2002 Annual Disinfection By-Products Summary of Greater Victoria's Drinking Water

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Executive Summary

This report provides a detailed summary of the disinfection by-product (DBPs) concentrations in water samples collected by the Water Quality Division of the Capital Regional District Water Department from the Greater Victoria Drinking Water System during 2002.

In this report, a distinction is made between sampling locations that receive water that has been disinfected at the Water Department's main treatment facility, Japan Gulch Treatment Plant, and sampling locations that receive water from chlorine booster stations located in the distribution system. The water at these latter locations is 'rechlorinated' since it is first treated with chlorine at the Japan Gulch Plant and then again at a booster station. This distinction is important because the United States Environmental Protection Agency (USEPA) is changing its criteria for disinfection by-products to track worst case locations individually rather than broad averages for the entire system. Canada may follow this lead at some point in the future.

Trihalomethanes. In 2002, the overall or combined trihalomethane (THM) average concentration for the entire Greater Victoria Distribution System was 25.2 μg/L. This is well below the limit of 100 μg/L in the *Guidelines for Canadian Drinking Water Quality* and also below the Stage 2 USEPA maximum contaminant level (MCL) of 80 μg/L. Chloroform was the predominant type of THM detected. There was no significant seasonal variation in THM concentrations in the samples tested during 2002.

The average concentration of THMs in the non-rechlorinated portion of the distribution system was 16.6 μg/L (**Figure 1**). The vast majority of people in Greater Victoria receive this water. The first customer sampling location just below the Japan Gulch Treatment Plant had relatively low THM levels that ranged from 10 to 17 μg/L. As expected, the rechlorinated sampling locations within the North Saanich distribution system had higher levels of THMs than the non-rechlorinated locations but did not exceed either the Canadian or the Stage 2a USEPA regulatory limits (**Figure 2**). The average concentration of THMs for the rechlorinated samples was 50.9 μg/L. The highest individual THM concentration observed in the rechlorinated portion of the distribution system was 84 μg/L.

Haloacetic Acids. Haloacetic acids (HAAs) were found at relatively low levels (18-20 μg/L) in the non-rechlorinated portion of the distribution system. However, in the rechlorinated portions of the distribution system, the HAA5 levels were elevated (68-86 μg/L) and while they did not exceed the temporary USEPA Stage 2a limit for HAA5s of 100 μg/L (**Figure 3**), they will exceed the Stage 2b USEPA limit of 60 μg/L when it is reinstated.

Other Disinfection By-Products. No chloropicrin was detected in any of the samples. The level of chloral hydrate (12 μg/L) was highest at the rechlorinated sampling locations but did not exceed the USEPA limit of 40 μg/L. The concentrations of haloacetonitriles, haloketones and total organic halogens were also highest in the rechlorinated portion of the distribution system. However, there are no regulatory limits for any of these latter DBPs. Cyanogen chloride was detectable only in the rechlorinated portion of the distribution system.

RECOMMENDATION. Recommendations include changing the rechlorination process at Deep Cove Pumphouse to chloramination (chlorine and ammonia) and increasing the sampling frequency during 2003 to provide baseline data prior to implementing UV disinfection.

Contents

1. Introduction

This report is a continuation of the 2002 annual report series and provides more complete information about of the disinfection by-products (DBPs) than was reported in the *2002 Annual Overview of Greater Victoria's Drinking Water Quality.* The disinfection by-product samples were collected by the Water Quality Division of the Capital Regional District Water Department from the Greater Victoria Drinking Water System during 2002.

In drinking water, disinfection by-products (DBPs) are formed when the disinfecting chemical or process changes one or more of the components in the untreated source water. Organic compounds including humic substances, such as humic and fulvic acids, and algae are the principal components that are changed by the disinfectant to form DBPs. In the past, the primary concern about DBPs has been long term (chronic) exposure, but more recent evidence points to some potential for short term (acute) health effects. Since most drinking water utilities use some form of chlorine to disinfect the water, the DBPs most commonly associated with chlorine that have public health implications are trihalomethanes (THMs) and haloacetic acids (HAAs). In addition to THMs, the Water Quality Division has been monitoring several other types of disinfection by-products to coincide with data collected by water utilities in the United States as a requirement of the United States Environmental Protection Agency (USEPA) Information Collection Rule (ICR).

1.1. TRIHALOMETHANES

The formation of trihalomethanes (THMs) is dependent on a number of factors including the pH of the water, water temperature, the amount of contact time between the disinfectant and the water, the concentration of the organic material in the source water, the concentration of chlorine used to disinfect the water, the form of chlorine (i.e. free or combined chlorine) and the concentration of bromide in the water. One of the major factors is the concentration of total organic carbon (TOC) present in the source water because in the absence of organic carbon, very little DBPs are formed. The TOC concentration directly affects the amount of disinfectant that must be added to achieve a target residual as it is the organic matter that exerts the main proportion of the disinfectant demand. The ideal situation is to have a source water supply that is very low in TOC. THM levels are expected to be highest in those seasons when the water temperature and/or organic concentrations are elevated. In the distribution system, THM concentrations tend to increase with increasing age of the water. The THM formation process will continue until all of organic material or chlorine has completely reacted and then, the concentration will level out.

