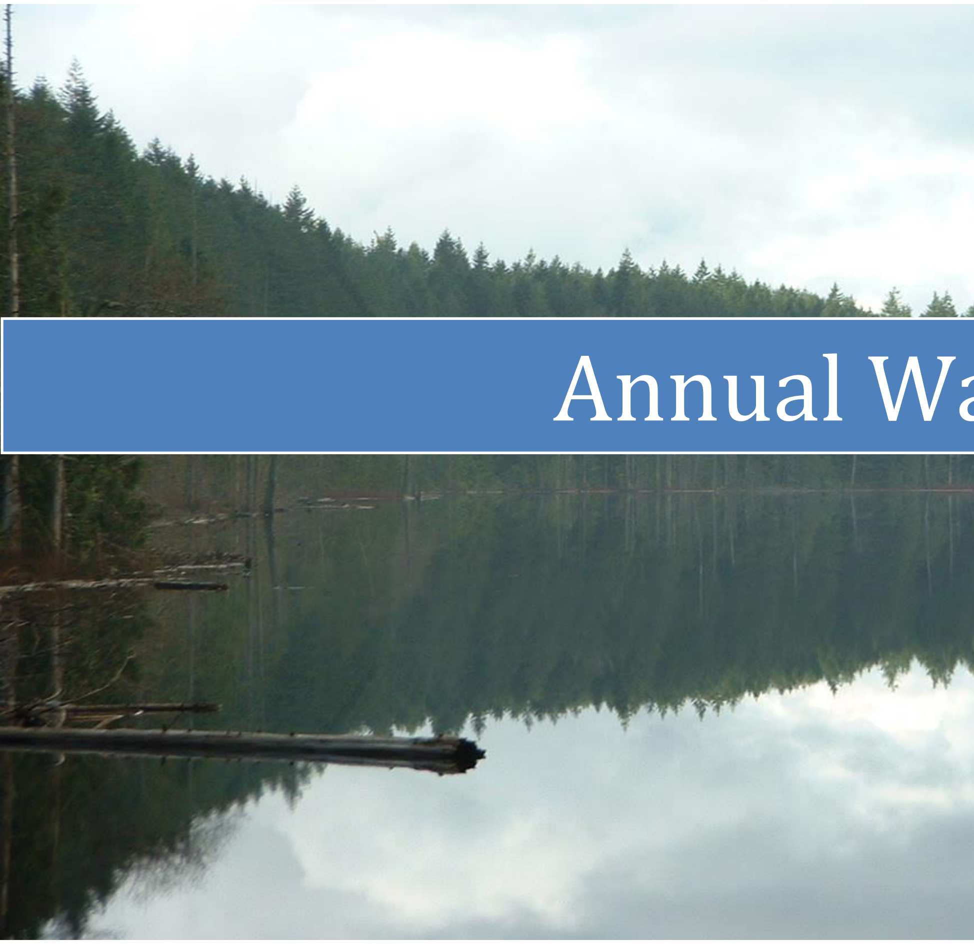

2014

Annual Water Report

Prepared by:

Town of Ladysmith

Infrastructure Services

Department

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1. Introduction

The 2014 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 and the Diamond Improvement District.

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. In late 2012, a remote turbidity meter was installed at the dam to measure turbidity year round. Annual dam inspections were carried out in 2014 and did not find any issues with either dam.

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 the lands contributory to the Lake is owned by TimberWest.

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 is under way in 2013/2014, which will be 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 is signed and 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, which is 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 is rated a low risk structure in accordance with the Provincial Dam Classification system.

The Stocking Lake area also is frequented by ATV users and occasional campers, as there is evidence of vandalism in the area. There is a trail system that travels the length of the Lake. The contributing areas of the Watershed are owned by TimberWest, the Crown, the CVRD, and the Town.

Arbutus Reservoir

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

Figure one 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 121 (approximate) meter contour will require the construction of additional reservoirs and pumping facilitates.

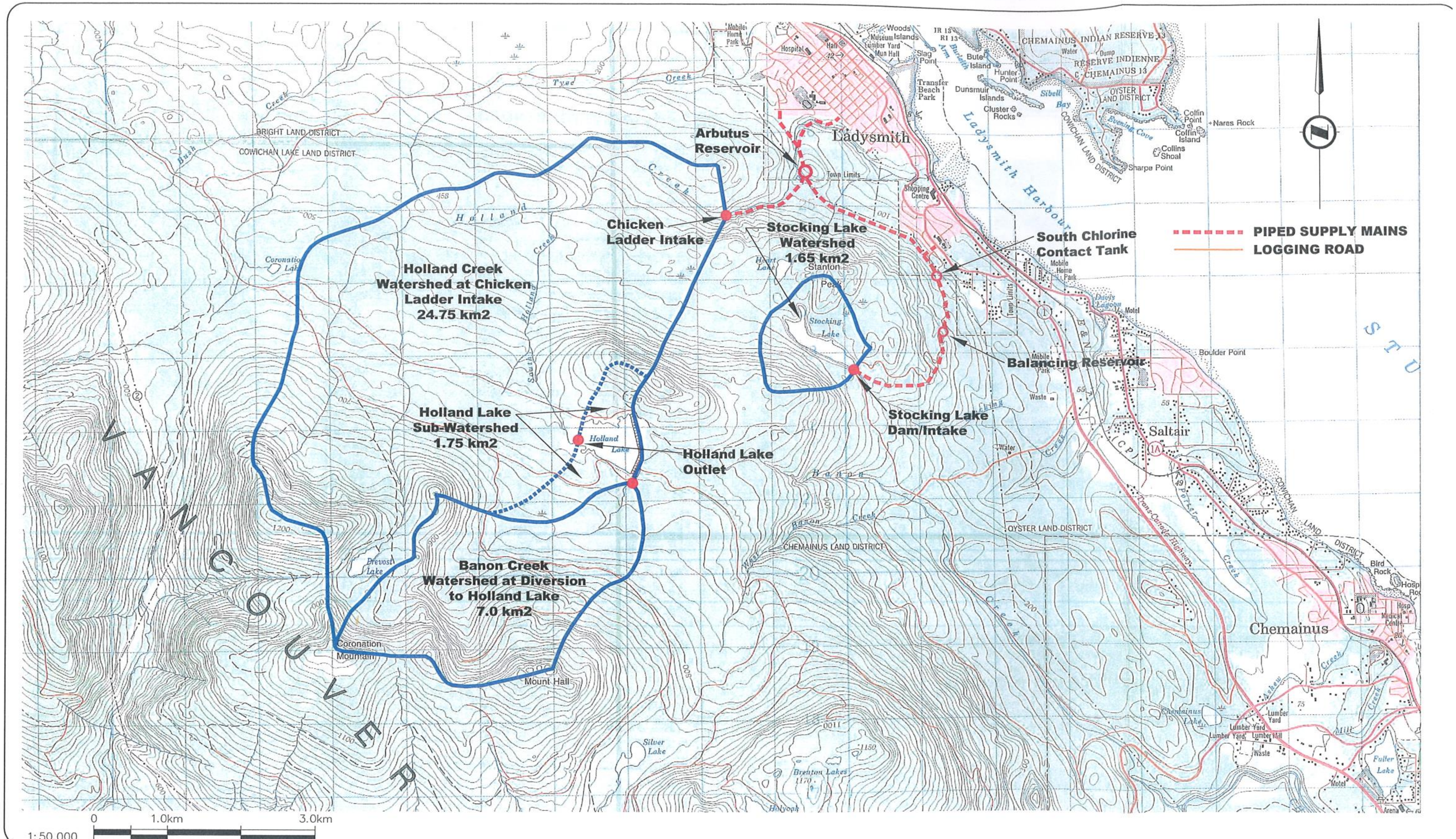
The distribution system for the Town consists of over 61 km of water main of varying sizes from 100mm to 250 mm. The mains are made of cast iron piping, asbestos cement piping or PVC piping. The cast iron and the asbestos cement piping (approximately 21 km) are located mainly in the older section of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

The Town has been actively working on a replacement program since 2000. Fire hydrants are situated throughout the distribution system at a spacing to 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 is nearing the completion of the replacement of the existing gas chlorination system with a new gas system, with provision to possibly manufacture 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.

