Drinking Water Source Quality Monitoring 2002-03

Parasite Sampling in Northwest Coastal Communities: Prince Rupert, Terrace and Kitimat

A.J. Downie
Environmental Protection Division
Skeena Region

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SUMMARY

Anecdotal information suggests that surface water sources experience deterioration in water quality during periods of high surface runoff, such as fall storms. Northwest British Columbia's three largest communities rely on surface water sources for their municipal water supplies. Woodworth Lake (Prince Rupert), Deep Creek and the Skeena River (Terrace) and the Kitimat River (Kitimat) are all estimated to be relatively high-risk drinking water sources due to a lack of filtration, and large populations being served. To help characterize drinking water-related health risks in these communities, a sampling program was designed and implemented in the fall of 2003. Three sets of water quality samples were collected and analyzed on four surface water sources during fall rain runoff peaks.

Unlike other monitoring programs that have been implemented recently, water quality analysis at northwest coastal communities included testing for parasites. Source water was filtered for 30 minutes and the filters were sent to the B.C. Centre for Disease Control (BCCDC) lab for *Giardia* and *Cryptosporidium* analysis. Parasite detection limits of between 1 and 5 organisms per 100 L were achieved, depending on the quality of the source water. Grab samples were also collected for analysis of three microbiological indicators (fecal coliforms, *E. coli* and enterococci) and a comprehensive range of physical and chemical parameters to determine overall water quality.

Lab results were compared to Ministry of Environment (MoE, formerly Ministry of Water, Land and Air Protection, WLAP) approved and working guidelines for drinking water quality. For microbiological indicators, sample concentrations for each indicator were compared to the *Disinfection Only* guideline limits, ***which assume treatment of the water before consumption***. Under the province's new Drinking Water Protection Regulation, this is the minimum treatment requirement for surface water sources.

The results of this study indicate that water quality varied significantly over a short period of time, depending on weather conditions. Potential contaminant concentrations in rivers were highest near the beginning of rainfall events, when water levels are rising. It is suspected that samples from this study do not reflect the worst water quality period in the fall season. Results from each source are summarized below:

Woodworth Lake is the water source for the City of Prince Rupert. Its watershed is designated as a community watershed and land use activities are restricted. Treatment consists of chlorination only. Raw (untreated) source water was sampled from a tap at the Shawatlan Lake treatment facility.

- Fecal coliforms and *E. coli* were both detected, but concentrations were below the MoE drinking water guideline ***for raw water that will receive disinfection prior to consumption***.
- *Giardia* cysts were not detected, but non-viable *Cryptosporidium* oocysts were found at the detection limit on one date.

- Colour values exceeded the aesthetic drinking water guideline in all samples and TOC (Total Organic Carbon) concentrations were also very close to the drinking water guideline. These results indicate that excessive disinfection by-product formation may be a concern in the Prince Rupert water system.

Deep Creek is one of two backup water sources for the City of Terrace water system. The watershed is also designated as a community watershed. A screened intake is located in an impoundment adjacent to the creek, and the water receives chlorination before it enters the distribution system. Source water was sampled from the impoundment near the intake, prior to chlorination treatment.

- Fecal coliforms, *E. coli* and enterococci were all detected. Fecal coliform and *E. coli* concentrations exceeded the drinking water guideline in some samples.
- Non-viable *Giardia* cysts were detected on one date; no *Cryptosporidium* oocysts were detected.
- Colour values exceeded the aesthetic drinking water guideline in all samples. TOC concentrations exceeded the guideline in two of three samples, indicating that disinfection by-product formation may be a concern when this water source is being used.

The Skeena River is the second backup water source used by the City of Terrace. Its watershed covers a large area (it is among the biggest in the province) and land use activities are varied and include forestry, development (residential, commercial and industrial) and agriculture. The intake consists of an infiltration gallery and chlorination occurs as the water enters the system. The water is then pumped directly into the distribution system without storage. This backup source was being used throughout the 2003 sampling program.

- Fecal coliforms, *E. coli* and enterococci were all detected; fecal coliform and enterococci concentrations exceeded the drinking water guideline in one sample.
- Non-viable *Giardia* cysts were found in all three samples and concentrations were the highest observed in this study. *Cryptosporidium* oocysts were not found.
- Turbidity values were above the (maximum) drinking water guideline of 5 NTU on two dates. All three samples had turbidity above the desirable level of 1 NTU for water entering a distribution system.
- Iron concentration exceeded the aesthetic drinking water guideline in one of three samples, and it is likely periodically exceeded in this source.

The Kitimat River serves as the water source for the District of Kitimat. The Kitimat River watershed drains an area which has been partially logged in the past, and there is limited development upstream from the intake. The District has infiltration galleries installed on the side of the river near the town site, and it adds chlorine to the water for disinfection. Raw (source) water was sampled from the river itself near the infiltration gallery, and also at a tap in pump house #7 (after the infiltration gallery, but prior to chlorination treatment).

- Fecal coliforms, *E. coli* and enterococci were all detected in the Kitimat River, and guideline levels for all three indicators were exceeded during the sampling. Water samples from the pump house tap (after the infiltration gallery) showed much lower indicator concentrations; however the enterococci concentration in one sample exceeded the guideline level.
- Non-viable *Giardia* cysts were detected in all samples from the Kitimat River, and *Cryptosporidium* oocysts were found (at the detection limit) once. No parasites were detected in samples from the pump house tap.
- Turbidity was highly variable, with values close to 40 NTU observed during high flows. Sampling results indicate that the infiltration gallery was effective at reducing all turbidity values to levels below the 5 NTU (maximum) guideline, and two of three samples from the pump house had turbidity below the desirable level of 1 NTU.
- Samples showed colour values and concentrations of TOC, aluminum, iron and titanium, which exceeded drinking water guidelines on one date. Once again, sampling results suggest that the infiltration gallery reduced concentrations of all these parameters to within acceptable guideline levels.

Based on monitoring conducted in Skeena Region during 2002-2003, we recommend that:

- The Ministry should continue to collaborate with the Northern Health Authority (NHA), local water suppliers, and other agencies interested in water quality in the Skeena Region.
- Monitoring of enterococci and *E. coli* levels (in addition to fecal coliform concentrations) should continue and these results should be included in water quality objectives development and updates.
- Monitoring of parasites should be considered in future surface water quality sampling programs, as these organisms pose a risk to human health.
- Future monitoring programs should include sampling in a range of (weather and flow) conditions to investigate variations in water quality. The severity of various “poor water quality episodes” (caused by rain-on-snow, spring runoff, and summer and fall storms) should be measured to characterize the highest-risk periods for these drinking water sources. Spring is suspected to be a critical time for parasite sampling due to the presence of young animals in the watershed. Field equipment and resources need to be ready to conduct sampling at the beginning of rainfall events.
- A review of each water system should be conducted to determine if current treatment processes provide adequate protection under the range of water quality conditions
- Through collaboration with NHA staff, residents and other users of land in (drinking water) watersheds should be made aware of the risks that land use activities pose on nearby surface water sources.
- Drinking water source quality data should be made readily available to any interested parties.

ACKNOWLEDGEMENTS

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Bob Watson and Ron Craig from the Northern Health Authority (NHA) provided input and made suggestions for designing the sampling program. Mohamad Khan provided equipment, coordinated laboratory analysis and helped with results interpretation. Water suppliers from all three communities provided background information and past data, site access, help with sampling, etc. MoE staff including Julia Kokelj, Sean Sharpe, Les Swain and Kevin Rieberger helped edit the draft reports.

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1.0 INTRODUCTION

This document is one of a series of reports presenting results of the B.C. Ministry of Water, Land and Air Protection (WLAP, now called Ministry of Environment - MoE) Skeena Region's 2002-03 drinking water source quality monitoring program. It assesses water quality in the surface water sources of three northwest coastal communities: Prince Rupert, Terrace and Kitimat. It outlines water quality sampling conducted in the fall of 2003, including testing and analysis for *Giardia* and *Cryptosporidium*. It also makes recommendations for future monitoring.

1.1 Provincial Expanded Water Quality Monitoring Program

A safe and dependable supply of drinking water is critical to the health of all British Columbians. Recent reviews and reports have identified public health concerns related to the quality of drinking water in B.C. and the provincial government has created a Drinking Water Action Plan to prevent contamination, identify potential risks and improve water quality. The Plan recognizes that while the safety of drinking water is a health issue, providing safe drinking water requires an integrated approach and source protection is critical (Province of B.C., Provincial Health Officer, 2001; Ministry of Health website, 2002). In 2003, the new *Drinking Water Protection Act* and regulations were brought into force to protect drinking water in B.C. The Ministry of Environment is responsible for managing and regulating activities in watersheds that have a potential to affect water quality. It monitors water quality at the source, and is mandated to provide and promote improved monitoring related to the protection of drinking water sources. Additional information about the Drinking Water Action Plan and the *Act* and regulations can be found on the Ministry of Health website (http://www.healthservices.gov.bc.ca/protect/water.html).

1.2 Skeena Region Overview

The Skeena Region covers an area of 266,441 km^2 (29% of the province) in the northwest quadrant of British Columbia. It includes the geographic area between Endako (near Burns Lake) in the east to Haida Gwaii (Queen Charlotte Islands) in the west; from Kitimat and North Tweedsmuir in the south to the Yukon and USA borders in the north. The region is relatively unpopulated; there are no large urban centers, and few communities are populated by greater than 5,000 people. Most of the region's communities are located along the Highway 16 corridor.

Water is abundant in the Skeena Region, and most drinking water systems use surface water sources. Surface water sources have a higher risk of contamination than groundwater, and MoE is working with the Northern Health Authority to ensure that all drinking water systems using surface water employ adequate forms of treatment. In general, there are very few large water suppliers in the region, and small water suppliers and private (single connection) water systems serve most of the population.

