except when active logging activities are taking place. Town staff travel to both Lakes on a minimum weekly basis.

In recent years, the Town has observed instances where 4 wheel ATV vehicles have entered the area by by-passing the locked gates, and the Town and TimberWest has been working to prevent this activity through the use of ditching and other means to block access into the area, with some success.

The Town also posts signs at entrances to both Lakes advising that public access to the lakes is not permitted. The Town continues to see evidence of occasional camping and recreational activity around the lakes, particularly Holland Lake which is more remote than Stocking Lake.

8. Routine Maintenance Program

The Town has a regular maintenance program described briefly as follows:

8.1. Distribution

- Water mains are flushed using a unidirectional flushing program
- Air relief valves are cleaned
- Fire Hydrants inspection program
- Paint and brush out around hydrants as needed

8.2. Source Intakes

- Periodic diver inspection of intakes
- Bi-weekly site inspections (varies in winter)
- Monthly calibration of turbidity analyzers

8.3. Reservoirs

- Daily security check of tanks and compounds
- Clean Reservoir using divers every 5 years.

The Town trains staff in accordance with current industry practises and requirements, and certified staff work on our system as required in the Town's Operating Permit.

9. Capital Planning

A summary of the major capital projects projected over the next 10 years is as follows:

Table 23 – Long Term Capital Plan

Title	Description	Purpose	Start Year	Cost
Stocking Lake Supply Main Replacement - Phase I	Replacement of the existing AC watermain from Stocking Lake to the balancing reservoir.	To provide a more secure Supply main.	2020	$800,000
Watermain Replacement Program	Annual Capital Watermain Replacement Program in the Town’s Distribution System.	To replace aging AC and Cast Iron mains throughout the distribution system.	annual	$300,000
Holland to Stocking Supply Main	New Supply main to connect Stocking Supply Main with Holland Lake.	To provide a direct system connection from Holland Lake to the Town's water system.	2022	$5,4000,000
Water Filtration Project	Design and Construction for new Water Filtration Plant near Arbutus Reservoir.	To provide Filtration as per VIHA 4-3-2-1 Water Supply Rule.	2018	$14,000,000
Holland Dam Capacity Increase	Doubling of current storage at Holland Dam	To provide for future water supply needs	2019-2021	$12,500,000
Replace Holland Supply Main: Public Works Yard to Colonia	Replacement of old AC supply main along the Holland Creek Trail	To provide a more secure Supply main.	2018	$400,000
Arbutus Reservoir - Capacity Increase	Doubling of Arbutus Reservoir	For future development	2024	$3,000,000
			10 year Plan - Cost of "Major' Projects Only	**$36,400,000**

Appendix A – Canadian Drinking Water Quality Guidelines

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 1 – Microbiological Parameters

Parameter (approval)	Guideline	Common sources	Health considerations	Applying the guideline
Bacterial waterborne pathogens (2006)	None required	Human and animal faeces; some are naturally occurring	Commonly associated with gastrointestinal upset (nausea, vomiting, diarrhoea); some pathogens may infect the lungs, skin, eyes, central nervous system or liver.	Use multi-barrier approach to reduce pathogens to levels that are non-detectable or not associated with illness.
Enteric viruses (2011)	Treatment goal: Minimum 4 log reduction and/or inactivation of enteric viruses	Human and animal faeces	Commonly associated with gastrointestinal upset (nausea, vomiting, diarrhoea); less common health effects can include respiratory symptoms, central nervous system infections, liver infections and muscular syndromes.	Routine monitoring for viruses is not practical; where possible, characterize source water to determine if greater than a 4 log removal or inactivation is necessary.
Escherichia coli(*E. coli*) (2006)	MAC: None detectable per 100 mL	Human and animal faeces	The presence of *E. coli* indicates recent faecal contamination and the potential presence of microorganisms capable of causing gastrointestinal illnesses; pathogens in human and animal faeces pose the most immediate danger to public health.	*E. coli* is used as an indicator of the microbiological safety of drinking water; if detected, enteric pathogens may also be present.
Heterotrophic plate count (HPC) (2006)	None required	Naturally occurring	HPC results are not an indicator of water safety and should not be used as an indicator of potential adverse human health effects; HPC is a useful operational tool for monitoring general bacteriological water quality through the treatment process and in the distribution system.	If increases in HPC values above baseline levels occur, the system should be inspected to determine the cause; HPC should be minimized through effective treatment and disinfection and remain constant over time.
Protozoa: *Giardia* and *Cryptosporidium*(2004)	Treatment goal: Minimum 3 log reduction and/or inactivation	Human and animal faeces	Commonly associated with gastrointestinal upset (nausea, vomiting, diarrhoea); less common health effects can include respiratory symptoms, central nervous system infections, liver infections and muscular syndromes.	Monitoring for *Cryptosporidium* and *Giardia* in source waters will provide valuable information for assessing treatment requirements.

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 1 – Microbiological Parameters

Parameter (approval)	Guideline	Common sources	Health considerations	Applying the guideline
Total coliforms (2006)	*At exit of municipal treatment plant or throughout semi-public systems*: MAC of none detectable/100 mL *In municipal distribution systems*: No consecutive samples or no more than 10% of samples should contain total coliforms	Human and animal faeces; naturally occurring in water, soil and vegetation	Total coliforms are not used as indicators of potential health effects from pathogenic microorganisms; they are used as an operational tool to determine how well the drinking water treatment system is operating.	In water leaving a treatment plant, the presence of total coliforms indicates that the water has been inadequately treated and may contain pathogenic microorganisms; in semi-public systems, the presence of total coliforms generally indicates that the system is vulnerable to contamination and that additional actions need to be taken; in a distribution and storage system, detection of total coliforms can indicate regrowth of the bacteria in distribution system biofilms or intrusion of untreated water; thus, exceedances of the distribution system goal should be investigated.
Turbidity (2003)	Guideline Treated water < 0.1 NTU Table 1 footnote1at all times. Where not achievable: ≤ 0.3 NTU Table 1 footnote2 ≤ 1.0 NTU Table 1 footnote3 ≤ 0.1 NTU Table 1 footnote4	Naturally occurring particles: *Inorganic*: clays, silts, metal precipitates *Organic*: decomposed plant & animal debris, microorganisms	Indirect associations: particles can harbour microorganisms, protecting them from disinfection, and can entrap heavy metals and biocides; elevated or fluctuating turbidity in filtered water can indicate a problem with the water treatment process and a potential increased risk of pathogens in treated water.	Guidelines apply to individual filter turbidity for systems that use surface water or GUDI; drinking water from some sources may meet exemption criteria from filtration requirements established by the appropriate authority; increases in distribution system turbidity can be indicative of deteriorating water quality and should be investigated.