The types of THMs that are most commonly present in drinking water include chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. Currently, chloroform (a proven animal carcinogen) is the type of THM detected most frequently and at the highest concentrations in drinking water. Other THMs have not been studied for toxicity to the same extent as chloroform.

1.2. HALOACETIC ACIDS

The second major group of disinfection by-products associated with chlorine disinfection of drinking water is the haloacetic acids (HAAs). Haloacetic acids are comprised of mono-, di-, and trichloroacetic acids plus mono- and dibromoacetic acids. The USEPA uses a group of 5 haloacetic acids (referred to as HAA5) for regulatory purposes (there are no Canadian regulations). As with trihalomethanes, haloacetic acid concentrations also increase with increasing age of the water as long as enough precursor (generally organics) material or chlorine is available. In addition, HAAs can be used as nutrients by bacteria and when bacteria are active, the concentration of HAAs may be lower. For this reason, HAAs values may be higher in winter than in the summer depending on the biological activity in the distribution system.

1.3. OTHER DISINFECTION BY-PRODUCTS

In July, 1997, all medium and large water utilities in the United States were required by the USEPA to begin monitoring the concentrations of a number of unregulated disinfection by-products under the Information Collection Rule (ICR). The data collected from this monitoring was to be used to formulate the Phase 2 Disinfectants/Disinfection By-Products Rule. The disinfection by-products to be monitored included haloacetonitriles, bromide, chloropicrin, chloral hydrate, cyanogen chloride, halogenated ketones and total organic halogens. In anticipation of new USEPA rules, the Water Quality Division began to collect similar information from the Greater Victoria Drinking Water System but on a less frequent basis than specified in the rule.

A general description of the parameters monitored under the ICR is provided below.

Haloacetonitriles (HANs, 4 in total for ICR monitoring). The haloacetonitriles are another chlorination byproduct that must be monitored quarterly (dichloro-, trichoro-, bromochoro-, and dibromoacetonitrile) under the ICR. No guidelines or limits have been set for these compounds.

Chloropicrin. This chlorination byproduct may be formed when the disinfectant used is free or combined chlorine. No guidelines or limits have been set for this compound.

Chloral Hydrate. The ICR requires quarterly monitoring of chloral hydrate for treatment plants using any form of chlorination or ozonation. The USEPA has set a Stage 1 MCL of 40 µg/L for choral hydrate.

Cyanogen Chloride. The ICR requires quarterly monitoring of cyanogen chloride for treatment plants using chloramines. Cyanogen chloride is the first reaction product when cyanide compounds are chlorinated. It is a volatile gas that is slightly soluble in water and highly toxic even in low concentrations. Although cyanogen chloride may be produced either with free or combined chlorine it is more stable in solutions containing monochloramine. Currently, there are no guidelines or regulations for this disinfection product.

Halogenated Ketones (HK, 2 in total). The haloketones in question are 1,1-dichloropropanone and 1,1,1-trichloropropanone. Halogenated ketones are byproducts of chlorination. There are no regulatory limits for these chemicals.

Total Organic Halogen (TOX). TOX is a measurement used to estimate the total quantity of halogenated organic matter in a water sample. The presence of halogenated organic molecules is indicative of synthetic chemical contamination. Halogenated compounds that contribute to TOX include trihalomethanes (THMs), organic solvents, halogenated alkanes and alkenes, chlorinated and brominated pesticides and herbicides, polychlorinated biphenyls (PCB5), chlorinated aromatics, and partially chlorinated aquatic humic substances. In addition, TOX can be used to estimate the level of formation of chlorinated organic byproducts after disinfection with chlorine. TOX has been shown to parallel the formation and removal of DBPs such as trihalomethanes (THMs) and haloacetic acids (HAAs) (removing TOX may lower the THMs and HAAs).

2. Regulatory Limits

2.1. PROVINCIAL AND CANADIAN REGULATIONS

In British Columbia, there are no provincial regulatory limits for any disinfection by-products in drinking water.

The Canadian limit for THMs in drinking water is listed in the current edition of the *Guidelines for Canadian Drinking Water Quality* as 100 μg/L as total trihalomethanes (2002 update). This guideline is set as an interim maximum acceptable concentration (IMAC) since there is insufficient toxicological data to set a maximum acceptable concentration for THMs. The guideline will be reviewed as new information becomes available. The IMAC is expressed as a running annual average based on quarterly samples from the distribution system. There is no Canadian guideline for HAAs or other disinfection by-products.

2.2. USEPA REGULATIONS

Effective January 2002, the USEPA has set a maximum contaminant level (MCL) of 80 μg/L for THMs and 60 μg/L for HAA5s in drinking water (previously the limit was 100 μg/L and 80 μg/L). However, for a brief period, the USEPA has relaxed the limits for both THMs and HAAs to allow utilities to improve their systems following a monitoring change in the Disinfectants/Disinfection By-Products Rule. This Stage 2 Rule is split into two parts, Stage 2a during which maximum contaminant levels (MCLs) will be temporarily increased to 120 μg/L and 100 μg/L for THMs and HAA5s, respectively and Stage 2b in which MCLs will return to 80 and 60 μg/L, respectively. The Stage 2 proposal is to accommodate the change in calculating THM and HAA5 concentrations for a distribution system. During Stage 2, utilities will calculate a running annual average for each location sampled rather than for the entire distribution system.