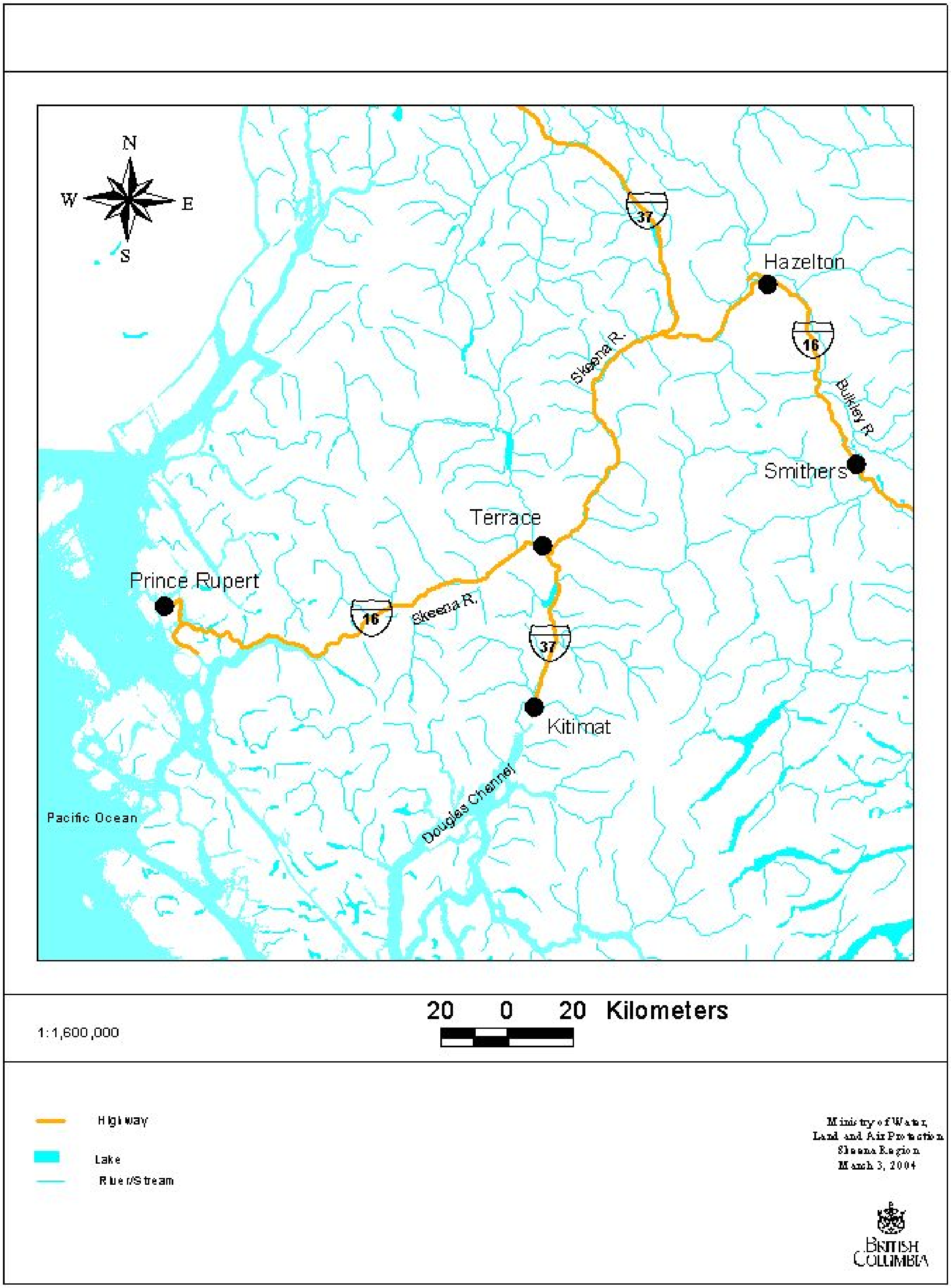
1.3 Northwest Coastal Communities

The northwest coast of British Columbia includes the largest population centres in Skeena Region: Prince Rupert, Terrace and Kitimat (Figure 1). The City of Prince Rupert (population approximately 15,000) is located on Ridley Island at the end of Highway 16. The community has obtained its water supply from the Shawatlan-Woodworth watershed for approximately 80 years. In the past, it pumped water from Shawatlan Lake (which is downstream from Woodworth), but now the city is supplied solely from Woodworth Lake by gravity feed and Shawatlan Lake is used as a backup. The water system serves the entire population of Prince Rupert (Watson, 1999).

The City of Terrace is located on Highway 16 beside the Skeena River, approximately 60 km inland from the Pacific Ocean. The Greater Terrace Area has a population of over 20,000 (with 12,000 in Terrace itself). The community of Terrace operates a groundwater well (Frank Street Well) which serves as its primary water source. When the well is not functioning (as was the case in the summer and fall of 2003 because of a broken pump), two surface water sources provide a backup supply: Deep Creek and the Skeena River. These subsidiary sources also augment the Frank Street well when demand exceeds supply (such as during the summer months). The Terrace water system provides water to approximately 12,600 people plus several forest products industries (Watson, 2000).

The District of Kitimat lies on the coast at the end of Douglas Channel in the Kitimat Valley, 60 km south from Terrace along Highway 37. It currently has a population of approximately 12,000. The community of Kitimat draws its water supply from the Kitimat River. The town site water system serves approximately 11,000 people, while a second water system in Cablecar Subdivision serves approximately 800 people using the same source.

Figure 1: Northwest Coastal Communities



2.0 B.C DRINKING WATER QUALITY GUIDELINES

In British Columbia the Ministry of Environment develops province-wide water quality guidelines (criteria) for assessing water quality data and preparing site-specific water quality objectives. Water quality guidelines are environmental benchmarks. They are considered to be safe levels of substances for the protection of a given water use, including drinking water, recreation, aquatic life, wildlife and agriculture. In most cases, B.C.'s drinking water source quality guidelines are based on Canadian guidelines developed by the Canadian Council of Ministers of the Environment (CCME, 1999 with periodic updates). The guidelines are intended to be a water quality-screening tool. If data do not exceed the guidelines, problems are unlikely. If data exceed the guidelines, then a detailed assessment is recommended to determine the extent of the problem.

Disease resulting from microbiological contamination of drinking water is widely recognized as a significant water quality issue, and detection of microbiological indicators is an important component of the multi-barrier approach to safe drinking water. Indicator organisms, such as coliform bacteria, provide an estimate of the degree of fecal contamination from human and animal wastes that are in the water. If the indicator suggests that fecal contamination of the water has occurred, then disease-causing organisms may also be present.

Provincial monitoring protocols and water quality guidelines for microbiological indicators were published by Warrington in 1988. There are three guideline levels, which allow different concentrations of microbiological indicators in raw (untreated) drinking water, depending on the degree of treatment that will be applied. B.C. Health Authorities recommend that all drinking water supplies derived from surface water sources receive disinfection as a minimum treatment, and thus we assess surface water microbiological water quality using the ***Disinfection Only*** guideline level (this is also the minimum treatment requirement for surface water sources under the Drinking Water Protection Regulation; see Table 1).

Table 1: MoE Water Quality Guidelines for Microbiological Indicators

Water Use	Fecal Coliform	*E. coli*	Enterococci
Raw Drinking Water – Disinfection Only (SURFACE WATER)	Less than or equal to 10/100 mL 90^{th} percentile	Less than or equal to 10/100 mL 90^{th} percentile	Less than or equal to 3/100 mL 90^{th} percentile

Other B.C. (MoE) approved and working guidelines for physical and chemical water quality parameters are listed in Table 2. Additional information is available in Province of B.C. (1998a and 1998b), or on the following websites:

- Canadian Guidelines
- http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/index_e.html
- B.C. Guidelines
  http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html

Table 2: MoE Physical /Chemical Drinking Water Source Quality Guidelines
(Province of B.C., 1998a and 1998b)

Parameter	Guideline (mg/L)	Guideline Type
PHYSICAL		
pH	6.5-8.5	aesthetic objective
Colour	≤ 15 TCU	aesthetic objective
Specific conductance	≤ 700 µS/cm	maximum acceptable concentration
Turbidity	≤ 5 NTU[1]	maximum acceptable concentration
Hardness Total – T	≤ 500	maximum acceptable concentration
TOTAL ORGANIC CARBON		
T.O.C.	≤ 4[2]	maximum, to prevent THM formation
ANIONS		
Chloride Dissolved	≤ 250	aesthetic objective
Fluoride Dissolved	≤ 1.5	maximum acceptable concentration
NUTRIENTS		
Nitrate Nitrogen Dissolved (N)	≤ 10	maximum acceptable concentration
Nitrite Nitrogen (N)	≤ 1	maximum acceptable concentration
Phosphorus Total (P)	≤ 0.01	maximum, to protect lakes from algae growth
SULFATE		
Sulfate	≤ 500	aesthetic objective
METALS TOTAL		
Aluminum	≤ 0.2	maximum acceptable concentration
Antimony	≤ 0.006	interim maximum acceptable concentration
Arsenic	≤ 0.025	interim maximum acceptable concentration
Barium	≤ 1	maximum acceptable concentration
Boron	≤ 5	maximum acceptable concentration
Cadmium	≤ 0.005	maximum acceptable concentration
Chromium	≤ 0.05	maximum acceptable concentration
Copper	≤ 1	aesthetic objective
Iron	≤ 0.3	aesthetic objective
Lead	≤ 0.01	maximum acceptable concentration
Magnesium	≤ 100	aesthetic objective
Manganese	≤ 0.05	aesthetic objective
Molybdenum	≤ 0.25	maximum acceptable concentration
Selenium	≤ 0.01	maximum acceptable concentration
Uranium	≤ 0.02[3]	maximum acceptable concentration
Vanadium	≤ 0.1	maximum acceptable concentration
Zinc	≤ 5	aesthetic objective

[1] Although some literature quotes a maximum acceptable level of 1 NTU, levels between 1 and 5 NTU do not typically pose a health concern. Depending on the origin of the turbidity (organic vs. inorganic), bacteria may be present and/or treatment system effectiveness may be compromised at levels between 1 and 5 NTU. Some site-specific Skeena Region reports apply a maximum level of 5 NTU and an average of 1 NTU. For this report, universal application of only the 5 NTU (max) guideline was decided by WLAP water quality specialists.

[2] No approved BC guideline, but US EPA guideline is 4 mg/L to prevent trihalomethane formation.

[3] BC interim max. acceptable concentration is ≤ 0.1 mg/L; Canadian guideline (≤ 0.02) is more stringent.

3.0 *GIARDIA* AND *CRYPTOSPORIDIUM* IN DRINKING WATER

Giardia and *Cryptosporidium* can be a serious public health concern and have caused many waterborne disease outbreaks across Canada. At least 28 serious outbreaks in British Columbia communities since 1980 have confirmed the vulnerability of B.C.'s drinking water sources to these parasites (Christensen, 2003).

Giardia lamblia and *Cryptosporidium parvum* are parasitic, intestinal protozoa responsible for disease outbreaks in humans (Warrington, 1988). Both parasites produce cysts (called oocysts for *Cryptosporidium*) that withstand harsh environmental conditions, lying dormant until ingestion. When ingested in contaminated water, they cause giardiasis ("beaver fever") and cryptosporidiosis.

Giardia and *Cryptosporidium* are widespread in the natural waters of Canada. Primary sources of cysts/oocysts are young calves and young wildlife, but other domestic animals, wildlife and people (sewage effluents) may be major sources. Terrestrial developments and activities (including forest harvesting and agriculture) have been shown to speed the passage of disease-causing agents from land to water, and large volumes are expected to be washed into creeks and lakes during snowmelt and heavy rainfall events (Christensen, 2003; Watson, 2003).

Parasites generally occur in low concentrations in aquatic environments, and thus are difficult to sample. There are currently no drinking water source guidelines for parasites, but Health Authorities and the U.S. Environmental Protection Agency recommend a minimal removal of 99.9% for *Giardia* cysts through filtration and/or disinfection between raw and tap water. With adequate doses and a sufficient contact time, *Giardia* can be inactivated with chlorine. *Cryptosporidium*, however, is much more difficult to kill through disinfection alone and generally requires further treatment (e.g. filtration combined with ultraviolet radiation (UV)).

Very little background data exist for parasite concentrations in local drinking water sources. Combined with inadequate protection, this makes parasites "the highest potential generic risk for Skeena Region waterworks with surface water sources" (Watson, 2003). Skeena Region sampling in October 2003 was expanded to include sampling for parasites in some sources deemed to be "high risk" due to inadequate protection (no filtration) and large populations being served.

4.0 METHODS

4.1 Northwest Coastal Communities Parasite Sampling Program (2003)

The northwest coastal communities parasite sampling program was designed in consultation with NHA representatives. It was intended to provide background information for evaluating the risks associated with *Giardia* and *Cryptosporidium* in Skeena Region water supplies. The 2003 program included testing of four major surface drinking water sources: Woodworth Lake (Prince Rupert), Deep Creek and Skeena River (Terrace) and Kitimat River (Kitimat). Sample locations were located directly in the rivers near intake sites, or at taps in the distribution system near the intake and prior to treatment.

Sampling was conducted on three dates during the fall 2003 runoff period: September 29/30, October 14/15 and October 21/22. In all three communities, weather conditions on September 29/30 were sunny and warm, with heavy rainfall the week before. Weather conditions between September 30 and October 14 were generally warm and dry. Conditions on October 14/15 were sunny and slightly cooler, with no recent rain. The October 21/22 sample was collected during cool, wet weather, following at least two to three days of (at times heavy) rain.

Large volumes (200-300 litres) of source water were filtered for analysis of *Giardia* and *Cryptosporidium*. Grab samples were also collected for analysis of three microbiological indicators (fecal coliforms, *E. coli* and enterococci) and a comprehensive range of physical and chemical parameters which have health and aesthetic implications in drinking water.