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
T	Aluminum (1998)		OG: < 0.1 (conventional treatment); < 0.2 (other treatment types)	Aluminum salts used as coagulants in drinking water treatment; naturally occurring		Current weight of evidence does not indicate adverse health effects at levels found in drinking water.
I	Ammonia (1987)	None required		Naturally occurring; released from agricultural or industrial wastes; added as part of chlorination for drinking water disinfection		Guideline value not necessary as it is produced in the body and efficiently metabolized in healthy people; no adverse effects at levels found in drinking water.
I	Antimony (1997)	0.006		Naturally occurring (erosion); soil runoff; industrial effluents; leaching from plumbing materials and solder	**Health basis of MAC:** Microscopic changes in organs and tissues (thymus, kidney, liver, spleen, thyroid)	MAC takes into consideration analytical achievability; plumbing should be thoroughly flushed before water is used for consumption.
I	Arsenic (2006)	0.01 ALARA		Naturally occurring (erosion and weathering of soils, minerals, ores)	**Health basis of MAC:** Cancer (lung, bladder, liver, skin) (classified as human carcinogen) **Other:** Skin, vascular and neurological effects (numbness and tingling of extremities)	MAC based on treatment achievability; elevated levels associated with certain groundwaters; levels should be kept as low as reasonably achievable.
I	Asbestos (1989, 2005)	None required		Naturally occurring (erosion of asbestos minerals and ores); decay of asbestos-cement pipes		Guideline value not necessary; no evidence of adverse health effects from exposure through drinking water.
P	Atrazine (1993)	0.005		Leaching and/or runoff from agricultural use	**Health basis of MAC:** Developmental effects (reduced body weight of offspring) **Other:** Potential increased risk of ovarian cancer or lymphomas (classified as possible carcinogen)	MAC applicable to the sum of atrazine and its*N*-dealkylated metabolites; persistent in source waters.

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
P	Azinphos-methyl (1989, 2005)	0.02		Leaching and/or runoff from agricultural use	**Health basis of MAC:** Neurological effects (plasma cholinesterase)	All uses to be phased out by 2012.
I	Barium (1990)	1		Naturally occurring; releases or spills from industrial uses	**Health basis of MAC:** Increases in blood pressure, cardiovascular disease	
O	Benzene (2009)	0.005		Releases or spills from industrial uses	**Health basis of MAC:** Bone marrow (red and white blood cell) changes and cancer (classified as human carcinogen) **Other:** Blood system and immunological responses	MAC considers additional exposure through showering and bathing; drinking water is generally a minor source of exposure.
O	Benzo[*a*]pyrene (1988, 2005)	0.000 01		Leaching from liners in water distribution systems	**Health basis of MAC:** Stomach tumours (classified as probable carcinogen)	
I	Boron (1990)	5		Naturally occurring; leaching or runoff from industrial use	**Health basis of MAC:** Reproductive effects (testicular atrophy, spermatogenesis) **Other:** Limited evidence of reduced sexual function in men	MAC based on treatment achievability.
DBP	Bromate (1998)	0.01		By-product of drinking water disinfection with ozone; possible contaminant in hypochlorite solution	**Health basis of MAC:** Renal cell tumours (classified as probable carcinogen)	MAC based on analytical and treatment achievability
P	Bromoxynil (1989, 2005)	0.005		Leaching or runoff from agricultural use	**Health basis of MAC:** Reduced liver to body weight ratios	
I	Cadmium (1986, 2005)	0.005		Leaching from galvanized pipes, solders or black polyethylene pipes; industrial and municipal waste	**Health basis of MAC:** Kidney damage and softening of bone	
I	Calcium (1987, 2005)	None required		Naturally occurring (erosion and weathering of soils, minerals, ores)		Guideline value not necessary, as there is no evidence of adverse health effects from calcium in drinking water; calcium contributes to hardness

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
P	Carbaryl (1991, 2005)	0.09		Leaching or runoff from agricultural use	**Health basis of MAC:** Decreased kidney function (may be rapidly reversible after exposure ceases)	
P	Carbofuran (1991, 2005)	0.09		Leaching or runoff from agricultural use	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition) and growth suppression	
O	Carbon tetrachloride (2010)	0.002		Industrial effluents and leaching from hazardous waste sites	**Health basis of MAC:** Liver toxicity **Other:** Kidney damage; liver tumours (classified as probable carcinogen)	MAC considers additional exposure through showering and bathing
D	Chloramines (1995)	3		Monochloramine is used as a secondary disinfectant; formed in presence of both chlorine and ammonia	**Health basis of MAC:** Reduced body weight gain **Other:** immunotoxicity effects	MAC is for total chloramines based on health effects associated with monochloramine and analytical achievability
DBP	Chlorate (2008)	1		By-product of drinking water disinfection with chlorine dioxide; possible contaminant in hypochlorite solution	**Health basis of MAC:** Thyroid gland effects (colloid depletion)	Formation of chlorate ion should be prevented, as it is difficult to remove once formed; chlorate formation should be controlled by respecting the maximum feed dose of 1.2 mg/L of chlorine dioxide and managing /monitoring formation in hypochlorite solutions.
I	Chloride (1979, 2005)		AO: ≤ 250	Naturally occurring (seawater intrusion); dissolved salt deposits, highway salt, industrial effluents, oil well operations, sewage, irrigation drainage, refuse leachates		Based on taste and potential for corrosion in the distribution system

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
D	Chlorine (2009)	None required		Used as drinking water disinfectant	Guideline value not necessary due to low toxicity at concentrations found in drinking water	Free chlorine concentrations in most Canadian drinking water distribution systems range from 0.04 to 2.0 mg/L
D	Chlorine dioxide (2008)	None required		Used as drinking water disinfectant	A guideline for chlorine dioxide is not required because of its rapid reduction to chlorite in drinking water	A maximum feed dose of 1.2 mg/L of chlorine dioxide should not be exceeded to control the formation of chlorite and chlorate
DBP	Chlorite (2008)	1		By-product of drinking water disinfection with chlorine dioxide	**Health basis of MAC:** Neurobehavioural effects (lowered auditory startle amplitude, decreased exploratory activity), decreased absolute brain weight, altered liver weights	Chlorite formation should be controlled by respecting the maximum feed dose of 1.2 mg/L of chlorine dioxide and managing /monitoring formation in hypochlorite solutions.
P	Chlorpyrifos (1986)	0.09		Leaching and/or runoff from agricultural or other uses	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition)	Not expected to leach significantly into groundwater
I	Chromium (1986)	0.05		Naturally occurring (erosion of minerals); releases or spills from industrial uses	**Health basis of MAC:** Enlarged liver, irritation of the skin, respiratory and gastrointestinal tracts from chromium (VI)	Chromium (III) is an essential element; MAC is protective of health effects from chromium (VI)
T	Colour (1979, 2005)		AO: ≤ 15 TCU	Naturally occurring organic substances, metals; industrial wastes		May interfere with disinfection; removal is important to ensure effective treatment
I	Copper (1992)		AO: ≤ 1.0	Naturally occurring; leaching from copper piping	Copper is an essential element in human metabolism. Adverse health effects occur at levels much higher than the aesthetic objective	Based on taste, staining of laundry and plumbing fixtures; plumbing should be thoroughly flushed before water is used for consumption
I	Cyanide (1991)	0.2		Industrial and mining effluents; release from organic compounds	**Health basis of MAC:** No clinical or other changes at the highest dose tested	Health effects from cyanide are acute; at low levels of exposure, it can be detoxified to a certain extent in the human body

