Assessment of the Sinclair Mills 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. An upstream view of the Pritchard Creek water supply dam.

MOE implemented a source 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 source water,
- whether past outbreaks of waterborne illness have 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 Sinclair Mills raw potable water source, Pritchard Creek (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.

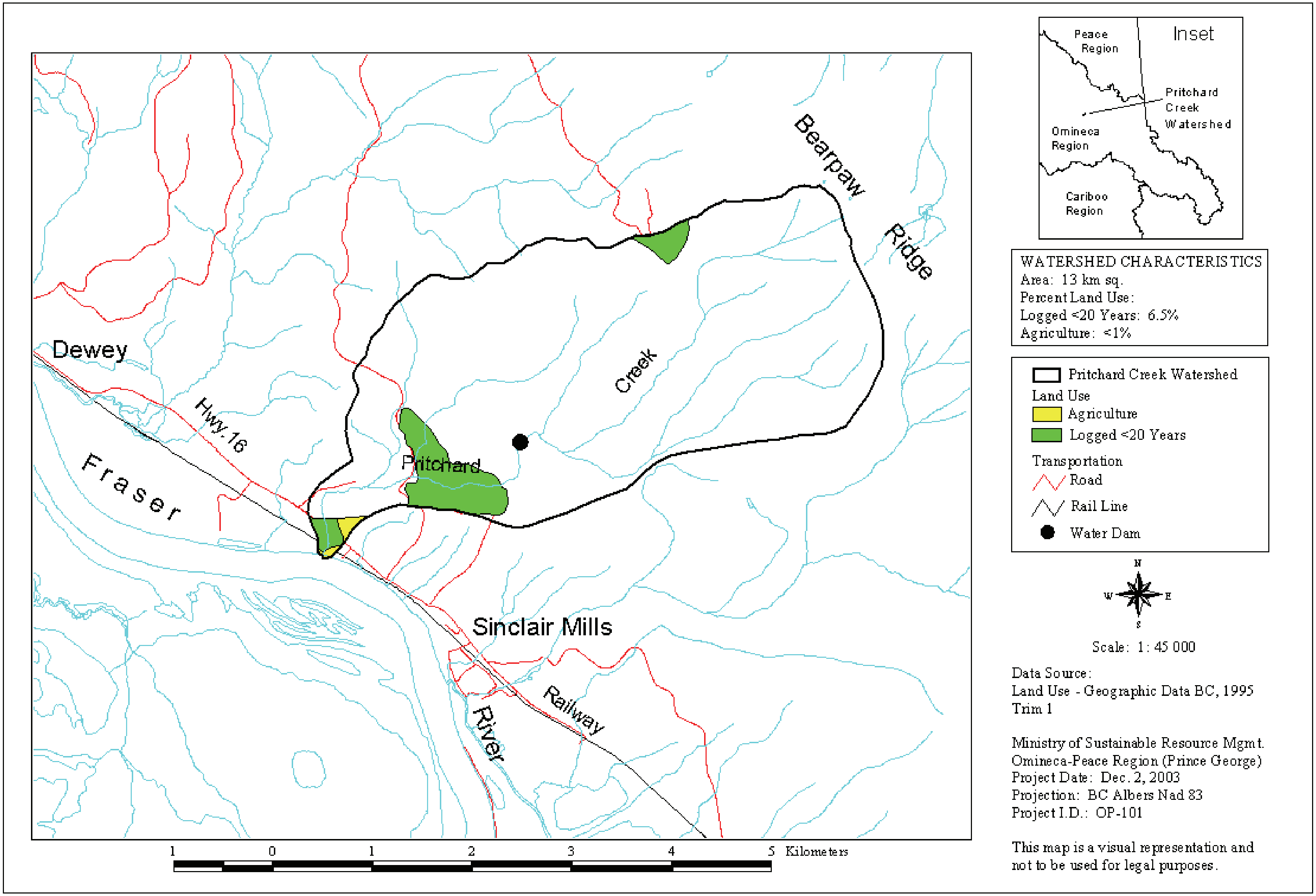

Figure 1. The Pritchard Creek watershed and associated land-use practices.

Site Description

Watershed Overview

The Pritchard Creek watershed lies within three biogeoclimatic zones including the Sub-Boreal Spruce, Interior Cedar-Hemlock, and Engleman Spruce-Subalpine Fir. The Sub-Boreal Spruce zone has gently rolling terrain, dense coniferous forests, and extremes in the annual temperature range. The Interior Cedar Hemlock zone generally has long warm summers, cool wet winters and productive coniferous forests. The Engleman Spruce-Subalpine Fir zone has hilly mountainous terrain, cold and snowy conditions (a snowpack of 2-3 m) for 5-7 months of the year, and short cool summers (B.C. Ministry of Forests, 1998).

Pritchard Creek drains the southwestern slope of Bear Paw Mountain and has a steep gradient through the upper sections of the watershed. The moderate to high gradient throughout generates a fast stream velocity that is dominated by a cobble-boulder substrate (Plate 2).

Plate 2. Pritchard Creek approximately 75m downstream of the water supply dam. The bottom substrate of Pritchard Creek is dominantly cobbles and boulders.

Pritchard Creek drains approximately 13 km^2 and has a total length of 7.58 km (Figure 1). The river flows to the southwest, with the mainstem originating north of Sinclair Mills. Pritchard Creek flows into the Fraser River west of Sinclair Mills and has no named tributaries.

There is not an abundance of land-use practices within the Pritchard Creek watershed, however, some old forestry cut-blocks are present. Other land clearing activities in the watershed include both agricultural and residential development, however, these are located downstream of the water supply dam. With a relatively low proportion of the land upstream of the water intake being cleared for forestry, the hydrologic cycle on Pritchard Creek has probably not been disturbed to any great extent. However, no hydrological data exist to corroborate this claim.