4.2 Sampling Methods

Samples for analysis of cysts and oocysts of *Giardia* and *Cryptosporidium* parasites were collected using the high volume filtering method described in Lucas (1997) and EPA (1995). The sampling apparatus and filters were provided by the B.C. Centre for Disease Control (BCCDC) Enhanced Water Laboratory. At each site the sampling apparatus was flushed with source water for 15 minutes prior to sampling (10 minutes if the apparatus had been thoroughly disinfected and dried). During sample collection between 200 and 300 litres of water was filtered through a 1 µm filter over a 30-minute period. The volume of water filtered was recorded from a water meter on the apparatus

Grab sampling for other parameters was conducted according to methods outlined in the *B.C. field sampling manual* (Clark, 1996). Microbiological samples were collected in 500 mL sterilized bacteriology bottles (provided by JR Laboratories Inc.). Total metals samples were collected in 250 mL acid-washed polyethylene bottles (provided by PSC Analytical Services) and were immediately preserved with nitric acid. Samples for physical and chemical analysis were collected in 1 L polyethylene bottles that were rinsed three times prior to collection, and samples for Total Organic Carbon were collected in 250 mL polyethylene bottles that were rinsed prior to collection. Samples were immediately placed in a cooler with ice and shipped to the analysis laboratories in Burnaby, B.C. The samples were received by the laboratory within the recommended holding time.

4.3 Analytical Methods

Parasite analysis was performed by the BCCDC's Enhanced Water Laboratory. Analysis was conducted using the USEPA Standard Method (Percoll method).

Microbiological analyses were performed by JR Laboratories. Analysis began within 48 hours of sample collection. JR uses the Membrane Filtration (MF) method of enumeration, and analyses are performed using approved procedures (Province of B.C., 1994; APHA, 1998).

Physical and chemical analyses were performed by PSC Analytical Services (now called Maxxam Analytics). Total metals samples were analyzed using the low-level ICPMS scan to detect low concentrations. PSC also follows standard methods provided in APHA (1998).

4.4 QA/QC

Both analytical labs (JR and PSC) must meet numerous QA/QC (Quality Assurance, Quality Control) requirements such as analysis of reference samples, blanks and duplicates, and are frequently audited. QA/QC information from individual batches of samples is reported with the results from each set of analyses. Other QA/QC procedures that were incorporated into our monitoring program include:

- Development of consistent sampling protocols,
- Training of field staff,
- Setting of data quality objectives, and
- Submission of QA samples (including field blanks and duplicates) to the lab.

Field blanks provide a test for potential contamination resulting from handling technique and from air exposure at the sampling location. A field blank was collected (for all parameters except parasites) on October 15 and complete results are included in Appendix 3:

- No microbiological indicators were detected in the sample, indicating that contamination during sampling, transport, and analysis was unlikely.
- The following physical and chemical parameters were detected at low concentrations which are far below drinking water guideline levels: turbidity, nitrate + nitrite, nitrite, and total copper, lead, lithium, strontium, tin and zinc. Sample contamination is not a concern.

Duplicate samples provide an estimate of the overall precision associated with the field technique and laboratory analysis. A duplicate sample for physical and chemical parameters was collected on September 30 at the Kitimat River and October 21 at the Skeena River. Duplicates were not collected for parasites or microbiological indicators because their occurrence in the natural environment is not expected to be uniform. Precision analysis of the duplicate results was calculated using the Relative Percent Difference (RPD, see data appendix for results and calculations).[4] The RPD for duplicate samples should be less than 25%, and data with precision values greater than 25% should be interpreted with caution. In the duplicate samples:

- from Kitimat River, RPD's for all parameters met the data quality objective.
- from Skeena River, RPD's for all parameters except total zinc were less than 25%. Zinc is notoriously ubiquitous and difficult to control in the analytical and collection process. Zinc concentrations observed throughout this sampling program were all far below the drinking water guideline, so data quality is not a major concern. In the Skeena River duplicate samples, variability in turbidity and iron concentrations spanned the drinking water guideline. RPD's were less than the data quality objective and it is suspected that the variation is due to natural variability of these parameters in a river environment. The samples indicate that results close to guideline levels should be interpreted with caution.

4.5 Reporting

Parasite results are reported as a concentration of cysts or oocysts per 100 L of sample. The method detection limit was variable, depending on the volume of water filtered and how much of the resulting sediment (extracted from the filter) was actually examined.[5] In this study, detection limits between 1 and 5 organisms per 100 L were achieved.

Microbiological water quality results are reported in colony forming units (CFU) per 100 mL of sample. A result of <1 indicates that no bacteria were detected in a sample of 100 mL. For each sampling site, individual sample concentrations for each indicator were compared to the *Disinfection Only* MoE guideline level (Table 1). Care must be taken when interpreting the results because the *Disinfection Only* guideline usually applies to a 90th percentile calculated from at least five samples collected in a 30-day period. This study did not include five samples, but comparison to the guideline still provides a preliminary indication of bacteria concentrations in the source water during the fall period.

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[4] Precision is influenced by how close the analytical value is to the Method Detection Limit (MDL - the minimum amount of a substance that can be routinely detected by the analytical instrument or technique with a high degree of confidence), and the use of RPD is limited to values that are at least five times the MDL. For parameters measured at or near the MDL, small differences that are not significant can result in large RPD's. Many parameters tested had concentrations below five times the MDL, so RPD was not calculated.

[5] Generally, a "dirtier" filter will give more sediment, and increase the detection limit (less sample is analyzed).

Other physical and chemical water quality parameters (including metals) from individual samples were compared to the Ministry guidelines listed in Table 2.

5.0 PROFILE OF NORTHWEST COASTAL COMMUNITIES' DRINKING WATER SOURCES AND SAMPLING LOCATIONS

Five water sampling sites were monitored to collect water quality data on four surface drinking water sources.

5.1 Woodworth Lake (City of Prince Rupert)

Woodworth Lake is located on the mainland northeast from the City of Prince Rupert. It lies in a protected watershed on Crown land, and can only be accessed through city land or the Shoowahtlans Indian Reserve. The single-entrance road is controlled by a locked gate, and signage informs boaters that the area is a watershed reserve. The watershed is 2488 ha (Province of B.C., MSRM, 2004a), and is characterised by steep slopes. It has never been logged and the area is designated as a community watershed under the Forest Practices Code. Furthermore, the city is able to restrict recreation in its watershed because it owns the land controlling access to it (Province of B.C., Office of the Auditor General, 1999).

From the intake in Woodworth Lake, water flows by gravity to the Shawatlan Lake treatment facility where chlorine gas and sodium silica-fluoride are added to the water. The minimum chlorine contact time in the distribution system ranges from four to six hours. Flows in the system typically range from about 16 ML/d during fall and winter, to approximately 30 ML/d during the summer.

Prince Rupert city staff have provided results from a number of water quality samples taken over the past few years. Treated water samples (from the distribution system) from 1998 to 2002 indicate excellent bacterial and viral quality (Watson, 2002a). *Giardia* and *Cryptosporidium* were checked at Woodworth Lake in October 1996, December 1999 and November 2002, and both were not detected (Thompson, 2003). Watson (2002a) has recommended that *Giardia* and *Cryptosporidium* in the lake water should continue to be checked seasonally, particularly in mid spring when young animals may be present and mid fall following heavy rain events. Physical/chemical results show that the water is soft with low alkalinity, typical of west coast surface water. The lake has pH levels between 6.8 and 7.0, with lower values (below the recommended range) in the distribution system following chlorination. Colour values in the source water have been about 35 TCU (above the aesthetic guideline), turbidity is generally about 0.3 NTU and none of the metals are elevated (Thompson, 2003; Watson, 2002a).

In October 2003, Woodworth Lake raw (untreated) source water was sampled from a tap at the Shawatlan Lake treatment facility (Figure 2 and Photos 1 and 2).

Figure 2: Prince Rupert and Woodworth Lake (Sampling Site Highlighted)

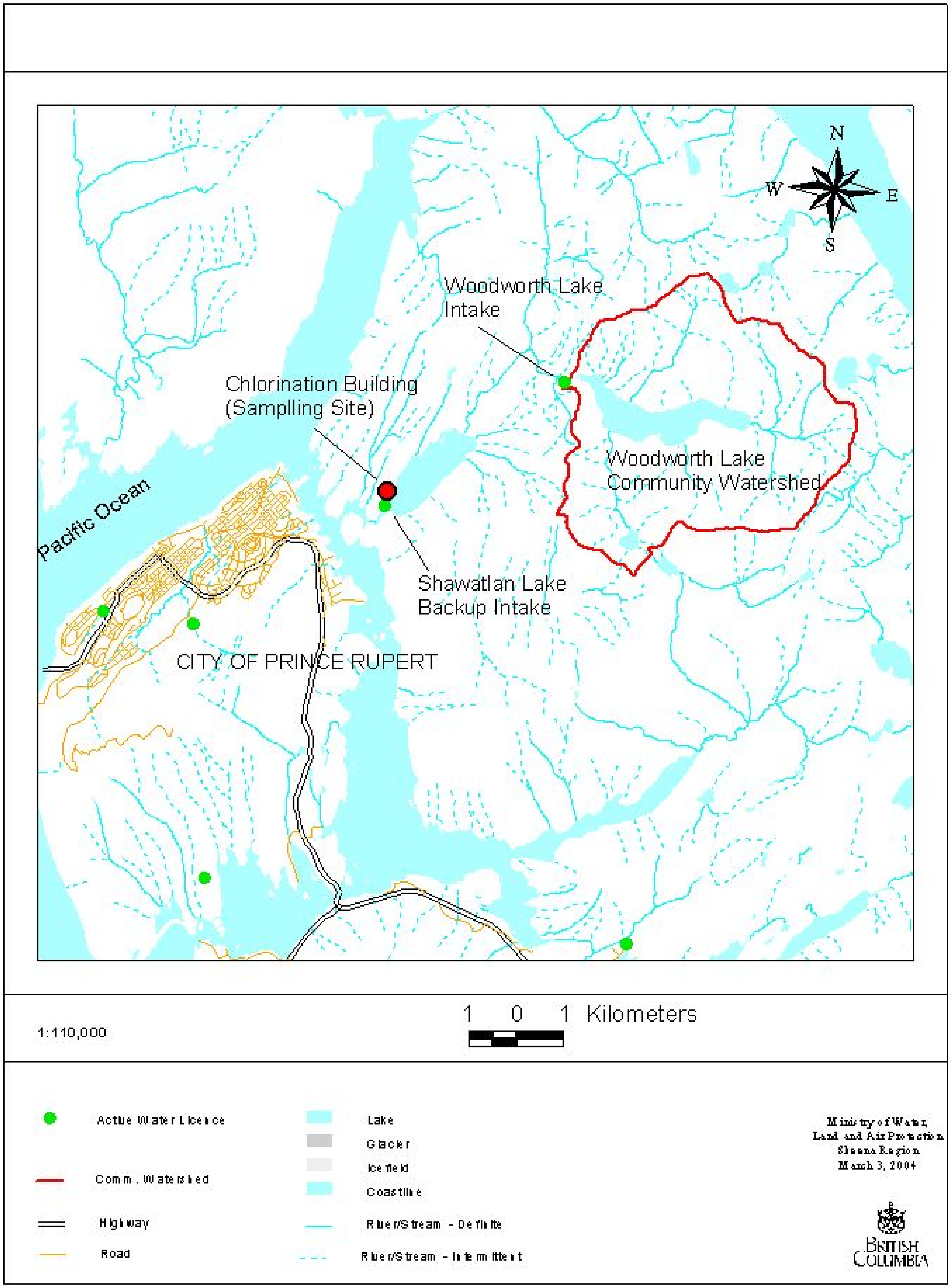


Photo 1: Shawatlan Lake treatment facility	Photo 2: Filtration apparatus set up outside Shawatlan Lake treatment facility
	

5.2 Deep Creek (City of Terrace)

The City of Terrace has two surface water supplies that serve as backup sources when its primary groundwater source is unavailable: Deep Creek and Skeena River. Deep Creek is the preferred alternate source, but the Skeena River is used when chlorine residuals cannot be maintained or when demand exceeds availability. The Skeena River was serving as Terrace's water source over the entire 2003 sampling program.

Deep Creek is located north-northeast from the city of Terrace and is a tributary to the Kitsumkalum River. The Deep Creek watershed covers an area of 1,382 ha and has been designated a community watershed under the Forest Practices Code (Province of B.C, MSRM, 2004a). Access to the watershed is restricted with a gate and signage. Some logging occurred in the watershed 20 to 30 years ago, and a limited amount of carefully-supervised selective logging was conducted in 2001-02 to salvage timber knocked down during a windstorm in 1999 (Marleau, 2004, pers. comm.). No effects on water quality were observed during or following the logging in 2001-02. There are no livestock grazing above the intake, but according to Watson (2000), the area appears inviting to wildlife and there is a beaver dam but no beaver.

