Assessment of the Fort Fraser Drinking Water Supply: Source Water Characteristics

James Jacklin, March 2004[1]

Introduction

In British Columbia, drinking water quality is becoming a significant public issue. We all want to have confidence in the quality of the water we consume. Its protection is also important to local purveyors, who act as our water suppliers, and to provincial government ministries responsible for water management. Within the Omineca-Peace region of B.C., our most common potable source is ground water, although many communities do make use of rivers, streams or lakes. Our basic drinking water quality is determined by a number of factors including local geology, climate and hydrology. In addition to these, human land use activities such as urbanization, agriculture and forestry, and the pollution they may cause, are becoming increasingly important influences. Environmental managers have a responsibility to control land use development so as to minimise the effects of these activities on source water quality.

The province's Drinking Water Protection Act, enacted in October, 2002, places the responsibility for drinking water quality protection with the B.C. Ministry of Health and local water purveyors. However, through the B.C. Environmental Management Act, the British Columbia Ministry of Environment (MOE) is responsible for managing and regulating activities in watersheds that have a potential to affect water quality. Accordingly, the Ministry plans to take an active role in protecting drinking water quality at its source.

Plate 1. A view of the sampling location for the Fort Fraser raw water supply. This sink is located at the village Petro-Can gas station.

MOE implemented a raw water quality and stream sediment monitoring program at selected communities in the Omineca-Peace region in 2002. Community sites were selected using a risk assessment process that considered:

- whether the source supply was surface water or ground water,
- the level of water treatment,
- the population size served,
- the potential for upstream diffuse and point-source pollution,
- the availability of current, high-quality and representative data on each raw water source,
- whether past outbreaks of waterborne illness had been reported,
- the ability/willingness of local purveyors to assist with sampling.

Through this process and with available funding, a total of 18 community water supplies in the Omineca-Peace region were selected for monitoring during 2002/03.

This brief report will summarise water quality data collected from the Fort Fraser raw potable water source (ground water) (Plate 1). The data are compared to current provincial drinking water quality guidelines meant to protect finished water if no treatment other than disinfection is present. This comparison should identify parameters with concentrations that represent a risk to human health. It is intended that this program will lead to the identification of human activities responsible for unacceptable source water quality, and that it will assist water managers to develop measures to improve raw water quality where needed.

[1]A template report was prepared for the author by Todd D. French of TDF Watershed Solutions, Research & Management and Bruce Carmichael, Ministry of Environment.