According to water licensing information made available by Land and Water B.C., the withdrawal rate from Pritchard Creek for domestic use is 10,500 gallons/day. Mr. Erwin Stoll (a director for the Willow River-Upper Fraser area with the Regional District of Fraser-Fort George) has indicated that there are no concerns with water shortages from Pritchard Creek, and that low flows are not a problem throughout the hydrological cycle.

Drinking Water Supply & Treatment

The residents of Sinclair Mills draw their domestic water from Pritchard Creek. Water samples were collected at Mr. Erwin Stoll's residence, which has geographic co-ordinates of 54.0217N/121.6788W. There is currently no treatment of the raw water, which is distributed to 13 water users (Stoll, p.c.).

The community has no current concerns with the existing water system, regarding both source raw water quality or quantity (Stoll, p.c.). There have been situations in the past where boil water advisories were issued, possibly originating from wildlife accessing the small reservoir which is not enclosed by fencing (Stoll, p.c.).

Materials & Methods

Review of Previous Data

Historical data relevant to the Sinclair Mills raw water supply assessment have been included in this report. The data were copied from Northern Health Authority (NHA) files, and include bacterial data.

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 at Erwin Stoll's residence (site E249346 - Water Source ID Tag 1329). The chemical results, analytical detection levels and drinking water quality guidelines are provided in Table 1, 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. Water samples were shipped by overnight courier in coolers with ice packs to CanTest Ltd. (from September 2002-March 2003) amd 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. Dissolved metal samples were lab filtered within 24 hours after collection through a 0.45 µm membrane filter. Samples for the analysis of cysts and oocysts of the *Giardia* and *Cryptosporidium* parasites were collected using the high volume filtering method described in EPA (1995) (Plate 3 and Figure 2). Filters were shipped by overnight courier in a cooler with ice packs to the B.C. Centre for Disease Control's Enhanced Water Laboratory for analysis.

Plate 3. The parasite filtration kit attached to the raw water tap at Erwin Stoll's residence.

Bottom Sediment Quality

Bottom sediments were collected from Pritchard Creek during the October, 2002 low flow. Stream sediment was analyzed to determine the possible presence of upstream sources of contaminants that were not detected in the water samples. Where follow up is deemed to be necessary, additional monitoring will depend on the type and level of contamination. Samples were collected from several submerged silt/clay areas in the stream using two acetone washed stainless steel spoons for organic analysis, and plastic spoons for metal/grain size analysis. At least one 3-5 cm deep sediment sample was gently scooped from each of a number of these depositional areas with the large spoon. Each of these scoops was sub-divided from the larger spoon into jars for grain size, total organic carbon, hydrocarbons and pesticides, using a second, smaller spoon. Sampling proceeded in an upstream direction with each depositional zone contributing a small amount of fine sediment to each container.

Sediment samples were kept cool and shipped to PSC Environmental Laboratories Ltd. for analysis within three days of collection. At the lab, the sample was dried, disaggregated, sieved at 2 mm and leached with a strong acid for metals analysis. The sample date and sample parameter concentrations are provided in Table 2, Appendix A.

For further details on the analytical methods abbreviated above, refer to Greenberg *et al.* (1992), EPA (1995), PSC (2002) and British Columbia Field Sampling Manual (2003).

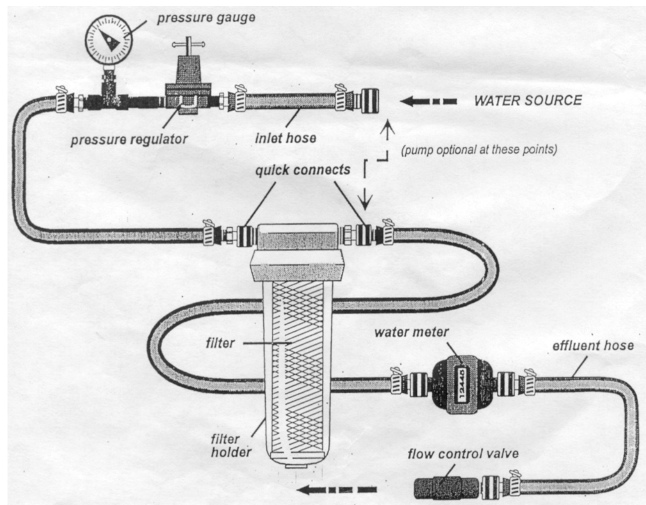

Figure 2. Schematic of the high-volume filtration unit used to sample raw water for Cryptosporidium oocysts and Giardia cysts (from EPA, 1995)

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 quality assurance 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.

Duplicate sediment samples were collected by distributing sediment from each scoop into both sample jars. Differences between duplicate results indicate collection and/or analytical inconsistencies and/or natural variability in physical and chemical properties.

Results

Review of Previous Data

Bacteriology

The Northern Health Authority (NHA) sampled the Sinclair Mills raw water supply from two different residences in 2002 for total and fecal coliforms. The results of this raw water bacterial program are presented in Table 3. There are no historical chemistry data known to exist for this site.

Table 3. Historical bacterial data for the Sinclair Mills raw water supply. Samples were collected from two different residences, both of which receive no water treatment.