The USEPA limit for chloral hydrate is 40 μg/L.

3. Water System Description

The following provides a brief description of the Greater Victoria Drinking Water System pertinent to this topic. A more complete description of the water system can be found in *the 2002 Annual Overview of Greater Victoria's Drinking Water Quality* at http://www.crdinfo.crd.bc.ca/report_files/over1035%2Epdf

3.1. SOURCE WATER SYSTEM

Drinking water for Greater Victoria comes from a protected watershed called the Greater Victoria Water Supply Area. This area, approximately 11,000 hectares and protected from public access, is located about 30 km north west of the city. The five reservoirs in the Supply Area have been used as a source of drinking water since the early 1900's. Sooke Lake Reservoir, the largest of the reservoirs, is the primary water source for the city, supplying approximately 95% of Greater Victoria's drinking water. The four reservoirs in the Goldstream system, including Butchart Reservoir, Lubbe Reservoir, Goldstream Reservoir and Japan Gulch Reservoir, typically remain off-line and are used as a backup water supply.

In 2002, there were no substantive changes from previous years in the source of the water being supplied to the Greater Victoria Drinking Water Service Area. Water received at the Japan Gulch Chloramination Plant was fed primarily from Sooke Lake Reservoir for the majority of 2002 except for a brief period (January 15 to 22, 2002) when Goldstream water and Japan Gulch Reservoir supplied the system while the Kapoor tunnel was drained and inspected.

3.2. DISTRIBUTION SYSTEM

The Greater Victoria drinking water distribution system is comprised of seven individual distribution systems. Six of the seven distribution systems are separately owned and operated by the municipalities of Central Saanich, North Saanich, Oak Bay, Saanich, Sidney, and Victoria (including Esquimalt) while the seventh distribution system is operated by the Juan de Fuca Water Commission for the Western Communities (comprised of Colwood, Langford, Metchosin, and View Royal).

3.3. DISINFECTION PLANT

Water in the Greater Victoria Drinking Water System is disinfected at the Japan Gulch Treatment Plant using free chlorine (contact period approximately 10-15 minutes) followed by the addition of ammonia. During most of 2002, the Water Department maintained a steady chlorine dosage rate of 1.5 mg/L. The dosage level was adjusted down to 1.3 mg/L on December 11th due to colder water temperatures and lower bacteriological numbers in the raw source water.

3.4. CHLORINE BOOSTER STATIONS

The CRD Environmental Services Department adds additional chlorine using sodium hypochlorite at the Deep Cove Pumping Station whenever the chlorine residual drops

below 0.3 mg/L at the outlet of Cloake Hill Reservoir. This occurred at several different time periods during 2002. This water is supplied directly to Cloake Hill Reservoir and then enters the North Saanich distribution system. Over the past 5 years, an increasing proportion of the North Saanich distribution system has been receiving re-chlorinated water.

Small amounts of free chlorine are also added at the Upper Dawson Reservoir and McTavish Reservoir to enhance the chlorine residual in these reservoirs and reduce the potential for bacterial regrowth.

In the fall of 2002, a chlorine booster station located at Rocky Point Reservoir was commissioned using a chloramine process.

4. Sampling Locations

In 2002, five primary sampling locations were monitored for THMs every two months (an additional three sampling locations were monitored in either January or September). Samples from three of the primary locations were collected semi-annually and analyzed for a number of disinfection by-products listed in the USEPA Information Collection Rule. A description of the sampling location (and sampling code number) along with the rationale for choosing the sampling locations is provided below.

4.1. PRIMARY SAMPLING LOCATIONS

PRV at 2818 Lakehurst (JGO-TR-01). This sampling point is located near the first customer downstream of the Japan Gulch Treatment Plant. The water at this location has been in contact with the chlorine disinfectant the shortest period of time of any of the sampling locations. This location provides a baseline for comparison to all the other sampling locations further downstream.

Dooley Meter Vault (SAN-CB-02). This sampling point is located on the #4 supply main approximately half way between the Japan Gulch Plant and the end of the distribution in North Saanich. This location provides a mid-point contact time.

Cloake Hill Reservoir (CLR-01-01). This sampling point is located just downstream of Cloake Hill Reservoir. The water at this location has been rechlorinated at Deep Cove Pumphouse (when rechlorination is used) and has passed through Cloake Hill Reservoir. This location provides information on the quality of water received by the first customers in North Saanich downstream of Cloake Hill Reservoir.

Swartz Bay Ferry Terminal (NOS-SB-03). This sampling point is located at an extremity of the North Saanich distribution system. During the period when the water is rechlorinated at Deep Cove, it is an example extremity location of that process. When the water is not rechlorinated, this location represents the maximum contact period with the chlorine from the Japan Gulch Plant.

Amwell and Aston (CES-BR-06). This sampling point is located in a small high elevation pressure zone fed by Upper Dawson Reservoir. Upper Dawson Reservoir

receives small amounts of additional chlorine from time to time and this location provides information on that process.

