Assessment Study of Water and Wastewater Systems and Associated Water Management Practices at the Burrard First Nation Community

for the
Indian and Northern Affairs Canada
BC Region

CH2MHILL

March, 2002

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Appendix C
Water Quality Test Results

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Is(are) under consultation


Greater Vancouver Water Supply Sources & Systems
Britannia Creek
Furry Creek
Capilano Mt.
Enchantment Lake
The Lions
Rogers Lake
Palisade Lake
Mt. Strachan
Hollyburn Mt.
Grouse Mt.
Fromme Mt.
Capilano Lake
Cleveland Dam
Eagle Lake
West Vancouver
City of North Vancouver
District of North Vancouver
Burrard Inlet
English Bay
Vancouver
Burnaby
Coquitlam
Port Coquitlam
Pitt Meadows
New Westminster
Richmond
Surrey
White Rock
Boundary Bay
Canada/USA Border
Mt. Seymour
Buntzen Lake
Anmore
Port Moody
Widgeon Lake
Seymour River
Capilano River
Hixon Creek
N

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water

The Greater Vancouver Water District
Quality Control Annual Report 2000

VOLUME 1

Greater
Vancouver
Regional
District

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improved system flexibility as discussed above. The average water temperature in the late summer and early fall was higher in 2000 than in 1999. A cool spring and a heavy snow pack in 1999 resulted in much lower than average temperatures during late summer and fall in 1999. In 2000, the colour of the Seymour source water reached a higher level than it had been for a number of years. Elevated iron levels in the late summer resulted in a yellowish tinge to the water. This was compounded by the events of early October when the first flush of organics occurred followed by a slight turbidity event. The apparent colour rose to 50 Apparent Colour Units (ACUs) which is much higher than the aesthetic standard of 15 TCUs. As a result of the two situations just discussed, the number of complaints of "yellow water" was significantly higher in 2000. Filtration will eliminate "yellow water" at the Seymour source. During the year, samples were collected from the intakes of the water sources for herbicides, pesticides, volatile organic compounds, radioactivity and uranium analysis. All values were at or below the detection limits.

Bacteriological water quality in the GVRD's transmission system and reservoirs was good in the year 2000. At no time did the percentage of samples positive for coliform bacteria exceed the 10% standard (a requirement of the BC Safe Drinking Water Regulation), in fact at no time did the percentage even reach 5%. The low level of coliform occurrences relative to the levels prior to secondary disinfection (1997 –1998) is most likely due to the increased chlorine residual in the distribution system and the extensive ongoing reservoir improvement plan. The average pH of the disinfected water from Coquitlam was higher in 2000 due to the start up of the ozonation and corrosion control facilities in the spring. The average pH of both Seymour and Coquitlam delivered water is now greater than 6.5. The number of calls to the Water Quality Inquiry Line about green staining of bathroom fixtures has declined most likely as a result of the implementation of low levels of corrosion control on the Seymour and Coquitlam systems. Corrosion control (pH and alkalinity adjustment) cannot begin at Capilano until completion of improved primary disinfection and corrosion control facilities, this work is just beginning and is slated for completion in late 2003.

Bacteriological water quality in the municipal distribution systems was not quite as good in 2000 as in 1999 but this may be due to the increased average water temperatures in 2000. In the 1999 Annual Report, it was noted that part of the very good results for coliform bacteria in that year might be the result of lower than normal water temperatures. Water temperature has a significant impact on regrowth, historically it only occurs when the water temperature exceeds approximately 14° C. There was concern that ozonation of the Coquitlam water supply would lead to increased regrowth in the areas supplied with Coquitlam water due to the changes (caused by ozone) in the nature of the naturally occurring organic carbon in the water. While there were slightly more coliform positive samples in 2000 than in 1999, the locations of the positive samples were spread across the entire GVRD, not concentrated in any one area or in any source water service area. Examination of the chlorine residuals in samples positive for coliform bacteria pre- and post-ozonation show that in all cases, the large majority of the coliform positive samples occurred when the free chlorine residual was 0.1 mg/L or less.

The scientific literature and pilot studies carried out on the GVRD water supplies predicted that by using chlorine rather than chloramine as the secondary disinfectant, the levels of disinfection by-products in the delivered water would increase. The results from the samples collected to date confirm this prediction. Trihalomethane and haloacetic acid levels have increased since the implementation of secondary disinfection in 1998, but trihalomethane levels remained below the

2.0 ACRONYMS

AO	Aesthetic Objective
AOC	Assimilable Organic Carbon
BCSDWR	British Columbia Safe Drinking Water Regulation
BDOC	Biodegradable Organic Carbon
BETX	Benzene, Ethylbenzene, Toluene, Xylene
BOM	Biodegradable Organic Matter
CAEAL	Canadian Association of Environmental Analytical Laboratories
CFU	Colony Forming Units
DBAA	Dibromoacetic Acid
D/DBP	Disinfectant/Disinfection By-products
DBP	Disinfection By-product
DCAA	Dichloroacetic Acid
DS	Distribution System
GCDWQ	Guidelines for Canadian Drinking Water Quality
DOC	Dissolved Organic Carbon
DWTP	Drinking Water Treatment Program
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency (USA)
GVWD	Greater Vancouver Water District
GVRD	Greater Vancouver Regional District
HAAs	Haloacetic Acids
HPC	Heterotrophic Plate Count
IMAC	Interim Maximum Acceptable Concentration
MAC	Maximum Acceptable Concentration
MBAA	Monobromoacetic Acid
MCAA	Monochloroacetic Acid
MCL	Maximum Contaminant Level
mg/L	Milligram per Litre (0.001 g/L)
µg/L	Microgram per litre (0.000001 g/L)
mL	Millilitre
NOM	Natural Organic Matter
NTU	Nephelometric Turbidity Unit
PAH	Polynuclear Aromatic Hydrocarbon
pH	Measure of acidity or basicity of water; pH 7 is neutral
ppb (µg/L)	Part per Billion
ppm (mg/L)	Part per Million
SCADA	Supervisory Control and Data Acquisition
SWTR	Surface Water Treatment Rule (USA)
TCAA	Trichloroacetic Acid
THAA	Total Haloacetic Acid
THM	Trihalomethane
TOC	Total Organic Carbon
TTHM	Total Trihalomethane
TS	Transmission System
UV_{254}	Ultraviolet Absorbance at 254 nm
WHO	World Health Organization
WQMRP	Water Quality Monitoring and Reporting Plan (for GVRD and Member Municipalities)

4.0 Source Water

The quality of the source water affects the level of treatment required in order to make a water supply safe for consumption. The GVRD is fortunate in having protected watersheds that greatly reduce the risk of contamination of the water, which could adversely affect public health. There is still the need, however, to monitor the quality of the source water to ensure it remains high and to provide analytical data required for the ongoing proof of the quality of the water supplies.

4.1 BACTERIOLOGICAL QUALITY OF THE SOURCE WATER

The bacteriological quality of the source water is an important indicator of the degree of contamination and the treatment required to ensure a safe potable water supply. Neither the Guidelines for Canadian Drinking Water Quality (GCDWQ) nor the B. C. Safe Drinking Water Regulation (BCSDWR) specify a Maximum Acceptable Concentration for microorganisms as far as raw water quality is concerned. Therefore, as a guide, the quality of the raw water was compared to the requirements of the U.S. Environmental Protection Agency's Surface Water Treatment Rule (SWTR) for an unfiltered supply:

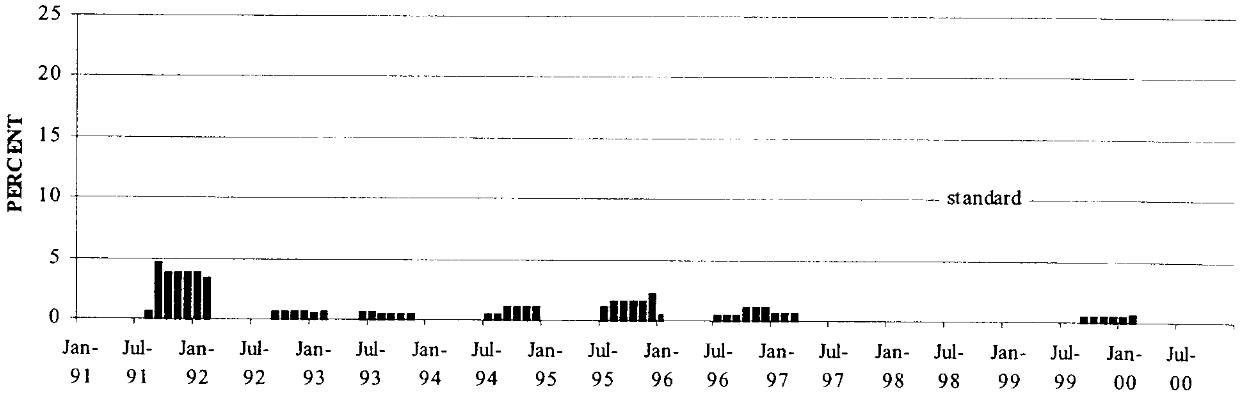
a) if total coliforms are determined, 90% of the samples in any consecutive six month period must contain less than 100 coliform bacteria per 100 mL; or

b) if fecal coliforms are determined, 90% of the samples in any consecutive six month period must contain less than 20 fecal coliform bacteria per 100 mL.