Parameter	Fecal Coliforms (CFU/100mL)		Total Coliforms (CFU/100mL)	
Provincial Guidelines	0 CFU/100 mL		No Provincial Guideline	
Residence	**Cook**	**Mueller**	**Cook**	**Mueller**
Apr. 8/02	<1	-	<1	-
Jun. 10/02	**3**	-	6	-
Jul. 2/02	**2**	**26**	22	63
Aug. 15/02	**4**	**2**	47	26

Of the six samples collected in 2002 for fecal coliform culturing, five exceeded the maximum guideline for untreated drinking water supplies (0 CFU/100mL). The sample that produced the greatest number of fecal coliform colonies was collected on July 2nd (26 CFU/100mL) from the Mueller residence.

High counts of total coliforms were also noted, especially on the July 2nd and August 15th sample dates. These values ranged from 22-63 CFU/100 mL. There are currently no provincial guidelines for total coliforms.

These historical bacterial data indicate that water from Pritchard Creek was not suitable for human consumption in an untreated state during certain periods of the year, as is the case for most surface waters. The most probable source of this contamination was from wildlife, as no agricultural activity were present upstream of the intake. This has been corroborated by local water purveyors.

Water Monitoring Program (2002/03)

Quality Assessment (QA)

The field blank and duplicate results indicate that no field or lab contamination of samples with bacteria occurred and that acceptable precision in bacterial sampling and analysis was observed. The parasite analysis provided duplicate precision results for *Giardia* of between 7 and 26%. No duplicate *Cryptosporidium* oocyst analysis produced detectable results.

The three water chemistry field blank samples that were prepared either the same day or within one day of the Sinclair Mills 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. Only one parameter was measured at a concentration over this threshold, and was detected on January 21st, 2003. The blind blank total zinc concentration was measured at 1.5 µg/L, greater than five times the MDL concentration of 0.1 µg/L. This value was well below the Sinclair Mills total zinc value of 90.9 µg/L for the same day. 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 drinking water guidelines.

Four of the five water chemistry duplicate samples that were prepared either the same day or within one day of the Sinclair Mills 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 is 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.

The duplicate sediment samples indicated that the variations between duplicates were most likely the result of natural in-stream variations rather than collection and/or analytical inconsistencies (Table 5, Appendix A). The lab acceptance criteria for duplicate variation is 35% for metals and other inorganics. All duplicate values, as indicated in Table 5, are within this range.

Bacteriology

The 2002/03 bacterial data are summarised in Table 6. Drinking water quality guidelines for *E. coli, Enterococci* and fecal coliforms are all 0 CFU/100mL in drinking water supplies that undergo no treatment.

Most samples collected from this water supply contained no detectable bacteria. The August 11th sample did have positive results for all of the tested parameters. These bacteria may have resulted from wildlife entering Pritchard Creek, as previously mentioned. Fecal coliform concentrations, such as those observed on August 11th, 2003 can induce human illness.

Table 6. Results of bacterial analyses for Sinclair Mills 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
Oct. 10/02	31	<1	**3**	<1
Jan. 21/03	<1	<1	<1	<1
Mar. 24/03	5	<1	<1	<1
Apr. 24/03	<2	<2	<2	<2
May 24/03	8	<2	<2	<2
Aug. 11/03	120; 110	**6; 10**	**3; 3**	**10; 9**

Parasitology

The 2002/03 parasite data are summarised in Table 7. No *Cryptosporidium* oocysts were detected in any of the six samples during the 2002/03 program. By comparison, *Giardia* cysts were detected on one occasion, October 24th, 2003, when 4.1 cysts/100L were detected.

The B.C. Ministry of Health, as well as the U.S. Environmental Protection Agency (EPA), recommend a minimal removal or deactivation of 3 log (99.9%) for *Giardia* cysts through filtration and/or disinfection between raw and tap water. The EPA further suggests that it is important to consider multiple barriers of protection: watershed management, filtration, disinfection, and the protection of the integrity of the distribution system. Sinclair Mills water users have no water treatment.

Table 7. Parasite densities observed in the Sinclair Mills raw water supply over the period October 24/2002 to August 11/2003.

Date	Cryptosporidium (oocysts/100L)	Giardia (cysts/100L)
Oct. 24/02	<1.4	**4.1**
Jan 21/03	<5	<5
Mar. 23/03	<1.9	<1.9
Apr. 24/03	<2.9	<2.9
May 21/03	<3.5	<3.5
Aug. 11/03	<1.6	<1.6

Water Chemistry

In 2002/03, Sinclair Mills raw water was sampled 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 both the total and dissolved form.

Of the chemical parameters tested through the duration of this study, none exceeded the provincial guidelines for raw drinking water. Two parameters had maximum concentrations ≥ 75% of their respective guideline value and are highlighted here:

Colour (TCU) - The mean colour concentration for the year was 7.9 TCU with a maximum of 15 TCU (the recommended water quality guideline is 15 TCU). The maximum recorded value was collected on April 24th, 2003, which may have been influenced by spring runoff. The colour of water is a measure of its dissolved compounds (attributed to the presence of organic and inorganic materials). High colour levels are regarded as a pollution problem in terms of aesthetics, and can be influenced by agricultural and industrial effluents (RIC, 1998). Colour can also occur naturally from the breakdown of organic material.

Total Organic Carbon (mg/L) - The mean TOC concentration for the year was 2.4 mg/L with a maximum of 3.9 mg/L (the recommended water quality guideline is 4 mg/L). This is a measure of the dissolved and particulate organic carbon in the water. TOC can be important in drinking water systems that use chlorination, as high levels can influence the formation of trihalomethanes which are considered carcinogens. Anthropogenic sources of TOC include agricultural, municipal and industrial waste discharges (RIC, 1998). TOC can also originate naturally from organic soils and wetlands.

The data from this study indicate that the chemical parameter concentrations in Pritchard Creek are generally low throughout the year.

A complete list of the results as well as their corresponding guideline, is attached in Table 1, Appendix A. A complete list of the raw data is attached in Table 8, Appendix A.