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
O	Cyanobacterial toxins--Microcystin-LR (2002)	0.0015		Naturally occurring (released from blooms of blue-green algae)	**Health basis of MAC:** Liver effects (enzyme inhibitor) **Other:** Classified as possible carcinogen	MAC is protective of total microcystins; avoid algicides like copper sulphate, as they may cause toxin release into water
P	Diazinon (1986, 2005)	0.02		Runoff from agricultural or other uses	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition)	Not expected to leach significantly into groundwater
P	Dicamba (1987, 2005)	0.12		Leaching or runoff from agricultural or other uses	**Health basis of MAC:** Liver effects (vacuolization, necrosis, fatty deposits and liver weight changes)	Readily leaches into groundwater
O	1,2-Dichlorobenzene Table 2 footnote2(1987)	0.2	AO: ≤ 0.003	Releases or spills from industrial effluents	**Health basis of MAC:** Increased blood cholesterol, protein and glucose levels	AO based on odour; levels above the AO would render drinking water unpalatable
O	1,4-Dichlorobenzene Table 2 footnote2(1987)	0.005	AO: ≤ 0.001	Releases or spills from industrial effluents; use of urinal deodorants	**Health basis of MAC:** Benign liver tumours and adrenal gland tumours (classified as probable carcinogen)	AO based on odour; levels above the AO would render drinking water unpalatable
O	1,2-Dichloroethane (1987)	0.005		Releases or spills from industrial effluents; waste disposal	**Health basis of MAC:** Cancer of the circulatory system (classified as probable carcinogen)	MAC based on treatment and analytical achievability
O	1,1-Dichloroethylene (1994)	0.014		Releases or spills from industrial effluents	**Health basis of MAC:** Liver effects (fatty changes)	
O	Dichloromethane (2011)	0.05		Industrial and municipal wastewater discharges	**Health basis of MAC:** Liver effects (liver foci and areas of cellular alteration). **Other:** Classified as probable carcinogen	MAC is protective of carcinogenic effects and considers additional exposure through showering and bathing
O	2,4-Dichlorophenol (1987, 2005)	0.9	AO: ≤ 0.0003	By-product of drinking water disinfection with chlorine; releases	**Health basis of MAC:** Liver effects (cellular changes)	AO based on odour; levels above the AO would render drinking water unpalatable

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
				from industrial effluents		
P	2,4-Dichlorophenoxy acetic acid (2,4-D) (1991)	0.1		Leaching and/or runoff from use as a weed controller; releases from industrial effluents	**Health basis of MAC:** Kidney effects (tubular cell pigmentation)	
P	Diclofop-methyl (1987, 2005)	0.009		Leaching and/or runoff from use as a weed controller; added directly to water to control aquatic weeds	**Health basis of MAC:** Liver effects (enlargement and enzyme changes)	Low potential for groundwater contamination
P	Dimethoate (1986, 2005)	0.02		Leaching and/or runoff from residential, agricultural and forestry use	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition)	
P	Diquat (1986, 2005)	0.07		Leaching and/or runoff from agricultural use; added directly to water to control aquatic weeds	**Health basis of MAC:** Cataract formation	Unlikely to leach into groundwater
P	Diuron (1987, 2005)	0.15		Leaching and/or runoff from use in controlling vegetation	**Health basis of MAC:** Weight loss, increased liver weight and blood effects	High potential to leach into groundwater
O	Ethylbenzene (1986, 2005)		AO: ≤ 0.0024	Emissions, effluents or spills from petroleum and chemical industries		Based on odour
I	Fluoride (2010)	1.5		Naturally occurring (rock and soil erosion); may be added to promote dental health	**Health basis of MAC:** Moderate dental fluorosis (based on cosmetic effect, not health)	Beneficial in preventing dental caries
DBP	Formaldehyde (1997)	None required		By-product of disinfection with ozone; releases from industrial effluents		Guideline value not necessary, as levels in drinking water are below the level at which adverse health effects may occur

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Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
O	Gasoline and its organic constituents (1986, 2005)	None required		Spill or leaking storage tank		No MAC due to complex composition of gasoline; strong taste and odour at concentrations well below those potentially eliciting adverse health effects (see benzene, ethylbenzene, toluene and xylenes for more information)
P	Glyphosate (1987, 2005)	0.28		Leaching and/or runoff from various uses in weed control	**Health basis of MAC:** Reduced body weight gain	Not expected to migrate to groundwater
DBP	Haloacetic acids - Total (HAAs)Table 2 footnote3(2008)	0.08		By-product of drinking water disinfection with chlorine	**Health basis of MAC:** Liver cancer (DCA); DCA is classified as probably carcinogenic to humans	Refers to the total of monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA) and dibromoacetic acid (DBA); MAC is based on ability to achieve HAA levels in distribution systems without compromising disinfection; precursor removal limits formation
		ALARA			**Other:** Other organ cancers (DCA, DBA, TCA); liver and other organ effects (body, kidney and testes weights) (MCA)	
T	Hardness (1979)	None required		Naturally occurring (sedimentary rock erosion and seepage, runoff from soils); levels generally higher in groundwater	Although hardness may have significant aesthetic effects, a guideline has not been established because public acceptance of hardness may vary considerably according to the local conditions; major contributors to hardness -- calcium and magnesium -- are not of direct public health concern	Hardness levels between 80 and 100 mg/L (as $CaCO_3$) provide acceptable balance between corrosion and incrustation; where a water softener is used, a separate unsoftened supply for cooking and drinking purposes is recommended

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Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
I	Iron (1978, 2005)		AO: ≤ 0.3	Naturally occurring (erosion and weathering of rocks and minerals); acidic mine water drainage, landfill leachates, sewage effluents and iron-related industries		Based on taste and staining of laundry and plumbing fixtures; no evidence exists of dietary iron toxicity in the general population
I	Lead (1992)	0.01		Leaching from plumbing (pipes, solder, brass fittings and lead service lines)	**Health basis of MAC:** Biochemical and neurobehavioral effects (intellectual development, behaviour) in infants and young children (under 6 years) **Other:** Anaemia, central nervous system effects; in pregnant women, can affect the unborn child; in infants and children under 6 years, can affect intellectual development, behaviour, size and hearing; classified as probably carcinogenic to humans	Because the MAC is based on chronic effects, it is intended to apply to average concentrations in water consumed for extended periods. Exposure to lead should nevertheless be kept to a minimum; plumbing should be thoroughly flushed before water is used for consumption; most significant contribution is generally from lead service line entering the building
I	Magnesium (1978)	None required		Naturally occurring (erosion and weathering of rocks and minerals)		Guideline value not necessary, as there is no evidence of adverse health effects from magnesium in drinking water
P	Malathion (1986, 2005)	0.19		Leaching and/or runoff from agricultural and other uses	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition)	Not expected to leach into groundwater
I	Manganese (1987)		AO: ≤ 0.05	Naturally occurring (erosion and weathering of rocks and minerals)		Based on taste and staining of laundry and plumbing fixtures
I	Mercury (1986)	0.001		Releases or spills from industrial effluents; waste disposal; irrigation or drainage of areas where agricultural pesticides are used	**Health basis of MAC:** Irreversible neurological symptoms	Applies to all forms of mercury; mercury generally not found in drinking water, as it binds to sediments and soil

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Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
P	2-Methyl-4-chlorophenoxyacetic acid (MCPA) (2010)	0.1		Leaching and/or runoff from agricultural and other uses	**Health basis of MAC:** Kidney effects (increased absolute and relative weights, urinary bilirubin, crystals and pH) **Other:** Systemic, liver, testicular, reproductive/developmental and nervous system effects	Can potentially leach into groundwater
O	Methyl tertiary-butyl ether (MTBE) (2006)		AO: ≤ 0.015	Spills from gasoline refineries, filling stations and gasoline-powered boats; seepage into groundwater from leaking storage tanks	There exist too many uncertainties and limitations in the MTBE database to develop a health based guideline.	AO based on odour; levels above the AO would render water unpalatable; as the AO is lower than levels associated with potential toxicological effects, it is considered protective of human health.
P	Metolachlor (1986)	0.05		Leaching and/or runoff from agricultural or other uses	**Health basis of MAC:** Liver lesions and nasal cavity tumours	Readily binds to organic matter in soil; little leaching expected in soils with high organic and clay content
P	Metribuzin (1986, 2005)	0.08		Leaching and/or runoff from agricultural use	**Health basis of MAC:** Liver effects (increased incidence and severity of mucopolysaccharide droplets)	Leaching into groundwater depends on the organic matter content of the soil
O	Monochlorobenzene (1987)	0.08	AO: ≤ 0.03	Releases or spills from industrial effluents	**Health basis of MAC:** Reduced survival and body weight gain	AO based on odour; levels above the AO would render water unpalatable
I	Nitrate/nitrite (1987)	*Nitrate*: 45 as nitrate; 10 as nitrate-nitrogen	*Nitrite (if measured separately)*: 3.2 as nitrite; 1.0 as nitrite-nitrogen	Naturally occurring; leaching or runoff from agricultural fertilizer use, manure and domestic sewage; may be produced from excess ammonia or from microbial activity in distribution systems	**Health basis of MAC:** Methaemoglobinaemia (blue baby syndrome) in infants less than 3 months old (short term) **Other:** Classified as possible carcinogen	MACs are protective of children and adults; systems using chloramine disinfection or that have naturally occurring ammonia should monitor nitrite and nitrate in distribution system
I	Nitrilotriacetic acid (NTA) (1990)	0.4		Sewage contamination	**Health basis of MAC:** Kidney effects (nephritis and nephrosis)	