Figure 1 System Overview



3. Water Licensing

The Town currently holds the following Water Licenses:

Table 1 - Town Water Licenses

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

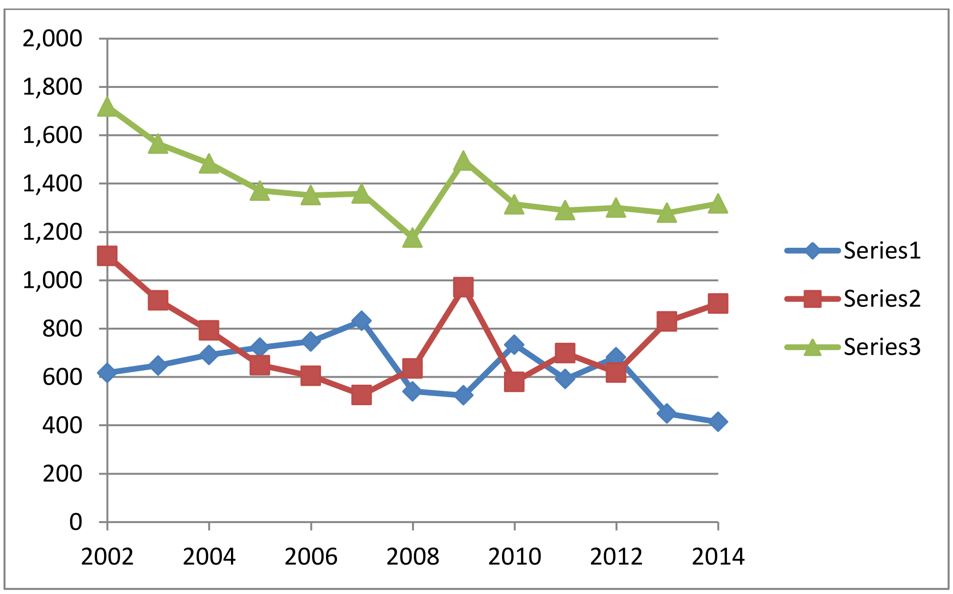
License	Type	Annual Storage (cm, or Diversion (cm/yr)	Max Day Flow (Cu m)	Location	Date of Original Issuance	Comments
CL 67482	Diversion	476,000		Stocking Lake	1984	All year, replaces 61318
CL 67481	Diversion	447,000		Stocking Lake	1955	All year, replaces 28487
Cl 67484	Storage	542,000		Stocking Lake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

4. Water Consumption

The Town used 1,317,000 cubic meters of water in 2014, an increase of 2.0% over 2013., but still considerably less than the consumption in 2002 (1.7M cu m). This reflects a trend that has been occurring at the Town since residential water metering was introduced in 2006. The Town is using approximately 25% less water now than 11 years ago (2002 annual consumption was 1,700,000 cu m). During the same period, the Town has grown over 20%, resulting in a net reduction of per capita water consumption in the order of 45%.

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, and is illustrated as follows:

Figure 2
Ladysmith Total Consumption and Flow Source – 2002-2014
(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 10 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 not able to be fed of the Holland Watershed due to piping

Table 3 Town of Ladysmith Water Consumption, 2002-2014

(In thousands of cubic meters)

Year	Totals			Jan			Feb			Mar		
	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total
2002	617,296	1,100,875	1,718,171	111968	2,264	114,232	100,195	1,394	101,589	78,008	34,171	112,179
2003	647,416	917,405	1,564,821	100,662	7,247	107,909	90,423	14,607	105,030	84,301	23,926	108,227
2004	691,495	792,116	1,483,611	112,122	3,034	115,156	103,451	1,804	105,255	102,936	1,394	104,330
2005	721,864	648,749	1,370,613	112,512	0	112,512	98,561	0	98,561	100,595	0	100,595
2006	746,986	604,784	1,351,770	102,631	0	102,631	76,455	685	77,140	89,795	0	89,795
2007	832,033	526,018	1,358,051	108,909	2,457	111,366	97,763	151	97,914	102,277	167	102,444
2008	540,694	635,254	1,175,948	76,184	0	76,184	34,923	0	34,923	62,425	0	62,425
2009	524,043	970,807	1,494,850	52,486	43,323	95,809	29,762	55,809	85,571	41,905	48,230	90,135
2010	733,566	580,294	1,313,860	94,215	530	94,745	66,683	18,763	85,446	53,712	51,296	105,008
2011	591,114	698,476	1,289,590	98,832	0	98,832	49,254	34,450	83,704	77,705	17,925	95,630
2012	681,701	618,568	1,300,269	73,561	14,887	88,448	79,886	338	80,224	90,632	0	90,632
2013	448,751	830,005	1,278,756	89,759	0	89,759	86,235	0	86,235	92,544	2,981	95,525
2014	413,948	903,369	1,317,317	31,772	68,018	99,790	52,492	35,031	87,523	80,922	14,046	94,968

Year	Apr			May			Jun			Jul		
	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total
2002	62,632	47,733	110,365	17,995	125,668	143,663	21,394	176,148	197,542	21,882	196,468	218,350
2003	91,124	10,682	101,806	10,848	121,234	132,082	19,948	185,552	205,500	22,979	193,965	216,944
2004	36,314	80,001	116,315	13,281	139,794	153,075	14,273	142,298	156,571	21,368	149,839	171,207
2005	89,583	7,981	97,564	45,736	76,963	122,699	11,427	116,536	127,963	15,125	134,275	149,400
2006	85,449	0	85,449	121,579	11,105	132,684	49,761	84,328	134,089	21,804	161,679	183,483
2007	98,558	3,665	102,223	66,489	60,609	127,098	21,794	125,909	147,703	27,653	140,573	168,226
2008	33,470	0	33,470	60,908	50,964	111,872	20,479	118,276	138,755	33,517	163,049	196,566
2009	38,626	80,462	119,088	29,813	133,864	163,677	35,621	160,221	195,842	31,068	158,057	189,125
2010	57,555	28,567	86,122	54,036	47,938	101,974	37,272	74,372	111,644	26,349	144,144	170,493
2011	52,997	36,900	89,897	66,702	30,816	97,518	15,036	115,018	130,054	18,591	134,989	153,580
2012	85,575	0	85,575	31,734	79,788	111,522	13,780	103,435	117,215	20,065	137,006	157,071
2013	46,305	38,418	84,723	15,166	92,829	107,995	23,506	94,528	118,034	1,922	168,656	170,578
2014	17,730	64,829	82,559	36	107,338	107,374	2,641	141,993	144,634	5,304	165,286	170,590