4.2. SECONDARY SAMPLING LOCATIONS

Boas in North Saanich (NOS-CP-01). This sampling point is located in the north east extremity of the North Saanich distribution system and provides information on the quality of water typically received in Curteis Point pressure zone. This location is an extremity of the Cloake Hill Reservoir pressure zone and reflects the maximum potential for THM production from the rechlorination of water at the Deep Cove Pumphouse. THM sampling at this location was discontinued when the sample point at the ferry terminal came into the pressure zone of Cloake Hill Reservoir (duplication of samples). Prior to this time the ferry terminal only received water that had not been re-chlorinated. Bacteriological sampling continues at the Boas location.

Rocky Point Reservoir outlet (ROR-01-03). This sampling point is located just downstream of Rocky Point Reservoir. In the fall of 2002, a new rechloramination station adding both chlorine and ammonia to form chloramines was installed at Rocky Point Reservoir. The installation is intended to boost chloramine residuals within the reservoir before the water leaves heading south to Becher Bay. This system would typically operate in the summer months when residuals are low and water temperature is high, a combination that often leads to bacterial regrowth. THMs were sampled during the time period when the rechloramination plant was operational.

Becher Bay Indian Reserve Meter Vault (MET-PB-01). This sampling point is located at the extremity of the water system on Rocky Point Road and supplies water to the Becher Bay Indian Reserve. This area is typically a low chlorine residual and low flow area.

5. Results

5.1. CHLORINE RESIDUAL RESULTS

Chlorine residuals can have a major impact on the concentration of disinfection by-products found in the water. The chlorine residuals at the various sampling locations used for DBP monitoring are provided below.

5.1.1. PRIMARY SAMPLING LOCATIONS

PRV at 2818 Lakehurst (JGO-TR-01). In 2002, the median (middle value between the maximum and minimum) chlorine residual at the first customer location downstream of the plant was 1.27 mg/L and ranged between a minimum of 1.00 to a maximum of 1.59 mg/L.

Dooley Meter Vault (SAN-CB-02). In 2002, the chlorine residual ranged from a minimum of 0.92 mg/L to a maximum of 1.31 mg/L with a median chlorine residual of 1.11 mg/L.

Cloake Hill Reservoir (CLR-01-01). In 2002, the chlorine residual ranged from a minimum of 0.30 mg/L to a maximum of 1.58 mg/L with a median of 0.75 mg/L.

Swartz Bay Ferry Terminal (NOS-SB-03). During 2002, the chlorine residual ranged from a minimum of 0.04 mg/L to a maximum of 0.98 mg/L with a median of 0.495 mg/L.

Amwell and Aston (CES-BR-06). In 2002, the chlorine residual ranged from a minimum of 0.43 mg/L to a maximum of 0.78 mg/L with a median of 0.57 mg/L.

5.1.2. SECONDARY SAMPLING LOCATIONS

Boas in North Saanich (NOS-CP-01). In 2002, the chlorine residual ranged from a minimum of 0.03 mg/L to a maximum of 1.07 mg/L with a median chlorine residual of 0.215 mg/L.

Rocky Point Reservoir outlet (ROR-01-03). In 2002, the chlorine residual at the time of the THM sampling in September was 0.28 mg/L.

Becher Bay Indian Reserve Meter Vault (MET-PB-01). In 2002, the chlorine residual ranged from 0.0 mg/L to 0.37 mg/L with a median of 0.035 mg/L.

5.2. TOTAL ORGANIC CARBON RESULTS

As noted earlier, in addition to chlorine, the amount of total organic carbon (TOC) that is present in the water can also affect the concentrations of disinfection by-products. Based on monthly samples collected from the raw source water entering the Japan Gulch Treatment Plant, the TOC levels entering the Greater Victoria Drinking Water System in 2002 were in the moderate range for water utilities. The median TOC concentration was 2.4 mg/L and ranged from 2.0 to 2.8 mg/L. There did not appear to be any particular seasonality to the TOC data.

5.3. TRIHALOMETHANE RESULTS

The trihalomethane sampling results for 2002 were divided into the following three groupings and are summarized below.

1. All sampling locations (combined data)
2. Non-rechlorinated sampling locations
3. Rechlorinated sampling locations

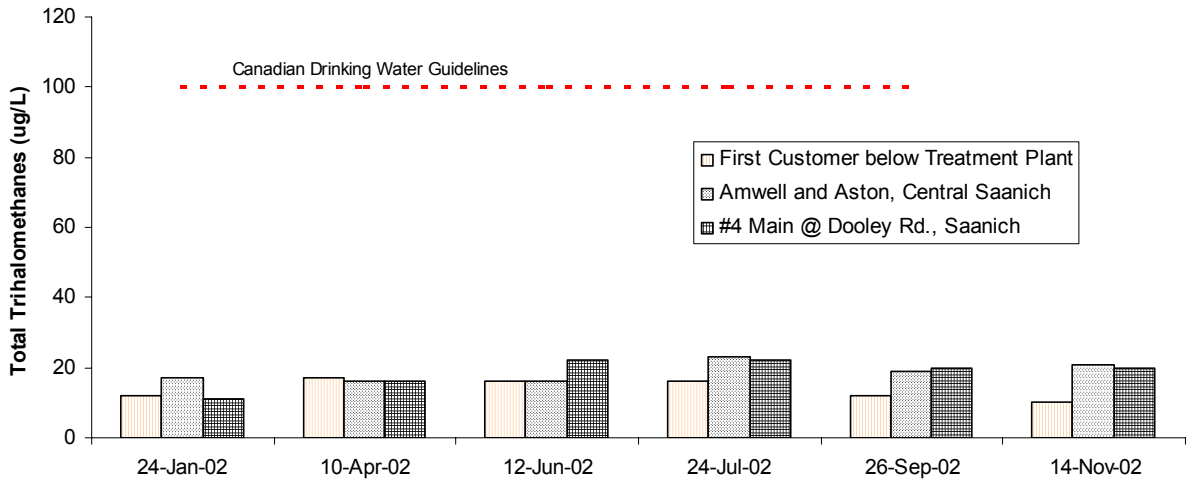
5.3.1. ALL SAMPLING LOCATIONS (COMBINED DATA)