Where both total and fecal coliform bacteria are determined, the fecal coliform data will be used to assess compliance with the rule. Utilities that exceed these standards along with other parameters, such as turbidity, are required to install filtration water treatment plants.

Figure 1 shows the results of the analysis of the source water from 1991 to 2000 at all three intakes compared to the U.S. SWTR standard. As in the previous years, all three sources easily met the SWTR fecal coliform standard. As was the case in previous years, samples collected at the intakes in the late summer and early fall had the highest fecal coliform levels. In both Capilano and Coquitlam no sample contained greater than 20 fecal coliform/100 mL but in Seymour climbed higher than 20 fecal coliform/100 mL with a maximum value of 62. These fecal coliform bacteria can be traced back to high levels at the main tributaries of the supply lakes and a first flush phenomenon after a period of dry weather. There is the appearance of a trend toward lower mean fecal coliform values in the last few years as compared to the values in the early 1990s but extreme caution must be used in drawing any conclusions. The relatively high values between 1990 to early 1992 on the Seymour and Capilano sources may simply be due to some related factor such as rainfall intensity and reservoir levels. If the first flush rainfall in the fall is of short duration and does not substantially change the amount of water in the impounding reservoirs, the dilution effects would be much less evident than if the first flush storm event was prolonged and as a results corresponding higher levels of coliform bacteria could be expected.

C. Coquitlam Source Water



At least 90% of samples in a six month period must have fecal coliform levels less than 20/100 mL.

4.2 ANALYSIS FOR *GIARDIA* AND *CRYPTOSPORIDIUM*

4.2.1 Source Water Monitoring for *Giardia* and *Cryptosporidium*

Unfiltered surface water supplies have the potential of containing protozoan pathogens. Outbreaks of Giardiasis occurred in a number of locations in B.C. and Washington State in the late 1980s and the District has been monitoring raw water and animal droppings for the organism responsible since 1987. Since 1992, the District has participated in a project with the Enhanced Water Testing Laboratory, University of British Columbia, to gather more information about the number and nature of the cysts found in the Greater Vancouver water supplies. The project involves collecting weekly samples from all three GVWD supplies upstream of disinfection, testing recovered cysts for their ability to infect (viability) and characterizing any viable cysts by the latest molecular biological techniques. Information gathered has the potential to indicate whether the cysts are the same types as cysts that have caused disease in other locales.

The results of the 2000 testing program are contained in the "Report to the Greater Vancouver Regional District - *Giardia* and *Cryptosporidium* Study January - December, 2000" which was prepared by the Enhanced Water Laboratory and can be found in the appendix of this report. In summary, 19 of 52 samples (37%) collected at Capilano were positive for *Giardia*, 18 of 50 (36%) at Seymour and 14 of 48 (29%) at Coquitlam. The level of positive samples is comparable to previous years, indicating similar relative levels of risk.

The tests for infectivity are difficult, time consuming, of questionable validity and involve the use of different animals for each parasite. There are methods for determining viability which may give information as useful as the tests requiring the use of animals. For this reason, the Enhanced Water Laboratory switched to viability testing. Details of the testing results are contained in the appendix of this report in "Giardia and Cryptosporidium Study January – December, 2000".

Dye Test for Viability

-This test uses a variety of reagents which react with the genetic material (DNA) of the organisms. The results are expressed as % or number of cysts and oocysts which are determined to be viable according to the specifications of the test.

***Crypto (or Giardia)* Vital Dye Stain % Viable (using DAPI & SYTO-59)**[1]

This result is the percentage of parasites that appeared viable by nucleic acid probes (NAPs). NAPs that we use are DAPI and SYTO-59. DAPI is a cell permeant dye whose fluorescent emission is increased 30 fold upon DNA binding. DAPI will stain viable and non-viable nucleic acids, while SYTO-59 will stain non-viable nucleic acids in these parasites.

- *IF* DAPI staining is bright and specific (present in nuclear structures, which are 1 to 4 sporozoites in *Cryptosporidium*, and 1 to 4 nuclei in *Giardia*), *AND* if SYTO-59 staining is negative, *THEN* the parasite is considered viable.
- *IF* DAPI staining is diffuse and dull *OR* SYTO-59 staining is positive, *THEN* the parasite is considered non-viable.
- *IF* both DAPI and SYTO-59 staining is negative *AND* the parasite is intact with some internal structure *THEN* the parasite is also considered viable.
- *IF* both DAPI and SYTO-59 staining is negative *AND* the parasite is ruptured or appears empty *THEN* the parasite is considered non-viable.

Microscopic Examination for Viability

-This test uses microscopic examination of the cysts or oocysts to determine viability. If the cyst or oocysts contains no structures that are recognizable as part of the suspect organism, the cyst it is rated as P1, presumptive. If the cyst or oocyst contains one structure it is rated as P2, presumptive. If it contains two or more structures it is rated as C, confirmed. The results are expressed as the number of confirmed cysts and oocysts that are detected.

Number and Characteristics of *Cryptosporidium* and *Giardia* Detected on Slides

These fields give a description of how the parasites appeared under DIC, or differential interference contrast microscopy. DIC allows us to better visualize the internal characteristics and morphology of the parasite. On every report issued you should see a key which describes the internal morphologies. These are P1 (presumptive 1), P2 (presumptive 2) and C (confirmed). Parasites are first detected by their bright green color and shape. The color comes from the fluorescent tag attached to the antibody which binds to the outer surface of the parasite. (FITC or fluorescien isothiocyanate is the name of this fluorescent tag). Generally, if a parasite is detected by fluoresence only, they are classified as presumptive (P1). If some undetermined internal morphology is present, they are also

4.2.2 Wildlife Survey

As in previous years, an informal survey for the presence of *Giardia* and *Cryptosporidium* in the stool of the large mammal population in the watershed was carried out. Weather permitting, Watershed Management staff collected samples of spoor from a variety of large animals that reside within the watershed. These samples were analyzed by the Parasitology Section of the Provincial Laboratory. Since these animals are potential sources for the organisms that end up in the water supply, a change in the number of animals carrying the organisms or a change in the number of organisms present in a sample (possibly indicative of disease) may be significant. The number of samples positive for *Cryptosporidium* was lower in 2000 than in 1999, however it is difficult to know the significance of this as this type of small survey is very prone to error. For example, the samplers may be collecting more than one specimen from the same animal. Regardless, since *Giardia* and *Cryptosporidium* may be transmitted between animals in the watershed, there is good reason to discourage the introduction of non-watershed animals into the watersheds. Natural migration remains a factor.

Table 5 Fraction of Wildlife Scat Samples Positive for *Giardia*.

	Capilano	Seymour	Coquitlam
Bear	1/12	0/7	0/13
Deer	0/12	0/11	0/12
Beaver			0/2

Table 6 Fraction of Wildlife Scat Samples Positive for Cryptosporidium .

	Capilano	Seymour	Coquitlam
Bear	1/12	1/7	1/13
Deer	3/12	2/11	1/12
Beaver			0/2

4.3 TURBIDITY

The Canadian Guidelines for Drinking Water Quality specify a Maximum Acceptable Concentration (MAC) for turbidity of 1 Nephelometric Turbidity Unit (NTU). For certain water sources, a maximum of 5 NTU may be permitted if the system has a history of acceptable microbiological quality and it can be demonstrated that disinfection is not compromised by this less stringent value.

GVWD sources have historically been susceptible to turbidity upsets due to high runoff from storms which can cause slides, stream scouring, etc., in the watersheds or from resuspension of sediment from the edges of the lakes during periods of low water levels (Figure 2). As can

Figure 3 Cumulative frequency distribution of turbidity of grab samples collected at the intakes, 2000.