Year	Aug			Sep			Oct			Nov			Dec		
	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total	Stocking	Holland	Total
2002	22,170	207,387	229,557	14,772	148,083	162,855	9,349	113,103	122,452	80,058	21,788	101,846	76,873	26,668	103,541
2003	14,703	155,289	169,992	8,381	103,237	111,618	54,219	46,953	101,172	48,870	52,404	101,274	100,958	2,309	103,267
2004	14,275	138,457	152,732	24,800	83,978	108,778	52,905	48,609	101,514	97,483	2,908	100,391	98,287	0	98,287
2005	20,243	152,390	172,633	16,166	117,875	134,041	45,123	42,729	87,852	74,729	0	74,729	92,064	0	92,064
2006	21,047	154,831	175,878	24,796	107,794	132,590	17,329	84,362	101,691	76,528	0	76,528	59,812	0	59,812
2007	25,391	60,630	86,021	17,062	101,539	118,601	86,800	10,537	97,337	72,907	18,868	91,775	106,430	913	107,343
2008	21,843	127,803	149,646	22,965	86,132	109,097	78,629	7,544	86,173	63,738	18,135	81,873	31,613	63,351	94,964
2009	25,602	125,827	151,429	24,434	82,249	106,683	61,179	35,006	96,185	99,150	2,462	101,612	54,397	45,297	99,694
2010	23,241	126,648	149,889	42,940	65,322	108,262	85,101	8,465	93,566	94,679	3,077	97,756	97,783	11,172	108,955
2011	20,409	139,897	160,306	28,537	89,158	117,695	77,843	12,664	90,507	48,756	35,708	84,464	36,452	50,951	87,403
2012	22,632	141,874	164,506	19,063	105,250	124,313	64,611	35,990	100,601	88,055	0	88,055	92,107	0	92,107
2013	1,333	148,963	150,296	11,610	94,429	106,039	20,307	70,124	90,431	52,620	30,010	82,630	7,444	89,067	96,511
2014	737	144,087	144,824	1318	112709	114,027	62,218	27,180	89,398	66,068	22,852	88,920	92,710	0	92,710

and chlorination equipment considerations. In 2012, a two way interconnecting pipe system was installed to connect 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.

5. Drinking Water Regulations

In Canada, drinking water is regulated by the Provincial and Local Governments. 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 the Vancouver Island Health Authority [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 Guidelines for Canadian Drinking Water Quality are established by the Federal-Provincial-Territorial Committee on Drinking Water 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 can, potentially, 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, drinking water is regulated by the British Columbia Drinking Water Protection Regulation (2003) and the Drinking Water Protection Act (2001) (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 1 sample per 1,000 people be collected per month. For Ladysmith, which currently serves 8,000 people, 8 samples per month are required. Moreover, the bacteriological analyses must be performed by a laboratory which has been 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. Also, 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* was 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*, was 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* which 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.

In 2009, The Town retained Koers and Associates to produce a Drinking Water System Assessment report which identified specific actions that the Town were to take to manage a number of potential risks associated with our water system. These risks included:

- Physical Priority Improvements;
- Water Quality Monitoring;
- Longer term Actions.

These actions have been the focus of efforts by the Town to meet the 4-3-2-1 water quality objectives laid out by VIHA since 2009. However, recent water quality test results, particularly related to turbidity at Holland Lake, recent e-coli raw water sampling, and continuing issues with higher levels of Haloacetic Acids in the water distribution system has resulted in the Town making the decision to proceed with filtration in April of 2014. The Town's Operating Permit was subsequently amended in June of 2014 to provide for the implementation of filtration, with a deadline for completion of the upgrade set to January 31, 2018. This project has subsequently been incorporated into the Town's capital plans.

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 Transmittance (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

The results of the annual lab tests (excluding turbidity and health Bacteriological testing) for Holland Lake, Stocking Lake, and Chicken Ladder Intake are detailed in Appendix F. Lab results are discussed in the following section.

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 water being released 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 water being delivered 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 that is used for the Ladysmith system. Details on the flow splits between Stocking and Chicken Ladder (Holland Creek) can be found in Section 4:

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

Month	Ave	High	Low	Days > 1 NTU	Days > 5 NTU	% Stocking Water	% Holland Water
January	0.332	0.781	0.000	0	0	31.8%	68.2%
February	0.324	0.660	0.000	0	0	60.0%	40.0%
March	0.344	0.580	0.000	0	0	85.2%	14.8%
April	0.362	0.600	0.230	0	0	21.5%	78.5%
May	0.329	0.470	0.260	0	0	0.0%	100.0%
June	0.485	0.840	0.330	0	0	1.8%	98.2%
July	0.480	0.640	0.370	0	0	3.1%	96.9%
August	0.411	0.640	0.136	0	0	0.5%	99.5%
September	0.174	0.320	0.140	0	0	1.2%	98.8%
October	0.422	0.820	0.080	0	0	69.6%	30.4%
November	0.328	0.500	0.000	0	0	74.3%	25.7%
December	0.470	0.720	0.420	0	0	100.0%	0.0%
Summary	0.372	0.840	0.000	0	0	31.4%	68.6%
				0.0%	0.0%		

Our blended water easily meets the VIHA Guidelines for Surface Water Supplies for turbidity in 2014.

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. The results for 2014 are as follows:

Holland Lake

The results of our second full year of continuous Holland Lake turbidity monitoring are as follows:

Table 6 Holland Lake Turbidity Summary (NTU)

Month	Ave	High	Low	Days > 1 NTU	Days > 5 NTU
January	0.868	1.766	0.599	5	0
February	0.646	1.444	0.556	0	0
March	0.745	2.27*	0.42	3	0
April	0.534	1.083	0.441	0	0
May	0.657	1.078	0.523	0	0
June	0.705	0.853	0.463	3	0
July	0.462	0.756	0.363	0	0
August	0.570	1.271	0.422	0	0
September	Results not available			0	0
October	0.755	1.949	0.409	6	0
November	1.055	1.169	1.012	6	0
December	1.060	1.190	0.860	26	0
Summary		6.142	0.000	34	0
* Sensor malfunction results excluded				9.3%	0.0%

In order for the Town to successfully argue for a filtration deferral under VIHA guidelines, Holland Lake turbidity must not exceed 1 NTU more than 5% of the year (all but 18 days), and must not exceed 5 NTU 99.5% of the year (all but 2 days). Holland Lake turbidity did not exceed 5 NTU at any time of the year, but exceeded 1 NTU a total of 34 days in 2014, exceeding the maximum limit of 18 days by a factor of about 2. This reinforces the turbidity issue identified in the 2013 water quality report, which continues to indicate that the Town would not have been able to secure a filtration deferral if using Holland Lake water directly (piped). We expect that the higher turbidity is the result of the Lake turning over during winter snow and icing conditions, but we did see some sporadic turbidity events during the summer as well.

The results shown above represent automatic turbidity recordings, however, staff also recorded manual samples on an approximately bi-weekly basis during 2014, which generally correspond to the turbidity recorder readings noted above.

The results confirm that it is not likely that the Town could obtain a filtration deferral should the Town wish to use Holland Lake water 'directly' 100% of the time (i.e. by construction of a pipeline connecting the Town's supply pipelines to Holland Lake). It might be possible to selectively use Stocking Lake water during periods of time when the turbidity levels in Holland Lake are above 1 NTU, but this would likely be limited in the future by water licensing considerations at Stocking (currently under review).

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. With the exception of two days of readings higher than 1, attributable to instrument errors, the turbidity results for 2014 are under 1.0 NTU for all of the year.

Table 7 Stocking Lake Continuous Turbidity Results

Month	Ave	High	Low	Days > 1 NTU	Days > 5 NTU
January	0.321	0.885	0.192	0	0
February	0.314	0.500	0.166	0	0
March	0.315	0.811	0.178	0	0
April*	0.239	0.376	0.000	0	0
May	0.270	0.347	0.183	0	0
June*	0.331	0.727	0.180	0	0
July	0.284	0.432	0.145	0	0
August	0.166	0.422	0.000	0	0
September	0.225	0.502	0.093	0	0
October	0.371	0.729	0.175	0	0
November	0.425	0.636	0.248	0	0
December	0.469	0.832	0.408	0	0
Summary	0.311	0.885	0.000	0	0
* Two Days of instrument error readings ignored				0.0%	0.0%

Chicken Ladder Intake (Lower Holland Creek)

Staff visit Chicken Ladder Intake on a daily basis, and collects a turbidity sample during that inspection. The sampling for 2014 includes a total of 376 readings and samples tested, and are summarized below:

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

Month	Ave	High	Low	Days > 1 NTU	Days > 5 NTU
January	0.468	2.100	0.140	2	
February	0.664	1.860	0.170	7	
March	0.947	5.050	0.280	6	1
April	0.396	0.680	0.230		
May	0.336	0.470	0.260		
June	0.343	0.540	0.230		
July	0.314	0.460	0.230		
August	0.305	0.430	0.240		
September	0.335	0.580	0.220		
October	0.900	4.450	0.230	5	
November	0.559	1.050	0.559	1	
December	0.580	9.900	0.580	11	3
Summary	0.512	9.900	0.140	32	4
				8.8%	1.1%

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 storms 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 2014.