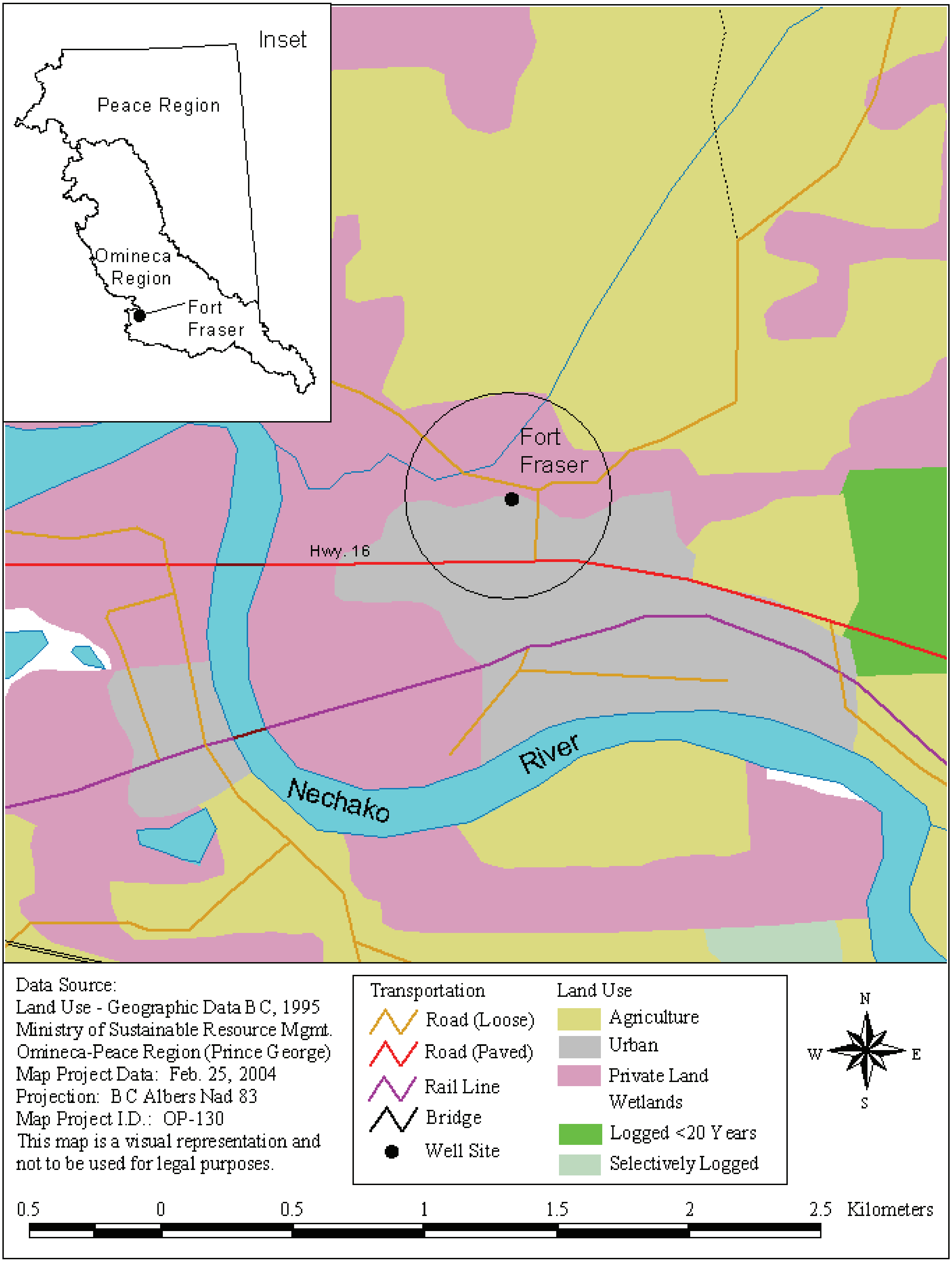

Figure 1. Fort Fraser water well and nearby land use practices. A 300 m radius surrounds the well indicating the zone where contamination is most probable to occur.

Site Description

Watershed Overview

The Village of Fort Fraser is located approximately 19 km east of the Village of Fraser Lake on Highway 16. The drinking water supply consists of one well, located in town near the Fort Fraser Elementary School. This area lies within the Sub-Boreal Spruce biogeoclimatic zone, which is characterized by gently rolling terrain, dense coniferous forests and extremes in the annual temperature range of $^{-}$40°C to 30°C (B.C. Ministry of Forests, 1998).

The predominant land use in the vicinity of the Fort Fraser well is urban activity and agriculture. Additionally, range and forestry practices are present at lower densities. The abundance of these activities may pose a risk to regional water quality.

According to Mr. Glenn Harold (Regional District of Bulkley Nechako), 11 million gallons (50,000 m^3) of water were pumped from the well in 2002. According to the log written during the well construction, the water withdrawal capacity is 5.7-6.0 litres/second. Furthermore, the log stated the well is 500 feet deep (152.4 m) and had a static water level of 49.10 feet (15 m) during the time of construction. According to the well lithology profile (Table 1), there is an abundance of clay materials in the top 180 feet (55 m). This suggests a low permeability in the soil, which would help to retard potential surface contaminants from leaching into the water supply.

Table 1. Lithology profile from the Village of Fort Fraser well (Well ID-1-94). Data supplied by the R.D.B.N.