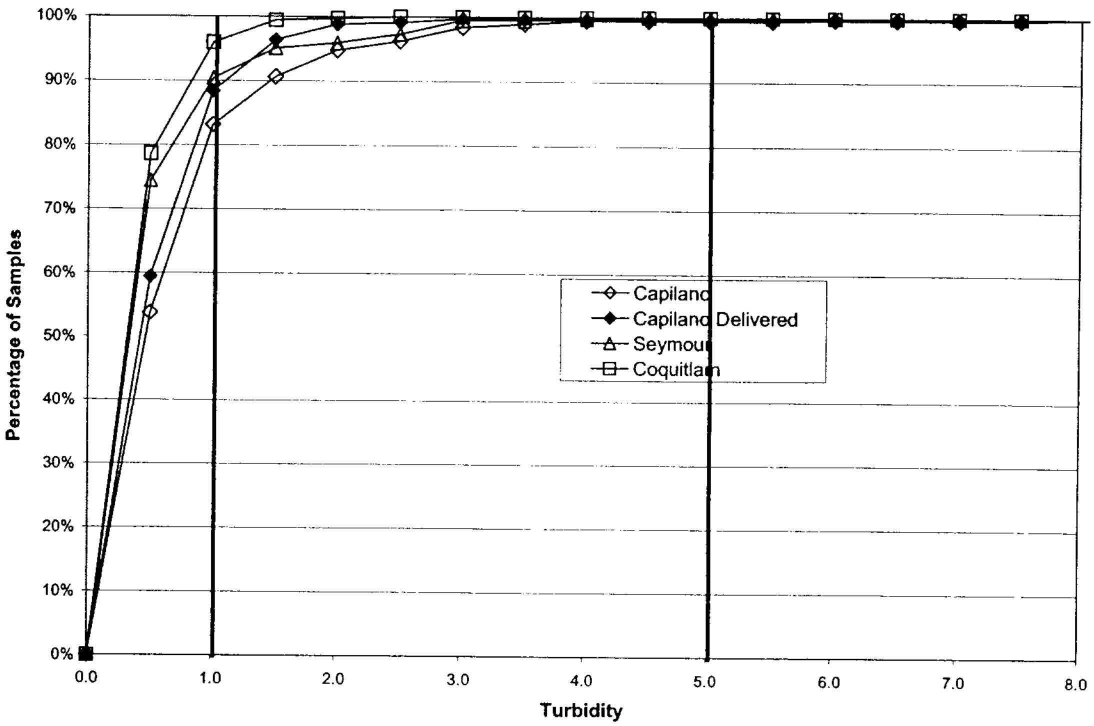


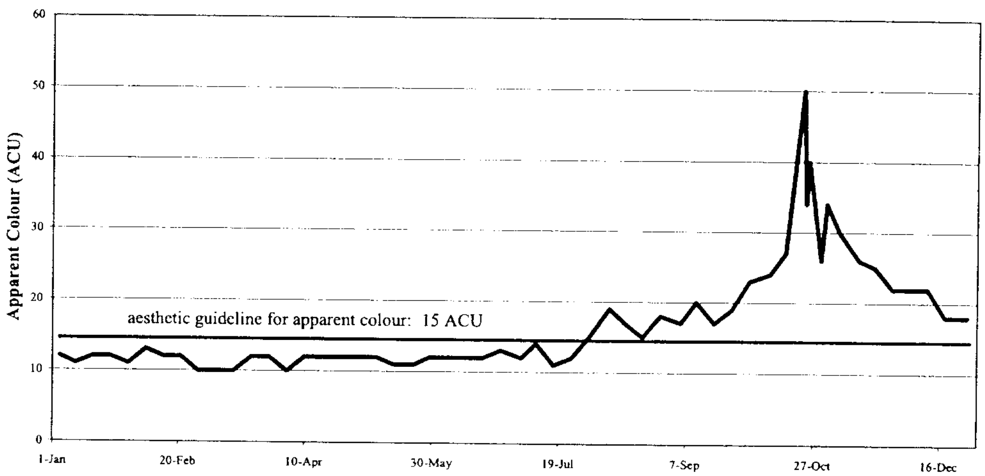
Figure 3 can be summarized as follows:

Source	Percent of Samples with Turbidity > 1 NTU	Percent of Samples with Turbidity >5 NTUs
Capilano Source	16.8	0.5
Capilano Delivered	11.6	0.3
Seymour Source	9.6	0
Coquitlam Source	4.1	0

There were three occasions in 2000 when the Capilano supply was taken out of service due to elevated turbidity. Capilano was off line from June 13 to June 23, October 20 to November 3 and from November 24 to December 7. During the turbidity event which started on October 20, there was no advance warning of high turbidity from the in-lake turbidity meters and for a short period of time some water with a turbidity of greater than 5 NTUs was delivered. Every effort was taken to minimize the flow during the event but it takes a significant period of time to safely take a source off-line. Following this event, procedures for taking the source off line were reviewed to see if the time required could be reduced.

The colour of the Seymour source water was also higher in 2000 than in previous years. The iron levels in the source water were high in September and the colour of the water from Seymour was in the range of 30 Apparent Colour Units (ACU). The aesthetic guideline for colour is 15 and, when the apparent colour of the water exceeds this values, consumers notice a yellowish cast particularly in bath and toilet water. In October, when the first flush of organics occurred followed by a slight turbidity event, the apparent colour rose to 50 ACUs. Since the Capilano source was taken out of service at this time, the "yellow" water was distributed to a large proportion of the population. The number of complaints of "yellow water" was significantly higher in 2000.

Figure 5 Apparent colour in Seymour source water, 2000.



4.4.1 Chemical and Physical Characteristics of the Source Water

Table 7 Chemical and Physical Characteristics of the Source Water, 2000. Average levels.

Parameter (mg/L unless shown)	**Canadian Guideline Limit**		**Capilano**	**Seymour**	**Coquitlam**	**Times Analyzed**
Alkalinity as $CaCO_3$	no limit		2.6	3.4	2.6	12
Aluminium Dissolved	no limit		0.07	0.05	0.06	6
Aluminium Total	no limit		0.12	0.09	0.10	6
Antimony Total	no limit		<0.002	<0.002	<0.002	2
Arsenic Total	0.025	health	<0.001	<0.001	<0.001	2
Barium Total	1.0	health	<0.004	<0.004	<0.004	2
Boron Total	5.0	health	<0.04	<0.04	<0.04	2
Cadmium Total	0.005	health	<0.0005	<0.0005	<0.0005	2
Calcium Total	no limit		1.27	1.75	0.92	12
Carbon Organic Dissolved	no limit		1.7	1.6	1.6	52
Carbon Organic Total	no limit		1.8	1.7	1.8	52

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uranium analyses. All values were at or less than detection limits and the results are shown in Table 8.

Table 8 Herbicides, Pesticides, PAHs, VOCs, and Radioisotopes in the Source Water, 2000 (Actual Results).

All results in mg/L	Date Sampled	MDL	MAC	IMAC	AO	Capilano	Seymour	Coquitlam
CARBAMATE INSECTICIDES								
aldicarb	16-Aug-00	0.0005	0.009			<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
aldicarb sulfone[1]	16-Aug-00	0.0005				<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
aldicarb sulfoxide[1]	16-Aug-00	0.0005				<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
bendiocarb	16-Aug-00	0.0005	0.04			<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
carbaryl	16-Aug-00	0.0005	0.09			<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
carbofuran	16-Aug-00	0.0005	0.09			<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
CHLORINATED PHENOLS								
dichlorophenol, 2,4-	16-Aug-00	0.0001	0.9		<0.0003	<0.0001	<0.0001	<0.0001
	20-Nov-00	0.0001				<0.0001	<0.0001	<0.0001
pentachlorophenol	16-Aug-00	0.0001	0.06		<0.030	<0.0001	<0.0001	<0.0001
	20-Nov-00	0.0001				<0.0001	<0.0001	<0.0001
tetrachlorophenol, 2,3,4,6-	16-Aug-00	0.0002	0.1		<0.001	<0.0002	<0.0002	<0.0002
	20-Nov-00	0.0002				<0.0002	<0.0002	<0.0002
trichlorophenol, 2,4,6-	16-Aug-00	0.0002	0.005		<0.002	<0.0002	<0.0002	<0.0002
	20-Nov-00	0.0001				<0.0001	<0.0001	<0.0001
HERBICIDES								
2,4,5-T[3]	16-Aug-00	0.0001				<0.0001	<0.0001	<0.0001
	20-Nov-00	0.0001				<0.0001	<0.0001	<0.0001
2,4,5-TP[3]	16-Aug-00	0.0001				<0.0001	<0.0001	<0.0001
	20-Nov-00	0.0001				<0.0001	<0.0001	<0.0001
2,4-D	16-Aug-00	0.0003		0.1		<0.0003	<0.0003	<0.0003
	20-Nov-00	0.0002				<0.0002	<0.0002	<0.0002
atrazine + metabolites	16-Aug-00	0.0002		0.005		<0.0002	<0.0002	<0.0002
	20-Nov-00	0.0002				<0.0002	<0.0002	<0.0002
Desethyl atrazine[2]	16-Aug-00	0.0003				<0.0003	<0.0003	<0.0003
	20-Nov-00	0.0003				<0.0003	<0.0003	<0.0003
bromoxynil	16-Aug-00	0.0002		0.005		<0.0002	<0.0002	<0.0002
	20-Nov-00	0.0002				<0.0002	<0.0002	<0.0002
cyanazine	16-Aug-00	0.0005		0.01		<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005		0.01		<0.0005	<0.0005	<0.0005
dicamba	16-Aug-00	0.0001	0.12			<0.0001	<0.0001	<0.0001
	20-Nov-00	0.0001				<0.0001	<0.0001	<0.0001
dinoseb	16-Aug-00	0.0002	0.01			<0.0002	<0.0002	<0.0002
	20-Nov-00	0.0002				<0.0002	<0.0002	<0.0002
diquat	16-Aug-00	0.01	0.07			<0.01	<0.01	<0.01