The above results confirms that Chicken Ladder, similar to Holland Lake, will not meet the "raw water" criteria for filtration deferral as both the 1NTU and 5NTU limits were exceeded in 2014.

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

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

Table 9 Holland Lake – Other Physical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Total Dissolved Solids	9	Mg/L	19.38	25	<10	<500	OK
PH	11	PH Units	6.43	6.5	6.2	6.5-8.4	OK
True Color	40	Col Unit	10.09	20.0	5.0	<15 (AO)	OK 1 test too High
Apparent Color	40	Col Unit	13.07	20.0	5.0		
Dissolved organic Carbon	9	Mg/L	2.55	3.25	1.87	<5 (AO)	OK
Total Organic Carbon	10	Mg/L	3.45	6.08	2.39	n/a	
Ultraviolet Transmittance	17	AU/cm	84.04	87.2	78.5	>80 (AO)	OK – review for UV Disinfection

(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	9	Mg/L	23.11	37.0	16.0	<500	OK
PH	12	PH Units	6.66	6.9	6.4	6.5-8.4	OK
True Color	42	Col Unit	13.45	40.0	7.0	<15 (AO)	Color Issues
Apparent Color	42	Col Unit	16.55	48.0	5.0		
Dissolved organic Carbon	10	Mg/L	2.68	3.86	1.34	<5 (AO)	OK
Total Organic Carbon	11	Mg/L	3.28	5.33	2.02	n/a	
Ultraviolet Transmittance	18	AU/cm	83.53	90.0	60.5	>80 (AO)	OK – review for UV Disinfection

(AO) Aesthetic Objective

Table 11 Stocking Lake – Other Physical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Total Dissolved Solids	9	Mg/L	27.33	33.0	16.0	<500	OK
PH	12	PH Units	6.88	7.1	6.5	6.5-8.4	OK
True Color	41	Col Unit	9.24	13.0	5.0	<15 (AO)	OK
Apparent Color	40	Col Unit	12.61	19.0	5.0		
Dissolved organic Carbon	9	Mg/L	2.67	3.53	1.77	<5 (AO)	OK
Total Organic Carbon	10	Mg/L	2.99	3.96	1.84	n/a	
Ultraviolet Transmittance	16	AU/cm	84.78	88.2	83.1	>80 (AO)	OK

(AO) Aesthetic Objective

The results meet the Canadian Drinking Water Guidelines, although some results, listed as aesthetic guidelines, may have a bearing on the design of water treatment facilitates.

6.2. Chemical Parameters

The Town is required to conduct bi-annual metals testing. Results for all three water sources are as follows in Table 12. All three water sources meet the Canadian Drinking Water Guidelines.

Table 12 Metals, Hardness Testing July, 2014

Maxxam ID		JZ8471	JZ8472	JZ8473		
Sampling Date		2014-07-03 8:00	2014-07-03 8:00	2014-07-03 8:40		
COC Number		08367831	08367831	08367831		
	UNITS	**HOLLAND LAKE**	**STOCKING LAKE**	**CHICKEN LADDER**	**CDW/BC Guideline**	**Comments**
Calculated Parameters						
Total Hardness (CaCO3)	mg/L	4.17	11.5	6.96	80-100	OK
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	25	29.6	27.9	100	OK
Total Antimony (Sb)	ug/L	<.50	<0.50	<0.50	6	OK
Total Arsenic (As)	ug/L	0.15	0.11	0.10	5	OK
Total Barium (Ba)	ug/L	3.2	3.2	3.8	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	500	OK
Total Cadmium (Cd)	ug/L	0.013	0.013	0.112	5	OK

Table 12 (Cont'd)
Metals Testing – July, 2014

Maxxam ID		JZ8471	JZ8472	JZ8473		
Sampling Date		2014-07-03 8:00	2014-07-03 8:00	2014-07-03 8:40		
COC Number		08367831	08367831	08367831		
	UNITS	**HOLLAND LAKE**	**STOCKING LAKE**	**CHICKEN LADDER**	**C,BC DW Guideline**	**Comments**
Total Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	50	OK
Total Cobalt (Co)	ug/L	<0.50	<0.50	<0.50		
Total Copper (Cu)	ug/L	2.95	1.72	2.04	1000 AO	
Total Iron (Fe)	ug/L	79	53	28	300 AO	OK
Total Lead (Pb)	ug/L	<0.20	<0.20	<0.20	1	OK
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0		
Total Manganese (Mn)	ug/L	11.2	2.5	1.4	50 AO	OK
Total Mercury (Hg)	ug/L	<0.050	<0.050	<0.050	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	2	OK
Total Silicon (Si)	ug/L	480	1510	1550		
Total Silver (Ag)	ug/L	<0.020	<0.020	<0.020		
Total Strontium (Sr)	ug/L	7.3	11.5	11.2	1.0	
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050		
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	5.1	<5.0	<5.0	7.5	OK
Total Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50		
Total Calcium (Ca)	mg/L	1.24	3.72	2.09		
Total Magnesium (Mg)	mg/L	0.26	0.531	0.421		
Total Potassium (K)	mg/L	0.15	0.255	0.137		
Total Sodium (Na)	mg/L	0.758	1.2	1.15	< 200 AO	OK
Total Sulphur (S)	mg/L	<3.0	<3.0	<3.0		

Metals Testing – Dec. 12, 2014

Maxxam ID		LH5919	LH5920	LH5921		
Sampling Date		2014-12-12 8:00	2014-12-12 8:00	2014-12-12 8:40		
COC Number		440549-01-01	440549-01-01	440549-01-01		
	UNITS	**HOLLAND LAKE**	**STOCKING LAKE**	**CHICKEN LADDER**	**C,BC DW Guideline**	**Comments**
Total Chromium (Cr)	ug/L	<1.0	<1.0	<1.0	50	OK
Total Cobalt (Co)	ug/L	<0.50	<0.50	<0.50		
Total Copper (Cu)	ug/L	1.11	0.91	0.80	1000	**OK**
Total Iron (Fe)	ug/L	267	46	41	300 AO	OK
Total Lead (Pb)	ug/L	<0.20	<0.20	<0.20	1	OK
Total Lithium (Li)	ug/L	<5.0	<5.0	<5.0		
Total Manganese (Mn)	ug/L	26.9	2.8	<1.0	50 AO	OK
Total Mercury (Hg)	ug/L	<0.010	<0.010	<0.010	1	OK
Total Molybdenum (Mo)	ug/L	<1.0	<1.0	<1.0	1	
Total Nickel (Ni)	ug/L	<1.0	<1.6	<1.0	1	
Total Selenium (Se)	ug/L	<0.10	<0.10	<0.10	2	OK
Total Silicon (Si)	ug/L	954	1840	3180	100	**OVER**
Total Silver (Ag)	ug/L	<0.020	<0.020	<0.020		
Total Strontium (Sr)	ug/L	8.3	11.1	9.9	1.0	**OVER**
Total Thallium (Tl)	ug/L	<0.050	<0.050	<0.050		
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	115	<5.0	<5.0	7.5	Holland is over
Total Zirconium (Zr)	ug/L	<0.50	<0.50	<0.50		
Total Calcium (Ca)	mg/L	1.88	3.79	1.99		
Total Magnesium (Mg)	mg/L	0.432	0.508	0.390		
Total Potassium (K)	mg/L	0.198	0.272	0.070		
Total Sodium (Na)	mg/L	1.23	1.16	1.22	< 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	11	Mg/L	3.16	3.6	2.4	n/a	Slightly low
Calcium	10	Mg/L	1.23	1.55	1.04	n/a	
Bromide	12	Mg/L	0.00	<0.02	<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	12	Mg/L	4.90	6.3	3.6	n/a	Slightly low
Calcium	11	Mg/L	6.25	50.0	1.5	n/a	
Bromide	12	Mg/L	0.00	<0.02	<0.01	n/a	