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Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
					Other: Classified as possible carcinogen	
DBP	*N*-Nitroso dimethylamine (NDMA) (2010)	0.000 04		By-product of drinking water disinfection with chlorine or chloramines; industrial and sewage treatment plant effluents	**Health basis of MAC:** Liver cancer (classified as probable carcinogen)	MAC considers additional exposure through showering and bathing; levels should be kept low by preventing formation during treatment
A	Odour (1979, 2005)		Inoffensive	Biological or industrial sources		Important to provide drinking water with no offensive odour, as consumers may seek alternative sources that are less safe
P	Paraquat (1986, 2005)	0.01 as paraquat dichloride; 0.007 as paraquat ion		Leaching and/or runoff from agricultural and other uses; added directly to water to control aquatic weeds	**Health basis of MAC:** Various effects on body weight, spleen, testes, liver, lungs, kidney, thyroid, heart and adrenal gland	Entry into drinking water unlikely from crop applications (clay binding); however, may persist in water for several days if directly applied to water
O	Pentachlorophenol (1987, 2005)	0.06	AO: ≤ 0.03	By-product of drinking water disinfection with chlorine; industrial effluents	**Health basis of MAC:** Reduced body weight, changes in clinical parameters, histological changes in kidney and liver, reproductive effects (decreased neonatal survival and growth)	AO based on odour; levels above the AO would render drinking water unpalatable
T	pH (1979)		6.5-8.5 Table 2 footnote4	Not applicable		pH can influence the formation of disinfection by-products and effectiveness of treatment
P	Phorate (1986, 2005)	0.002		Leaching and/or runoff from agricultural and other uses	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition)	Some potential to leach into groundwater
P	Picloram (1988, 2005)	0.19		Leaching and/or runoff from agricultural and other uses	**Health basis of MAC:** Changes in body and liver weights and clinical chemistry parameters **Other:** Kidney effects (liver to body weight ratios and histopathology)	Significant potential to leach into groundwater

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
I	Selenium (1992)	0.01		Naturally occurring (erosion and weathering of rocks and soils)	**Health basis of MAC:** Essential nutritional element **Other:** Hair loss and weakened nails at extremely high levels of exposure	Most exposure from food; little information on toxicity of selenium from drinking water
I	Silver (1986, 2005)	None required		Naturally occurring (erosion and weathering of rocks and soils)		Guideline value not required as drinking water contributes negligibly to an individual's daily intake
P	Simazine (1986)	0.01		Leaching and/or runoff from agricultural and other uses	**Health basis of MAC:** Body weight changes and effects on serum and thyroid gland	Extent of leaching decreases with increasing organic matter and clay content
I	Sodium (1979)		AO: ≤ 200	Naturally occurring (erosion and weathering of salt deposits and contact with igneous rock, seawater intrusion); sewage and industrial effluents; sodium-based water softeners		Based on taste; where a sodium-based water softener is used, a separate unsoftened supply for cooking and drinking purposes is recommended
I	Sulphate (1994)		AO: ≤ 500	Industrial wastes	High levels (above 500 mg/L) can cause physiological effects such as diarrhoea or dehydration	Based on taste; health authorities should be notified of drinking water sources containing above 500 mg/L
I	Sulphide (1992)		AO: ≤ 0.05	Can occur in the distribution system from the reduction of sulphates by sulphate-reducing bacteria; industrial wastes		Based on taste and odour; levels above the AO would render water unpalatable
A	Taste (1979, 2005)		Inoffensive	Biological or industrial sources		Important to provide drinking water with no offensive taste, as consumers may seek alternative sources that are less safe

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
T	Temperature (1979, 2005)		AO: ≤ 15°C	Not applicable		Temperature indirectly affects health and aesthetics through impacts on disinfection, corrosion control and formation of biofilms in the distribution system
P	Terbufos (1987, 2005)	0.001		Leaching and/or runoff from agricultural and other uses	**Health basis of MAC:** Nervous system effects (cholinesterase inhibition)	Based on analytical achievability
O	Tetrachloroethylene (1995)	0.03		Industrial effluents or spills	**Health basis of MAC:** Increased liver and kidney weights **Other:** Classified as possible carcinogen; limited evidence of an increased risk of spontaneous abortion	Readily leaches into groundwater; MAC considers additional exposure through showering and bathing
O	2,3,4,6-Tetrachlorophenol (1986, 2005)	0.1	AO: ≤ 0.001	By-product of drinking water disinfection with chlorine; industrial effluents and use of pesticides	**Health basis of MAC:** Developmental effects (embryotoxicity)	AO based on odour; levels above the AO would render drinking water unpalatable
O	Toluene (1986, 2005)		AO: ≤ 0.024	Release of effluents or spills from petroleum and chemical industries		AO based on odour; levels above the AO would render drinking water unpalatable
A	Total dissolved solids (TDS) (1991)		AO: ≤ 500	Naturally occurring; sewage, urban and agricultural runoff, industrial wastewater		Based on taste; TDS above 500 mg/L results in excessive scaling in water pipes, water heaters, boilers and appliances; TDS is composed of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate and nitrate
O	Trichloroethylene (2005)	0.005		Industrial effluents and spills from improper disposal	**Health basis of MAC:** Developmental effects (heart malformations) **Other:** Classified as probable carcinogen	MAC considers additional exposure through showering and bathing
O	2,4,6-Trichlorophenol (1987, 2005)	0.005	AO: ≤ 0.002	By-product of drinking water disinfection with	**Health basis of MAC:** Liver cancer (classified as probable carcinogen)	AO based on odour; levels above the AO would render drinking water unpalatable

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Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/IL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
				chlorine; industrial effluents and spills		
P	Trifluralin (1989, 2005)	0.045		Runoff from agricultural uses	**Health basis of MAC:** Changes in liver and spleen weights and in serum chemistry	Unlikely to leach into groundwater
DBP	Trihalomethanes Table 2 footnote3(THMs) (2006)	0.1		By-product of drinking water disinfection with chlorine; industrial effluents	**Health basis of MAC:** Liver effects (fatty cysts) (chloroform classified as possible carcinogen) **Other:** Kidney and colorectal cancers	Considers the most commonly found THMs, namely chlorodibromomethane, chloroform, bromodichloromethane and bromoform; MAC based on health effects of chloroform and considers additional exposure through showering and bathing; precursor removal limits formation
I	Uranium (1999)	0.02		Naturally occurring (erosion and weathering of rocks and soils); mill tailings; emissions from nuclear industry and combustion of coal and other fuels; phosphate fertilizers	**Health basis of MAC:** Kidney effects (various lesions); may be rapidly reversible after exposure ceases	Based on treatment achievability; MAC based on chemical effects, as uranium is only weakly radioactive; uranium is rapidly eliminated from the body
O	Vinyl chloride (1992)	0.002		Industrial effluents; degradation product from trichloroethylene and tetrachloroethylene in groundwater; leaching from polyvinyl chloride pipes	**Health basis of MAC:** Liver cancer (classified as human carcinogen) **Other:** Raynaud's disease, effects on bone, circulatory system, thyroid, spleen, central nervous system	Based on treatment and analytical achievability; leaching from polyvinyl chloride pipe is not expected to be significant
O	Xylene (1986, 2005)		AO: ≤ 0.3	Industrial effluents and spills		AO based on taste and odour; levels above the AO would render water unpalatable