Depth (Ft)	Grain Size
0-13	Brown clay
13-170	Blue clay containing a few pebbles
170-180	Blue clay containing broken bedrock
180-500	Volcanic bedrock, with red inter-flow zones from 180-330 feet and 350-470 feet

There are two waste disposal permits in the proximity of the Fort Fraser well, a landfill and a sewage treatment facility. These two facilities have the potential to impact ground water quality, however the prominence of clay will limit contaminant migration.

Drinking Water Supply & Treatment

The Village of Fort Fraser draws its domestic water from a ground water supply, consisting of one well. The well is situated at the northeast corner of the Fort Fraser School property, however samples were collected at a different location. Because the village uses no form of water treatment (chlorine is available if a water quality situation arises), samples were collected from the raw water tap located inside the Petro-Can station located on Highway 16. This site was also chosen because of access issues with the community pump house. The GPS co-ordinates of the this sample location are 54°0.'40.4"N/124°33'04.0"W.

There are some concerns regarding the distribution of water. Village water pumps have malfunctioned in the past, forcing the village to use the Nechako River as an alternate water source. The Nechako River was also used in 2001 when a pump was being replaced.

Materials & Methods

Sample Collection & Analyses for the 2002/03 Water Monitoring Program

Water Quality

An experienced consultant and/or MOE staff member collected water samples in laboratory certified polyethylene bottles for a variety of chemical and bacterial analyses. Representative grab samples were collected from the raw water tap inside the village Petro-Can gas station (site E249354 - Water Source ID Tag 1336). The chemical results, analytical detection levels and drinking water quality guidelines are provided in Table 2, Appendix A.

Bottles used for general ion analyses were rinsed three times with source water prior to sample collection. Metal and bacterial bottles were not rinsed and metal samples were lab preserved. Prior to sampling the raw water tap, the source was flushed for 5 minutes in order to minimize contamination by system piping. Water samples were shipped by overnight courier in coolers with ice packs to CanTest Ltd. (from September 2002-March 2003) and JR Laboratories Inc. (April 2003 to September 2003) for bacteria and PSC Environmental Services Ltd. for chemistry. Bacterial samples were analysed using membrane filtration. Metals analysis made use of ICPMS technology.

Quality Assessment (QA)

To ensure accuracy and precision of data, quality assurance and control (QA/QC) procedures were incorporated into the monitoring program. This included use of rigorous sampling protocols, proper training of field staff, setting of data quality objectives and the submission of QA samples to the lab. Field QA included duplicate and blind blank samples. Blank samples detect contamination introduced in the field and/or in the lab. A comparison of duplicate results measures the effect of combined field error, laboratory error and real between-sample variability. The blind blank and duplicate program accounted for roughly 20% of the overall chemistry and bacterial sample numbers.

Results

Water Monitoring Program (2002/03)

Quality Assessment (QA)

The field blank and duplicate results indicate that minimal field or lab contamination of samples with bacteria occurred and that acceptable precision in bacterial sampling and analysis was observed.

The six water chemistry field blank samples that were prepared either the same day or within one day of the Fort Fraser collections tested positive for some parameters. The concentration of most of these parameters was either very close to or less than 5-fold the minimum detectable concentration, an acceptable threshold as per the lab acceptance criteria. Six parameters exceeded these acceptance criteria and are listed below in Table 3.

Table 3. Blind blank samples that tested strongly positive (≥ 5-fold MDL) for chemical contamination.