Table 15 Stocking Lake - Other Chemical Results

Parameter	No of Samples	Units	Ave	High	Low	CDW Guideline	Comments
Alkalinity	12	Mg/L	7.99	9.9	3.3	n/a	Slightly low
Calcium	11	Mg/L	3.75	4.51	3.42	n/a	
Bromide	12	Mg/L	0.00	<0.10	<0.01	n/a	

6.4. 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. The E-Coli tests are used to determine generally eligibility for filtration deferral – in any 6 month period, no more than 10% of raw water samples can test over 20 cfu/100ml. Results for 2014 are summarized 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	22	Cfu/100ml	1.67	4	<1	0.0% > 20 cfu/100ml	10% max
Total Coliforms	22	Cfu/100ml	495.29	1900	7	68% > 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	23	Cfu/100ml	17.88	69	<1	21.7% > 20 cfu/100ml	10% max **Over Regulated allowable limit**
Total Coliforms	23	Cfu/100ml	346.17	990	16	71% >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	22	Cfu/100ml	3.11	13	<1	0% > 20 cfu/100ml	10% max
Total Coliforms	22	Cfu/100ml	387.62	1600	<1	34% > 100 cfu/100ml	

For 2014, approximately 22% of the raw E-Coli tests for Chicken Ladder exceeded the maximum allowable E-Coli value of 20 cfu/100ml. This does not meet the requirement for filtration deferral under VIHA's filtration deferral policy.

6.5. 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.

A total of 8 tests were conducted within the water system in 2014 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.05.14	0.063	0.054	0.100	Meets CDWG
Jun.16.14	0.051	0.051	0.100	Meets CDWG
Sept.24.14	0.059	0.054	0.100	Meets CDWG
Dec.12.14	0.0	0.0	0.100	Meets CDWG

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

	558 Hooper	1280 Rocky Creek	CDW Guideline	Comments
Mar.05.14	0.100	0.081	0.080	Marginally Fails CDWG
Jun.16.14	0.082	0.079	0.080	Marginally Fails CDWG
Oct.06.14	0.082	0.056	0.080	Marginally Fails CDWG
Dec.12.14	0.079	0.070	0.080	Marginally Meets CDWG

Table 21 THM Component Results, in mg/L

Concentrations in micrograms per liter (ug/l)

Year	Q	MCAA Location Hooper	MCAA Location Rocky	MBAA Location Hooper	MBAA Location Rocky	DCAA Location Hooper	DCAA Location Rocky	TCAA Location Hooper	TCAA Location Rocky
2014	1	ND	ND	ND	ND	45	36	58	55
2014	2	ND	ND	ND	ND	47	42	35	37
2014	3	ND	ND	ND	ND	38	19	44	37
2014	4	ND	ND	ND	ND	22	27	58	43

Year	Q	BCAA Location Hooper	BCAA Location Rocky	DBAA Location Hooper	DBAA Location Rocky	Total Location Hooper	Total Location Rocky	% Can Guideline Location Hooper	% Can Guideline Location Rocky
2014	1	ND	ND	ND	ND	100	81	125%	101%
2014	2	ND	ND	ND	ND	82	79	103%	99%
2014	3	ND	ND	ND	ND	82	56	103%	70%
2014	4	ND	ND	ND	ND	79	70	99%	88%

It should be noted that the HAA testing for 2014 were around the maximum recommended level under the current Canadian Drinking Water Quality Guideline, which is consistent with results from the previous years.

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

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

A copy of the executive summary follows, and provides an overview of this issue:

"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. Based on this review, the guideline for total haloacetic acids in drinking water is 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."

With respect to the impact of water treatment on HAA values, the study notes that:

"The removal of organic precursors is the most effective way to reduce the concentrations of all DBPs, including HAAs, in finished water (U.S. EPA, 1999c; Reid Crowther & Partners Ltd., 2000). These precursors include synthetic organic compounds and NOM, which can react with disinfectants to form HAAs. Removing HAA precursors will also result in the formation of lower concentrations of HAAs (Reid Crowther & Partners Ltd., 2000). Conventional municipal-scale water treatment techniques (coagulation, sedimentation, dissolved air flotation, precipitative softening and filtration) can reduce the amount of HAA precursors, but are ineffective in removing HAAs once they are formed."

We expect that the removal of organic compounds, likely found in the greatest concentrations at Holland Creek (Chicken ladder), will effectively by dealt with through additional treatment, including filtration.

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. Signs are posted at a number of strategic locations prohibiting vehicle access to the Lakes, and recreational lake use such as boating, swimming, and fishing is prohibited.

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. These gates are normally 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.

The Town has been working with the various stakeholders of the southern access area (South Watts Road) to improve the gate at that location, possibly through the use of access cards and video security, as this gate is located nearer a source of power. Funds have been allocated in the capital budget for this purpose.

8. Routine Maintenance Program

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

8.1. Distribution

- Water mains are flushed using a unidirectional flushing program
- Air relief valves are cleaned
- Fireline meters are cleaned
- Fire Hydrants are completely disassembled and inspected on a 2 year rotation
- Paint and brush out around hydrants as needed
- All irrigation backflow prevention devices tested and repaired if needed

8.2. Source Intakes

- Winter maintenance of chlorination system while off line
- Weekly blowing of air lines through intake screens
- Daily checks of pump flows and chlorine levels
- Monthly calibration of turbidity analyzers

8.3. Reservoirs

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

8.4. Pump Stations

- Daily checks of pumps and chlorination system
- Security checks of compounds
- Bi-Annual calibration of chlorine analyzers and turbidimeters

The Town trains it's staff in accordance with current industry practises and requirements, and staff are certified to 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 22 – Long Term Capital Plan

Title	Description	Purpose	Start Year	Cost
Chlorination Facility	Construction of a new Chlorination Facility	To upgrade the present chlorination facility.	2013	$1,500,000
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.	2015	$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.	2018	$5,4000,000
Stocking Lake Supply Main Replacement - Phase II	Replacement of the AC Supply watermain from balancing reservoir to the Old Chlorination Station.	To provide a more secure Supply Main.	2022	$2,000,000
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	$6,265,000
Holland Dam Capacity Increase	Doubling of current storage at Holland Dam	To provide for future water supply needs	2019-2012	$6,000,000
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	2023	$2,720,000
New Upper Pressure Zone Reservoir	To service Couverdon, possibly others.	For development in upper zone	2021	$2,000,000
Upper Pressure Zone - Pump Station		For development in upper zone	2021	$900,000
			10 year Plan - Cost of "Major' Projects Only	**$30,000,000**

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 NTUTable 1 footnote1at all times. Where not achievable: ≤ 0.3 NTUTable 1 footnote2 ≤ 1.0 NTUTable 1 footnote3 ≤ 0.1 NTUTable 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/lL	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 chloramination 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/lL	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/lL	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/lL	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/lL	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-DichlorobenzeneTable 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-DichlorobenzeneTable 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 from industrial	**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/lL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
				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

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
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

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	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 neurobehavioural 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

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
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)	

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
					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)		6.5-8.5Table 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/lL	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/lL	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 chlorine; industrial	**Health basis of MAC:** Liver cancer (classified as probable carcinogen)	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/lL	Other value (mg/L)	Common sources of parameter in water	Health considerations	Comments
				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	TrihalomethanesTable 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 – 2014