All results in mg/L	Date Sampled	MDL	MAC	IMAC	AO	Capilano	Seymour	Coquitlam
	20-Nov-00	0.0003				<0.0003	<0.0003	<0.0003
VOLATILE ORGANIC COMPOUNDS								
carbon tetrachloride	16-Aug-00	0.001	0.005			<0.001	<0.001	<0.001
	20-Nov-00	0.001				<0.001	<0.001	<0.001
monochlorobenzene	16-Aug-00	0.0005	0.08		<0.03	<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
dichlorobenzene, 1,2-	16-Aug-00	0.0005	0.20		<0.003	<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
dichlorobenzene, 1,4-	16-Aug-00	0.0004	0.005		<0.001	<0.0004	<0.0004	<0.0004
	20-Nov-00	0.0004				<0.0004	<0.0004	<0.0004
dichloroethane, 1,2-	16-Aug-00	0.0005		0.005		<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
dichloroethylene, 1,1-	16-Aug-00	0.0004	0.014			<0.0004	<0.0004	<0.0004
	20-Nov-00	0.0004				<0.0004	<0.0004	<0.0004
dichloromethane	16-Aug-00	0.0009	0.05			<0.0009	<0.0009	<0.0009
	20-Nov-00	0.0009				<0.0009	<0.0009	<0.0009
tetrachloroethylene	16-Aug-00	0.0005	0.03			<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
trichloroethylene	16-Aug-00	0.0006	0.05			<0.0006	<0.0006	<0.0006
	20-Nov-00	0.0006				<0.0006	<0.0006	<0.0006
vinyl chloride	16-Aug-00	0.001	0.002			<0.001	<0.001	<0.001
	20-Nov-00	0.001				<0.001	<0.001	<0.001
benzene	16-Aug-00	0.0005	0.005			<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
ethylbenzene	16-Aug-00	0.0005			<0.0024	<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
toluene	16-Aug-00	0.0005			<0.024	<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
xylene(total)	16-Aug-00	0.0005			<0.3	<0.0005	<0.0005	<0.0005
	20-Nov-00	0.0005				<0.0005	<0.0005	<0.0005
POLYCYCLIC AROMATIC HYDROCARBONS[4]								
Acenaphthene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Acenaphthylene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Anthracene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Benzo(a)anthracene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Benzo(k)fluoranthene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Benzo(g,h,i)perylene	16-Aug-00	0.00002				<0.00002	<0.00002	<0.00002
	20-Nov-00	0.00002				<0.00002	<0.00002	<0.00002
benzo(a)pyrene	16-Aug-00	0.00001	0.00001			<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001	0.00001			<0.00001	<0.00001	<0.00001
Chrysene	16-Aug-00	0.00001				<0.00001	<0.00001	<0.00001
	20-Nov-00	0.00001				<0.00001	<0.00001	<0.00001
Dibenzo(a,h)anthracene	16-Aug-00	0.00002				<0.00002	<0.00002	<0.00002

5.0 Transmission System Water Quality

5.1 MICROBIOLOGICAL QUALITY

As in previous years the GVRD bacteriology laboratory routinely analyzed daily samples of treated water in the GVRD transmission system for two groups of indicator organisms, coliform bacteria and aerobic heterotrophic plate count (HPC) bacteria. The coliform group of organisms is used to monitor the effectiveness of disinfection and to ensure that the water supply system has not become contaminated with sewage through back siphonage or other means. The analysis of samples for the HPC group of bacteria is useful in monitoring the effectiveness of disinfection and in assessing changes in finished water quality during distribution and storage.

B. C. Safe Drinking Water Regulation: The B. C. Safe Drinking Water Regulation was promulgated under the Health Act in October of 1992. Under this regulation, water utilities are required to provide water that meets the criteria contained in the "schedule" that reads as follows:

I. Microbiological Standard

1. For a waterworks system to meet the microbiological standard, sample tests must meet the following criteria:

(a) Fecal Coliform	0 fecal coliform/100 mL
(b) Total Coliform:	
i) one sample within a 30 day period	0 total coliform/100 mL
ii) more than one sample in a consecutive 30 day period	90% or more of the samples must have 0 total coliform /100 mL
iii) no sample must contain more than 10 coliform / 100 mL	

In order to meet the requirements of the regulation, treated water should contain no fecal coliform bacteria, a minimum of 90% of the samples taken in a 30 day period should be negative for total coliform bacteria (or no more than 10% of the samples should be positive) and no sample should contain more than 10 total coliform bacteria/100 mL.

transmission main sampling locations exceed the 10% standard, in fact, at no time did the percentage even reach 5% of the samples. Of the more than 5000 samples collected, one sample collected in July was positive for fecal coliform and it typed as *Klebsiella pneumoniae*. Unlike *E. coli*, *Klebsiella pneumoniae* has environmental sources other than fecal material and therefore the presence of *Klebsiella pneumoniae* does not indicate fecal contamination. All repeat samples and samples from adjacent areas were negative. There were three samples where greater than 10 total coliform bacteria were detected. Again all repeat samples were negative.

The low level of coliform occurrences in both 2000 and 1999 relative to the levels observed prior to secondary disinfection (before 1998) is most likely due to the increased chlorine residual in the system. It should be noted that there was increased sampling at certain reservoirs and mains because of coliforms being detected, and these repeat sample results were not included in the calculations.

5.1.2 GVWD Reservoirs

As shown below in Figure 7, no samples from the reservoirs contained fecal coliforms, and only one contained more than 10 total coliforms/ 100 mL. The reservoirs were similar to the mains in that less than 5% of the samples contained total coliforms in any 30-day period. This is a significant improvement over previous years and is due to the increased transmission system chlorine residual and the extensive ongoing reservoir improvement plan (discussion follows).

Figure 7. Bacteriological Quality of Water in GVRD Reservoirs, 2000

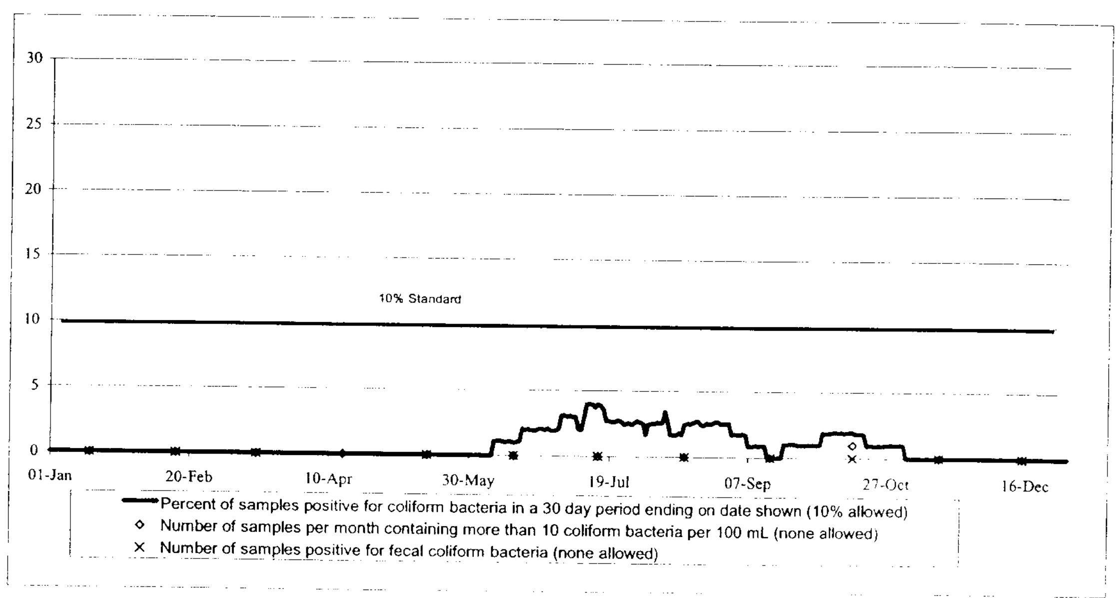


Table 9 Water Quality Status of GVRD Reservoirs, 2000

RESERVOIR (Capacity Million Gallons)	AVER. CHLORINE mg/L '97 '98 '99 '00	DISCUSSION	STATUS 1999	STATUS 2000
Burnaby Mtn. Reservoir (3.0)	0.06 0.35 0.33 0.31	Sufficient circulation	No upgrades planned.	No upgrades planned. Water quality is satisfactory.
Burnaby Tank (0.5)	0.19 0.39 0.50 0.54	Sufficient circulation	Minor adjustments may be required in the future to increase the cycle depth.	No upgrades planned. Water quality is satisfactory.
Cape Horn Reservoir (9.6)	0.08 0.21 0.36 0.41	Some changes to the downstream configuration have improved drawdown and circulation.	Valve work is complete.	Cycling of this reservoir adversely impacted the chlorine residual in Westburnco Reservoir and in South Burnaby #2 main. Need to reconsider options.
Clayton Tank (1.6)	0.02 0.06 0.58 0.64	Water could not be used during low demand periods so circulation pump installed in 1999.	Water quality in the reservoir is now satisfactory	Early in 2000 circulation pump turned off and reservoir used to feed City of Langley. Water quality is satisfactory.
Central Park (8.1)	0.07 0.14 0.08 0.18	Under certain operating conditions exercising has been a problem at this site. Installation of remote control valves downstream in 1999 and using rechlorinated water to fill the reservoir will improve water quality but there are concerns with adversely affecting water quality downstream.	Monitoring in 2000 to continue with assessment of current operating conditions to be made by year-end.	In 2000 began pumping on a daily basis. Primarily being filled with 50% Coquitlam water from Westburnco and 50% with Seymour