Date	Parameter	Measured Concentration	MDL
Sep. 25/02	Total Dissolved Phosphorus	0.031 mg/L	0.002 mg/L
Sep. 25/02	Total Phosphorus	0.038 mg/L	0.002 mg/L
Sep. 25/02	Strontium-Dissolved	0.047 µg/L	0.005 µg/L
Sep. 25/02	Tin-Dissolved	0.23 µg/L	0.01 µg/L
Jan. 20/03	Sulfate	14.6 mg/L	0.5 mg/L
Mar. 10/03	Lead-Total	0.19 µg/L	0.01 µg/L

Although the levels of some of these blank results are equal to or greater than the actual concentrations observed in Fort Fraser on some dates, the values are usually well below provincial raw drinking water guidelines by greater than two orders of magnitude. The contamination that did occur may have resulted during the deionization process in the lab or during the transfer of the deionized water between bottles in the field. Regardless, these levels of blank contamination should not limit the comparison of data to water quality guidelines.

The five water chemistry duplicate samples that were prepared either the same day or within one day of the Fort Fraser collections did have some values outside the lab acceptance criteria of 25% relative percent difference (Table 4, Appendix A). The differences that are present may be due to problems with collection and/or analytical precision. Of particular concern is the imprecision of copper, which occurred well above its respective detection level. All of the parameters that did have differences greater than 25% between the duplicates were well below recommended drinking water guidelines.

Bacteriology

The 2002/03 bacterial data are summarised in Table 5.

Drinking water quality guidelines for *E. coli, Enterococci* and fecal coliforms are all 0 CFU/100mL in drinking water supplies that undergo no treatment.

All six samples collected from this water supply contained no detectable bacteria. This data suggests that bacterial concentrations are low throughout the year.

Table 5. Results of bacterial analyses for the Fort Fraser raw water supply. Units are CFU/100mL.

Date	Total Coliform	*E. coli*	*Enterococci*	Fecal Coliform
Provincial Guideline	No Provincial Guideline	0 CFU/100 mL	0 CFU/100 mL	0 CFU/100 mL
Sep. 25/02	<1	<1	<1	<1
Jan. 20/03	<1	<1	<1	<1
Mar. 10/03	<1; <1	<1; <1	<1; <1	<1; <1
Apr. 23/03	<2	<2	<2	<2
May 22/03	<1	<1	<1	<1
Sep. 4/03	<1	<1	<1	<1

Water Chemistry

In 2002/03, ground water samples were collected on six different dates. The water samples were analysed for 15 general parameters as well as for the ICPMS low level metals package that includes 27 metals in the total form.

Of the chemical parameters tested through the duration of this study, none exceeded the provincial guidelines for raw drinking water.

Water hardness, which can often be a problem in ground water supplies, had a mean concentration of 38.5 mg/L $CaCO_3$. Waters that are below 60 mg/L $CaCO_3$ are considered soft. Soft water can cause pipes to corrode and can increase the solubility of heavy metals. Additionally, soft water can be aesthetically unpleasant.

A complete list of the results as well as their corresponding guideline is attached in Table 2, Appendix A. A complete list of the raw data collected during the 2002/03 program is attached in Table 6, Appendix A.

Conclusions & Recommendations

Review of the Fort Fraser ground water data indicates an overall high raw drinking water quality. Water soluble contaminants were present at concentrations well below drinking water guidelines. The only parameter of note was water hardness. The ground water sampled had low hardness concentrations, suggesting very soft water. Although this isn't a major concern, the water may be aesthetically unpleasant and their may be problems with the corrosion of piping.

Based on the lack of information regarding the well, a

300 m radius is arbitrarily assigned as the zone where contamination is most likely (Mike Wei, Senior Hydrogeologist, MOE, p.c.). Since the lithology profile of the well indicates dominantly clay in the upper layers, the aquifer is probably confined and therefore has a very low permeability. This would effectively retard the downward movement of many leachates to the ground water table. Good land use practices within this 300 m zone are still encouraged, as system contamination is always possible.

Because Fort Fraser currently uses no form of water treatment, and there is an abundance of nearby agricultural and range activities, it is also recommended that periodic bacterial samples are collected to ensure that levels do not exceed recommended drinking water guidelines of 0 CFU/100 mL.