Guidelines for Canadian Drinking Water Quality (Aug 2012)

Table 2 - Chemical and Physical Properties

Type	Parameter approval, OR reaffirmation	MAC (mg/lL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
I	Zinc (1979, 2005)		AO: ≤ 5.0	Naturally occurring; industrial and domestic emissions; leaching may occur from galvanized pipes, hot water tanks and brass fittings		AO based on taste; water with zinc levels above the AO tends to be opalescent and develops a greasy film when boiled; plumbing should be thoroughly flushed before water is consumed

Appendix B – Water Quality Test Results – 2018

Holland Lake

	Coliforms										Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS	Hydro Carbons	PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Apr 12 2018	60			<1						6.76	14.5	15	0.5			80.2	
Apr 19 2018					2.4	1040	<0.010			6.29	14.6	15	0.8				
Apr 26 2018								<20			12.3	15	0.4	2.44	2.65	81.2	
May 03 2018									<0.20	7.01	12.4	10	0.6				
May 09 2018	570			1						6.83	14.5	15	0.6			82.3	
May 16 2018					3.2	1130	<0.010			6.5	13.6	10	0.5				
May 23 2018								23		6.81	11.8	15	0.5	2.38	2.61	82.7	
Jun 06 2018									<0.20		11.1	10	0.8				
Jun 14 2018	280			1						7.1	10.1	10	0.5			84	
Jun 20 2018					5.8	1260	<0.010			6.94	10.9	10	0.4				
Jun 27 2018	920			<1				<10		6.78	13.2	15	0.6	0.97	2.85	82	
Jul 19 2018					4.7	1250	<0.010			6.86	11	10	0.6				
Jul 25 2018									<0.20		23.6	5	0.8				
Aug 2 2018	9000			1						6.77	9.3	15	0.9			82.3	
Aug 15 2018	3700			1				12		7.38	8	20	0.6	2.54	2.53	85.9	
Aug 22 2018										6.88	10.9	10	0.7				
Aug 29 2018	2300			<1						7.1	8.7	10	0.7			85.9	
Sep 6 2018					3.5	1350	<0.010			6.49	8.8	10	0.4				
Sep 12 2018	2600			2				15		6.71	8.1	10	0.4	2.6	2.6	86.1	
Sep 18 2018										6.59	5.6	10	0.5				
Sep 26 2018	930			1							5.6	10	0.6			87.2	
Oct 10 2018	400			<1				15			9.9	10	0.5	2.1	2.9	87.5	
Oct 17 2018											11.3	10	0.67				
Oct 24 2018	620			29							6.3	10	0.47			87.9	
Oct 31 2018					3.7	1420	<0.010			6.62	8	10	0.79				
	Coliforms										Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS		PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Nov 8 2018	78			2				<10			22	10	0.53	2.6	2.1	83.4	
Nov 14 2018										6.88	11.7	10	0.73				
Nov 21 2018	570			1							14.6	15	0.47			81.8	
Nov 27 2018										6.95	17.8	15	0.42				
Dec 5 2018	250			<2				15			16.4	15	0.58	1.7	3	76.8	
Dec 12 2018					2.6	1250	<0.010			6.32	16.2	20	1.12				
	1591.29	#DIV/0!	#DIV/0!		3.70	1242.86		16.00		6.79	12.03	12.10	0.60	2.17	2.66	83.58	#DIV/0!

Stocking Lake Lab Results, 2018

	Coliforms										Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS	Hydro Carbons	PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Jan 04 2018											11.2	15	0.4				
Mar 08 2018				<1					<0.20	6.98	10.2	15	0.5				
Mar 12 2018	19			<1						7.15	13.8	15	0.3			82.2	
Mar 21 2018					7.9	3130	<0.01			7.08	10.3	15	0.4				
Mar 28 2018	25			<1				26		7.22	13	10	0.3	2.35	2.96	81.8	
Apr 12 2018	18			<1						7.14	12	10	0.3			81	
Apr 19 2018					6.4	2830	<0.010			6.69	10.8	15	0.4				
Apr 26 2018	2300			<10				32			13.2	15	0.2	2.34	2.8	83.2	
May 03 2018									<0.20	6.93	15.2	15	0.4				
May 09 2018	100			<1						6.99	7.6	15	0.5			83.3	
May 16 2018					8.8	2950	<0.010			6.9	13.2	10	0.4				
May 23 2018								25		7.04	11.9	15	0.5	1.87	2.69	83.9	
Jun 06 2018									<0.20		14.9	15	1.4				
Jun 14 2018	440			2						710	8.4	10	0.6			84.7	
Jun 27 2018	1000			2				14		7.06	10.5	15	0.7	1.58	3.72	84.2	
Jul 19 2018					9.9	3340	<0.010			7.06	10.8	10	0.4				
Jul 25 2018									<0.20		9.7	5	0.5				
Aug 2 2018	2700			3						7.1	5.2	10	0.5			86.3	
Aug 15 2018	2700			4				24		7.27	6.6	10	0.4	1.88	1.83	86	
Aug 22 2018										7.31	7.9	10	1				
Aug 29 2018	890			1						7.27	6.8	15	0.4			85.7	
Sep 6 2019					8.5	3540	<0.010			6.82	7.2	10	0.5				
Sep 12 2019	1000			<1				29		7.03	7.5	10	0.5	2.5	2.7	86.1	
Sep 18 2018										7.11	<5	10	0.7				
Sep 26 2018	450			3							8.5	5	0.5			86	
Oct 4 2018					7.6	3270	<0.010			6.7	10	20	0.8				
Oct 10 2018	390			1							8	10	1	2	3.1	85.4	
Oct 18 2018											9.2	10	0.43				
	Coliforms										Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS		PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Oct 25 2018	240			1							<5.0	10	0.49			85.6	
Nov 1 2018					8.9	3540	<0.010			7.02	6.8	5	1.63				
Nov 8 2018	81			<1				18			16.7	10	0.52	2.32	2.15	85.8	
Nov 14 2018										6.97	7.8	10	0.68				
Nov 22 2018	60			<1							9.7	10	0.58			85.4	
Nov 28 2018										7.28	12.5	15	0.37				
Dec 5 2018	94			<2				<10			8.9	10	0.49	1.4	2.4	82.8	
Dec 12 2018					3.5	3300	<0.010			6.47	23.8	30	0.71				
	735.71	#DIV/0!	#DIV/0!	2.13	7.69	3237.50		24.00		35.14	10.58	12.22	0.57	2.03	2.71	84.41	#DIV/0!