Holland Lake

	Coliforms									Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS	PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Jan.9/14	430	0	0	<1				<10		10	12	0.7	2.6	3		
Jan15/14										10	13	1.2				250
Jan23/14	8			<1						7	12	0.8				290
Jan30/14					3	1.12	<0.010		6.5	10	13	0.8				
Feb5/14	9			<1				17		11	17	0.6	2.89	3.64	82.2	
Feb.20/14	7			<1						14	20	0.7			82.2	
Mar.19/14	20			<1						10	13	0.9			81.6	
mar 27/14					2.4	1.12	<.01		6.4	12	14	0.5				
Apr 3/14	110			<1				21		12	14	0.4	2.62	2.46	82.2	
Apr.10/14										12	14	0.5				290
Apr.17/14	58			<1						11	14	0.9			82.8	
Apr.24/14					3	1.04	<0.02		6.5	<5	5	0.9				
May.8/14										11	14	0.9				
May.15/14	1200			<1						10	17	0.8			82.3	
May.22/14					3.4	1.31	<0.02		6.5	10	13	1				
May.29/14	1300			<1				15		8	13	1	2.7	3.4	81.2	
Jun.5/14										5	10	0.7				
Jun.12/14	1200			<1						11	13	0.7			83.4	
Jun.19/14					3.3	1.12	<.02		6.5	11	13	0.8				
Jun.26/14	130			<1				22		10	13	0.6	1.87	6.08	86.1	
Jul.3/14										11	13	0.6				
Jul.10/14	480			<1						5	10	0.6			86.6	180
Jul.17/14					3.3		<0.02		6.4	10	12	0.5				
Jul.24/14	570			1				21		8	10	0.4	2.05	2.39	87.2	
Jul.31/14										5	10	0.4				
Aug.7/14	1900			<1						5	10	0.5				85.2
Aug 14/14					3.3	1.24	<0.02		6.2	5	10	0.6				
Aug 21/14				<1				14		11	14	0.8	2.64	2.82	86.5	
Aug 28/14										7	12	0.9				
Sept 4/14	1000			<1						8	12	1.2			85.6	
Sept 11/14					3.5	1.23	<0.02		6.5	9	12	0.5				
Sept 18/14	290			1				25		9	13	0.6	3.25	3.34	86.7	
Sept 25/14										10	13	0.6				240
Oct 2/14	840			1						10	12	0.8			87.2	
Oct 9/14					3.6	1.2	<.02		6.5	8	12	0.5				
Oct 16/14	84			<1				20		9	14	0.8	2.36	4.37	86.4	
Oct 23/14										9	14	1.2				
Oct 29/14	460			4						15	20	1.3		2.98	78.5	
Nov 6/14					3.1	1.34	<0.02		6.4	5	5	1.4				
Nov 13/14	220			2				15		15	20	1.3	4.08	5.52	78.7	
Nov 20/14										15	15	1.1				
Nov 27/14	85			1						15	20	1.4			76.6	
Dec 4/14										15	15	1.2				360
Dec 11/14																
Dec 18/14					2.9	1.55	<0.02		6.3	20	10	1.3				
	495.29	0.00	0.00	1.67	3.16	1.23		18.89	6.43	10.09	13.07	0.82	2.71	3.64	83.37	242.17

Stocking Lake Lab Results, 2014

	Coliforms									Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS	PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Jan.9/14	14	0	0	<1				16		5	15	0.4	2.29	2.4		
Jan16/14										5	10	1				200
Jan23/14	16			2						10	15	0.4				210
Jan29/14					9.3	3.45	<0.10		7	10	15	0.6				
Feb5/14	17			<1				29		13	17	0.5	3.46	3.52	83.7	
feb20/14	13			<1						13	19	0.4			85	
feb27/14					8.8	3.63	<.01		6.9	12	14	1.5				
Mar 6/14	15			<1				29		11	15	0.7	2.28	2.4		
Mar 13/14										10	13	0.4				
Mar.20/14	2			<1						10	12	0.8			83.5	
mar 27 /14					8.4	3.71	<.01		6.8	12	13	0.6				
Apr 3/14	21			<1				33		13	14	0.3	2.27	1.84	83.8	
Apr.10/14										12	14	0.2				270
Apr.17/14	87			<1						11	13	0.6			83.4	
Apr.24/14					8.5	3.59	<0.2		7.1	5	7	0.3				
May.8/14										11	13	0.6				
May.15/14	140			1						12	15	0.4			83.1	
May.22/14					8.6	3.44	<.02		7	8	12	0.6				
May.29/14	<1			<1				24		12	15	0.6	2.91	3.6	83.6	
Jun.5/14										7	13	0.3				
Jun.12/14	440			<1						10	12	0.4			83.8	
Jun.19/14					9.4	3.42	<.02		7	11	14	0.5				
Jun.26/14	700			13				30		12	14	0.5	1.77	3.96	84.9	
Jul.3/14										10	14	0.3				
Jul.10/14	140			<1						5	10	0.8			84.8	180
jul.17/14					9.9		<0.02		6.9	11	13	0.3				
Jul.24/14	920			1				26		10	12	0.3	2.75	2.81	85.4	
Jul.31/14										5	10	0.4				
Aug.7/14	1600			<1						10	12	0.4				85.4
Aug 14/14					3.3	4.02	<0.02		6.7	7	12	0.6				
Aug 28/14										5	10	0.7				
Sept 4/14	560			3						10	12	0.5			85.8	
Sept 11/14					8.4	4.03	<.02		6.9	9	11	0.5				
Sept 18/14	1300			<1				32		10	13	0.5	3.53	3.38	86.3	
Sept 25/14										10	12	0.5				260
Oct 2/14	730			1						9	14	0.7			88.2	
Oct 9/14					3.6	3.6	<.02		6.5	8	12	0.5				
Oct 16/14	680			2				27		9	13	0.6	2.74	3.72	86.7	
Oct 23/14										10	13	0.6				
Oct 29/14	510			2						5	5	0.6		2.23	84.5	
Nov 6/14					9.4	3.87	<0.02		6.9	5	5	0.6				
Nov 13/14	180			3				24		5	10	0.7	4.63	3.97	84	
Nov 20/14										10	10	0.5				
Nov 27/14	55			<1						10	10	0.7			83.1	
Dec 4/14										5	5	0.6				320
Dec 11/14																