Bottom Sediment Chemistry

Of the 29 sediment metals analyzed, 24 were detected (Table 2, Appendix A). High concentrations of copper, iron and nickel were found, however, water samples collected throughout the duration of this project showed very low concentrations relative to existing drinking water guidelines.

No compounds in the following classes (which are or could be man made) were detected in Pritchard Creek sediments:

- Total oil & grease
- Chlorinated phenols
- Phenoxy acid herbicides
- Organochlorine pesticides
- Polychlorinated biphenyls
- Organophosphorus pesticides
- Polycyclic aromatic hydrocarbons

Conclusions & Recommendations

Review of the Pritchard Creek/Sinclair Mills data indicates an overall high raw drinking water quality. All water chemistry parameters were below recommended water quality guidelines with only two parameters at levels of some interest. Three sediment parameters exceeded their aquatic life guidelines, however, these parameters were detected at low concentrations in the raw water samples. Bacterial data collected during the 2002/03 program, as well as the historical Northern Health Authority data, suggest that concentrations are problematic during certain times of the year (mainly late summer). The levels appear to rise significantly above the recommended guideline of 0 CFU/100 mL for a drinking water source receiving no treatment. As previously noted, these high bacterial levels are probably attributable to wildlife feces entering the stream above the water intake.

One way to help prevent/decrease the level of fecal contamination would be to fence off the water dam and reservoir. This is a quick and cost effective method and would probably help decrease the wildlife access. Another way to help decrease resulting health issues would be to disinfect the water. However, chlorination may react with the high TOC levels and result in the formation of trihalomethane's. Regardless, on a system showing fecal contamination that does not receive water treatment, water sampling should continue so that boil water advisories can be issued when needed. High frequency sampling is recommended during late summer when data from this program as well as historical programs, show high fecal concentrations.

Acknowledgements

We thank Mr. Erwin Stoll for allowing us to use the raw water taps at his residence, as well as for his knowledge on Pritchard Creek. Mr. Todd French is recognized for his help in designing and implementing the project (TDF Watershed Solutions, Research & Management). Mr. Mohamad Khan (Enhanced Water Laboratory, B.C. Centre for Disease Control, Vancouver) provided us with the *Cryptosporidium* and *Giardia* sampling equipment, documentation on parasite collection methodologies and information critical to data interpretation.

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Contact Information

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Appendix A

Table 1. 2002/03 sample parameters, their Minimum Detectable Limit (MDL), and their associated B.C. water quality guideline.

Parameter	# of Values	Min.	Max.	Mean	Std. Dev.	MDL	D.W. Guideline	Guideline Type
General								
pH	6	7.8	8.1	7.92	0.133	0.1	6.5-8.5	aesthetic objective
Colour (TCU)	6	5	15	7.9	4.00	5	≤ 15	aesthetic objective
Specific Conductance (μS/cm)	6	121	215	168.6	38.96	1	≤ 700	maximum acceptable concentration
Turbidity (NTU)	6	0.16	0.61	0.30	0.184	0.1	≤ 5	maximum acceptable concentration
Hardness Total (mg/L)	6	63.1	111	87.43	21.970			
Hardness Total -Diss. (mg/L)	6	63.1	108	86.56	19.907		≤ 500 $CaCO_3$	aesthetic objective
Alkalinity (mg/L)	6	50	79	65.6	11.65	0.5		
Residue Non-Filterable (mg/L)	6	4	4	4.0	0.00	4		
Total Organic Carbon (mg/L)								
TOC	6	0.9	3.9	2.41	1.045	0.5	≤ 4	maximum, to control THM production
Anions (mg/L)								
Chloride Dissolved	6	0.5	0.9	0.57	0.163	0.5	≤ 250	aesthetic objective
Fluoride Dissolved	6	0.02	0.06	0.040	0.014	0.01	≤ 1.5	maximum acceptable concentration
Bromide Dissolved	6	0.1	0.1	0.10	0.000	0.1		
Nutrients (mg/L)								
Nitrate+Nitrite	6	0.043	0.168	0.110	0.058	0.002	≤ 45 (Nitrate)	maximum acceptable concentration
Phosphorus Total	6	0.002	0.005	0.000	0.001	0.002		
Phosphorus Total-Diss.	6	0.0025	0.005	0.000	0.001	0.002		
Sulphate (mg/L)								
Sulphate	6	8.5	27.6	17.50	8.564	0.5	≤ 500	aesthetic objective
Metals Total (ug/L)								
Aluminum-T	6	4.2	43.6	15.56	14.277	0.3		
Aluminum-D	6	3.3	23.2	10.29	7.375	0.3	≤ 200	maximum acceptable concentration
Antimony-T	6	0.005	0.038	0.02	0.014	0.005	≤ 6	interim maximum acceptable concentration
Antimony-D	6	0.005	0.030	0.020	0.010	0.005		
Arsenic-T	6	0.1	0.3	0.15	0.084	0.1	≤ 25	interim maximum acceptable concentration
Arsenic-D	6	0.1	0.3	0.16	0.080	0.1		
Barium-T	6	18.8	29.7	23.98	5.561	0.02	≤ 1000	maximum acceptable concentration
Barium-D	6	17.95	29.4	23.44	5.715	0.02		
Beryllium-T	6	0.02	0.02	0.02	0.000	0.02		
Beryllium-D	6	0.02	0.02	0.02	0.000	0.02		
Bismuth-T	6	0.02	0.03	0.02	0.004	0.02		
Bismuth-D	6	0.02	0.02	0.02	0.000	0.02		
Cadmium-T	6	0.01	0.04	0.02	0.012	0.01	≤ 5	maximum acceptable concentration
Cadmium-D	6	0.01	0.01	0.01	0.000	0.01		
Calcium-T (mg/L)	6	19.8	34.7	27.29	6.920	0.05		
Calcium-D (mg/L)	6	19.4	34	26.99	6.396	0.05		
Chromium-T	6	0.2	0.2	0.20	0.000	0.2	≤ 50	maximum acceptable concentration
Chromium-D	6	0.2	0.2	0.20	0.000	0.2		
Cobalt-T	6	0.005	0.040	0.020	0.013	0.005		
Cobalt-D	6	0.005	0.032	0.010	0.011	0.005		
Copper-T	6	1.09	10.85	3.38	3.728	0.05	≤ 1000	aesthetic objective
Copper-D	6	1.11	5.64	2.23	1.741	0.05		
Iron-T (mg/L)	6	0.005	0.094	0.030	0.036	0.005	≤ 0.3	aesthetic objective
Iron-D (mg/L)	6	0.005	0.023	0.010	0.008	0.005		
Lead-T	6	0.26	1.275	0.550	0.362	0.01	≤ 10	maximum acceptable concentration
Lead-D	6	0.12	0.47	0.300	0.164	0.01		
Lithium-T	6	0.05	0.31	0.170	0.107	0.05		
Lithium-D	6	0.05	0.32	0.180	0.114	0.05		
Magnesium-T (mg/L)	6	3.44	5.94	4.670	1.092	0.05		
Magnesium-D (mg/L)	6	3.56	5.82	4.660	0.964	0.05	≤ 100	aesthetic objective