The Deep Creek intake was constructed in the 1980s as a gravity-fed alternative to the Spring Creek Dam intake. It consists of a small impoundment on the side of the creek, and a fine screen. Water flows by gravity to the Spring Creek treatment facility where chlorination (chlorine gas) and fluoridation (hydrofluosilicic acid) occurs. The water then flows to the Wilson Street reservoirs before entering the distribution system so chlorine contact time is ample for bacteria and viruses. However, it may not meet current standards for *Giardia*, and provides no protection against *Cryptosporidium* (Watson, 2000). The Deep Creek supply has a capacity of 11 ML/d.

Past water quality data are not available for the source itself, but tests in the distribution system reveal that the water is very soft with very low alkalinity. The pH (distribution system, post-chlorination) was measured at 5.9 when last checked on October 17, 2001, and was 6.1 on December 1990 – both values are below the recommended range of 6.5-8.5 (Watson, 2000 and Northern Labs, 2001). Values less than 6.5 potentially can result in metals becoming dissolved in the distribution system; however, all metals values meet guidelines at present. Bacteriological water quality data is unavailable for the raw source water, and there has been very little sampling for parasites. The source is expected to be medium risk for *Giardia* and *Cryptosporidium*, and a March 2, 1991 sample indicated *Giardia* at 1+ (means 3-20 organisms/100 L) (Watson, 2000).

In October 2003, Deep Creek source water was sampled from the impoundment where the City of Terrace intake is located (Figure 3 and Photos 3 and 4). The Water Survey of Canada (WSC) has a gauging station on Deep Creek directly above the intake site; discharge levels over the September-October 2003 sampling season are shown in Figure 4. Sampling dates are indicated by arrows on the graph. Appendix 1 contains a graph of historical daily discharge values for Deep Creek.

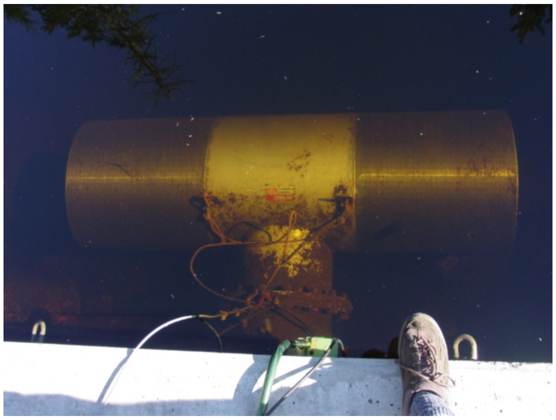
Photo 3: Deep Creek with intake impoundment pool in foreground	**Photo 4: Deep Creek intake screen in impoundment pool, with submersible sampling pump and hose at bottom of photo**
	

Figure 3: City of Terrace, with Deep Creek and Skeena River (Sampling Sites Highlighted)

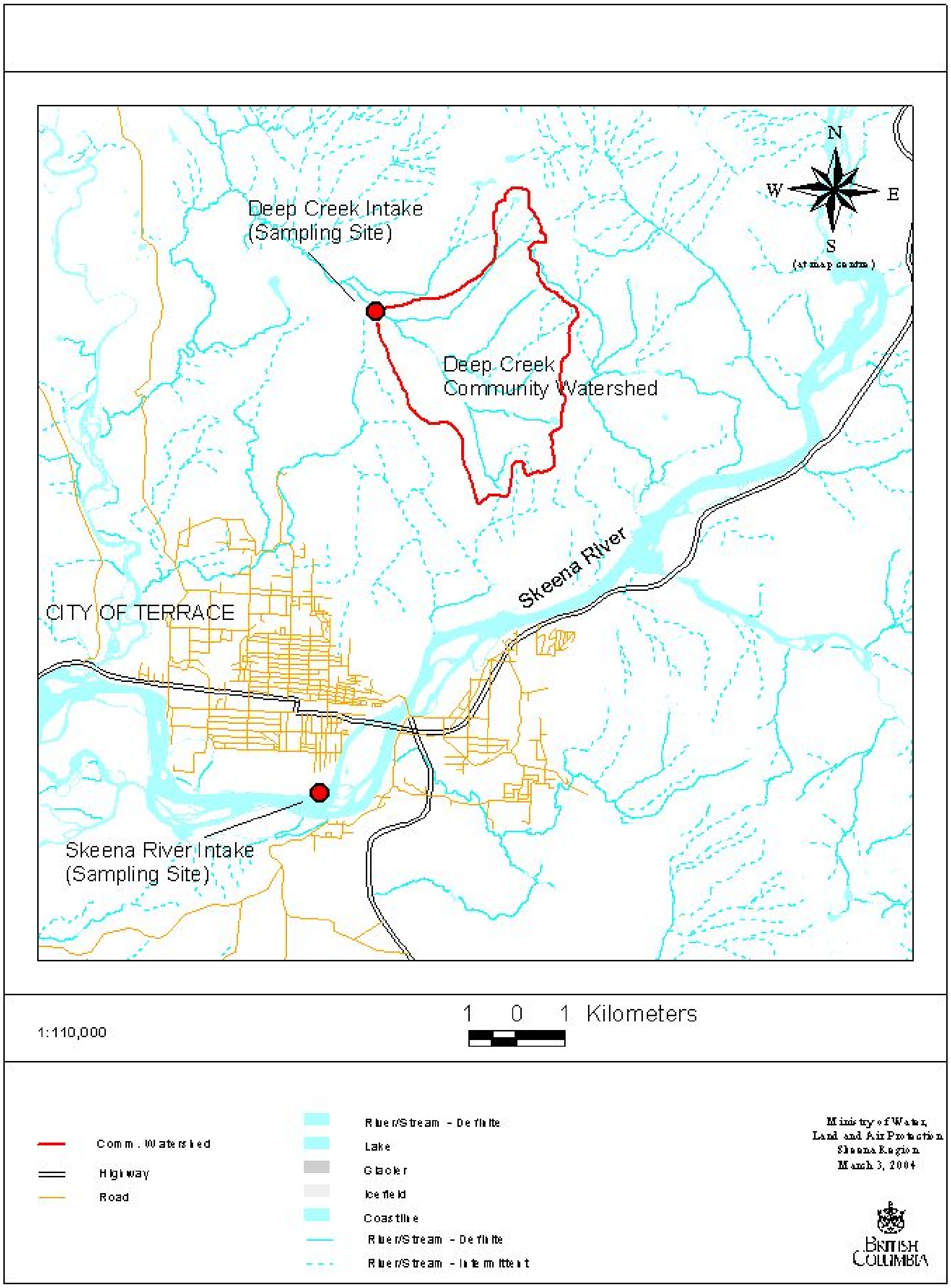
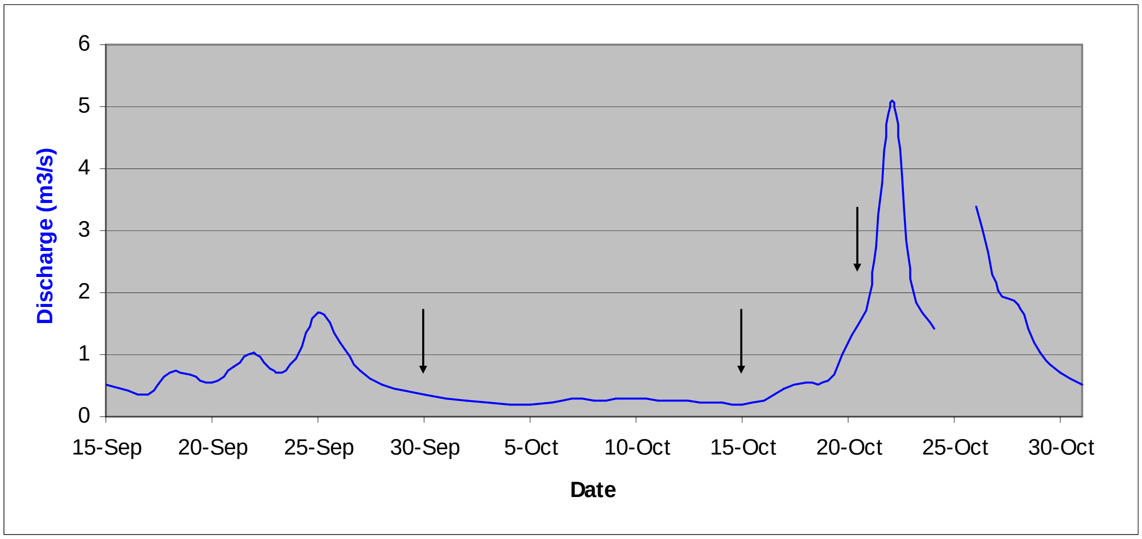


Figure 4: September and October 2003 Daily Discharge for Deep Creek (WSC, 2004a)



5.3 Skeena River (City of Terrace)

The Skeena River watershed covers an area of approximately 54,000 km^2 and is among the largest in B.C. (Gottesfeld, 2002). The river extends through the Coast Ranges and its tributaries drain areas as far east as the Nechako Plateau near Babine Lake. Because of its large size, different areas of its watershed experience very different climatic and hydrological conditions. The watershed is densely forested throughout, and with the exception of communities along the Highway 16 corridor, it is largely undeveloped. At least 45,000 km^2 of the Skeena River's watershed lies above the City of Terrace, and land use activities are varied. Specific land use data is not available, but primary activities which may impact water quality include forest harvesting, urban, rural and industrial development and agriculture (including livestock grazing and feedlots in the Bulkley Valley). There are also a number of permitted discharges to the Skeena River and its tributaries above Terrace.

The City of Terrace's Skeena River intake is an infiltration gallery that was constructed on Little Island (downstream from Ferry Island) in 1967-68. A pump house is located on the adjacent mainland at the south end of Kalum Street. Treatment consists of chlorination and fluoridation (same as Deep Creek), and it occurs immediately after the water enters the system through the infiltration gallery. The water is then pumped directly into the distribution system without storage, so chlorine contact time is limited to about 20 minutes at the rated capacity. This contact time is likely adequate for bacteria and viruses, but provides almost no protection against *Giardia* or *Cryptosporidium* (Watson, 2000).

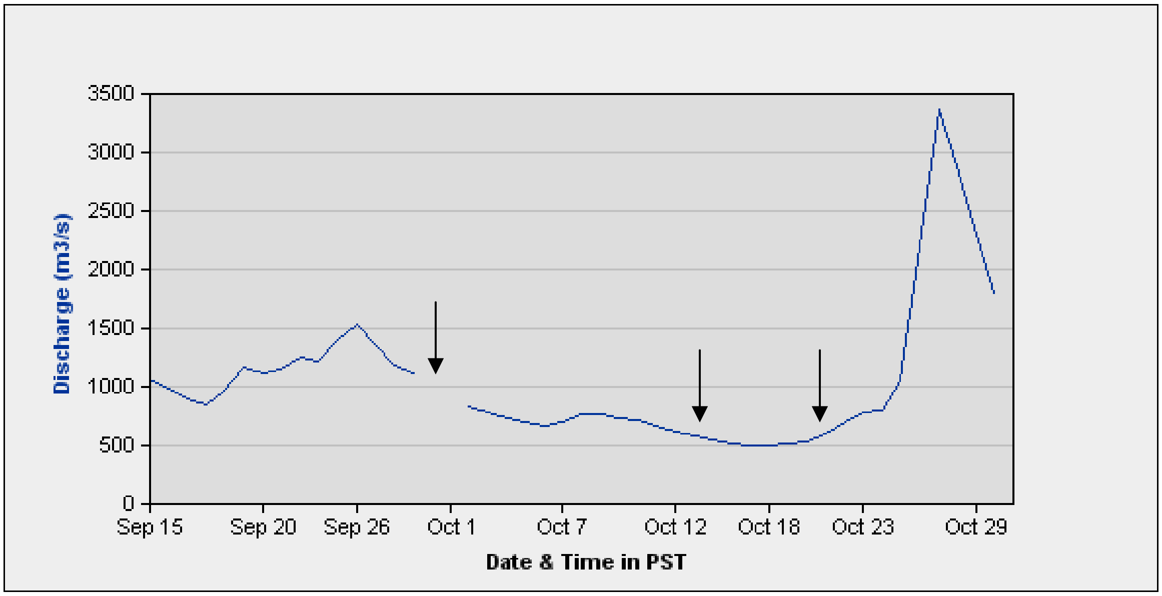
Past water quality tests (from the distribution system, post-chlorination) indicated satisfactory water quality (Watson, 2000). The iron concentration was at the aesthetic guideline on December 18, 1990, but this was deemed to be abnormal and the concentration was considerably lower in the most recent tests from October 17, 2001. The large size of the river (and watershed) likely results in considerable variation in water quality. Watson (2000) commented that "Skeena River water becomes quite turbid during spring runoff and fall storms, and should not be used without coagulation, sedimentation and filtration during these periods." The Skeena River was being used for Terrace's water supply (without these additional treatment processes, but with careful monitoring of finished water quality) during September and October 2003 due to the unavailability of other sources (Marleau, 2004 pers. comm.).