Chicken Ladder (Lower Holland Creek) Lab Results, 2014

	Coliforms									Colour						
Date	total	fecal	non-coli	E-coli	Alkalinity	Calcium	Bromide	TDS	PH	TCU	ACU	Turbidity	DOC	TOC	UVT	THM
Jan.9/14	130	0	0	2				16		12	20	0.7	3.4	3.6		
Jan15/14										10	15	0.9				350
Jan23/14	46			<1						10	12	0.1				280
Jan30/14					5.9	50	<0.01		6.8	15	17	0.4				
Feb6/14	16			<1						13	16	0.8	2.38	2.57	83.4	
feb20/14	45			<1						17	23	0.3			78.4	
Feb27/14					5	1.83	<.01		6.7	15	18	0.4				
Mar 6/14	490			20				37		16	35	0.4	3.86	3.89		
Mar 13/14										14	16	0.4				
Mar.20/14	18			<1						12	15	0.5			79.2	
mar 27/14					3.6	1.5	<.01		6.5	16	25	0.9				
Apr 3/14	31			<1				24		16	18	0.2	2.91	2.52	80.2	
Apr.10/14										14	15	0.3				300
Apr.17/14	76			<1						14	16	0.6			80.3	
Apr.24/14					4.4	1.66	<0.02		6.8	12	15	1.3				
May.8/14										13	16					
May.15/14	220			22						13	15	0.5			81.4	
May.22/14					6.3	2.08	<.02		6.9	12	13	0.3				
May.29/14	420			69				24		12	13	0.2	2.92	2.9	83.2	
Jun.5/14										7	13	0.3				
Jun.12/14	700			17						11	14	0.3			86.3	
Jun.19/14					5.9	1.99	<.02		6.8	13	15	0.1				
Jun.26/14	110			2				24		13	14	0.2	1.34	5.33	88.2	
Jul.3/14										13	14	0.3				
Jul.10/14	430			17						10	12	0.2			88.1	160
jul.17/14					5.3		<0.02		6.6	12	13	0.1				
Jul.24/14	990			53				17		10	13	0.2	2.28	2.15	85.7	
Jul.31/14										5	10	0.2				
Aug.7/14	280			32						10	13	0.2			87.7	
Aug 14/14					4.9	1.86	<0.02		6.4	10	13	0.3				
Aug 21/14	320			10				16		13	15	0.6	1.83	2.02	89	
Aug 28/14										10	12	0.5				
Sept 4/14	730			10						10	12	0.1			89.4	
Sept 11/14					5	1.8	<.02		6.7	9	11	0.2				
Sept 18/14	900			13				23		9	13	0.2	3.47	2.92	89.9	
Sept 25/14										11	14	0.2				250
Oct 2/14	330			2						10	14	0.4			90	
Oct 9/14					3.6	1.88	<.02		6.5	8	12	0.5				
Oct 16/14	860			8				27		12	15	0.3	2.43	3.41	82.6	
Oct 23/14										40	48	1.2				
Oct 29/14	490			14						25	30	0.6		4.76	60.5	
Nov 6/14					4.7	2.05	<0.02		6.6	20	25	0.5				
Nov 13/14	170			1				26		15	20	0.3	4.31	5.1	75.6	
Nov 20/14										15	15	0.4				
Nov 27/14	160			12						25	30	1.7			64	
Dec 4/14										10	10	0.5				440
Dec 11/14																
Dec 18/14					4.2	2.06	<0.02		6.6	20	5	0.3				
	346.17	0.00	0.00	17.88	4.90	6.25		23.40	6.66	13.45	16.55	0.44	2.83	3.43	82.16	296.67

Appendix C – Haloacetic Acids in Domestic Water Supplies

The following additional information is related to Haloacetic Acid concentrations in domestic water supplies. More information is available on this topic from Vancouver Island Health, and from:

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

Part II. Science and Technical Considerations

7.0 Treatment Technology

Although HAA formation in water is largely a function of the amount of organic compounds in water and their contact time with chlorine, it is important to recognize that the use of chlorination and other disinfection processes has virtually eliminated waterborne microbial diseases. In order to reduce HAA levels in the finished water, it is important to characterize the source water to ensure that the treatment process is optimized for precursor removal.

7.1 Municipal scale

There are three approaches to limiting the concentrations of HAAs in municipally treated drinking water:

- treatment of water to remove HAA precursors prior to disinfection;
- the use of alternative disinfectants and disinfection strategies; and
- treatment of water to remove HAAs after their formation.

The majority of changes occurring in the water industry now focus on strategies to remove DBP precursors prior to disinfection and the use of alternative disinfectants and alternative disinfection strategies.

7.1.1 Removal of precursors prior to municipal disinfection

The removal of organic precursors is the most effective way to reduce the concentrations of all DBPs, including HAAs, in finished water (U.S. EPA, 1999c; Reid Crowther & Partners Ltd., 2000). These precursors include synthetic organic compounds and NOM, which can react with disinfectants to form HAAs. Removing HAA precursors will also result in the formation of lower concentrations of HAAs (Reid Crowther & Partners Ltd., 2000). Conventional municipal-scale water treatment techniques (coagulation, sedimentation, dissolved air flotation, precipitative softening and filtration) can reduce the amount of HAA precursors, but are ineffective in removing HAAs once they are formed. Granular activated carbon (GAC), membranes and ozone-biofiltration systems can also remove organic matter from water. The U.S. EPA has identified precursor removal technologies such as GAC and membrane filtration, specifically nanofiltration, as Best Available Technologies (BAT) for controlling DBP formation (U.S. EPA, 2005b).

Potassium permanganate can be used to oxidize organic precursors at the head of the treatment plant, thus minimizing the formation of by-products at the disinfection stage (U.S. EPA, 1999a). The use of ozone for oxidation of precursors is currently being studied. Early work has shown that the effects of ozonation, prior to chlorination, depend on treatment design and raw water quality and thus are unpredictable. The key variables that seem to determine the effect of ozone are dose, pH, alkalinity and the nature of the organic material in the water. Ozone has been shown to be effective at reducing precursors at low pH. However, at pH levels above 7.5, ozone may actually increase the production of CDBP precursors (U.S. EPA, 1999a).

7.1.2 Alternative municipal disinfection strategies

The use of alternative disinfectants, such as chloramines (secondary disinfection only), ozone (primary disinfection only) and chlorine dioxide (primary and secondary disinfection), is increasing. However, each of these alternatives has also been shown to form its own set of DBPs. Combinations of disinfectants, when optimized, can help controlHAA formation. Preozonation is feasible for water sources that have turbidity levels below 10 nephelometric turbidity units (NTU) and bromide concentrations below 0.01 mg/L, to minimize the formation of bromate (Reid Crowther & Partners Ltd., 2000). Ultraviolet (UV) disinfection is also being used as an alternative disinfectant. Since UV disinfection is dependent on light transmission to the microbes, water quality characteristics affectingUV transmittance must be considered in the design of the system. UV irradiation at typical doses and wavelengths does not affect HAA formation in subsequent chlorination or chloramination steps (Reid Crowther & Partners Ltd., 2000). Neither ozone nor UVdisinfection leaves a residual disinfectant, and both must therefore be used in combination with a secondary disinfectant to maintain a residual in the distribution system.

It is recommended that any change made to the treatment process, particularly when changing the disinfectant, be accompanied by close monitoring of lead levels in the distributed water. A change of disinfectant has been found to affect the levels of lead at the tap; in Washington, DC, for example, a change from chlorine to chloramines resulted in significantly increased levels of lead in the distributed drinking water. When chlorine, a powerful oxidant, is used as the disinfectant, lead dioxide scales formed in distribution system pipes reach a dynamic equilibrium in the distribution system. In Washington, DC, switching from chlorine to chloramines decreased the oxidation-reduction potential of the distributed water and destabilized the lead dioxide scales, which resulted in increased lead leaching (Schock and Giani, 2004). Subsequent laboratory experiments by Edwards and Dudi (2004) and Lytle and Schock (2005) confirmed that lead dioxide deposits could be readily formed and subsequently destabilized in weeks to months under realistic conditions of distribution system pH, oxidation-reduction potential and alkalinity.

7.1.3 Removal of HAAs after formation

Although precursor removal is considered the most effective approach to reduce HAAconcentrations, removal of HAAs is also possible. Adsorption onto activated carbon is widely used to remove organic compounds such as HAAs from drinking water. This method involves pumping water through a bed of activated carbon onto which HAA molecules become attached (adsorbed). If an activated carbon filter bed is deep enough to allow sufficient contact time, it can be effective in removing HAAs from drinking water. Biofiltration may be an effective process for removing biodegradable organic matter and biodegradable DBPs from water. GAC, anthracite, sand and garnet are common media that support colonization by bacteria and can be used as biological filters. Information on the use of biofiltration for HAA removal is limited, although work has shown that bacteria-colonized GAC (biologically active carbon) is an effective process for HAA removal (Xie, 2004).