RESERVOIR (Capacity Million Gallons)	AVER. CHLORINE mg/L '97 '98 '99 '00	DISCUSSION	STATUS 1999	STATUS 2000
Little Mountain Reservoir (31)	0.28 0.32 0.62 0.63	The large capacity of this reservoir makes circulation and exercising it operationally difficult. In 1999 rechlorinated water from Central Park was used to supply the reservoir resulting in an increased chlorine residual.	Monitoring will continue in 2000. Work on seismic upgrading of this reservoir is required and requirements for water circulation will be considered during design.	No changes to operation. Water quality is satisfactory.
Maple Ridge Reservoir (4.8)	0.01 0.16 0.18 0.38	Improvements to the flow patterns have improved the cycling routine.	Planned pump improvements should provide a greater degree of flow control to the reservoir. Water quality is borderline but with increasing population and increasing water demand, the chlorine residual should increase.	This reservoir's cycling frequency was increased and the fill level reduced. Average chlorine residual has improved. Will continue to monitor.
Newton Reservoir (7.2)	0.09 0.15 0.27 0.45	Water is chlorinated downstream of the reservoir.	No upgrades planned.	No changes or upgrades occurred this year.
Pebble Hill Reservoir (9.9)	0.01 0.01 0.01 0.06	This reservoir has a large capacity and the water is only used under high flow conditions.	Options for improving the circulation being considered - no decision at this time.	No changes to operation. Water quality is still unsatisfactory.
Prospect Reservoir (1.2)	0.31 0.41 0.47 0.37	The incoming water has a very high chlorine residual and there is good daily turnover.	No upgrades planned.	Water quality is satisfactory. An additional parallel pipe is planned.

RESERVOIR (Capacity Million Gallons)	AVER. CHLORINE mg/L '97 '98 '99 '00	DISCUSSION	STATUS 1999	STATUS 2000
Whalley Reservoir (7.8)	0.02 0.14 0.51 0.49	Surrey continues to pump from this reservoir, allowing a satisfactory turnover.	Water quality satisfactory. Evaluations of options to supply Surrey are under way.	Surrey installed smaller pumps in 2000, but continue to pump from this reservoir with a daily turnover of approx. 20% daily.

staining" calls. With the commissioning of the secondary disinfection stations in 1998, the effect of boosting up residual chlorine in these stations using bleach or sodium hypochlorite solution was to increase free residual chlorine in the distribution areas with a resultant increase in disinfection by-products. This is discussed in Section 6, Impacts of Drinking Water Treatment Program.

Table 10 Treated Water Chemical and Physical Characteristics

Parameter (mg/L unless shown)	Canadian Guideline Limit		Capilano	Seymour	Coquitlam	Times Analyzed
Alkalinity* as $CaCO_3$	No limit		1.3	7.4	5.8	12
Aluminium Dissolved	No limit		0.07	0.05	0.06	6
Aluminium Total	No limit		0.14	0.09	0.09	6
Antimony Total	No limit		<0.002	<0.002	<0.002	2
Arsenic Total	0.025	health	<0.001	<0.001	<0.001	2
Barium Total	1.0	health	<0.004	<0.004	<0.004	2
Boron Total	5.0	health	<0.04	<0.04	<0.04	2
Cadmium Total	0.005	health	<0.0005	<0.0005	<0.0005	2
Calcium Total	No limit		1.28	1.76	0.92	12
Carbon Organic Dissolved	No limit		1.7	1.6	1.6	52
Carbon Organic Total	No limit		1.8	1.7	1.7	52
Chloride Total	250	aesthetic	1.5	1.7	1.6	12
Chromium Total	0.05	health	<0.001	<0.001	<0.001	2
Color Apparent	No limit		8	10	6	52
Color True	15	aesthetic	6	7	4	52
Conductivity	No limit		13	26	20	52
Copper Total	1.0	aesthetic	<0.02	<0.02	<0.02	6
Cyanide Total	0.2	health	<0.005	<0.005	<0.005	2
Fluoride	1.5	health	<0.05	<0.05	<0.05	12
Hardness as $CaCO_3$	No limit		3.94	5.09	2.76	12
Iron Dissolved	No limit		0.03	0.08	0.02	52
Iron Total	0.3	aesthetic	0.10	0.18	0.05	52
Lead Total	0.01	health	<0.001	<0.001	<0.001	2
Magnesium Total	No limit		0.17	0.17	0.11	12
Manganese Dissolved	No limit		<0.01	<0.01	<0.01	12
Manganese Total	0.05	aesthetic	0.01	0.02	0.01	12
Mercury Total	0.001	health	<0.0002	<0.0002	<0.0002	2
Nickel Total	No limit		<0.001	<0.001	<0.001	2
Nitrogen - Ammonia as N	No limit		<0.01	<0.01	<0.01	52
Nitrogen - Nitrate as N	10	health	0.11	0.09	0.13	12
Nitrogen - Nitrite as N	1.0	health	<0.01	<0.01	<0.01	12
PH*	6.5 to 8.5	aesthetic	6.1	6.7	6.5	60

operational changes were instituted such that flows were maximized in the affected pipeline sections. The 1994 monitoring program pinpointed the source of the PAHs as the coal-tar enamel lining on some recently installed water transmission mains. In 1995, PAH monitoring was expanded to include water at the ends of GVRDs water transmission mains and areas, which are wholly or in part supplied by water mains with potential PAH leaching problems. Results in 1995 confirmed that PAHs were detected only in those areas where the mains had been recently installed (within approximately 5 years). Since 1996, monitoring for PAHs has been conducted at sites which are wholly or in part supplied by mains with a leaching problem to monitor the level of PAHs in the water. The main observations/conclusions to be drawn from the monitoring for PAHs are:

- PAHs are still being detected in trace levels in water in the areas supplied by relatively recently installed water mains that have coal-tar enamel interior pipe coating.
- PAH levels in 2000 were similar to levels detected in previous years. These compounds are not very soluble in water and leaching of low levels is expected for a number of years.

The WHO, in its 1996 "Guidelines for Drinking Water Quality', Volume 2, recommends that "the use of coal-tar-based and similar materials for pipe linings and coatings on storage tanks should be discontinued." The District, therefore, has discontinued the use of coal-tar enamel for lining its new mains and in its place has chosen liquid epoxy. PAH monitoring results for 2000 are shown in Table 9.

Table 11 Results of PAH Monitoring In GVRD Transmission mains, 2000, mg/L. (Positive results in bold.)

Parameters	**Date Sampled**	**MDL**	**MAC**	Coq. #2	Sap#2 at Westburnco	Queens-53	Haney #3 at Pitt River	Whalley - Kennedy	Barnston	36th Ave Main
Acenaphthene	23-Aug-00	0.00001		<0.00001	<0.00001	**0.00001**	<0.00001	<0.00001	<0.00001	<0.00001
	22-Nov-00			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Acenaphthylene	23-Aug-00	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
	22-Nov-00			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Anthracene	23-Aug-00	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00002
	22-Nov-00			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(a)anthracene	23-Aug-00	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
	22-Nov-00			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	23-Aug-00	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
	22-Nov-00			<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(k)fluoranthene	23-Aug-00	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
	22-Nov-00	0.00001		<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(g,h,i)perylene	23-Aug-00	0.00002		<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002

Table 12 Results of BETX Monitoring in GVRD Transmission Mains, 2000 (mg/L). (Positive results in bold.)

Parameters	**Date Sampled**	**MDL**	**MAC**	**AO**	Barnston @ 73A Ave & 202 St.	Maple Ridge Main	Maple Ridge Main at Reservoir	South Burnaby #2	Jericho-Clayton	44th AveMain
Benzene	22-Aug-00	0.0005	0.005		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	22-Nov-00	0.0005			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Ethylbenzene	22-Aug-00	0.0005		<0.0024	<0.0005	**0.0013**	<0.0005	<0.0005	<0.0005	**0.0013**
	22-Nov-00	0.0005			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**0.0009**
Toluene	22-Aug-00	0.0005		<0.024	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	22-Nov-00	0.0005			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Xylenes (Total)	22-Aug-00	0.0005		<0.3	**0.0011**	**0.0065**	**0.0022**	<0.0005	**0.0010**	**0.0070**
	22-Nov-00	0.0005			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**0.0061**

5.2.3 Disinfection By-Products

See section 6.2.2 Impacts of Drinking Water Treatment Program.

Chlorine is added after ozonation as a secondary disinfectant to maintain water quality in the distribution system but the amount added is significantly less that what would have been required to give the same level of disinfection as ozone (for primary disinfection). Soda ash or sodium carbonate is also being added at Coquitlam to adjust the pH of water up to between 6.8 and 7. This is a considerable improvement on the pH prior to adjustment of 5.5 to 6. During the commissioning of the ozone facility, there have been some start up problems and the ozonation plant has not been operating 100% of the time.. This is normal for a such a facility, especially since this is the largest ozonation facility on an unfiltered source in North American, possibly the world, and some of the design features are new. The problems have been resolved and the plant is now operating as planned except for during power outages, which appear to be happening quite frequently.