In 2002, a total of thirty-two samples were collected from the Greater Victoria Drinking Water System and analyzed for THMs. These results were combined into a single data set and are provided in **Table 1**. When combined, the average concentration of THMs was 25.2 μg/L. This is below the Canadian Guideline maximum concentration of 100 μg/L. None of the samples analyzed had THM levels greater than the Guideline limit.

5.3.2. NON-RECHLORINATED SAMPLING LOCATIONS

The results of the THM sampling of non-rechlorinated sampling locations are provided in **Table 2** and illustrated in **Figure 1**. The average for THMs was 16.6 µg/L. This is well below the guideline (100 µg/L). The minimum level of total trihalomethanes found was 10 µg/L and the maximum was 23 µg/L. All of these results are well within the regulatory limits (**Figure 1**).

Figure 1. 2002 Greater Victoria Distribution System Trihalomethanes - Non-Rechlorinated Water

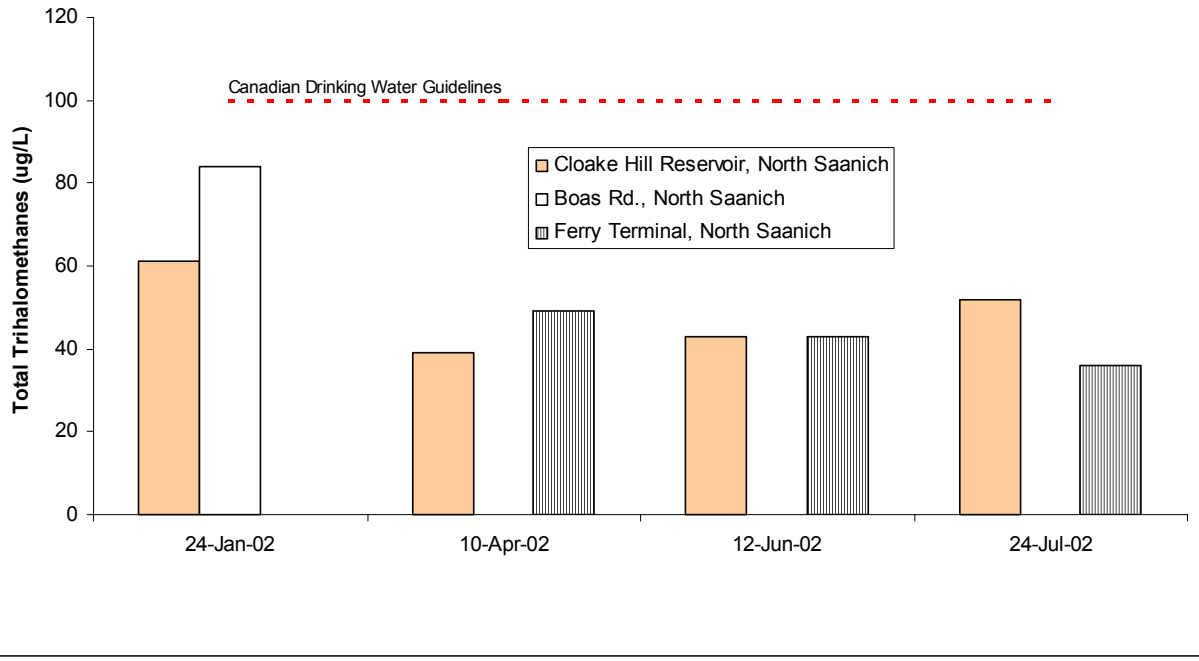


5.3.3. RECHLORINATED SAMPLING LOCATIONS

The results of the THM monitoring of the rechlorinated sampling locations in North Saanich Peninsula are listed in **Table 3** and illustrated in **Figure 2**. As expected, all of the rechlorinated samples showed higher levels of THMs than the non-rechlorinated samples **(Table 3**). The average for these rechlorinated sampling locations was 50.9 µg/L, significantly higher than either the combined average for all locations or the non-rechlorinated average (25.2 µg/L and 16.6 µg/L, respectively). Nevertheless, none of the rechlorinated sampling locations had THM levels that exceeded the Canadian Guideline (**Figure 2**). The maximum level of THMs detected was 84 µg/L from the North Saanich Boas Road location (NOS-CP-01) (a re-chlorinated sampling location).