Chicken Ladder (Lower Holland Creek) Lab Results, 2018

	Coliforms										Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS	Hydro Carbons	PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Jan 04 2018											15.3	15	0.1				
Mar 08 2018				<1					<0.20	6.68	12	15	0.2				
Mar 12 2018	21			1						7.01	15.4	15	0.2			81.4	
Mar 22 2018					8.4	1630	<0.010			7.17	15.8	20	0.4				
Mar 28 2018	79			2				<10		6.99	18	10	0.2	2.75	2.86	76.1	
Apr 12 2018	87			1						6.97	19.2	10	0.3			73.8	
Apr 19 2018					3.9	1560	<0.010			6.61	14.3	15	0.3				
Apr 26 2018	510			20				<20			16.8	15	0.2	2.29	2.77	81.1	
May 03 2018									<0.20	6.97	16.8	15	0.4				
May 09 2018	91			9						7.02	13	20	0.1			80.1	
May 16 2018					5.7	1640	<0.010			6.8	15.7	10	0.4				
May 23 2018								11		6.99	12.4	15	0.1	1.61	2.44	85.2	
Jun 06 2018									<0.20		9.1	10	0.2				
Jun 14 2018										7.15	8.5	10	0.8			87.2	
Jun 20 2018					6.3	1990	<0.010			6.79	10.3	10	0.1				
Jun 27 2018	1000			16				<10		6.99	9.9	15	0.3	0.75	1.83	85.8	
Jul 19 2018					5.1	1770	<0.010			6.77	10.6	5	<0.1				
Jul 25 2018									<0.20		19.9	5	0.3				
Aug 2 2018	3800			40						6.95	9.2	10	0.1			87.6	
Aug 15 2018	2500			25				16		7.05	9.9	20	0.3	1.8	1.57	88.6	
Aug 22 2018										6.89	5.5	10	0.2				
Aug 29 2018	1100			16						7.1	10.2	15	0.3			89.6	
Sep 6 2018					5.4	1920	<0.010			6.66	9.3	10	0.1				
Sep 12 2018	2900			32				24		6.96	23.2	10	0.5	2.5	2.5	87.6	
Sep 18 2018										6.77	9.6	15	0.7				
Sep 26 2018	810			2							7.4	10	0.2			84.2	
Oct 4 2018					5	1920	<0.010			6.68	21.1	10	0.1				
Oct 10 2018	420			<1							12.3	10	0.2	2	2.7	83.4	
	Coliforms										Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS		PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Oct 17 2018											9.3	10	0.16				
Oct 25 2018	1200			4							10.3	10	0.2			86.5	
Nov 1 2018					4.6	2410	<0.010			6.67	27.2	20	0.18				
Nov 8 2018	110			4				28			23.3	15	0.2	4.21	3.41	70.1	
Nov 15 2018										6.92	30.1	20	0.37				
Nov 22 2018	230			1							24.2	20	0.21			69.2	
Nov 28 2018										7.06	29.2	20	1.19				
Dec 5 2018	100			<2				<10			16.5	15	0.36	2.4	2.7	75.6	
Dec 12 2018					7.6	1570	<0.010			6.73	10.2	10	0.59				
	934.88	#DIV/0!	#DIV/0!	12.36	5.78	1823.33		19.75		6.90	14.89	13.24	0.30	2.26	2.53	81.84	#DIV/0!

Source: http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/water-haloacetic-haloacetique-eau/index-eng.php

Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Haloacetic Acids (Executive Summary)

1.0 Guideline

The maximum acceptable concentration (MAC) for total haloacetic acids* in drinking water is 0.08 mg/L (80 µg/L) based on a locational running annual average of a minimum of quarterly samples taken in the distribution system.
Utilities should make every effort to maintain concentrations as low as reasonably achievable (or ALARA) without compromising the effectiveness of disinfection.

2.0 Executive summary

Haloacetic acids (HAAs) are a group of compounds that can form when the chlorine used to disinfect drinking water reacts with naturally occurring organic matter (e.g., decaying leaves and vegetation). The use of chlorine in the treatment of drinking water has virtually eliminated waterborne diseases, because chlorine can kill or inactivate most microorganisms commonly found in water. The majority of drinking water treatment plants in Canada use some form of chlorine to disinfect drinking water: to treat the water directly in the treatment plant and/or to maintain a chlorine residual in the distribution system to prevent bacterial regrowth. Disinfection is an essential component of public drinking water treatment; the health risks from disinfection by-products, including haloacetic acids, are much less than the risks from consuming water that has not been appropriately disinfected.

The haloacetic acids most commonly found in drinking water are monochloroacetic acid (MCA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid (MBA) and dibromoacetic acid (DBA). Of these, DCA and TCA have been most extensively studied, and there are some scientific data available on MCA and DBA. However, insufficient data were available to allow the development of an individual guideline for MBA.

This Guideline Technical Document reviews the health risks associated with haloacetic acids in drinking water. It assesses all identified health risks, taking into account new studies and approaches, as well as treatment considerations. Exposure to haloacetic acids from drinking water through inhalation and skin contact has been considered for inclusion, but is not deemed significant.

* *Total haloacetic acids refers to the total of monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid.*

Based on this review, the guideline for total haloacetic acids in drinking water was established at a maximum acceptable concentration of 0.08 mg/L. This guideline takes into consideration the availability of appropriate treatment technologies and the ability of treatment plants to meet the guideline without compromising the effectiveness of disinfection.

2.1 Health effects

The health effects associated with exposure to haloacetic acids will vary with the specific compound. MCA is considered unlikely to be carcinogenic to humans, based on the lack of evidence for carcinogenicity. Changes in body, liver, kidney and testes weights were observed in studies with rats. A health-based target concentration of 0.1 mg/L can be calculated for MCA in drinking water. DCA is considered to be a probable carcinogen to humans, based on sufficient evidence in animals and inadequate evidence in humans. Animal studies have shown links between exposure to DCA and liver tumours in both mice and rats. A health-based target concentration of 0.01 mg/L can be calculated for DCA in drinking water. TCA is considered a possible carcinogen in humans, based on limited evidence in experimental animals and inadequate evidence in humans. Animal studies have shown a link between exposure to TCA and liver tumours in mice only, but it is still uncertain whether the mechanism causing these tumours is relevant to humans. A health-based target concentration of 0.3 mg/L can be calculated for TCA in drinking water. MBA is unclassifiable with respect to carcinogenicity in humans, based on inadequate data from animal studies. DBA is considered to be probably carcinogenic in humans, based on sufficient evidence in animals and inadequate evidence in humans. Animal studies have shown links between exposure to DBA and tumours in several organs in both mice and rats. A health-based target concentration of 0.002 mg/L can be calculated for DBA in drinking water.

There is only one study currently available looking at the incidence or significance of health effects associated with human exposure to haloacetic acids. A small population-based study that was conducted in two eastern provinces did not find a link between exposure to haloacetic acids and risk of stillbirths. Other human studies on the incidence of cancer or reproductive effects have been conducted with chlorinated disinfection by-products, but not specifically with haloacetic acids.

Some animal studies suggest a possible link between developmental effects (heart defects) and exposure to DCA or TCA, whereas other studies fail to show a link. Animal studies also suggest a possible link between male reproductive effects (on sperm and sperm formation) and exposure to DCA or DBA, at levels significantly higher than those found in drinking water. Further studies are required to confirm these effects as well as their long-term significance to human health.

A single guideline for total haloacetic acids is established, based on the health effects of the individual haloacetic acids, and taking into consideration both treatment technology and the ability of treatment plants, particularly smaller ones, to achieve the guideline. The guideline is considered to be protective of health for all haloacetic acids, based on the ratio of haloacetic acids expected to be found in drinking water. The guideline value is primarily designed to be protective of the health effects of DCA, the haloacetic acid that would pose the most significant health concerns and is found at the highest levels in drinking water.