Appendix D – Ministry of Health – Microbiological Results, 2014

The following pages provide the Ministry of Health Microbiological Sampling for The Town's distribution system for 2014. For more information, please visit www.healthspace.ca

Location	Date	Total Coliform	E. Coli
405 Blair Place, 405 Blair Place	17-Dec-2014	L1	L1
558 Hooper Place, 558 Hooper Place	17-Dec-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	8-Dec-2014	L1	L1
432 Davis Road, 432 Davis Road	8-Dec-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	8-Dec-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	8-Dec-2014	L1	L1
604 Farrell Road, 604 Farrell Road	1-Dec-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	1-Dec-2014	L1	L1
City Hall, 410 Esplanade	1-Dec-2014	L1	L1
Public Works Yard, 340 6th Avenue	1-Dec-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	26-Nov-2014	L1	L1
Public Works Yard, 340 6th Avenue	26-Nov-2014	L1	L1
558 Hooper Place, 558 Hooper Place	18-Nov-2014	L1	L1
405 Blair Place, 405 Blair Place	18-Nov-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	18-Nov-2014	L1	L1
432 Davis Road, 432 Davis Road	12-Nov-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	12-Nov-2014	L1	L1
604 Farrell Road, 604 Farrell Road	4-Nov-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	4-Nov-2014	L1	L1
City Hall, 410 Esplanade	4-Nov-2014	L1	L1
432 Davis Road, 432 Davis Road	28-Oct-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	28-Oct-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	28-Oct-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	21-Oct-2014	L1	L1
558 Hooper Place, 558 Hooper Place	21-Oct-2014	L1	L1
AUDIT- Town of Ladysmith, any available source	20-Oct-2014	L1	L1
405 Blair Place, 405 Blair Place	14-Oct-2014	L1	L1
Public Works Yard, 340 6th Avenue	14-Oct-2014	L1	L1
604 Farrell Road, 604 Farrell Road	8-Oct-2014	L1	L1

Location	Date	Total Coliform	E. Coli
606 Oakwood Road, 606 Oakwood Road	8-Oct-2014	L1	L1
City Hall, 410 Esplanade	8-Oct-2014	L1	L1
558 Hooper Place, 558 Hooper Place	30-Sep-2014	L1	L1
Public Works Yard, 340 6th Avenue	30-Sep-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	23-Sep-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	23-Sep-2014	L1	L1
405 Blair Place, 405 Blair Place	16-Sep-2014	L1	L1
City Hall, 410 Esplanade	16-Sep-2014	L1	L1
604 Farrell Road, 604 Farrell Road	9-Sep-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	9-Sep-2014	L1	L1
432 Davis Road, 432 Davis Road	3-Sep-2014	L1	L1
Kinsmen Park, 1000 Colonia Drive	3-Sep-2014	L1	L1
405 Blair Place, 405 Blair Place	26-Aug-2014	L1	L1
City Hall, 410 Esplanade	26-Aug-2014	L1	L1
604 Farrell Road, 604 Farrell Road	19-Aug-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	19-Aug-2014	L1	L1
432 Davis Road, 432 Davis Road	12-Aug-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	12-Aug-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	12-Aug-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	5-Aug-2014	L1	L1
558 Hooper Place, 558 Hooper Place	5-Aug-2014	L1	L1
Public Works Yard, 340 6th Avenue	5-Aug-2014	L1	L1
558 Hooper Place, 558 Hooper Place	29-Jul-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	29-Jul-2014	L1	L1
405 Blair Place, 405 Blair Place	22-Jul-2014	L1	L1
Public Works Yard, 340 6th Avenue	22-Jul-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	15-Jul-2014	L1	L1
Kinsmen Park, 1000 Colonia Drive	15-Jul-2014	L1	L1
604 Farrell Road, 604 Farrell Road	9-Jul-2014	1	L1
City Hall, 410 Esplanade	9-Jul-2014	L1	L1
432 Davis Road, 432 Davis Road	2-Jul-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	2-Jul-2014	L1	L1
405 Blair Place, 405 Blair Place	25-Jun-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	25-Jun-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	17-Jun-2014	L1	L1
558 Hooper Place, 558 Hooper Place	17-Jun-2014	L1	L1
604 Farrell Road, 604 Farrell Road	11-Jun-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	11-Jun-2014	L1	L1

Location	Date	Total Coliform	E. Coli
Public Works Yard, 340 6th Avenue	11-Jun-2014	L1	L1
432 Davis Road, 432 Davis Road	3-Jun-2014	L1	L1
City Hall, 410 Esplanade	3-Jun-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	3-Jun-2014	L1	L1
405 Blair Place, 405 Blair Place	27-May-2014	L1	L1
City Hall, 410 Esplanade	27-May-2014	L1	L1
558 Hooper Place, 558 Hooper Place	21-May-2014	L1	L1
604 Farrell Road, 604 Farrell Road	21-May-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	21-May-2014	L1	L1
432 Davis Road, 432 Davis Road	13-May-2014	L1	L1
Public Works Yard, 340 6th Avenue	13-May-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	6-May-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	6-May-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	6-May-2014	L1	L1
432 Davis Road, 432 Davis Road	29-Apr-2014	L1	L1
City Hall, 410 Esplanade	29-Apr-2014	L1	L1
558 Hooper Place, 558 Hooper Place	23-Apr-2014	L1	L1
Public Works Yard, 340 6th Avenue	23-Apr-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	15-Apr-2014	L1	L1
405 Blair Place, 405 Blair Place	15-Apr-2014	L1	L1
604 Farrell Road, 604 Farrell Road	8-Apr-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	8-Apr-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	1-Apr-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	1-Apr-2014	L1	L1
405 Blair Place, 405 Blair Place	25-Mar-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	25-Mar-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	18-Mar-2014	L1	L1
558 Hooper Place, 558 Hooper Place	18-Mar-2014	L1	L1
604 Farrell Road, 604 Farrell Road	11-Mar-2014	L1	L1
City Hall, 410 Esplanade	11-Mar-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	11-Mar-2014	L1	L1
432 Davis Road, 432 Davis Road	4-Mar-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	4-Mar-2014	L1	L1
Public Works Yard, 340 6th Avenue	4-Mar-2014	L1	L1
604 Farrell Road, 604 Farrell Road	26-Feb-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	26-Feb-2014	L1	L1

Location	Date	Total Coliform	E. Coli
405 Blair Place, 405 Blair Place	19-Feb-2014	L1	L1
432 Davis Road, 432 Davis Road	19-Feb-2014	L1	L1
Public Works Yard, 340 6th Avenue	19-Feb-2014	L1	L1
1280 Rocky Creek Road, 1280 Rocky Creek Road	12-Feb-2014	L1	L1
558 Hooper Place, 558 Hooper Place	12-Feb-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	12-Feb-2014	L1	L1
City Hall, 410 Esplanade	5-Feb-2014	A	
Wastewater Treatment Plant, Oyster Cove Road	5-Feb-2014	A	
1280 Rocky Creek Road, 1280 Rocky Creek Road	28-Jan-2014	L1	L1
558 Hooper Place, 558 Hooper Place	28-Jan-2014	L1	L1
432 Davis Road, 432 Davis Road	21-Jan-2014	L1	L1
Kinsmen Park , 1000 Colonia Drive	21-Jan-2014	L1	L1
Public Works Yard, 340 6th Avenue	21-Jan-2014	L1	L1
604 Farrell Road, 604 Farrell Road	14-Jan-2014	L1	L1
Wastewater Treatment Plant, Oyster Cove Road	14-Jan-2014	L1	L1
405 Blair Place, 405 Blair Place	7-Jan-2014	L1	L1
606 Oakwood Road, 606 Oakwood Road	7-Jan-2014	L1	L1
City Hall, 410 Esplanade	7-Jan-2014	L1	L1

Appendix E – Permit To Operate

VANCOUVER ISLAND health authority

HEALTH PROTECTION

PERMIT
to OPERATE

A WATER SUPPLY SYSTEM

Water System Name:	**TOWN OF LADYSMITH WATER WORKS**
Premises Number:	1310824
Premises Address:	330 6th Avenue Ladysmith, BC V0R 2E0
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: February 14, 2011

Issued By:
Environmental Health Officer

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

Place Decal Here

island health

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