As a result of the improvements to the primary disinfection at Coquitlam, there have been some changes in the characteristics of the treated water.

- Increase in dissolved oxygen. The dissolved oxygen (DO) level in the treated water has increased at least 100%. There were concerns that this increase in DO would result in "red water" complaints from areas supplied by cast iron pipes. This has not occurred most likely due to the high DO levels in the treated water prior to ozonation.

- Increase in sodium and pH. The sodium and pH levels are slightly higher in the treated water due to the addition of soda ash. Sodium levels in the treated water have increased from 0.5 to approximately 6 mg/L.

- Change in organic carbon. Ozone is a strong oxidizing agent and has an effect on the nature of the dissolved organic carbon in the water. One of the disadvantages in using ozone is the conversion of the dissolved organic carbon to a form that is more readily used by microorganisms as a source of carbon and energy. This is referred to as biodegradable organic matter (BOM) and there are two tests, assimilable organic carbon (AOC) or biodegradable organic carbon (BDOC) which demonstrate that following ozonation the level of BOM will increase significantly. The question is "How will this increase in BOM impact the distribution system?" Will the amount of regrowth in those areas supplied by Coquitlam increase or will the level of secondary disinfectant necessary to control regrowth prior to ozonation be adequate to control regrowth after ozonation? Due to unexpected heavy demands on laboratory staff in the fall months, it was not possible to perform any AOC or BDOC tests on the ozonated water. Work done during the pilot testing in 1995, however, showed that the levels of both would increase significantly with ozonation and there is no reason to believe that this has not occurred. Routine monitoring for another characteristic of the organic carbon, Specific Ultraviolet Absorbance (SUVA) at 254 nm, does show a change following the use of ozone. SUVA, calculated from the UV_{254} absorbance and the dissolved organic carbon, is often used to determine whether or not the dissolved organic carbon present in a water sample can be removed by filtration. The drop in the SUVA values is due to the decrease in the bromate and a standard of 0.9 mg/L for formaldehyde. The Guidelines for Canadian Water Quality have an interim Maximum Acceptable Concentration of <0.01 mg/L.

- Effect of ozone on regrowth. There was concern that the increase in BOM that would result from ozonation could increase the coliform regrowth in the municipal distribution systems. The experts on the Technical Review Board emphasized the importance of getting a free chlorine residual out to the extremities of the distribution system before ozonation was put in place in order to prevent an increase in regrowth. This is the reason why it was critical to have the Secondary Disinfection Program in place and operating optimally before the ozone plant went on line. In 2000, the level of regrowth was slightly higher than in 1999, however, the average water temperature was also significantly higher which would increase coliform regrowth as well. There were months when more member municipalities failed the BC Safe Drinking Water Regulation than in 1999 but there were also months when fewer member municipalities failed at least in part. Regrowth was not concentrated in those areas supplied by Coquitlam but were scattered across areas supplied by all three sources. There was also a question of whether it would take a higher chlorine residual to control regrowth after ozonation. To answer this question, all the samples which had been positive for coliform bacteria for the last four years were categorized according to the level of free chlorine measured at the time the samples were taken. The results are presented in figure 9. It is obvious that, both before and after the start-up of the ozonation facility, the majority of samples positive for total coliform bacteria occurred when the chlorine residual was 0.1 mg/L or lower. If the chlorine residual is greater than 0.1, the number of coliform positive samples is minimal. The other concern is that the number of total coliform bacteria in a positive sample will increase when the water is ozonated. There is insufficient data from the year 2000 to determine if this is occurring but the situation will be evaluated again at the end of 2001.

regrowth. The Secondary Disinfection component of the Drinking Water Treatment Program has developed (or encouraged the development of) the required infrastructure and work programs to carry out these initiatives.

The goal of the Secondary Disinfection initiative is to deliver water to consumers that meets the bacteriological requirements of BCSDWR. The chlorination pilot study carried out in Newton beginning in 1988 determined that a residual of at least 0.2 mg/L free chlorine was necessary to accomplish this goal. This was confirmed by data gathered in the City of Vancouver following the construction of their rechlorination stations. It is probably not possible to accomplish the delivery of this level of disinfection to every consumer in every municipality. The chlorine demand in the water, dead ends and very low flow areas will always be a problem, but the attempt must be made to get as close to the ultimate goal as reasonable. The first step of Stage I of the Secondary Disinfection initiative involved increasing the level of chlorination at some existing facilities and the construction of new facilities on the GVRD Transmission system. As well, additional initiatives to decrease levels of bacteria were undertaken such as circulation of the water in storage reservoirs, flushing and cleaning of mains in the municipal systems, and operating the GVRD transmission system to eliminate, where possible, dead ends or low flow areas. In practical terms, the goal was to increase the chlorine in GVRD mains to a minimum of 0.5 mg/L. This would ensure that all the water delivered to member municipalities would have a free chlorine residual of between 1 and 0.5 mg/L, the level believed to be required to achieve a minimum chlorine residual of 0.2 mg/L in most of the municipal systems.

Following the startup of the secondary disinfection facilities in 1998 and increased municipal flushing and cleaning programs, there was a significant improvement in the bacteriological quality of the water in member municipalities as demonstrated by the decrease in the number of member municipalities that failed to comply with the B. C. Safe Drinking Water Regulation. These improvements were discussed in detail in the 1998 and 1999 Quality Control Annual Reports.

had been used to achieve the same level of disinfection, the THM levels would have increased substantially, especially with upward pH adjustment.

THM levels remained below the IMAC of 100 parts per billion in 2000.

Table 13 Average Yearly Total Trihalomethane levels, ppb.

Sources	**1997**	**1998**	**1999**	**2000**
Capilano				
Stanley Park (T.S.)	4.7	8	7	13
Vancouver (COV-20 D.S.)	12	13	14	21
Richmond258 (D.S.)	19	22	33	29
Richmond251(D.S.)	26	31	41	47
Richmond1(D.S.)	17	32	29	35
Capilano Area Average	**16**	**21**	**25**	**29**
Coquitlam				
Haney-Moody (T.S.)	4.8	6.5	6	13
Coquitlam - 601 (D.S.)	8.3	16	18	23
Coquitlam - 604 (D.S.)	10	12	12	24
Maple Ridge - 438 (D.S.)	11	22	22	28
Maple Ridge - 440 (D.S.)			29	32
City of Langley - 451 (D.S.)	14	25	22	37
Coquitlam Area Average	**10**	**16**	**18**	**26**
Seymour				
Rice Lake - 8 (T.S.)	5.9	7.5	10	15
Vancouver (COV - 24 D.S.)	12	13	27	33
64th Ave. & 126th St. (T.S.)	12	13	20	29
Delta Control. - 386 (D.S.)	16	23	26	33
Delta Control. - 387 (D.S.)	21	24	33	35
Seymour Area Average	**14**	**16**	**23**	**29**
Surrey - South Surrey				
S. Surrey #356 (D.S.)	40	52	56	69
S. Surrey #308 (D.S.)	41	58	71	61
S. Surrey #301 (D.S.)	58	50	46	60
S. Surrey Area Average	**46**	**53**	**58**	**63**
Surrey - Newton				
Newton #361 (D.S.)	42	40	52	
Newton #365 (D.S.)	56	55	41	67
Newton #364 (D.S.)	61	77	60	65
Newton #369 (D.S.)			51	
Newton Area Average	**53**	**51**	**51**	**66**

Sources	**1997**	**1998**	**1999**	**2000**
Newton #365 (D.S.)	72	63	76	76
Newton #364 (D.S.)	69	58	65	74
Newton #369 (D.S.)			63	
Newton Area Average	**70**	**60**	**67**	**75**

Pilot studies on the water in the GVRD suggested that the levels of HAAs in pH unadjusted water would increase significantly with rechlorination. Factors affecting the production of these compounds, including pH, are not as well understood as for THMs. As predicted in pilot studies, the levels of HAAs in the rechlorinated water have risen substantially.

The scientific literature and the pilot studies carried out on the GVRD water supplies predicted that by using chlorine as the secondary disinfectant rather than the alternative, chloramine, the levels of disinfection by-products in the delivered water would increase. The results from the samples collected to date confirm this prediction. The HAA levels in the area supplied by Coquitlam have not increased following the start up of the ozonation facility. This is significant as the primary disinfection of the Coquitlam source water has been substantially improved without increasing theses chlorinated disinfection by-products. This could not have been achieved with chlorine. The data does, however, show that HAAs are at least as much of a concern as THMs, if not more so. With chlorine as the secondary disinfectant, removal of the precursors of these by-products through filtration is the only method of decreasing the levels of DBPs.