2.2 Exposure

Levels of haloacetic acids are generally higher in treated surface water than in treated groundwater, because of the high organic content in lakes and rivers. Levels of haloacetic acids will be higher in warmer months, because of the higher concentrations of precursor organic materials in the raw water and especially because the rate of formation of disinfection by-products increases at higher temperatures. It should be noted that the presence of by-products such as MBA and DBA would also depend on the presence of bromine in the source water.

Available data suggest that drinking water may be a significant source of exposure to haloacetic acids, but there are few data available to determine the exposure from other media, such as food and air.

2.3 Treatment

Haloacetic acids and trihalomethanes are the two major groups of chlorinated disinfection by-products found in drinking water and generally at the highest levels. Together, these two groups can be used as indicators for the presence of all chlorinated disinfection by-products in drinking water supplies, and their control is expected to reduce the levels of all chlorinated disinfection by-products and the corresponding risks to health.

The approach to reduce exposure to haloacetic acids is generally focused on reducing the formation of chlorinated disinfection by-products. The concentrations of haloacetic acids and other chlorinated disinfection by-products in drinking water can be reduced at the treatment plant by removing the organic matter from the water before chlorine is added, by optimizing the disinfection process, by using alternative disinfection methods or by using a different water source. It is critical that any method used to control levels of haloacetic acids ***must not*** compromise the effectiveness of disinfection. The Federal-Provincial-Territorial Committee on Drinking Water also recommends that every effort be made not only to meet the guideline, but to maintain concentrations of haloacetic acids as low as reasonably achievable.

3.0 Application of the guideline

Note: Specific guidance related to the implementation of this guideline should be obtained from the appropriate drinking water authority in the affected jurisdiction.

The concentrations of haloacetic acids (HAAs) and trihalomethanes (THMs) can be used as indicators of the total loading of all chlorinated disinfection by-products (CDBPs) that may be found in drinking water supplies. The guideline for HAAs is also designed to take into consideration exposure and potential health effects related to other CDBPs, on which very little is known. The guideline is measured as a locational running annual average of quarterly samples, because HAA levels can vary significantly over time, including seasonally, with factors such as the levels of organic matter in the raw water and temperature.

Given the limited information on the risks and uncertainties associated with other CDBPs, it is recommended that treatment plants strive to maintain HAA levels as low as reasonably achievable (ALARA) without compromising disinfection. This should also be considered when changes, upgrades or expansions are made to the treatment plants or distribution systems. Any effort aimed at reducing disinfection by-products, such as changing disinfection strategies, needs to be considered in light of changes in water quality that may inadvertently increase the levels or leaching of other contaminants, such as lead, in the distributed water.

Table 1 lists the estimated lifetime (70 years) risk of excess liver cancer (in addition to the background lifetime cancer risk) associated with the ingestion of HAAs in drinking water at various concentrations, based on animal studies. It is expressed as a range, which represents estimated proportions of 40-60% of DCA in total HAAs.

Table 1: Estimated lifetime range of risk of excess liver cancer (in addition to the background lifetime cancer risk) from exposure to DCA associated with various concentrations of HAAs in drinking water	
Levels of HAAs in drinking water (µg/L)	**Estimated lifetime range of risk of excess cancers ($\times10^{-5}$)***
40	**1.6-2.4**
60	**2.4-3.6**
80	**3.2-4.8**
100	**4.0-6.0**
120	**4.8-7.2**

Table 1 Footnote *

The estimated lifetime range of risk of excess cancers above background levels is calculated from the risk associated with ingesting DCA at a concentration of 1 µg/L in drinking water, assuming a proportion of 40-60% of DCA in total HAAs.

3.1 Monitoring

At a minimum, quarterly monitoring of treated water from surface water and groundwater sources is recommended for total HAAs. Increased frequency of monitoring may be required for facilities using surface water sources Footnote* during periods when water characteristics are more favourable to the formation of by-products, which will vary according to the specific system. Since total HAA concentrations vary within and between distribution systems, depending on different factors, including water quality characteristics (e.g., HAA precursors, pH, season, temperature) and treatment conditions (e.g., disinfectant type, disinfectant dose, contact time), it is recommended that monitoring samples be taken at the water treatment plant and at points in the distribution system where historical data show the highest HAA concentrations.

Where historical data are not available, a program should be put in place to monitor HAA levels in the middle and extremities of the distribution system. Areas with extremely low or no disinfectant residual should be avoided, but areas where disinfectant residuals are significantly lower than the system average because of a long residence time (e.g., dead ends, low flow areas) should be targeted. In systems with booster chlorination stations and water tanks or reservoirs, it is expected that higher HAA concentrations would be found downstream of these components.

Monitoring/reporting may be reduced if drinking water monitoring does not show elevated levels of disinfection by-products within the distribution system.

(See website for Part Two of this document)

Appendix D – Ministry of Health – Microbiological Results, 2018

The following pages provide the Ministry of health Microbiological Sampling for The Town's distribution system for 2018.

604 Farrell Road, 604 Farrell Road	17-Dec-2018	L1	L1
606 OAKWOOD, 606 Oakwood	17-Dec-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	17-Dec-2018	L1	L1
432 Davis Road, 432 Davis Road	10-Dec-2018	L1	L1
558 Hooper Place, 558 Hooper Place	10-Dec-2018	L1	L1
City Hall , 410 Esplanade	10-Dec-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	3-Dec-2018	L1	L1
405 Blair Place, 405 Blair Place	3-Dec-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	3-Dec-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	3-Dec-2018	L1	L1
432 Davis Road, 432 Davis Road	27-Nov-2018	L1	L1
558 Hooper Place, 558 Hooper Place	27-Nov-2018	L1	L1
City Hall , 410 Esplanade	27-Nov-2018	L1	L1
405 Blair Place, 405 Blair Place	19-Nov-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	19-Nov-2018	L1	L1
604 Farrell Road, 604 Farrell Road	14-Nov-2018	L1	L1
606 OAKWOOD, 606 Oakwood	14-Nov-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	14-Nov-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	7-Nov-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	7-Nov-2018	L1	L1
558 Hooper Place, 558 Hooper Place	31-Oct-2018	A	
606 OAKWOOD, 606 Oakwood	31-Oct-2018	A	
405 Blair Place, 405 Blair Place	22-Oct-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	22-Oct-2018	L1	L1
432 Davis Road, 432 Davis Road	17-Oct-2018	L1	L1
City Hall , 410 Esplanade	17-Oct-2018	L1	L1
604 Farrell Road, 604 Farrell Road	9-Oct-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	9-Oct-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	1-Oct-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	1-Oct-2018	L1	L1
405 Blair Place, 405 Blair Place	25-Sep-2018	L1	L1
606 OAKWOOD, 606 Oakwood	25-Sep-2018	L1	L1
432 Davis Road, 432 Davis Road	18-Sep-2018	L1	L1