Acknowledgements

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Contact Information

For more information regarding either this short report, watershed protection and/or drinking water, please contact the Ministry of Environment (Contact: Bruce Carmichael (Prince George), 250-565-6455) or the Northern Health Authority (Contact: Bruce Gaunt (Prince George), 250-565-2150 or Caroline Alexander (Fort St. John), 250-787-3355).

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B.C. Ministry of Environment,
1011—4th Avenue (3rd Floor),
PRINCE GEORGE, B.C., CANADA,
V2L 3H9
Tel: (250) 565-6135
Fax: (250) 565-6629

Appendix A

Table 2. 2002/03 sample parameters, summaries of current results and associated B.C. drinking water guidelines.

Parameter	# of Values	Min.	Max.	Mean	Std. Dev.	MDL	D.W. Guideline	Guideline Type
General								
pH	6	8.1	8.4	8.2	0.12	0.1	6.5-8.5	aesthetic objective
Colour (TCU)	6	5	5	5	0.0	5	≤ 15	aesthetic objective
Specific Conductance (µS/cm)	6	217	229	224	4.28	1	≤ 700	maximum acceptable concentration
Turbidity (NTU)	4	0.1	0.2	0.13	0.049	0.1	≤ 5	maximum acceptable concentration
Hardness Total (mg/L)	6	37.1	40.1	38.5	1.05		≤ 500 $CaCO_3$ (Diss.)	aesthetic objective
Alkalinity (mg/L)	6	98	104	101	2.2	0.5		
Residue Non-Filterable (mg/L)	5	4	4	4	0.0	4		
Total Organic Carbon (mg/L)								
TOC	6	0.5	1.3	0.6	0.32	0.5	≤ 4	maximum, to control THM production
Anions (mg/L)								
Chloride Dissolved	6	1.7	2.2	1.8	0.20	0.5	≤ 250	aesthetic objective
Fluoride Dissolved	6	0.12	0.15	0.14	0.012	0.01	≤ 1.5	maximum acceptable concentration
Bromide Dissolved	6	0.1	0.1	0.1	0.00	0.1		
Nutrients (mg/L)								
Nitrate+Nitrite	6	0.002	0.495	0.086	0.200	0.002	≤45 (Nitrate)	maximum acceptable concentration
Phosphorus Total	1	0.004	0.004	0.004		0.002		
Phosphorus Total-Diss.	1	0.003	0.003	0.003		0.002		
Sulphate (mg/L)								
Sulphate	6	13.3	17.3	14.5	1.43	0.5	≤ 500	aesthetic objective
Metals Total (ug/L)								
Aluminum-T	6	0.3	0.8	0.5	0.21	0.3	≤ 200 (Diss.)	maximum acceptable concentration
Antimony-T	6	0.005	0.023	0.008	0.007	0.005	≤ 6	interim maximum acceptable concentration
Arsenic-T	6	0.4	0.6	0.5	0.09	0.1	≤ 25	interim maximum acceptable concentration
Barium-T	6	1.24	1.41	1.33	0.070	0.02	≤ 1000	maximum acceptable concentration
Beryllium-T	6	0.02	0.02	0.02	0.000	0.02		
Bismuth-T	6	0.02	0.02	0.02	0.000	0.02		
Cadmium-T	6	0.01	0.03	0.02	0.008	0.01	≤ 5	maximum acceptable concentration
Calcium-T (mg/L)	6	10.4	11.3	10.9	0.31	0.05		
Chromium-T	6	0.2	0.2	0.2	0.00	0.2	≤ 50	maximum acceptable concentration
Cobalt-T	6	0.005	0.012	0.008	0.003	0.005		
Copper-T	6	1.51	2.23	1.97	0.266	0.05	≤ 1000	aesthetic objective
Iron-T (mg/L)	5	0.008	0.011	0.010	0.001	0.005	≤ 0.3	aesthetic objective
Lead-T	6	0.01	0.03	0.02	0.008	0.01	≤ 10	maximum acceptable concentration
Lithium-T	6	1.62	2.02	1.80	0.160	0.05		
Magnesium-T (mg/L)	6	2.64	2.89	2.74	0.084	0.05	≤ 100 (Diss.)	aesthetic objective
Manganese-T	6	1.15	3.77	2.94	0.911	0.008	≤ 50	aesthetic objective
Molybdenum-T	6	11.7	13	12.5	0.45	0.05	≤ 250	maximum acceptable concentration
Nickel-T	6	0.05	0.05	0.05	0.000	0.05		
Selenium-T	6	0.2	0.2	0.2	0.00	0.2	≤ 10	maximum acceptable concentration
Silver-T	6	0.02	0.02	0.02	0.000	0.02		
Sodium-T (mg/L)	5	36.4	40	37.4	1.52	0.05	≤ 200	aesthetic objective
Strontium-T	6	66.2	72.2	69.3	2.58	0.005		
Thallium-T	6	0.004	0.01	0.008	0.002	0.002	≤ 2	maximum acceptable concentration
Tin-T	6	0.01	3.93	0.67	1.596	0.01		
Uranium-T	6	0.368	0.411	0.394	0.015	0.002	≤ 100	maximum acceptable concentration
Vanadium-T	6	1.98	5.9	5.03	1.528	0.06	≤ 100	maximum acceptable concentration
Zinc-T	6	0.1	3.5	2.6	1.30	0.1	≤ 5000	aesthetic objective