Table 1 Continued.

Parameter	# of Values	Min.	Max.	Mean	Std. Dev.	MDL	D.W. Guideline	Guideline Type
Manganese-T	6	0.462	3.05	1.180	1.013	0.008	≤ 50	aesthetic objective
Manganese-D	6	0.183	0.494	0.310	0.135	0.008		
Molybdenum-T	6	0.28	0.68	0.460	0.144	0.05	≤ 250	maximum acceptable concentration
Molybdenum-D	6	0.28	0.505	0.420	0.092	0.05		
Nickel-T	6	0.05	0.15	0.080	0.052	0.05		
Nickel-D	6	0.05	0.16	0.080	0.046	0.05		
Selenium-T	6	0.2	0.2	0.20	0.000	0.2	≤ 10	maximum acceptable concentration
Selenium-D	6	0.2	0.2	0.20	0.000	0.2		
Silver-T	6	0.02	0.02	0.020	0.000	0.02		
Silver-D	6	0.02	0.02	0.020	0.000	0.02		
Sodium-T (mg/L)	6	0.58	0.81	0.730	0.102	0.05	≤ 200	aesthetic objective
Strontium-T	6	70.1	140	101.0	29.19	0.005		
Strontium-D	6	70.5	142	99.38	29.329	0.005		
Thallium-T	6	0.002	0.007	0.003	0.002	0.002	≤ 2	maximum acceptable concentration
Thallium-D	6	0.002	0.004	0.003	0.001	0.002		
Tin-T	6	0.01	0.08	0.020	0.029	0.01		
Tin-D	6	0.01	0.065	0.020	0.022	0.01		
Uranium-T	6	0.056	0.125	0.080	0.028	0.002	≤ 100	maximum acceptable concentration
Uranium-D	6	0.05	0.122	0.080	0.029	0.002		
Vanadium-T	6	0.27	1.69	0.590	0.543	0.06	≤ 100	maximum acceptable concentration
Vanadium-D	6	0.09	0.49	0.330	0.137	0.06		
Zinc-T	6	28.35	90.9	59.56	26.592	0.1	≤ 5000	aesthetic objective
Zinc-D	6	18.9	117	58.08	37.909	0.1		

Table 2. Sediment sampling results from the October 24th, 2002 sampling date.