In October 2003, Skeena River source water was sampled directly from the river (at a depth of approximately 15 cm) near the City of Terrace intake (Figure 3 and Photos 5 and 6). The WSC has a gauging station on the Skeena River at Usk, approximately 25 km upstream from the Terrace intake site.[6] Discharge levels over the September-October 2003 sampling season are shown in Figure 5. Sampling dates are indicated by arrows on the graph. Appendix 1 contains a graph of historical daily discharge values for the Skeena River.

Photo 5: Skeena River; infiltration gallery is under gravel near left river bank, pump house is on right side of river	**Photo 6: Skeena River with submersible sampling pump under water near river bank**
	

[6] This gauging station does not include flows from the Zymoetz (Copper) River, which flows into the Skeena River between Usk and Terrace. Watershed area for Zymoetez is approximately 3,100 km^2 so it contributes a significant volume to the Skeena River (watershed area for Skeena above Usk is approximately 42,200 km^2).

Figure 5: September and October 2003 Daily Discharge for the Skeena River (WSC, 2004b)



5.4 Kitimat River (District of Kitimat)

The Kitimat River originates in the Coast Mountains and flows to the Pacific Ocean at Kitimat. It is approximately 100 km long (FISS website, 2003) and its watershed covers an area of approximately 2,060 km^2 (Province of B.C., MSRM, 2004 and Province of B.C., WLAP GIS, 2004). Land use in the watershed is summarized in Table 3. The intake site is near the mouth of the river, so these land uses provide a good indication of upstream activities which may influence water quality at the Kitimat intake site. There is no commercial development above the intake site, and Cablecar Subdivision is the only residential area. There are no permitted discharges to the Kitimat River above the intake site.

Table 3: Land use in the Kitimat River Watershed
(Source: WLAP GIS, 2004)

Land Use Category	Area (km^2)
Alpine, sub-alpine, glaciers, etc.	749
Water (including wetlands)	14
Recently logged or burned	264
Forest (young and old)	1017
Agriculture	0
Recreation	1
Urban[7]	12

[7] Much of this area is below the Kitimat intake site.

The District of Kitimat water system contains three facilities, all located near the east edge of the Kitimat River, just downstream from the highway bridge. These facilities include a shallow well and infiltration galleries under the river. The southern-most facility consists of two infiltration galleries connected to Pump house #7. The infiltration galleries were re-constructed in 1990 after high river flows washed out previous galleries. The infiltration gallery trenches were excavated at the bank toe and the intake consists of 30" diameter perforated corrugated metal pipe and graded granular bedding and gravel surrounding it to prevent fines migration. The upper portion of the trench consists of cobbles (Watson, 2002b and Gleig, 2004 pers. comm.). Treatment, consisting of disinfection with chlorine gas, occurs at a chlorination building located close by. Watson (2002b) commented that the chlorine contact time to customers near the disinfection facilities appears to be only a few minutes when the pumps are running, and it is "unlikely that anyone in Kitimat is well protected from *Giardia* cysts". The average daily flows in the system are about 7 ML/d.

Past water quality results indicate good bacteriological quality in the water system (treated water). Recent sampling data have not been provided by the District of Kitimat, but Watson (2002b) states that water chemistry results indicate that the water is soft and corrosive typical of West Coast sources. Northern Health Authority officials have been unable to track down the results of past sampling for *Giardia* and *Cryptosporidium*, but an outbreak was confirmed in 1990 when the infiltration gallery was damaged (Christensen, 2003; Watson, 2002b). Since 1995, there have been four or less reported *Giardia* cases per year at Kitimat. Watson (2002b) expects *Giardia* and *Cryptosporidium* risk to increase during flood periods as overland flow washes animal faeces into the Kitimat River, and that increased turbidity (values up to 200 NTU have been reported in this source) likely coincides with increased *Giardia* and *Cryptosporidium* levels.

In October 2003, Kitimat River source water was sampled directly from the river (at a depth of approximately 15 cm) near the District of Kitimat intake (Figure 6 and Photos 7 and 8) and at Pump house #7 after the infiltration gallery (Figure 6 and Photo 9). This enabled a comparison of source water quality before and after the infiltration gallery, to examine its effectiveness in reducing levels of turbidity, bacteria and parasites.

The WSC has a gauging station on the Kitimat River just downstream from the intake site; discharge levels over the September-October 2003 sampling season are shown in Figure 7. Sampling dates are indicated by arrows on the graph. Appendix 1 contains a graph of historical daily discharge values for Kitimat River.

Figure 6: Kitimat River at Kitimat (with Sampling Site Highlighted)

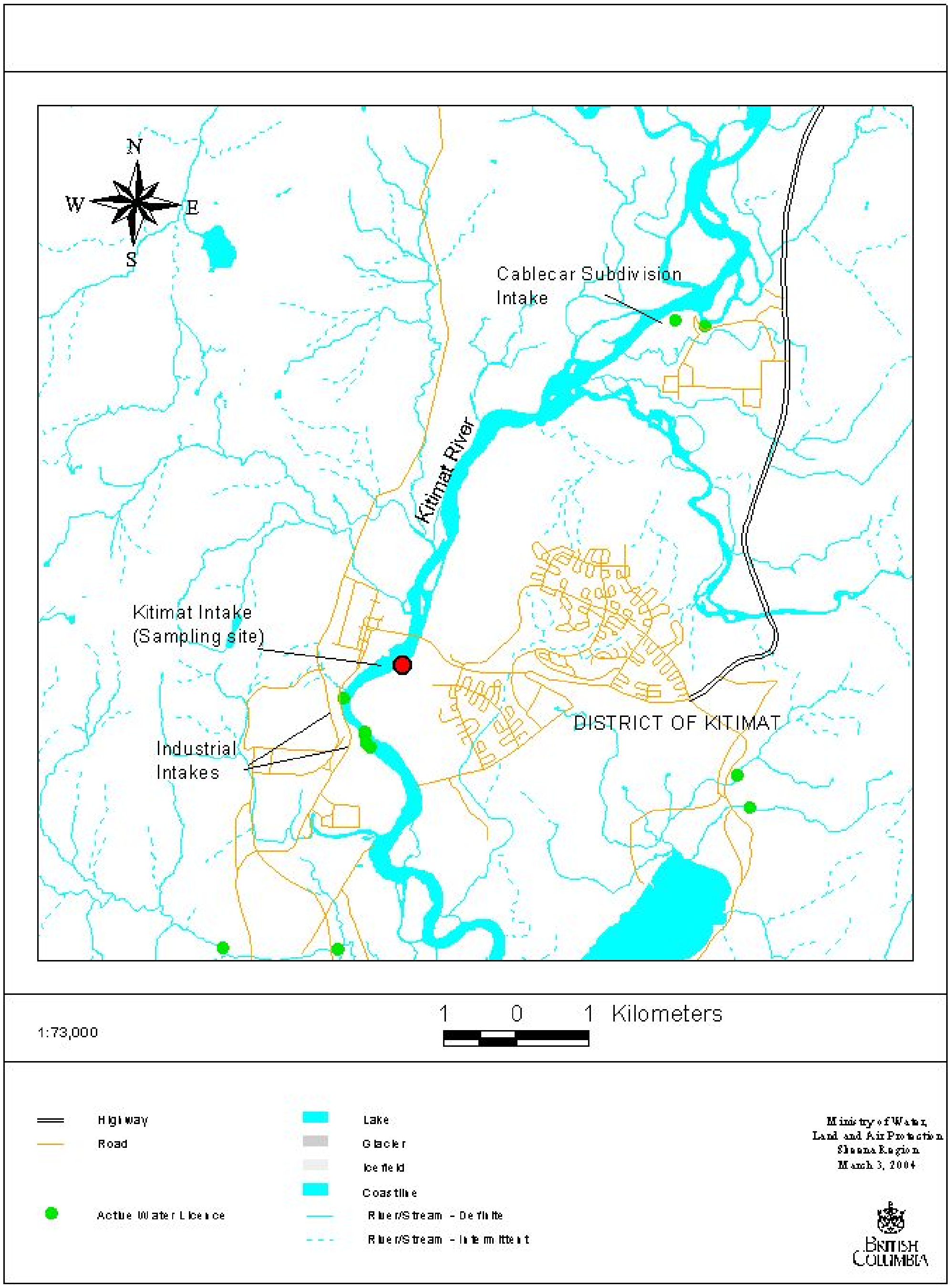
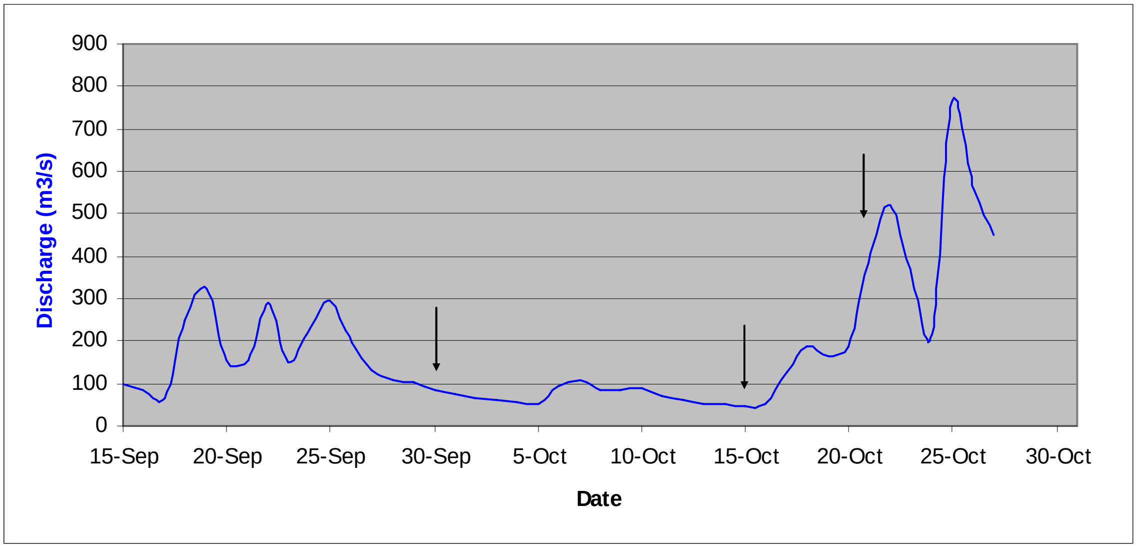


Photo 7: Kitimat River with pump house #7	**Photo 8: Kitimat River sampling site**
	

Photo 9: Sampling tap inside pump house #7


Figure 7: September and October 2003 Daily Discharge for the Kitimat River (WSC, 2004a)



6.0 RESULTS

Complete results of the water quality sampling at northwest coastal communities are included in Appendix 2. The final column of the tables lists drinking water guidelines (for applicable parameters) and indicates whether the guideline was met. ***The microbiological indicator guidelines used for surface water sources in this study assume that the raw water is receiving disinfection prior to consumption.***

6.1 Woodworth Lake

Bacteria:

Fecal coliforms and *E. coli* were present, but concentrations were well below Ministry guideline levels. Fecal coliforms were detected in two of three samples and *E. coli* were detected in one of three samples. Enterococci were not detected. Although Woodworth Lake source water met the guidelines, the presence of microbiological indicators may present a health risk if treatment becomes ineffective.