Appendix 1

Physical and Chemical Analysis of Water Supply

Greater Vancouver Water District

2000 - Seymour Water System

Parameter	Untreated Average	Treated Average	Treated Range	Days Guideline Exceeded	Canadian Guideline Limit	Reason Guideline Established
Alkalinity as $CaCO_3$ (mg/L)	3.4	7.4	2.0 to 11		none	
Aluminium Dissolved (mg/L)	0.05	0.05	0.04 to 0.07		none	
Aluminium Total (mg/L)	0.09	0.09	0.06 to 0.11		none	
Antimony Total (mg/L)	<0.002	<0.002	<0.002		none	
Arsenic Total (mg/L)	<0.001	<0.001	<0.001	0	0.025	health
Barium Total (mg/L)	<0.004	<0.004	<0.004 to 0.004	0	1.0	health
Boron Total (mg/L)	<0.04	<0.04	<0.04	0	5.0	health
Cadmium Total (mg/L)	<0.0005	<0.0005	<0.0005	0	0.005	health
Calcium Total (mg/L)	1.75	1.76	1.54 to 2.05		none	
Carbon Organic Dissolved (mg/L)	1.6	1.6	1.2 to 2.9		none	
Carbon Organic Total (mg/L)	1.7	1.7	1.2 to 3.3		none	
Chloride Total (mg/L)	0.4	1.7	1.3 to 2.4	0	250	aesthetic
Chromium Total (mg/L)	<0.001	<0.001	<0.001	0	0.05	health
Color Apparent (ACU)	16	10	4 to 23		none	
Color True (TCU)	13	7	3 to 17	7	15	aesthetic
Conductivity (umhos/cm)	14	26	13 to 39		none	
Copper Total (mg/L)	<0.02	<0.02	<0.02	0	1.0	aesthetic
Cyanide Total (mg/L)	<0.005	<0.005	<0.005	0	0.2	health
Fluoride (mg/L)	<0.05	<0.05	<0.05	0	1.5	health
Hardness as $CaCO_3$ (mg/L)	5.03	5.09	4.42 to 5.94		none	
Iron Dissolved (mg/L)	0.07	0.08	0.02 to 0.24		none	
Iron Total (mg/L)	0.18	0.18	0.06 to 0.62	56	0.3	aesthetic
Lead Total (mg/L)	<0.001	<0.001	<0.001	0	0.01	health
Magnesium Total (mg/L)	0.16	0.17	0.14 to 0.20		none	
Manganese Dissolved (mg/L)	<0.01	<0.01	<0.01 to 0.02		none	
Manganese Total (mg/L)	0.02	0.02	<0.01 to 0.04	0	0.05	aesthetic
Mercury Total (mg/L)	<0.0002	<0.0002	<0.0002	0	0.001	health
Nickel Total (mg/L)	<0.001	<0.001	<0.001		none	
Nitrogen - Ammonia as N (mg/L)	<0.01	<0.01	<0.01		none	
Nitrogen - Nitrate as N (mg/L)	0.09	0.09	0.05 to 0.15	0	10	health
Nitrogen - Nitrite as N (mg/L)	<0.01	<0.01	<0.01	0	1.0	health
pH	6.5	6.7	6.1 to 7.2	35	6.5 to 8.5	aesthetic
Phenols (mg/L)	<0.005	<0.005	<0.005		none	
Phosphorus Total (mg/L)	<0.005	<0.005	<0.005 to 0.007		none	
Potassium Total (mg/L)	0.17	0.19	0.15 to 0.23		none	
Residue Total (mg/L)	18	25	19 to 29		none	
Residue Total Dissolved (mg/L)	16	24	18 to 28	0	500	aesthetic
Residue Total Fixed (mg/L)	11	18	12 to 21		none	
Residue Total Volatile (mg/L)	6	7	5 to 10		none	
Selenium Total (mg/L)	<0.001	<0.001	<0.001	0	0.01	health
Silica as SiO_2 (mg/L)	3.3	3.3	2.8 to 3.8		none	
Silver Total (mg/L)	<0.001	<0.001	<0.001		none	
Sodium Total (mg/L)	0.52	3.57	2.40 to 5.20	0	200	aesthetic
Sulphate (mg/L)	1.5	1.5	1.1 to 2.0		500	aesthetic
Turbidity (NTU)	0.52	0.55	0.17 to 4.5	0	5	aesthetic
Turbidity (NTU)	0.52	0.55	0.17 to 4.5	38	1	health
UV254 (Abs/cm)	0.064	0.046	0.028 to 0.087		none	
Zinc Total (mg/L)	<0.01	<0.01	<0.01	0	5.0	aesthetic

These figures are average values from a number of laboratory analyses done throughout the year. Where the range is a single value no variation was measured for the samples analysed. Methods and terms are based on those of "Standard Methods of Water and Waste Water" 20th Edition 1998. Less than (<) denotes not detectable with the technique used for determination. Untreated water is from the intake prior to chlorination, treated water is from a single site in the GVRD distribution system downstream of chlorination. Guidelines are taken from "Guidelines for Canadian Drinking Water Quality - Sixth Edition" Health and Welfare Canada 1996, updated to 1999.

In addition to chlorination for disinfection Seymour water is treated with low levels of sodium carbonate added to increase pH and alkalinity.

Appendix 2

Report to Greater Vancouver Regional District
Giardia and *Cryptosporidium* Study
January - December, 2000

Study Goals:

The Greater Vancouver Regional District continues to monitor its Seymour, Capilano and Coquitlam watersheds on a weekly basis in regards to the waterborne parasites *Giardia* and *Cryptosporidium*. The continued goal of this work is to expand the present database on the protozoan parasites *Giardia* and *Cryptosporidium* in the three GVRD watersheds and to assess the viability of any protozoan parasite retrieved. It is known that cysts/oocysts may be present in surface waters intermittently and may fluctuate in concentrations. Another continuing goal is to evaluate new methods for the quantitation of *Giardia* cysts and *Cryptosporidium* oocysts in raw and drinking water sources in conjunction with other supplementary projects.

The specific aims continue to be:

1. To detect and estimate the number of *Giardia* cysts and *Cryptosporidium* oocysts in three drinking water sources for the Greater Vancouver Regional District using the latest methods

2. To assess the viability of isolated *Giardia* cysts and *Cryptosporidium* oocysts

3. To assist in analysis of project data and to help investigate the source of cyst and oocyst contamination of the watersheds as requested.

4. To evaluate new methods for the quantitation and characterization of *Giardia* cysts and *Cryptosporidium* oocysts.

Methods:

The following methods were used :

1. Using the standard string wound filter method (Percoll method), 500-1000 litres were collected from three designated sites once weekly. Filters were transported to the laboratory and processed (elution and washing of fibres, Percoll/sucrose gradient and centrifugation, IFA and viability staining and epifluorescence microscopy with DIC). Semi-quantitative results for both *Giardia* cysts and *Cryptosporidium* oocysts were reported weekly and microscopic descriptions of parasites as presumptive or confirmed as well as percent viability were reported monthly.

Table 2. Overall Average of Parasites and Detection Limits for all Three Sites

	Filters Tested	Average Crypto/100L	Average Giardia/100L	Average Detection Limit
All Sites	150	1.7	4.3	7.8
Seymour	50	2.4	5.9	10.6
Capilano	52	0.5	3.8	5.4
Coquitlam	48	2.4	3.3	7.4

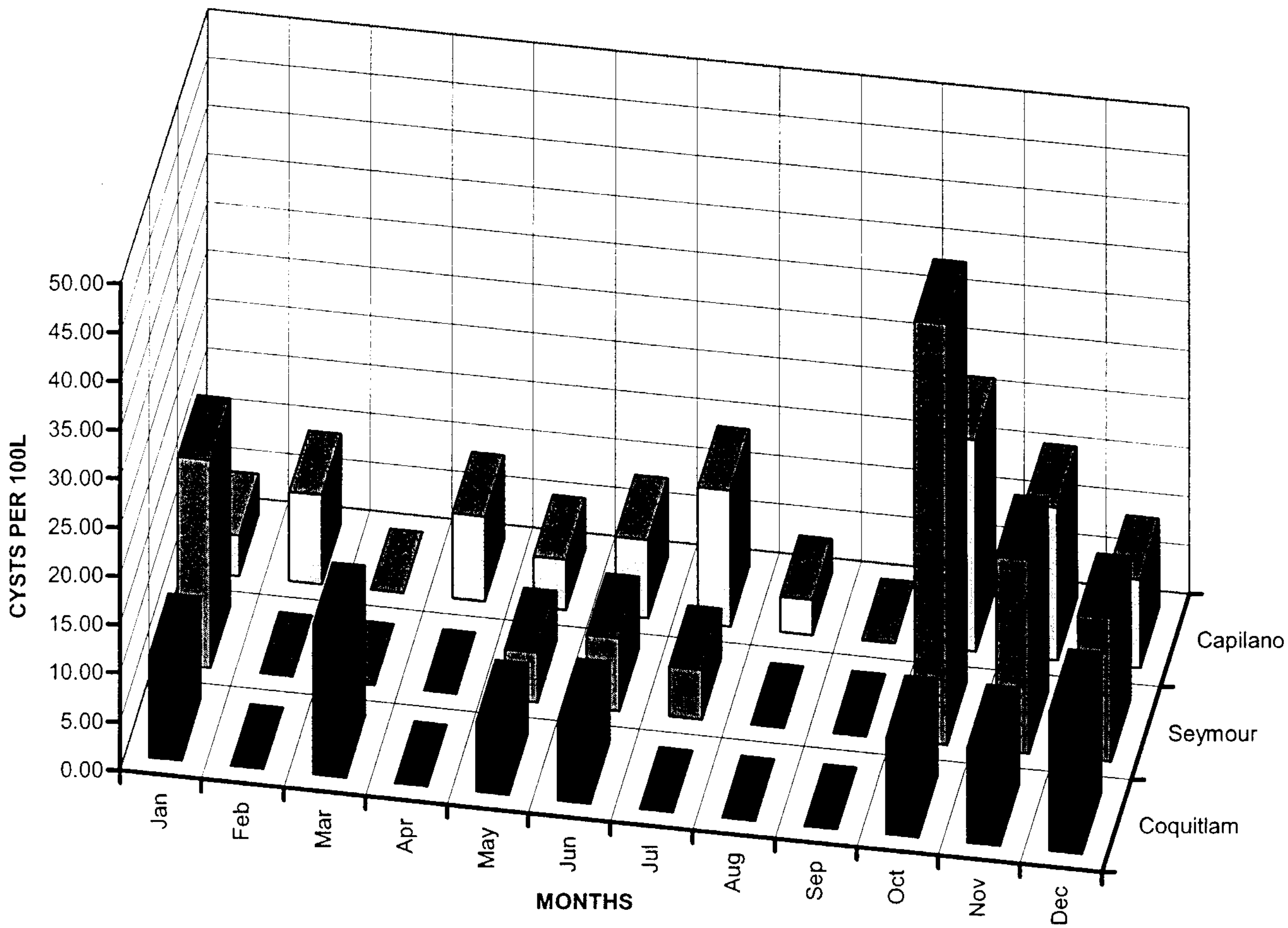
Table 3. Summary of *Cryptosporidium* and *Giardia* Viability for all Three Sites