Parameter	Unit	Value	Parameter	Unit	Value	Parameter	Unit	Value
% Moisture	(% W/W)	16.1	Pentachlorophenol	(µg/g)	<0.005	Dimethoate	(µg/g)	<0.02
Gravel (2.0 mm)	(% (W/W)	14.6	Bromoxynil	(µg/g)	<0.01	Ethion	(µg/g)	<0.05
Solid Content	(%)	84	2,4-D	(µg/g)	<0.01	Fenitrothion	(µg/g)	<0.02
Coarse Sand (0.59 mm)	(% W/W)	39.3	Dicamba	(µg/g)	<0.005	Fensulfothion	(µg/g)	<0.01
Medium Sand (0.297 mm)	(% W/W)	26.9	Dichlorprop	(µg/g)	<0.01	Fenthion	(µg/g)	<0.02
Fine Sand (0.149 mm)	(% W/W)	14.8	Dinoseb	(µg/g)	<0.1	Fonofos	(µg/g)	<0.02
Very Fine Sand (0.053 mm)	(% W/W)	4.1	MCPA	(µg/g)	<0.01	Iodofenphos	(µg/g)	<0.01
Silt (0.037 mm)	(% W/W)	0.2	Picloram	(µg/g)	<0.01	Malathion	(µg/g)	<0.01
Clay (<0.037 mm)	(% W/W)	0.3	2,4,5-T	(µg/g)	<0.005	Mevinphos-cis	(µg/g)	<0.05
Carbon - Tot. Inorg.	(µg/L)	570	2,4,5-TP	(µg/g)	<0.005	Methamidophos	(µg/g)	<0.05
Carbon - Tot. Org.	(µg/L)	2900	Triclopyr	(µg/g)	<0.005	Naled	(µg/g)	<0.01
Carbon - Tot.	(µg/g)	3500	Aldrin	(µg/g)	<0.002	Omethoate	(µg/g)	<0.02
Phosphorus - Tot.	(µg/g)	2110	BHC, Alpha-	(µg/g)	<0.002	Parathion	(µg/g)	<0.01
Aluminum - Tot.	(µg/g)	7390	BHC, Beta-	(µg/g)	<0.002	Parathion Methyl	(µg/g)	<0.02
Antimony - Tot.	(µg/g)	0.2	BHC, Delta-	(µg/g)	<0.002	Phorate	(µg/g)	<0.02
Arsenic - Tot.	(µg/g)	4	Chlordane, Alpha-	(µg/g)	<0.01	Phosalone	(µg/g)	<0.05
Barium - Tot.	(µg/g)	72.5	Chlordane, Gamma-	(µg/g)	<0.01	Phosmet	(µg/g)	<0.03
Beryllium - Tot.	(µg/g)	0.3	DDD,p,p'-	(µg/g)	<0.01	Phosphamidon	(µg/g)	<0.05
Bismuth - Tot.	(µg/g)	<0.1	DDE-p,p'	(µg/g)	<0.005	Sulfotep	(µg/g)	<0.02
Cadmium - Tot.	(µg/g)	0.14	DDT-o,p'-	(µg/g)	<0.01	Tetrachlorvinphos	(µg/g)	<0.02
Calcium - Tot.	(µg/g)	10800	DDT-p,p'-	(µg/g)	<0.02	Oil & Grease - Tot.	(µg/g)	<100
Chromium - Tot.	(µg/g)	31.5	Dieldrin	(µg/g)	<0.01	Acenaphthene	(µg/g)	<0.01
Cobalt - Tot.	(µg/g)	11.8	Endosulfan I	(µg/g)	<0.01	Acenaphthylene	(µg/g)	<0.01
Copper - Tot.	(µg/g)	49.5	Endosulfan II	(µg/g)	<0.01	Anthracene	(µg/g)	<0.01
Iron - Tot.	(µg/g)	31700	Endosulfan Sulphate	(µg/g)	<0.02	Benzo(a)anthracene	(µg/g)	<0.01
Lead - Tot.	(µg/g)	6.9	Endrin	(µg/g)	<0.02	Benzo(b)fluoranthene	(µg/g)	<0.01
Magnesium - Tot.	(µg/g)	7260	Hepatachlor	(µg/g)	<0.002	Benzo(k)fluoranthene	(µg/g)	<0.01
Manganese - Tot.	(µg/g)	291	Hepatachlor epoxide	(µg/g)	<0.004	Benzo(g,hi)perylene	(µg/g)	<0.02
Molybdenum - Tot.	(µg/g)	0.8	Lindane, BHC, Gamma-	(µg/g)	<0.002	Benzo(a)pyrene	(µg/g)	<0.01
Nickel - Tot.	(µg/g)	32.5	Methidathion	(µg/g)	<0.02	Chrysene	(µg/g)	<0.01
Potassium - Tot.	(µg/g)	290	Methoxychlor	(µg/g)	<0.02	Dibenz(a,h)anthracene	(µg/g)	<0.02
Selenium - Tot.	(µg/g)	<0.5	Mirex	(µg/g)	<0.02	Fluoranthene	(µg/g)	<0.01
Silver - Tot.	(µg/g)	<0.05	Nonchlor, Trans-	(µg/g)	<0.01	Fluorene	(µg/g)	<0.01
Sodium - Tot.	(µg/g)	102	Oxychlordane	(µg/g)	<0.01	Indeno(1,2,3-c,d)pyrene	(µg/g)	<0.02
Strontium - Tot.	(µg/g)	32.3	PCBs- Tot.	(µg/g)	<0.05	Naphthalene	(µg/g)	<0.01
Tellurium - Tot.	(µg/g)	<0.1	Acephate	(µg/g)	<0.05	C1-Naphthalenes	(µg/g)	<0.01
Thallium - Tot.	(µg/g)	0.09	Azinphos Methyl	(µg/g)	<0.05	C2-Naphthalenes	(µg/g)	<0.02
Tin - Tot.	(µg/g)	0.8	Bromophos	(µg/g)	<0.01	Phenanthrene	(µg/g)	<0.01
Titanium - Tot.	(µg/g)	419	Carbophenothion	(µg/g)	<0.01	C1-Phen/Anthracene	(µg/g)	<0.02
Vanadium - Tot.	(µg/g)	71	Chlorfenvinphos(e)	(µg/g)	<0.01	C2-Phen/Anthracene	(µg/g)	<0.02
Zinc - Tot.	(µg/g)	43.1	Chlorpyrifos	(µg/g)	<0.01	Pyrene	(µg/g)	<0.01
Zirconium - Tot.	(µg/g)	<1.8	Demeton	(µg/g)	<0.02	Total PAHs	(µg/g)	<0.01
2,3,4,5 - Tetrachlorophenol	(µg/g)	<0.1	Diazinon	(µg/g)	<0.02	Total Low MW PAHs	(µg/g)	<0.01
2346+2356-TeClPhenol	(µg/g)	<0.1	Dichlorvos	(µg/g)	<0.01	Total High MW PAHs	(µg/g)	<0.01

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

Parameter	MDL (µg/L)	January 20/03			January 22/03			April 23/03			August 11/03		
		Conc. 1	Conc. 2	RPD%	Conc. 1	Conc. 2	RPD%	Conc. 1	Conc. 2	RPD%	Conc. 1	Conc. 2	RPD%
Antimony-T	0.005	0.03	0.042	**33**									
Copper-T	0.05							0.36	0.78	**74**	15	6.7	**76.5**
Copper-D	0.05										8.53	2.75	**102**
Lead-T	0.01							<0.01	0.09	**160**			
Lead-D	0.01										0.52	0.39	**29**
Lithium-D	0.05				0.69	2.15	**103**						
Manganese-T	0.008										1.86	1.42	**27**
Tin-T	0.01				0.01	0.1	**164**				0.06	0.1	**50**
Zinc-T	0.1				<0.1	1.7	**178**	0.9	1.4	**43**			
Zinc-D	0.1				<0.1	0.8	**155**						

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

Table 5. Percent difference in measures taken from duplicate sediment samples.