City Hall , 410 Esplanade	18-Sep-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	18-Sep-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	10-Sep-2018	L1	L1
558 Hooper Place, 558 Hooper Place	10-Sep-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	10-Sep-2018	L1	L1
604 Farrell Road, 604 Farrell Road	5-Sep-2018	OG	OG
Public Works Yard, 340 6th Avenue, Ladysmith	5-Sep-2018	L1	L1
405 Blair Place, 405 Blair Place	27-Aug-2018	L1	L1
City Hall , 410 Esplanade	27-Aug-2018	L1	L1
558 Hooper Place, 558 Hooper Place	20-Aug-2018	L1	L1
606 OAKWOOD, 606 Oakwood	20-Aug-2018	L1	L1
604 Farrell Road, 604 Farrell Road	14-Aug-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	14-Aug-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	14-Aug-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	7-Aug-2018	L1	L1
432 Davis Road, 432 Davis Road	7-Aug-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	7-Aug-2018	L1	L1
405 Blair Place, 405 Blair Place	31-Jul-2018	L1	L1
City Hall , 410 Esplanade	31-Jul-2018	L1	L1
432 Davis Road, 432 Davis Road	24-Jul-2018	L1	L1
604 Farrell Road, 604 Farrell Road	24-Jul-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	17-Jul-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	17-Jul-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	10-Jul-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	10-Jul-2018	L1	L1
558 Hooper Place, 558 Hooper Place	3-Jul-2018	L1	L1
606 OAKWOOD, 606 Oakwood	3-Jul-2018	L1	L1
405 Blair Place, 405 Blair Place	27-Jun-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	27-Jun-2018	L1	L1
432 Davis Road, 432 Davis Road	18-Jun-2018	L1	L1
City Hall , 410 Esplanade	18-Jun-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	12-Jun-2018	2	L1
604 Farrell Road, 604 Farrell Road	12-Jun-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	12-Jun-2018	L1	L1
558 Hooper Place, 558 Hooper Place	5-Jun-2018	L1	L1
606 OAKWOOD, 606 Oakwood	5-Jun-2018	L1	L1

Public Works Yard, 340 6th Avenue, Ladysmith	5-Jun-2018	L1	L1
432 Davis Road, 432 Davis Road	30-May-2018	L1	L1
558 Hooper Place, 558 Hooper Place	30-May-2018	L1	L1
604 Farrell Road, 604 Farrell Road	22-May-2018	L1	L1
City Hall , 410 Esplanade	22-May-2018	L1	L1
405 Blair Place, 405 Blair Place	14-May-2018	L1	L1
606 OAKWOOD, 606 Oakwood	14-May-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	14-May-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	8-May-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	1-May-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	1-May-2018	L1	L1
405 Blair Place, 405 Blair Place	24-Apr-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	24-Apr-2018	L1	L1
432 Davis Road, 432 Davis Road	17-Apr-2018	L1	L1
City Hall , 410 Esplanade	17-Apr-2018	L1	L1
558 Hooper Place, 558 Hooper Place	10-Apr-2018	L1	L1
606 OAKWOOD, 606 Oakwood	10-Apr-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	10-Apr-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	3-Apr-2018	L1	L1
604 Farrell Road, 604 Farrell Road	3-Apr-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	3-Apr-2018	L1	L1
405 Blair Place, 405 Blair Place	28-Mar-2018	L1	L1
City Hall , 410 Esplanade	28-Mar-2018	L1	L1
558 Hooper Place, 558 Hooper Place	20-Mar-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	20-Mar-2018	L1	L1
604 Farrell Road, 604 Farrell Road	13-Mar-2018	L1	L1
606 OAKWOOD, 606 Oakwood	13-Mar-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	13-Mar-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	6-Mar-2018	L1	L1
432 Davis Road, 432 Davis Road	6-Mar-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	6-Mar-2018	L1	L1
405 Blair Place, 405 Blair Place	27-Feb-2018	L1	L1
City Hall , 410 Esplanade	27-Feb-2018	L1	L1
604 Farrell Road, 604 Farrell Road	20-Feb-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	20-Feb-2018	L1	L1
558 Hooper Place, 558 Hooper Place	13-Feb-2018	L1	L1

606 OAKWOOD, 606 Oakwood	13-Feb-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	13-Feb-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	7-Feb-2018	L1	L1
432 Davis Road, 432 Davis Road	7-Feb-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	7-Feb-2018	L1	L1
405 Blair Place, 405 Blair Place	23-Jan-2018	L1	L1
City Hall , 410 Esplanade	23-Jan-2018	L1	L1
558 Hooper Place, 558 Hooper Place	16-Jan-2018	L1	L1
606 OAKWOOD, 606 Oakwood	16-Jan-2018	L1	L1
Public Works Yard, 340 6th Avenue, Ladysmith	16-Jan-2018	L1	L1
432 Davis Road, 432 Davis Road	8-Jan-2018	L1	L1
Kinsmen Park , 1000 Colonia Drive, Ladysmith	8-Jan-2018	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Rd	2-Jan-2018	L1	L1
604 Farrell Road, 604 Farrell Road	2-Jan-2018	L1	L1
Wastewater Treatment Plant, Oyster Cove Road, Ladysmith	2-Jan-2018	L1	L1

Appendix E – Permit To Operate

island health

HEALTH PROTECTION

PERMIT

to OPERATE

A WATER SUPPLY SYSTEM

Water System Name:	**TOWN OF LADYSMITH WATER WORKS**
Premises Number:	1310824
Premises Address:	410 Esplanade Ladysmith, BC V9G 1A2
Water System Owner:	Town Of Ladysmith

Town Of Ladysmith is hereby permitted to operate the above potable water supply system and is required to operate this system in accordance with the *Drinking Water Protection Act* and in accordance with the conditions set out in this operating permit and conditions established as part of any construction permit.

The water supply system for which this operating permit applies is generally described as:

Service Delivery Area:	Town of Ladysmith and Diamond Improvement District
Source Water:	Banon Creek, Stocking Lake, Holland Lake, Chicken Ladder Dam
Water Treatment methods are:	None
Water Disinfection methods are:	Chlorine
Number of Connections	301-10,000 Connections - DWT

Operating conditions specific to this water supply system are in Appendix A.

Date: October 4, 1993
Re-issued: November 22, 2018
Re-issued: August 28, 2019

Issued By:
Cina Opal, CPHI(C)
Environmental Health Officer

This permit must be displayed in a conspicuous place and is not transferable

island health
Expires March 2020
2177

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APPENDIX A

WATER SYSTEM OPERATING CONDITIONS FOR

TOWN OF LADYSMITH WATER WORKS

330 6th Avenue

Ladysmith, BC, V0R 2E0

Compliance with these Operating Permit Terms and Conditions do not relieve the operator of other legislated responsibilities and obligations.

The specific items and conditions of this operating permit are listed below as:

1. **Existing Performance Standards**

The Water System Owner (Town of Ladysmith) shall ensure the disinfection system is in good working order and provide the following:

- a 4-log inactivation of viruses, and
- raw water turbidity must be recorded on a continuous basis and shall not exceed 1 NTU in more than 5% of the average daily measurements in each calendar month. If the raw water exceeds an average of 5 NTU for a period of more than 12 hours, the Drinking Water Officer must be contacted immediately.

2. **Future Treatment Specifications**

On or before January 31, 2018, the Water System Owner shall provide two treatment processes acceptable to Island Health (Vancouver Island Health Authority), to achieve a 4-log removal/inactivation of viruses; a 3-log removal/inactivation of Giardia cysts and Cryptosporidium oocysts and produce finished water with less than 1 NTU turbidity.

The Water System Owner is required to meet the following implementation plan dates:

A. **Pilot Testing Program and Selection of Treatment Process**
By March 31, 2015 a final treatment process shall be determined and submitted to our office.

B. **Final Selection of the Filtration Plant**
By May 31, 2016, the filtration process selected is to be completed.

C. **Completion of the Filtration Plant Project**
By January 31, 2018, the construction of the Filtration Plant is to be completed and in operation.

Date: July 7, 2014

Environmental Health Officer

Health Protection & Environmental Services
3rd Floor – 6475 Metral Drive
Nanaimo BC V9T 2L9

Tel: 250-755-6215 | Fax: 250-755-3372
viha.ca