Parasites:

Giardia cysts were not detected in any source water samples. *Cryptosporidium* oocysts were found at the detection limit (4.7 per 100 L) on October 14, 2003, but were not detected in the September 29 or October 22 samples. The *Cryptosporidium* oocysts were not viable when the lab analysis occurred (Khan, 2003 pers. comm.) but their viability in the lake is not known. Regardless, their presence indicates a potential water quality concern as chlorination alone is generally considered to be inadequate protection against *Cryptosporidium*.

Physical and Chemical Water Quality Parameters:

Most physical and chemical water quality parameters (including metals) were below the Ministry's approved and working guidelines for drinking water quality. Parameters that did not meet guideline levels are described below:

- Colour values ranged from 20 to 40 TCU, and all three samples exceeded the aesthetic drinking water guideline of ≤ 15 TCU. These results are consistent with past sampling results that show colour levels to be between 30 and 46 TCU. Watson (2002a) indicated that dissolving vegetation is causing the colour in the lake, and it is assumed that this continues to be the case. A primary concern with colour guidelines failures is the possibility of disinfection by-product formation (see below).

- Total Organic Carbon (TOC) concentrations were 3.9, 3.7 and 3.5 mg/L on the three sampling dates. These concentrations are very close to the guideline set at ≤ 4 mg/L to avoid excessive disinfection by-product production. Higher TOC levels make it difficult to maintain the chlorine residual necessary for protection from pathogenic bacteria and viruses, and can also result in the formation of disinfection by-products including trihalomethanes (THMs) and halo-acetic acids (HAAs). THMs are a known carcinogen and their formation in drinking water is a serious drinking water quality issue (see Moore, 1998 or Health Canada, 2003 for more information). In the past, Prince Rupert has had THM values near the guideline level; Watson (2002b) has recommended ongoing monitoring and that treatment to reduce disinfection by-products should be considered.

6.2 Deep Creek

Bacteria:

All three microbiological indicators were present in Deep Creek water samples with highest concentrations observed on October 21. Fecal coliforms and *E. coli* were each detected in two of three samples at concentrations that exceed Ministry drinking water guidelines. Enterococci were detected at a concentration of 1 CFU/100 mL in the sample on October 21, but were not detected in other samples. The guideline for enterococci was met. The presence of microbiological indicators in Deep Creek may present a health risk if treatment becomes ineffective. Values observed on September 30 and October 21 in excess of the guideline indicate that disinfection alone may not provide adequate treatment for this water source.

Parasites:

Non-viable *Giardia* cysts were found at the detection limit (4.1 per 100 L) on October 21, 2003, but were not detected in the September 30 or October 15 samples (Khan, 2003 pers. comm.). *Cryptosporidium* oocysts were not detected in any of the Deep Creek source water samples. The current treatment system may provide adequate protection against the low levels of *Giardia* that were observed, but further study is recommended.

Physical and Chemical Water Quality Parameters:

Most physical and chemical water quality parameters (including metals) were below the Ministry's approved and working guidelines for drinking water quality. Parameters that did not meet guideline levels are described below:

- Colour values ranged from 30 to 60 TCU, and all three samples exceeded the aesthetic drinking water guideline of ≤ 15 TCU. Past water quality data (raw source water) is not available for Deep Creek, but a post-chlorination sample from

October 17, 2001 indicated a colour value of 27 TCU A primary concern with values in excess of colour guidelines is the possibility of disinfection by-product formation (see above for information on disinfection by-products).

- TOC concentrations were 6.2, 3.7 and 10.2 mg/L on the three sampling dates. Two values are above the drinking water guideline of ≤ 4 mg/L. The observed concentrations are consistent with the October 17, 2001 sample (post-chlorination) that had a TOC concentration of 5.1 mg/L, so formation of excessive disinfection by-products is possible with this source.

6.3 Skeena River

Bacteria:

Skeena River source water samples showed measurable levels for all three microbiological indicators, with highest concentrations observed on October 21. Fecal coliforms were detected in all three samples; on October 21 the concentration was above the drinking water guideline level. *E. coli* and enterococci were each detected in two of three samples. Observed enterococci concentrations were at or above the guideline level. The presence of microbiological indicators in the Skeena River may present a health risk if treatment becomes ineffective. Values observed on October 21 in excess of guidelines indicate that disinfection alone may be inadequate treatment for this water source.

Parasites:

Giardia cysts were measured in all three source water samples from the Skeena River, at concentrations of 28.0, 24.2, and 51.3 per 100 L. These concentrations are the highest observed in this study. *Cryptosporidium* oocysts were not detected in any Skeena River samples. None of the *Giardia* cysts were viable when the lab analysis occurred (Khan, 2003 pers. comm.) but their viability in the river is not known. Regardless, their occurrence in the Skeena River indicates a potential water quality concern because water from this source enters the distribution system immediately and chlorine contact time is minimal.

Physical and Chemical Water Quality Parameters:

Most physical and chemical water quality parameters (including metals) were below the Ministry's approved and working guidelines for drinking water quality. Parameters that did not meet guideline levels are described below:

- Turbidity values in Skeena River source water samples were 5.16, 2.00 and 5.89 (duplicate sample concentration was 4.68) NTU. The September 30 and October 21 values were above the drinking water (maximum) guideline of 5 NTU, and all three values were above the desirable level of ≤ 1 NTU for water entering a distribution system. This indicates that chlorination effectiveness could be compromised by suspended materials in the water. Past water quality data (raw source water) is not available for the Skeena River, but a post-chlorination sample from October 17, 2001 indicated a turbidity value of 1.31 NTU which is also above the recommended level.

- The iron concentration on October 21 was just below the guideline level in the sample and just above the guideline level in a duplicate sample. This result is consistent with data from October 17, 2001, which also exceeded the guideline level. These results suggest that iron concentrations in the Skeena River are variable and may periodically exceed the drinking water aesthetic guideline. For more information on iron in drinking water, see Health Canada (2003).

6.4 Kitimat River

Bacteria:

Water samples collected directly from the Kitimat River showed measurable levels of all three microbiological indicators. Fecal coliforms and enterococci were each detected in all three samples and *E. coli* were detected in two of three samples. Fecal coliform and *E. coli* concentrations exceeded the MoE guideline level in two samples, and enterococci exceeded the guideline level in all three samples. October 21 concentrations were considerably higher than the previous two dates, with concentrations of 165, 78, and 140 CFU/100 mL for fecal coliforms, *E. coli* and enterococci respectively. These were the highest concentrations observed in this study.

Water samples collected from the tap in pump house #7 (after the infiltration gallery) showed much better microbiological water quality. Observed concentrations were one to two orders of magnitude lower, and drinking water guidelines for fecal coliforms and *E. coli* were met. The enterococci guideline was exceeded in one of the three samples. The presence of microbiological indicators in the Kitimat River may present a health risk if treatment becomes ineffective. The enterococci value far in excess of the guideline on October 21 at the pump house indicates that disinfection alone may be inadequate treatment for this water source.

Parasites:

Giardia cysts were measured in all three samples taken directly from the Kitimat River. Observed concentrations were 12.5, 43.6 and 23.8 per 100 L, but all cysts were non-viable when the lab analysis was conducted (Khan, 2003 pers. comm.). *Cryptosporidium* oocysts (also non-viable in the lab) were found at the detection limit (4.8 per 100 L) in one sample but were not detected in the other two samples. No parasites were detected in water samples collected from the tap in pump house #7. The absence of parasites after the infiltration gallery is reassuring; however, the presence of both parasites in the source water remains a concern. The relatively short chlorine contact time in the distribution system does not provide adequate protection against any parasites able to pass through the infiltration gallery. Effectiveness of the infiltration gallery should be closely monitored at other times of the year and under a variety of flow conditions to confirm that it continues to provide effective filtration of the source water.

Physical and Chemical Water Quality Parameters:

Most physical and chemical water quality parameters (including metals) were below the Ministry's approved and working guidelines for drinking water quality. Parameters that did not meet guideline levels are described below:

- The colour of the sample from October 21 was 50 TCU, which is well above the aesthetic drinking water guideline of ≤ 15 TCU. Other samples from the river were below the guideline level indicating high variability in this source. In all cases, colour values were reduced after the infiltration gallery, and the colour of the October 21 sample was reduced to 15 TCU, which just meets the drinking water guideline.

- As expected, turbidity values in the Kitimat River were also highly variable, with results ranging from 1.76 to 37.5 NTU. Samples from September 30 and October 21 were above the drinking water (maximum) guideline of 5 NTU, and all three turbidity values were above the desirable level of ≤ 1 NTU for water entering a distribution system. This indicates that treatment system effectiveness potentially could be compromised by suspended materials in the water; however, the infiltration gallery effectively eliminates most suspended matter. Turbidity values after the infiltration gallery were significantly lower, with all values falling below the 5 NTU maximum, and two of three falling below 1 NTU. The infiltration gallery reduced the October 21 turbidity from 37.5 to 1.22 NTU but the final value is still above the recommended level and indicates that chlorination could be compromised when river turbidity is high.

- TOC concentrations in the Kitimat River were 2.5 (duplicate sample concentration was 2.3), 1.2 and 5.1 mg/L on the three sampling dates. The October 21 sample was above the guideline level of ≤ 4 mg/L. Samples from after the infiltration gallery were lower on all dates, and the guideline was met at all times.

- The aluminum concentration observed on October 21 was 0.672 mg/L, which exceeds the MoE guideline of ≤ 0.2 mg/L. The pump house sample concentration from this date was 0.076 mg/L, which is below the guideline level. It is likely that the much of the aluminum measured in the river was particulate material that was filtered out by the infiltration gallery. For information on aluminum in drinking water, see Butcher (1988) or Health Canada (2003).

- Iron concentrations in the river water were above the aesthetic guideline of ≤ 0.3 mg/L on September 30 (0.325 mg/L) and October 21 (3.30 mg/L). However, once the water was screened through the media in the infiltration gallery, all three samples from the pump house tap were well below the guideline level and the results are not a health concern. For information on iron in drinking water, see Health Canada (2003).

- The titanium concentration in the river on October 21 was 0.129 mg/L which exceeds the guideline of ≤ 0.1 mg/L. The pump house sample from this date was below the detection limit (≤ 0.003 mg/L). The high concentration in the river is likely either associated with particulate matter or is an analytical error; however, the exact cause of this sample result is unknown and a review of past sample data is recommended to confirm if this occurrence represents a concern.

Infiltration Gallery Effectiveness:

Based on sampling done in the fall of 2003, the Kitimat River infiltration gallery appears to be quite effective at reducing levels of parameters that include suspended materials, such as bacteria, parasites, colour, turbidity, and some total metals concentrations.[8] Parameters related to materials dissolved in the water (such as pH, conductance, total dissolved solids, hardness, nutrients, and many metals) were largely unaffected by the infiltration gallery as expected, and their concentrations at the tap were the same as in the river.

Samples taken during this study showed bacteria concentrations were lowered by one to two orders of magnitude by the infiltration gallery. Only when Kitimat River water concentrations approached 100 CFU/100 mL did bacteria show up above the detection limit in the water after the infiltration gallery. Parasite concentrations up to 43.6 per 100 L were detected in the river during this study, but no parasites were found in the water after it had gone through the infiltration gallery. Significant reductions in colour and turbidity were also observed on October 21, when water quality in the river was poor due to recent heavy rainfall and overland flow.

Although the results of this study suggest that the infiltration gallery provides effective protection against bacteria and parasites, the results should be interpreted with caution as they do not represent the entire range of water quality conditions in the Kitimat River. Further sampling should be conducted at other times of the year to further investigate the effectiveness of the infiltration gallery under a range of flow conditions.

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[8] Total metals concentrations include particulate and dissolved fractions of the metals. It is assumed that elevated levels of some total metals (such as aluminum, iron and titanium) are the result of particulate forms in the water column. It is expected that metals with particulate fractions had their concentrations reduced by the infiltration gallery, while other metals concentrations were largely unaffected by the gallery because they consisted mostly of dissolved metal.