Parameter	Unit of Measure	% Difference
PART I: PHYSICAL PROPERTIES		
Moisture	% (W/W)	15%
Percent Gravel	% (W/W)	68%
Solid Content	%	7%
Percent Coarse Sand	% (W/W)	41%
Percent Medium Sand	% (W/W)	8%
Percent Fine Sand	% (W/W)	15%
Percent Very Fine Sand	% (W/W)	10%
Percent Silt	% (W/W)	8%
Percent Clay	% (W/W)	8%
PART II. CARBON AND PHOSPHORUS		
Organic Carbon - Total	µg/g	20%
Carbon - Total	µg/g	20%
Phosphorus - Total	µg/g	12%
PART III. TOTAL METALS		
Aluminum - Total	µg/g	21%
Arsenic - Total	µg/g	11%
Barium - Total	µg/g	25%
Calcium - Total	µg/g	2%
Chromium - Total	µg/g	34%
Cobalt - Total	µg/g	20%
Copper - Total	µg/g	29%
Iron - Total	µg/g	20%
Lead - Total	µg/g	20%
Magnesium - Total	µg/g	18%
Manganese - Total	µg/g	20%
Molybdenum - Total	µg/g	0%
Nickel - Total	µg/g	23%
Potassium - Total	µg/g	21%
Strontium - Total	µg/g	1%
Tin - Total	µg/g	25%
Titanium - Total	µg/g	20%
Vanadium - Total	µg/g	0%
Zinc - Total	µg/g	17%

Table 8. 2002/03 raw water quality data collected from the Sinclair Mills drinking water supply.

Date	Cryptosporidium (oocysts/100L)	Giardia (cysts/100L)	Total Coliform (CFU/100mL)	Fecal Coliform (CFU/100mL)	Enterococci (CFU/100mL)
10-Oct-02			31	<1	3
24-Oct-02	<1.4	4.1			
21-Jan-03	<5	<5	<1	<1	<1
23-Mar-03	<1.9	<1.9			
24-Mar-03			5	<1	<1
24-Apr-03	<2.9	<2.9	<2	<2	<2
21-May-03	<3.5	<3.5	8	<2	<2
21-May-03					
11-Aug-03	<1.6	<1.6	120	10	3
11-Aug-03			110	9	3

E. Coli (CFU/100mL)	pH (pH Units)	True Colour (Col. Unit)	Specific Conductance (µS/cm)	Residues - NonFilt. (mg/L)	Turbidity (NTU)
<1	7.8	10	143	<4	0.34
<1	8	5	215	<4	
<1	7.8	5	202	<4	0.22
<2	7.8	15	121	<4	0.61
<2	8	10	139	<4	0.17
	8	5	139	<4	0.15
6	8.1	5	191	<4	0.2
10	8.1	5	192	<4	0.18

Hardness - Total (mg/L)	Hardness - Dissolved (mg/L)	Alkalinity - T as $CaCO_3$ (mg/L)	Bromide - Diss. (mg/L)	Chloride - Diss. (mg/L)	Fluoride - Diss. (mg/L)
68.2	71.9	60	<0.1	<0.5	0.05
111	107	79	<0.1	<0.5	0.06
108	108	74	<0.1	0.9	0.05
63.1	63.1	50	<0.1	<0.5	0.02
72.4	71.8	56.5	<0.1	<0.5	0.04
71.1	71.8	56.6	<0.1	<0.5	0.03
103	97.6	74.2	<0.1	<0.5	0.03
102	97.5	73.9	<0.1	<0.5	0.04

Carbon - Tot. Org. (mg/L)	$NO_2 + NO_3$ (mg/L)	Phosphorus - Tot. Diss. (mg/L)	Phosphorus - Tot. (mg/L)	Sulfate (mg/L)	Aluminum - Tot. (µg/L)
3.2	0.051	0.004	0.003	10.8	16.3
0.9	0.168	0.005	0.002	27.6	4.2
2.3	0.161	0.005	<0.002	27.6	8.6
3.9	0.158	0.005	0.005	8.5	43.6
2.3	0.087	0.002	0.005	11.7	10.7
2.3	0.083	0.003	0.005	11.5	10.3
2.2	0.044	0.005	0.002	18.6	10.5
1.5	0.042	<0.002	0.002	19.2	9.8

Aluminum - Diss. (µg/L)	Antimony - Tot. (µg/L)	Antimony - Diss. (µg/L)	Arsenic - Tot. (µg/L)	Arsenic - Diss. (µg/L)	Barium - Tot. (µg/L)
14.4	<0.005	<0.005	0.2	0.2	19
3.3	0.018	0.018	<0.1	<0.1	29.7
5.1	0.038	0.024	<0.1	<0.1	29.5
23.2	<0.005	<0.005	0.1	0.1	18.8
8.7	0.028	0.022	0.1	0.1	19
8.4	0.023	0.021	0.1	0.2	19
7.1	0.033	0.033	0.3	0.3	27.7
7.3	0.028	0.028	0.3	0.3	28