Chloroform was the only THM detected at significant levels from the rechlorinated sampling locations (**Table 3**). Bromodichloromethane was detected at very low levels (average of 2.2 µg/L). Bromoform was not detected in any of the samples analyzed, while dibromochlormethane was detected in one of the rechlorinated sampling locations (0.11 µg/L).

Figure 2. 2002 Greater Victoria Distribution System Trihalomethanes - Rechlorinated Water



5.4. HALOACETIC ACID RESULTS

In addition to monitoring for THMs, samples from the distribution system were monitored semi-annually for haloacetic acids. During 2002, three sampling locations were monitored for these disinfection byproducts in March and September (**Table 4** and **Figure 3**). HAA5s were found at relatively low levels (18-20 µg/L) in the majority of the Greater Victoria Distribution System that is not subject to rechlorination. However, in the rechlorinated portions of the distribution system, the HAA5 levels were elevated (68-86 µg/L) and while they did not exceed the temporary USEPA Stage 2a limit for HAA5s of 100 µg/L, they will exceed the USEPA limit of 60 µg/L when it is reinstated. To date, there are no guidelines for these disinfection by-products in Canada.

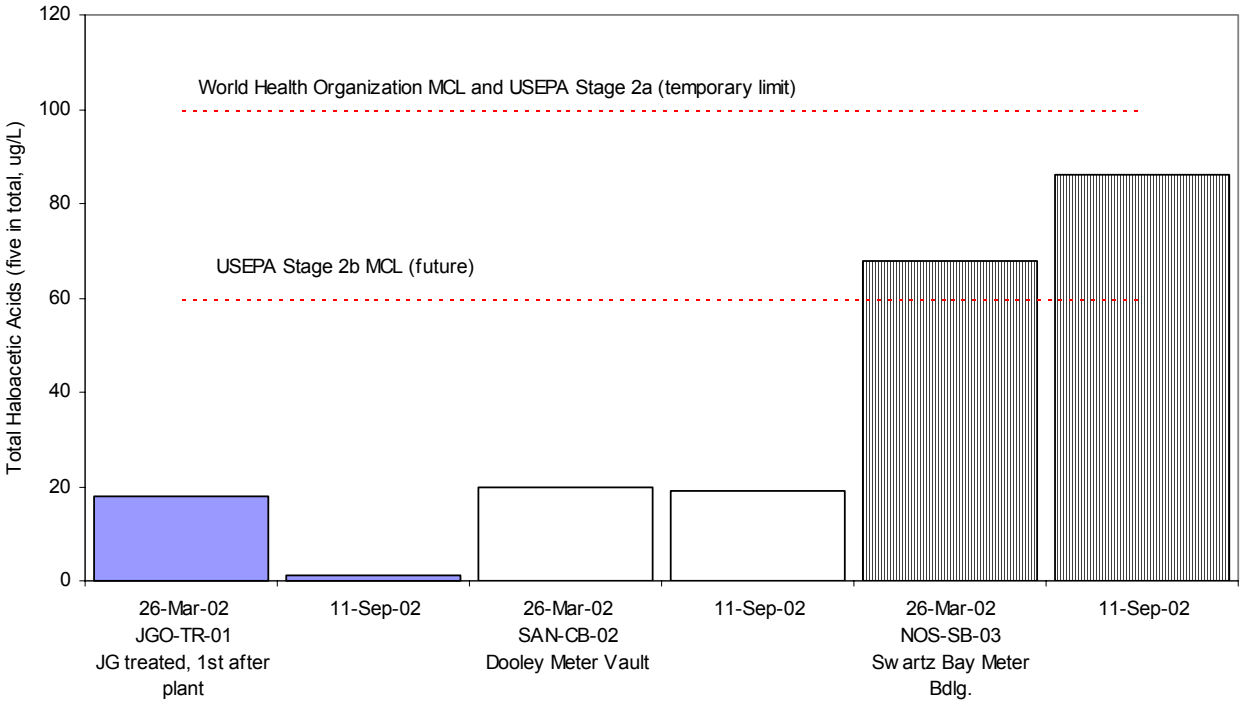
5.5. OTHER DISINFECTION BY-PRODUCT RESULTS

During 2002, three sampling locations were also monitored for the following other disinfection by-products including haloacetonitriles, bromide, chloropicrin, chloral hydrate, cyanogen chloride, haloketones, and total organic halogens in March and September. The results are provided in **Table 4.**

No chloropicrin was detected in any of the samples. The level of chloral hydrate (12 µg/L) was highest at the rechlorinated sampling locations but did not exceed the USEPA limit of 40 µg/L. The concentrations of haloacetonitriles, haloketones and total organic halogens were also highest in the rechlorinated portion of the distribution system. However, there are no regulatory limits for any of these DBPs. Cyanogen chloride was

detected only in the rechlorinated portion of the distribution system.

Figure 3. Haloacetic Acids in Greater Victoria Distribution System in 2002 (March and September)



6. Recommendations

1. It is recommended that the rechlorination process at Deep Cove Pumphouse be changed to a chloramination process. This will reduce the level of disinfection by-products in that portion of the North Saanich distribution system and still retain satisfactory bacterial disinfection.