Table 4. Duplicate samples that exceeded precision acceptability criteria (≤25% difference when >5-fold MDL). All concentrations in µg/L.

Parameter	MDL (µg/L)	September/02			January/03			April/03			May/03		
		Conc. 1	Conc. 2	RPD %	Conc. 1	Conc. 2	RPD %	Conc. 1	Conc. 2	RPD %	Conc. 1	Conc. 2	RPD %
Antimony-T	0.005	0.034	0.057	**50.5**	0.03	0.042	**33.3**						
Copper-T	0.05	4.85	8.97	**59.6**				0.36	0.78	**73.7**			
Copper-D	0.05	6.19	3.49	**55.8**									
Lead-T	0.01	0.38	0.69	**57.9**				0.01	0.09	**160**			
Lithium-T	0.05	0.28	0.05	**139**							0.22	0.29	**27.4**
Tin-T	0.01	0.04	0.09	**76.9**									
Zinc-T	0.1							0.9	1.4	**43.5**			

RPD %=Relative Percent Difference
**Data are presented for the purpose of batch specific QA assessment. Most QA samples were not collected at Fort Fraser.*

Table 6. 2002/03 raw water quality data collected from the Fort Fraser drinking water supply.

	Total Coliform (CFU/100mL)	Fecal Coliform (CFU/100mL)	Enterococci (CFU/100mL)	E. Coli (CFU/100mL)	pH (pH Units)
25-Sep-02	<1	<1	<1	<1	8.1
20-Jan-03	<1	<1	<1	<1	8.1
10-Mar-03	<1	<1	<1	<1	8.1
10-Mar-03	<1	<1	<1	<1	8.1
23-Apr-03	<2	<2	<2	<2	8.2
22-May-03	<1	<1	<1	<1	8.2
13-Aug-03					8.4
04-Sep-03	<1	<1	<1	<1	

True Colour (Col. Unit)	Specific Conductance (µS/cm)	Residues - NonFilt. (mg/L)	Turbidity (NTU)	Hardness - Total (mg/L)	Alkalinity - T as $CaCO_3$ (mg/L)
<5	225			37.8	98
5	217	<4		37.1	102
5	229	<4	<0.1	38.8	104
5	229	<4	0.1	38.7	104
<5	228	<4	0.11	39.1	103
<5	225	<4	<0.1	40.1	101
<5	223	<4	0.2	38.3	99.9