Barium - Diss. (µg/L)	Beryllium - Tot. (µg/L)	Beryllium - Diss. (µg/L)	Bismuth - Tot. (µg/L)	Bismuth - Diss. (µg/L)	Cadmium - Tot. (µg/L)
18.7	<0.02	<0.02	<0.02	<0.02	<0.01
29.4	<0.02	<0.02	<0.02	<0.02	0.04
28.7	<0.02	<0.02	<0.02	<0.02	<0.01
18.1	<0.02	<0.02	0.03	<0.02	<0.01
18.1	<0.02	<0.02	<0.02	<0.02	<0.01
17.8	<0.02	<0.02	<0.02	<0.02	<0.01
28	<0.02	<0.02	<0.02	<0.02	0.01
27.6	<0.02	<0.02	<0.02	<0.02	<0.01

Cadmium - Diss. (µg/L)	Calcium - Tot. (mg/L)	Calcium - Diss. (mg/L)	Chromium - Tot. (µg/L)	Chromium - Diss. (µg/L)	Cobalt - Tot. (µg/L)
<0.01	21.2	22.4	<0.2	<0.2	<0.005
<0.01	34.7	33.4	<0.2	<0.2	<0.005
<0.01	33.9	34	<0.2	<0.2	0.02
<0.01	19.8	19.4	<0.2	<0.2	0.027
<0.01	22.4	22.2	<0.2	<0.2	0.016
<0.01	22	22.2	<0.2	<0.2	0.016
0.01	32.1	30.6	<0.2	<0.2	0.044
<0.01	31.8	30.5	<0.2	<0.2	0.035

Cobalt - Diss. (µg/L)	Copper - Tot. (µg/L)	Copper - Diss. (µg/L)	Iron - Tot. (mg/L)	Iron - Diss. (mg/L)	Lead - Tot. (µg/L)
<0.005	1.09	1.11			0.5
<0.005	1.1	1.15	0.012	<0.005	0.43
0.007	2.5	1.37	0.036	0.007	0.45
<0.005	2.85	2.44	0.094	0.023	0.41
0.013	1.9	1.65	0.017	0.008	0.27
0.013	1.89	1.68	0.017	0.009	0.25
0.035	15	8.53	0.005	0.005	1.41
0.03	6.7	2.75	0.005	0.006	1.14

Lead - Diss. (µg/L)	Lithium - Tot. (µg/L)	Lithium - Diss. (µg/L)	Magnesium - Tot. (mg/L)	Magnesium - Diss. (mg/L)	Manganese - Tot. (µg/L)
0.42	<0.05	<0.05	3.7	3.88	0.805
0.47	<0.05	0.08	5.94	5.82	0.464
0.12	0.21	0.19	5.59	5.53	0.675
0.18	0.17	0.12	3.44	3.56	3.05
0.16	0.22	0.29	4	3.98	0.471
0.16	0.29	0.31	3.92	3.97	0.454
0.52	0.34	0.36	5.45	5.15	1.86
0.39	0.28	0.28	5.37	5.18	1.42

Manganese - Diss. (µg/L)	Molybdenum - Tot. (µg/L)	Molybdenum - Diss. (µg/L)	Nickel - Tot. (µg/L)	Nickel - Diss. (µg/L)	Selenium - Tot. (µg/L)
0.494	0.33	0.33	<0.05	0.05	<0.2
0.183	0.46	0.47	<0.05	<0.05	<0.2
0.187	0.68	0.49	<0.05	<0.05	<0.2
0.377	0.28	0.28	0.15	0.16	<0.2
0.206	0.48	0.42	<0.05	<0.05	<0.2
0.204	0.47	0.41	<0.05	<0.05	<0.2
0.442	0.53	0.48	0.12	0.13	<0.2
0.38	0.54	0.53	0.18	0.08	0.2

Selenium - Diss. (µg/L)	Silver - Tot. (µg/L)	Silver - Diss. (µg/L)	Sodium - Tot. (mg/L)	Strontium - Tot. (µg/L)	Strontium - Diss. (µg/L)	Thallium - Tot. (µg/L)	Thallium - Diss. (µg/L)
<0.2	<0.02	<0.02		80.4	81.4	<0.002	<0.002
0.2	<0.02	<0.02	0.8	120	112	0.007	0.003
<0.2	<0.02	<0.02	0.78	140	142	<0.002	0.004
<0.2	<0.02	<0.02	0.58	70.1	70.5	<0.002	<0.002
<0.2	<0.02	<0.02	0.66	75.7	71.4	<0.002	<0.002
<0.2	<0.02	<0.02	0.65	75.8	71.4	<0.002	<0.002
0.2	<0.02	<0.02	0.82	121	121	0.003	0.003
<0.2	<0.02	<0.02	0.8	119	117	0.003	<0.002

Tin - Tot. (µg/L)	Tin - Diss. (µg/L)	Uranium - Tot. (µg/L)	Uranium - Diss. (µg/L)	Vanadium - Tot. (µg/L)	Vanadium - Diss. (µg/L)	Zinc - Tot. (µg/L)	Zinc - Diss. (µg/L)
<0.01	<0.01	0.057	0.055	0.51	0.49	90.8	87.9
0.01	0.02	0.125	0.122	0.27	0.09	90.9	117
<0.01	<0.01	0.102	0.093	1.69	0.29	39.3	18.9
<0.01	<0.01	0.056	0.05	0.4	0.42	45.9	41.6
0.01	0.01	0.061	0.055	0.36	0.34	29	26.4
<0.01	<0.01	0.062	0.054	0.32	0.31	27.7	26
0.1	0.07	0.09	0.09	0.35	0.34	63.5	58.8
0.06	0.06	0.089	0.085	0.35	0.37	60.7	54.9