6.5 Trends and Seasonal Variations in Water Quality

The results and guideline comparisons discussed above reflect conditions at the time of sampling and do not necessarily represent all conditions in the northwest coastal communities' drinking water sources. Remington (2002) found that monitoring over only one season does not reflect the range of year-round source water quality and recommended a varied temporal schedule be devised for drinking water quality monitoring of surface water sources which includes spring and fall periods.

This study was designed to collect data during the fall when rainfall and surface runoff are high and values in excess of guidelines would be likely. It has shown that even over a single month, water quality can vary significantly depending on weather conditions. The first samples (September 29/30) were collected the week after significant rainfall, when water levels were dropping (see Figures 4, 5 and 7 for hydrographs). The samples showed moderately high levels of turbidity, bacteria and parasites. The second samples (October 14/15) were collected after two weeks of unseasonably warm and dry weather, and the results show significantly improved water quality. The third sample set (October 21/22) was collected approximately two days after the onset of more heavy rains, when water levels were rising. The results show a significant degradation in water quality (from the week before).

Large volumes of contaminants are washed into surface waters during the early stages of a storm or rainfall event, and this is when we expect contaminant concentrations in rivers to be the highest. As expected, this study found that samples collected on an ascending limb of the hydrograph (October 21/22) showed higher levels of turbidity, bacteria and parasites than samples from a descending limb (September 29/30). It is suspected that if samples were obtained from the ascending limb of earlier fall hydrograph peaks (such as the September 18-30 peak), even higher contaminant levels would be observed because of a longer prior accumulation of contaminants on the ground. The results of this study do not include sampling during what we estimate would have been the worst water quality episode in the fall season (likely observed around September 20). Furthermore, the results provide no indication of the relative severity of these fall episodes compared to other seasonal episodes (caused by rain-on-snow, spring runoff, or summer storms).

Results from this study highlight the need for additional data collection. The severity of various "poor water quality episodes" should be measured, therefore field equipment and resources need to be ready to conduct sampling at the beginning of rainfall events. Furthermore, spring sampling is recommended for all sites because this may be the highest-risk period (associated with parasites) because young animals are present in the watershed and overland flow is occurring (Watson 2000, 2002a, 2002b).

6.6 Review of Data from Other Drinking Water Sources in Northern B.C.

Sampling for parasites is logistically challenging and many Skeena Region drinking water sources have not been tested for parasites in the past. Thus, there is very little data for comparison. To provide some context for interpreting the results found in this study, comparisons can be made to results from drinking water sources in the Omineca-Peace region of Northeast B.C. Tables 3 and 4 below present results of parasite testing that was done in 2002-2003 in the Omineca-Peace. These results indicate that parasite concentrations show a high degree of variability from one source to another, and also over time within the same source. For example, rivers showed *minimum* concentrations ranging from zero (NPD = No Parasites Detected) to 76.7 per 100 L, and River 3 showed sample concentrations ranging from zero to 758.2 per 100 L. In both regions, *Giardia* concentrations were generally higher than *Cryptosporidium* concentrations. Overall, Skeena Region river sources had lower concentrations of *Giardia* and *Cryptosporidium* than Omineca-Peace river sources. Woodworth Lake parasite concentrations appear to be similar to lakes in the Omineca-Peace. The timing of the Omineca-Peace samples in relation to weather patterns is not known, so discussion of temporal variations associated with rain storms and other weather conditions is beyond the scope of this report.

Table 3: *Giardia* Concentrations (cysts/100 L water) in Northern B.C. Drinking Water Sources
(Source: Jacklin, 2003)

Water Source	# Samples	Minimum	Maximum	Mean
River 1	3	146.6	218.9	177.8
River 2	7	76.7	961.7	402.5
River 3	4	NPD	758.9	214.7
Lake 1	1	NPD	NPD	NPD
Unknown	6	NPD	4.1	0.7
Lake 2	6	NPD	NPD	NPD
Lake 3	6	NPD	82.7	30.9
River/Spring	6	NPD	4.2	1.3
Creek 1	4	NPD	9.8	2.5
Creek 2	4	NPD	10.2	4.3
TOTAL	47	NPD	961.7	99.2

Table 4: *Cryptosporidium* Concentrations (oocysts/100 L water) in Northern B.C. Drinking Water Sources
(Source: Jacklin, 2003)

Water Source	# Samples	Minimum	Maximum	Mean
River 1	3	NPD	8.8	2.9
River 2	7	NPD	NPD	NPD
River 3	4	NPD	30.4	5.1
Lake 1	1	NPD	NPD	NPD
Unknown	6	NPD	NPD	NPD
Lake 2	6	NPD	NPD	NPD
Lake 3	6	NPD	4.9	0.8
River/Spring	6	NPD	NPD	NPD
Creek 1	4	NPD	2.2	0.6
Creek 2	4	NPD	NPD	NPD
TOTAL	47	NPD	30.4	0.9

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Final Conclusions

The purpose of the northwest coastal communities sampling program was to characterize source water quality and collect data on parasite concentrations in four surface water sources during fall rain runoff peaks. The four water sources are estimated to be higher-risk due to inadequate filtration and/or large populations being served. Sampling conducted in the fall of 2003 found that water quality varied significantly over a short period of time, depending on weather conditions. This study found that potential contaminant concentrations in rivers were highest near the beginning of fall rainfall events, when water levels are rising. It is suspected that samples from this study do not reflect the worst water quality period in the fall or spring seasons. Results from each source are summarized below:

Woodworth Lake

- Fecal coliforms and *E. coli* were both detected, but concentrations were below the MoE drinking water guideline ***for raw water that will receive disinfection prior to consumption***.
- *Giardia* cysts were not detected, but non-viable *Cryptosporidium* oocysts were found at the detection limit on one date. This indicates a water quality concern as chlorination alone is not considered adequate to protect against *Cryptosporidium*.
- Colour values exceeded the aesthetic drinking water guideline in all samples, and indicate a possibility of disinfection by-product formation. Total Organic Carbon concentrations were also very close to the drinking water guideline (set to avoid disinfection by-product production) so THMs and HAAs may be a concern in the Prince Rupert water system.

Deep Creek

- Fecal coliforms, *E. coli* and enterococci were all detected. Fecal coliform and *E. coli* concentrations exceeded the drinking water guideline in some samples, indicating that disinfection alone may be inadequate treatment for this water source.
- Non-viable *Giardia* cysts were detected on one date; no *Cryptosporidium* oocysts were detected. The current treatment system may provide adequate protection against the low levels of *Giardia* that were observed, but further study is recommended.
- Colour values exceeded the aesthetic drinking water guideline in all samples. Total Organic Carbon concentrations exceeded the guideline in two of three samples, indicating that disinfection by-product production may be a concern when this water source is being used.

Skeena River

- Fecal coliforms, *E. coli* and enterococci were all detected. Fecal coliform and enterococci concentrations exceeded the drinking water guideline in one sample, indicating that disinfection alone may be inadequate treatment for this water source.
- Non-viable *Giardia* cysts were found in all three samples and concentrations at this site were the highest observed in the study. *Cryptosporidium* oocysts were not found but the occurrence of *Giardia* indicates a water quality concern because water from this source enters the distribution system immediately and chlorine contact time is minimal.
- Turbidity values were above the (maximum) drinking water guideline of 5 NTU on two dates. All three samples had turbidity above the desirable level of 1 NTU for water entering a distribution system so disinfection could be compromised by suspended materials in the water.
- Iron concentration exceeded the aesthetic drinking water guideline in one of three samples; this guideline is likely periodically exceeded in this source.

Kitimat River

- Microbiological indicator concentrations in the Kitimat River were the highest detected in this study. Fecal coliforms, *E. coli* and enterococci were all detected, and guideline levels for all three indicators were exceeded often. Water samples from the pump house tap (after the infiltration gallery) showed much lower indicator concentrations. The enterococci concentration in one sample exceeded the guideline level indicating that disinfection may be inadequate treatment for this source.
- Non-viable *Giardia* cysts were detected in all samples from the Kitimat River; *Cryptosporidium* oocysts were found (at the detection limit) once. No parasites were detected in samples from the pump house tap.
- Turbidity was highly variable, with values close to 40 NTU observed during high flows. Sample results indicate that the infiltration gallery was effective at reducing all turbidity values to levels below the 5 NTU (maximum) guideline, and two of three samples from the pump house had turbidity below the desirable level of 1 NTU.
- Samples showed colour values and concentrations of TOC, aluminum, iron and titanium, which exceeded drinking water guidelines on one date. Once again, sampling results suggest that the infiltration gallery reduced concentrations of all these parameters to within acceptable guideline levels.
- The infiltration gallery was effective at reducing levels of bacteria, parasites, colour, turbidity, and some total metals. The effectiveness of the infiltration gallery should be closely monitored to confirm that it continues to provide effective filtration of the source water under a range of weather conditions and river flows.

7.2 Recommendations

Based on monitoring conducted in Skeena Region during 2002-2003 we recommend that:

- The Ministry should continue to collaborate with the NHA, local water suppliers, and other agencies interested in water quality in the Skeena Region.
- Monitoring of enterococci and *E. coli* levels (in addition to fecal coliform concentrations) should continue and these results should be included in water quality objectives development and updates.
- Monitoring of parasites should be considered in future surface water quality sampling programs, as these organisms pose a risk to human health.
- Future monitoring programs should include sampling in a range of weather and flow conditions to investigate variations in water quality. The severity of various "poor water quality episodes" (caused by rain-on-snow, spring runoff, and summer and fall storms) should be measured to characterize the highest-risk periods for these drinking water sources. Spring is suspected to be a critical time for parasite sampling due to the presence of young animals in the watershed. Field equipment and resources need to be ready to conduct sampling at the beginning of rainfall events.
- A review of each water system should be conducted to determine if current treatment processes provide adequate protection under the range of water quality conditions.
- Through collaboration with NHA staff, residents and other users of land in (drinking water) watersheds should be made aware of the risks that land use activities pose on nearby surface water sources.
- Drinking water source quality data should be readily available to any interested parties.

REFERENCES

American Public Health Association (APHA), American Water Works Association, Water Environment Federation. 1998. Standard Methods for the Examination of Water and Wastewater (20th edition). *Edited by* Greenberg, A.E., L. S. Clesceri, and A. D. Eaton. American Public Health Association, Washington DC.

Butcher, G. 1988. Water quality criteria for aluminium, technical appendix. Resource Quality Section, Ministry of Environment, Victoria.

Clark, M. J. (editor). 1996. British Columbia Field Sampling Manual. Laboratory and Systems Management, Ministry of Environment, Lands and Parks, Victoria.

Canadian Council of Ministers of the Environment (CCME). 1999, revised March 2001. Canadian Environmental Quality Guidelines. CCME, Winnipeg.

Christensen, R. 2003. Watered Down: A report on waterborne disease in British Columbia. Sierra Legal Defence Fund (Vancouver).

Environmental Protection Agency (EPA). 1995. ICR protozoan method for detecting Giardia cysts and Cryptosporidium oocysts in water by a fluorescent antibody procedure. United States EPA.

Gleig, T. 2004. Personal communication. Director of Engineering Services, District of Kitimat (Kitimat).

Gottesfeld, A., K. Rabnett and P. Hall. 2002. Conserving Skeena Fish Populations and their Habitat. Skeena Fisheries Commission, Hazelton, BC.

Health Canada. 2003. Guidelines for Canadian drinking water quality - supporting documents.
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/index_e.html

Jacklin, J. 2003. Draft water quality data for Omineca-Peace Region, provided via email. Impact Assessment Biologist, Ministry of Environment (Prince George).

Khan, M. 2003. Personal communication. Program Coordinator, B.C. Centre for Disease Control Enhanced Water Laboratory (Vancouver).

Lucas, B. 1997. Field methods for *Giardia* and *Cryptosporidium* sample collection. Water Management Branch, BC Environment.

Marleau, L. 2004. Personal communication. Environmental Health Foreman, City of Terrace (Terrace).