		Cryptosporidium		*Giardia*	
	Filters Tested	Filters Positive	% Viable	Filters Positive	% Viable
All Sites	150	23	10.9	51	1.7
Seymour	50	8	18.8	18	2.8
Capilano	52	6	8.3	19	0
Coquitlam	48	9	5.6	14	2.4

Table 4. Results of DIC - Internal Morphology for all Presumptive and Confirmed Parasites

	Presumptive	Confirmed	Total Presumptive and Confirmed	% of Total Confirmed
Cryptosporidium	38	10	48	20.8
Giardia	123	3	126	2.4

MEAN PER MONTH *GIARDIA* CYST CONCENTRATION BY SAMPLING SITE JANUARY 2000 - DECEMBER 2000



WF#	Site Location	Date of Sample, at Start (M/D/Y)	Detection Limit	No. Giardia Cysts/100L	No. Crypto Oocysts/100L	% Viable Cysts	% Viable Oocysts	Average # Cyts per month (NPD excluded)	Average # Oocyts per month (NPD excluded)
3525	CAPILANO	2000/04/23	4.7	0.0	0.0				
3526	COQUITLAM	2000/04/23	16.9	0.0	0.0				
3529	SEYMOUR	2000/04/30	5.9	0.0	0.0			0.00	0.00
3530	CAPILANO	2000/04/30	5.5	5.5	0.0	0.0		8.75	0.00
3531	COQUITLAM	2000/04/30	12.1	0.0	0.0			0.00	0.00
3533	SEYMOUR	2000/05/07	4.6	0.0	0.0				
3534	CAPILANO	2000/05/07	5.2	5.2	0.0	0.0			
3535	COQUITLAM	2000/05/08	5.3	0.0	0.0				
3538	SEYMOUR	2000/05/14	5.2	5.2	0.0	0.0			
3539	CAPILANO	2000/05/14	4.8	0.0	0.0				
3540	COQUITLAM	2000/05/14	7.2	7.2	0.0	0.0			
3543	SEYMOUR	2000/05/21	4.4	0.0	0.0				
3544	CAPILANO	2000/05/21	5.0	0.0	0.0				
3545	COQUITLAM	2000/05/21	5.0	0.0	5.0		0.0	7.20	5.00
3547	SEYMOUR	2000/05/28	5.0	5.0	0.0	0.0		5.10	0.00
3548	CAPILANO	2000/05/28	5.1	0.0	0.0			5.20	0.00
3551	SEYMOUR	2000/06/04	5.3	5.3	10.6	0.0	0.0		
3552	CAPILANO	2000/06/04	4.9	9.8	0.0	0.0			
3559	SEYMOUR	2000/06/11	5.0	5.0	5.0	0.0	100.0		
3560	CAPILANO	2000/06/11	4.9	0.0	0.0				
3561	COQUITLAM	2000/06/11	4.1	8.2	4.1	0.0	0.0		
3566	SEYMOUR	2000/06/18	4.8	14.5	38.7	0.0	0.0		
3567	CAPILANO	2000/06/18	4.8	4.8	0.0	0.0			
3568	COQUITLAM	2000/06/18	5.0	0.0	0.0				
3578	SEYMOUR	2000/06/25	5.0	5.0	0.0	0.0		7.45	18.10
3579	CAPILANO	2000/06/25	4.9	9.7	0.0	0.0		8.10	0.00
3580	COQUITLAM	2000/06/25	5.0	0.0	0.0			8.20	4.10
3590	SEYMOUR	2000/07/02	5.0	5.0	0.0	0.0			
3591	CAPILANO	2000/07/02	5.0	15.0	5.0	0.0	0.0		
3592	COQUITLAM	2000/07/02	5.0	0.0	0.0				
3603	SEYMOUR	2000/07/09	5.0	0.0	5.0		0.0		
3604	CAPILANO	2000/07/09	5.0	15.0	0.0	0.0			
3605	COQUITLAM	2000/07/09	5.0	0.0	0.0				
3610	SEYMOUR	2000/07/16	5.0	0.0	0.0				
3611	CAPILANO	2000/07/16	4.0	12.0	4.0	0.0	0.0		
3612	COQUITLAM	2000/07/16	5.0	0.0	0.0				
3616	SEYMOUR	2000/07/23	5.0	0.0	0.0				
3617	CAPILANO	2000/07/23	3.9	0.0	0.0				
3618	COQUITLAM	2000/07/23	4.0	0.0	0.0			0.00	0.00
3622	SEYMOUR	2000/07/30	4.6	0.0	0.0			5.00	5.00
3623	CAPILANO	2000/07/30	5.0	0.0	0.0			14.00	4.50
3626	SEYMOUR	2000/08/06	5.0	0.0	0.0				
3627	CAPILANO	2000/08/06	3.6	3.6	0.0	0.0			
3628	COQUITLAM	2000/08/06	4.7	0.0	0.0				
3632	SEYMOUR	2000/08/12	5.0	0.0	0.0				
3633	CAPILANO	2000/08/12	3.2	0.0	0.0				

WF#	Site Location	Date of Sample, at Start (M/D/Y)	Detection Limit	No. Giardia Cysts/100L	No. Crypto Oocysts/100L	% Viable Cysts	% Viable Oocysts	Average # Cyts per month (NPD excluded)	Average # Oocyts per month (NPD excluded)
3749	CAPILANO	2000/12/03	5.0	0.0	0.0				
3750	COQUITLAM	2000/12/03	5.0	10.0	0.0	0.0			
3755	SEYMOUR	2000/12/09	6.5	13.0	0.0	0.0			
3756	CAPILANO	2000/12/09	5.0	0.0	0.0				
3757	COQUITLAM	2000/12/09	5.0	0.0	0.0				
3762	SEYMOUR	2000/12/16	5.2	10.4	0.0	0.0			
3763	CAPILANO	2000/12/16	4.5	9.1	0.0	0.0			
3764	COQUITLAM	2000/12/16	4.7	4.7	4.7	0.0	0.0		
3768	SEYMOUR	2000/12/26	7.4	22.2	7.4	0.0	0.0	14.65	7.40
3769	CAPILANO	2000/12/26	3.9	0.0	3.9		0.0	9.10	3.90
3770	COQUITLAM	2000/12/26	4.7	28.1	46.8	0.0	0.0	14.27	25.75

Quality Control/Quality Assurance

In 1994, as required by a new Ministry of Health program, the GVRD Bacteriology Laboratory received approval from the Provincial Medical Health Officer to perform bacteriological analysis of potable water as required in the B. C. Safe Drinking Water Regulation. An ongoing requirements of this approval is successful participation in the Clinical Microbiology Proficiency Testing (CMPT) program or its equivalent. The microbiology laboratory has successfully participated in this program since 1994. Representatives of the Approval Committee for Bacteriology Laboratories carried out an inspection of the new laboratory facilities at LCOC in the fall. Written confirmation of approval is expected shortly.

In addition to the program discussed above, the Chemistry and Bacteriology Laboratories are certified by CAEAL, the Canadian Association of Environmental Analytical Laboratories for the analysis of parameters for which the laboratory has requested certification. The laboratories have been inspected by representatives from CAEAL in 1995, 1997, and in 1999 as required in the accreditation process. Accreditation for the laboratories from the Standards Council of Canada was first received early in 1996 and continues through 2000. The laboratory will be inspected again in 2001. Details are available in the Quality Control office, 12th floor, 4330 Kingsway.

Appendix D
Wastewater Quality Test Results

No wastewater information was seen.