2. It is recommended that the sampling frequency be increased to provide a good baseline of DBP data for comparing the impact of the ultraviolet disinfection process when it is implemented in early 2004.

TABLE 1. 2002 GREATER VICTORIA DISTRIBUTION SYSTEM TRIHALOMETHANES - All Locations

LOCATION DESCRIPTION		DATE	ANALYTICAL RESULTS (All units are in ug/L)					Field Measurements	
			BDCM Bromodichloromethane	BRFM Bromoform	CHLF Chloroform	DBCM Dibromochloromethane	TTHM Total Trihalomethanes	Water Temperature	Total Chlorine Residual
LOCATION CODE	SAMPLING DESCRIPTION	SAMPLING DATE	MDL - 1.0	MDL - 0.2	MDL - 0.3	MDL - 0.1	MDL - 1.0	Degrees Celcius	mg/L
JGO-TR-01	PRV at 2818 Lakehurst Dr.	24-Jan-02	0.64	L .2	11	L .1	12	1.17	5.7
		10-Apr-02	1.1	L 1	16	L 1	17	1.20	8.0
		12-Jun-02	L 1	L .2	16	L .1	16	1.33	15.6
		24-Jul-02	1.2	L .2	15	L .1	16	1.34	21.7
		26-Sep-02	0.9	L.2	11	L.1	12	1.59	17.0
		14-Nov-02	1.3	L .2	9	L .1	10	1.24	10.2
CES-BR-06	Amwell and Aston, SE corner	24-Jan-02	1.5	L .2	15	L .1	17	7.5	0.49
		10-Apr-02	1.5	L .2	14	L 1	16	8.5	0.56
		12-Jun-02	L 1	L .2	16	L .1	16	NA	NA
		24-Jul-02	2	L .2	21	L .1	23	NA	0.53
		26-Sep-02	2.2	L .2	17	L.1	19	NA	0.62
		14-Nov-02	2.4	L .2	18	L .1	21	NA	NA
CLR-01-01	Cloake Hill Reservoir	24-Jan-02	3.9	L .2	57	L .1	61	6.5	0.46
		10-Apr-02	2.3	L .2	37	L .1	39	7.2	0.58
		12-Jun-02	2.2	L .2	41	L .1	43	14.5	0.44
		24-Jul-02	4.3	L .2	48	L .1	52	20.7	0.76
		14-Nov-02	2.3	L .2	11	L .1	13	10.9	0.64
MET-PB-01	E. Sooke Rd at Rocky Pt. Rd.	26-Sep-02	2.2	L .2	19	L .1	21	NA	0.05
NOS-CP-01	Lot N. of 10943 Boas Rd.	24-Jan-02	6.1	L .2	78	L .1	84	8.0	0.08
NOS-SB-03	Swartz Bay Meter Bdlg.	24-Jan-02	1.4	L .2	11	L .1	12	8.5	0.34
		10-Apr-02	3.1	L .2	46	L .1	49	9.0	0.24
		12-Jun-02	2.4	L .2	41	L .1	43	15.2	0.04
		24-Jul-02	2.9	L .2	33	0.11	36	NA	0.71
		26-Sep-02	1.4	L .2	12	L .1	13	NA	0.23
		14-Nov-02	2.3	L .2	9.6	L .1	12	12.9	0.45
ROR-01-03	Rocky Pt. Reservoir-outlet	26-Sep-02	2.3	L .2	19	L .1	21	NA	0.28
SAN-CB-02	Dooley Meter Vault	24-Jan-02	1.0	L .2	9.6	L .1	11	6.5	1.09
		10-Apr-02	1.3	L .2	15	L .1	16	7.5	1.06
		12-Jun-02	L 1	L .2	22	L .1	22	15.3	0.99
		24-Jul-02	1.9	L .2	20	L .1	22	20.4	0.92
		26-Sep-02	2.2	L .2	18	L .1	20	NA	1.23
		14-Nov-02	2.3	L .2	17	L .1	20	NA	NA
						Average:	**25.2**		
						Canadian Guideline: (Maximum Concentration)	100		

TABLE 2. 2002 GREATER VICTORIA DISTRIBUTION SYSTEM TRIHALOMETHANES - Non-rechlorinated Water