Bromide - Diss. (mg/L)	Chloride - Diss. (mg/L)	Fluoride - Diss. (mg/L)	Carbon - Tot. Org. (mg/L)	$NO_2 + NO_3$ (mg/L)	Phosphorus - Tot. Diss. (mg/L)
<0.1	1.7	0.15	0.6	<0.002	
<0.1	2.2	0.13	1.3	0.009	
<0.1	1.7	0.15	<0.5	<0.002	
<0.1	1.8	0.14	<0.5	<0.002	
<0.1	1.9	0.12	<0.5	0.006	
<0.1	1.7	0.15	0.5	<0.002	0.003
<0.1	1.7	0.14	<0.5	0.495	

Phosphorus - Tot. (mg/L)	Sulfate (mg/L)	Aluminum - Tot. (µg/L)	Antimony - Tot. (µg/L)	Arsenic - Tot. (µg/L)	Barium - Tot. (µg/L)
	14	<0.3	0.023	0.4	1.36
	14.6	0.5	0.005	0.4	1.39
	13.8	<0.3	0.008	0.5	1.31
	13.8	<0.3	<0.005	0.5	1.29
	14	0.6	0.005	0.6	1.41
0.004	17.3	0.7	<0.005	0.6	1.26
	13.3	0.8	<0.005	0.5	1.24

Beryllium - Tot. (µg/L)	Bismuth - Tot. (µg/L)	Cadmium - Tot. (µg/L)	Calcium - Tot. (mg/L)	Chromium - Tot. (µg/L)	Cobalt - Tot. (µg/L)
<0.02	<0.02	0.02	10.8	<0.2	<0.005
<0.02	<0.02	<0.01	10.4	<0.2	<0.005
<0.02	<0.02	0.03	11	<0.2	0.01
<0.02	<0.02	0.02	11	<0.2	<0.005
<0.02	<0.02	0.03	11.1	<0.2	<0.005
<0.02	<0.02	0.02	11.3	<0.2	0.011
<0.02	<0.02	0.03	10.9	<0.2	0.012

Copper - Tot. (µg/L)	Iron - Tot. (mg/L)	Lead - Tot. (µg/L)	Lithium - Tot. (µg/L)	Magnesium - Tot. (mg/L)	Manganese - Tot. (µg/L)
1.51		<0.01	1.65	2.64	1.15
2.01	0.01	<0.01	1.62	2.71	3.27
1.85	0.009	0.03	1.77	2.74	3.14
1.84	0.008	0.03	2.27	2.73	3.14
1.99	0.01	<0.01	1.73	2.76	3.19
2.23	0.008	0.02	1.94	2.89	3.15
2.21	0.011	0.02	1.83	2.7	3.77

Molybdenum - Tot. (µg/L)	Nickel - Tot. (µg/L)	Selenium - Tot. (µg/L)	Silver - Tot. (µg/L)	Sodium - Tot. (mg/L)	Strontium - Tot. (µg/L)
11.7	<0.05	<0.2	<0.02		71.7
12.3	<0.05	<0.2	<0.02	36.4	70.9
12.5	<0.05	<0.2	<0.02	36.6	66.9
12.5	<0.05	<0.2	<0.02	36.6	68
13	<0.05	<0.2	<0.02	36.5	72.2
12.8	<0.05	<0.2	<0.02	40	67.4
12.6	<0.05	<0.2	<0.02	37.4	66.2

Thallium - Tot. (µg/L)	Tin - Tot. (µg/L)	Uranium - Tot. (µg/L)	Vanadium - Tot. (µg/L)	Zinc - Tot. (µg/L)
0.01	3.93	0.395	1.98	3.5
0.004	0.02	0.411	5.9	3.4
0.009	<0.01	0.391	5.89	<0.1
0.008	<0.01	0.386	5.86	<0.1
0.009	0.01	0.407	5.61	3.5
0.007	0.01	0.392	5.78	2.6
0.009	0.05	0.368	5.01	2.5