LOCATION DESCRIPTION		DATE	ANALYTICAL RESULTS (All units are in ug/L)					Field Measurements	
			BDCM Bromodichloromethane	BRFM Bromoform	CHLF Chloroform	DBCM Dibromochloromethane	TTHM Total Trihalomethanes	Water Temperature	Total Chlorine Residual
LOCATION CODE	SAMPLING DESCRIPTION	SAMPLING DATE	MDL - 1.0	MDL - 0.2	MDL - 0.3	MDL - 0.1	MDL - 1.0	Degrees Celcius	mg/L
JGO-TR-01	PRV at 2818 Lakehurst Dr.	24-Jan-02	0.64	L .2	11	L .1	12	1.17	5.7
		10-Apr-02	1.1	L 1	16	L 1	17	1.20	8.0
		12-Jun-02	L 1	L .2	16	L .1	16	1.33	15.6
		24-Jul-02	1.2	L .2	15	L .1	16	1.34	21.7
		26-Sep-02	0.9	L.2	11	L.1	12	1.59	17.0
		14-Nov-02	1.3	L .2	9	L .1	10	1.24	10.2
CES-BR-06	Amwell and Aston, SE corner	24-Jan-02	1.5	L .2	15	L .1	17	7.5	0.49
		10-Apr-02	1.5	L .2	14	L 1	16	8.5	0.56
		12-Jun-02	L 1	L .2	16	L .1	16	NA	NA
		24-Jul-02	2	L .2	21	L .1	23	NA	0.53
		26-Sep-02	2.2	L .2	17	L.1	19	NA	0.62
		14-Nov-02	2.4	L .2	18	L .1	21	NA	NA
CLR-01-01	Cloake Hill Reservoir	14-Nov-02	2.3	L .2	11	L .1	13	10.9	0.64
MET-PB-01	E. Sooke Rd at Rocky Pt. Rd.	26-Sep-02	2.2	L .2	19	L .1	21	NA	0.05
NOS-SB-03	Swartz Bay Meter Bdlg.	24-Jan-02	1.4	L .2	11	L .1	12	8.5	0.34
		26-Sep-02	1.4	L .2	12	L .1	13	NA	0.23
		14-Nov-02	2.3	L .2	9.6	L .1	12	12.9	0.45
ROR-01-03	Rocky Pt. Reservoir-outlet	26-Sep-02	2.3	L .2	19	L .1	21	NA	0.28
SAN-CB-02	Dooley Meter Vault	24-Jan-02	1.0	L .2	9.6	L .1	11	6.5	1.09
		10-Apr-02	1.3	L .2	15	L .1	16	7.5	1.06
		12-Jun-02	L 1	L .2	22	L .1	22	15.3	0.99
		24-Jul-02	1.9	L .2	20	L .1	22	20.4	0.92
		26-Sep-02	2.2	L .2	18	L .1	20	NA	1.23
		14-Nov-02	2.3	L .2	17	L .1	20	NA	NA
						Average:	**16.6**		
						Canadian Guideline: (Maximum Concentration)	100		

TABLE 3. 2002 GREATER VICTORIA DISTRIBUTION SYSTEM TRIHALOMETHANES - Rechlorinated Water

LOCATION DESCRIPTION		DATE	ANALYTICAL RESULTS (All units are in ug/L)					Field Measurements	
			BDCM	BRFM	CHLF	DBCM	TTHM	Water	Total Chlorine
			Bromodichloromethane	Bromoform	Chloroform	Dibromochloromethane	Total Trihalomethanes	Temperature	Residual
LOCATION CODE	SAMPLING DESCRIPTION	SAMPLING DATE	MDL - 1.0	MDL - 0.2	MDL - 0.3	MDL - 0.1	MDL - 1.0	Degrees Celcius	mg/L
CLR-01-01	Cloake Hill Reservoir	24-Jan-02	3.9	L .2	57	L .1	61	6.5	0.46
		10-Apr-02	2.3	L .2	37	L .1	39	7.2	0.58
		12-Jun-02	2.2	L .2	41	L .1	43	14.5	0.44
		24-Jul-02	4.3	L .2	48	L .1	52	20.7	0.76
NOS-CP-01	Lot N. of 10943 Boas Rd.	24-Jan-02	6.1	L .2	78	L .1	84	8.0	0.08
NOS-SB-03	Swartz Bay Meter Bdlg.	10-Apr-02	3.1	L .2	46	L .1	49	9.0	0.24
		12-Jun-02	2.4	L .2	41	L .1	43	15.2	0.04
		24-Jul-02	2.9	L .2	33	0.11	36	NA	0.71
						Quarterly Average:	**50.9**		
						Canadian Guideline:			
						(Maximum Concentration)	100		

TABLE 4. 2002 GREATER VICTORIA DISTRIBUTION SYSTEM DISINFECTION BYPRODUCTS OTHER THAN TRIHALOMETHANES All Locations

LOCATION DESCRIPTION		DATE	ANALYTICAL RESULTS (All units are in ug/L except as otherwise noted)						
			HAA5	HAN	CPICRN	CHYDR	CNCL	HK	TOX
			Haloacetic Acids (5 in total)	Haloacetonitriles (4 in total)	Chloropicrin	Chloral Hydrate	Cyanogen Chloride	Haloketones	Total Organic Halogen
LOCATION CODE	SAMPLING DESCRIPTION	SAMPLING DATE	MDL - 2.0	MDL - 0.5	MDL - 0.5	MDL - 0.5	MDL - 0.5	MDL - 0.5	MDL - 50
JGO-TR-01	PRV at 2818 Lakehurst Dr.	26-Mar-02	18	L .5	L .5	0.9	L .5	2.0	114
		11-Sep-02	L 1	0.6	L .5	NA	L .5	2.7	94
NOS-SB-03	Swartz Bay Meter Bdlg.	26-Mar-02	68	4.7	L .5	12	1.8	4.8	285
(Rechlorinated)		11-Sep-02	86	6.6	L .5	NA	NA	6.2	232
SAN-CB-02	Dooley Meter Vault	26-Mar-02	20	L .5	L .5	1.1	L .5	2.0	119
		11-Sep-02	19	1.1	L .5	NA	NA	2.7	96