Moore, D. 1998. Ambient Water Quality Criteria for Organic Carbon in British Columbia. Environment and Resource Management Department, Ministry of Environment, Lands and Parks.

Northern Labs Ltd. 2001. Analysis Final Report (for City of Terrace water samples collected October 17, 2001).

Province of British Columbia, BC Environment. 1994. B.C. environmental laboratory manual for the analysis of water, wastewater, sediment, and biological materials. Ministry of Environment, Lands and Parks.

Province of British Columbia, BC Environment. 1998a . British Columbia water quality guidelines (criteria). Water Quality Section, Ministry of Environment, Lands and Parks. http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#approved

Province of British Columbia, BC Environment. 1998b. A compendium of working water quality guidelines for British Columbia. Water Quality Section, Ministry of Environment, Lands and Parks.
http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#working

Province of British Columbia, Ministry of Health. 2002. Drinking Water Program website – News release, backgrounder, and cabinet submission from June 19, 2002. http://www.healthplanning.gov.bc.ca/protect/water.html

Province of British Columbia, Office of Auditor General. 1999. 1998/99 Report 5: Protecting drinking water sources. Office of the Auditor General.

Province of British Columbia, Provincial Health Officer. 2001. A report on the health of British Columbians. Provincial Health Officer's Annual Report 2000, *Drinking water quality in British Columbia: The public health perspective.* Ministry of Health Planning, Victoria. http://www.moh.hnet.bc.ca/pho/pdf/phoannual2000.pdf.

Province of British Columbia, Ministry of Sustainable Resource Mgt (MSRM). 2004a. Community Watersheds website. http://srmwww.gov.bc.ca/wat/cws/cwshome.htm

Province of British Columbia, MSRM. 2004b. Fisheries Information Summary System (FISS) website. http://www.bcfisheries.gov.bc.ca/fishinv/fiss.html

Province of British Columbia, Ministry of Water, Land and Air Protection (WLAP) GIS. 2004. GOAT G.I.S. Tool.

Remington, D. 2002. Drinking water source quality monitoring: Skeena Region 2001.

Thompson, B. 2003. Water quality data sheets for Prince Rupert, provided to WLAP via mail. Director of Engineering Services, City of Prince Rupert (Prince Rupert).

Warrington, P. D. 1988. Water quality criteria for microbiological indicators. Water Management Branch, Ministry of Environment, Lands and Parks.

Watson, B. 1999. Memorandum to Andy Malloy (EHO) regarding Prince Rupert Waterworks, dated April 20, 1999. Public Health Engineer, Northern Health Authority (Saltspring Island).

Watson, B. 2000. Memorandum to Neil Nabata (EHO) regarding City of Terrace Waterworks, dated July 18, 2000. Public Health Engineer, Northern Health Authority (Saltspring Island).

Watson, B. 2002a. Memorandum to Andy Malloy (EHO) regarding Prince Rupert Waterworks, dated July 4, 2002. Public Health Engineer, Northern Health Authority (Saltspring Island).

Watson, B. 2002b. Memorandum to Russell Seltenrich (EHO) regarding Kitimat Townsite Waterworks, dated May 21, 2002. Public Health Engineer, Northern Health Authority (Saltspring Island).

Watson, B. 2003. Personal Communication. Public Health Engineer, Northern Health Authority (Saltspring Island).

Water Survey of Canada (WSC). 2004a. MS Excel Data for Deep Creek and Kitimat River, provided by email from Lynne Campo, Water Survey of Canada (Vancouver).

WSC. 2004b. Real-Time Hydrometric Data website. http://scitech.pyr.ec.gc.ca/waterweb/main.asp?lang=0

WSC. 2004c. Water Level and Streamflow Statistics website. http://www.wsc.ec.gc.ca/index_e.cfm?cname=main_e.cfm

LIST OF ACRONYMS

BCCDC – British Columbia Centre for Disease Control

CCME – Canadian Council of Ministers of the Environment

CFU – Colony Forming Unit

EHO – Environmental Health Officer

EPA – United States Environmental Protection Agency (also referred to as USEPA)

HAA – Haloacetic Acid

ICPMS – Inductively Coupled Plasma - Mass Spectrometry

MDL – Method Detection Limit

MF – Membrane Filtration

MoE – Ministry of Environment (previously called Ministry of Water, Land and Air Protection (WLAP) from June 2001 – June 2005)

MSRM – Ministry of Sustainable Resource Management

NHA – Northern Health Authority

NTU – Nephelometric Turbidity Units

QA/QC – Quality Assurance / Quality Control

RPD – Relative Percent Difference

TCU – True Colour Units

THM – Trihalomethane

WLAP – Ministry of Water, Land and Air Protection (ministry name from June 2001 – June 2005; now called Ministry of Environment (MoE))

WSC – Water Survey of Canada

GLOSSARY

Aesthetic objective: The substance concentration or characteristic of drinking water that can affect its acceptance by consumers. Where an aesthetic objective is specified, the values are below those considered to constitute a health hazard.

Aquifer: A geological formation that consists of saturated permeable materials that yield economical quantities of water to wells and springs.

Bacteria: Single-celled, microscopic organisms, some of which cause diseases in plants or animals.

Blank sample: A sample of distilled, de-ionized water that has been exposed to the sampling environment at the sample site and handled in the same manner as the actual sample (e.g., preserved, filtered). It provides information on contamination resulting from the handling technique and from exposure to the atmosphere.

Carcinogen: A substance capable of causing cancer.

Colour (True): A measure of the dissolved colouring compounds in water, attributed to the presence of organic and inorganic materials. Reported in true colour units (TCU).

Coliform bacteria: A bacteria carried in human and animal wastes. The presence of coliforms in water may indicate contamination from human or animal wastes.

Cryptosporidium (*Cryptosporidium parvum*) A parasite often found in the intestines of livestock. When it contaminates drinking water, it causes the severe gastrointestinal illness *Cryptosporidiosis* which is characterized by stomach cramps and diarrhea. Chlorination is not effective at killing *Cryptosporidium*.

Cyst A resting or dormant stage of a protozoan (for example *Giardia*) usually found in the environment where it awaits introduction into a new host.

Disinfection: The process of destroying microorganisms in water by the application of a chemical agent (disinfectant) such as chlorine.

Disinfectant By-product: A compound formed by the reaction of a disinfectant such as chlorine with organic material in the water supply

Duplicate sample: Two samples taken at the same time and place, designed to provide a rough estimate of the overall precision associated with the field technique and laboratory analysis.

E. coli **(***Escherichia coli***)**—A species of fecal coliform bacteria that is specific to the intestinal tract of humans and other warm-blooded animals. Unlike some fecal coliforms, *E. coli* do not naturally multiply outside a body, so they are more direct indicator of fecal contamination. Most species don't pose a threat to human health, but their presence in drinking water does indicate the possibility of other, more dangerous bacteria.

Enterococci A group of fecal streptococci bacteria that is used as an indicator of water quality. Enterococci are especially useful for monitoring the risk of gastrointestinal disease in marine waters, where they survive much better than *E. coli*.

Eutrophic: Describes a lake with high nutrient concentrations resulting in elevated productivity.

Eutrophication: The process of physical, chemical and biological changes associated with nutrient, organic matter and silt enrichment of a water body that cause it to age.

Fecal coliforms Bacteria that are present in the intestine or feces of warm-blooded animals. By themselves they are not necessarily pathogenic, but they are often used as indicators of water quality. In the laboratory they are defined as all the organisms that produce blue colonies within 24 hours when incubated at 44.5C plus or minus 0.2C on M-FC medium (nutrient medium for bacterial growth). Their concentrations are expressed as numbers of colonies per 100 ml of sample.

Giardia (*Giardia lamblia*) A parasite that causes the severe gastrointestinal illness *Giardiasis*, when it contaminates drinking water. *Giardiasis* occurs when drinking water is either not filtered or not chlorinated, and it is characterized by abdominal discomfort, nausea, and alternating constipation and diarrhea.

Groundwater: Water below the surface of the ground.

Hardness: A property of water which causes an increase in the amount of soap that is needed to produce foam or lather and that also produces scale in hot water pipes, heaters, boilers and other units in which the temperature of water is increased. Hardness is generally due to the presence of calcium and magnesium in the water. Reported in milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$); greater than 120 mg/L is considered hard; less than 60 mg/L is soft.

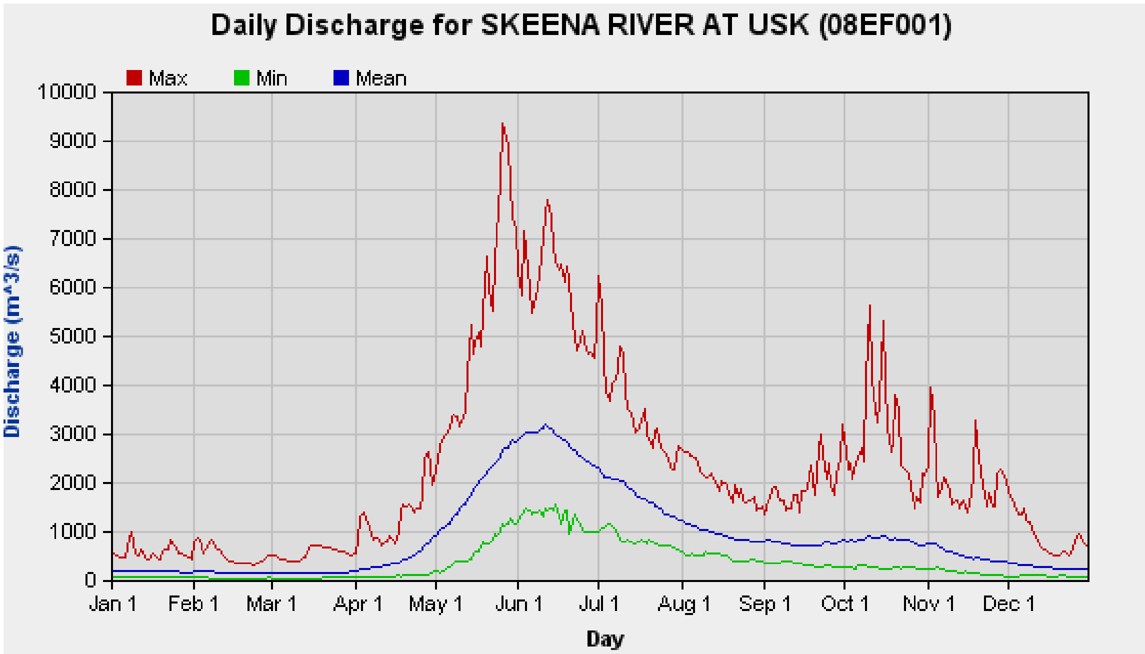
Interim maximum acceptable concentration:	Where there is insufficient toxicological data to derive a maximum acceptable concentration with reasonable certainty, the recommended maximum level based on the available health data and employing an uncertainty factor.
Maximum acceptable concentration:	The concentration established for certain substances that are known or suspected to cause adverse effects on health. These concentrations are derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration.
Method detection Limit (MDL):	The minimum amount of a substance that can be routinely detected by the analytical instrument or technique with a high degree of confidence.
Microbiological indicator:	Bacteria indicating a risk of disease from pathogenic bacteria; If it can be shown that fecal contamination of the water has occurred, then pathogenic organisms may also be present. Common indicator bacteria include fecal coliforms, *Escherichia* coli (*E. coli*) and enterococci.
Micrograms per litre (µg/L):	One one-thousandth of one milligram per litre.
Milligrams per litre (mg/L):	A concentration unit of chemical constituents in solution; the weight of solute (substance) per unit volume of solvent (water).
Nutrient:	A substance (element or compound) necessary for the growth and development of plants and animals. Lake studies commonly focus on nutrients critical to plant growth: nitrogen and phosphorus.
Oligotrophic:	Describes a lake of low plant productivity.
Oocyst	The dormant form of *Cryptosporidium* (see “Cyst”)
Parasite:	An organism that causes harm or death to its host organism when it lives or breeds on or within the host organism. Examples include *Giardia lamblia* and *Cryptosporidium parvum.*
pH:	A measure of the hydrogen-ion concentration in water. A quantitative expression for acidity or alkalinity of solution. The scale ranges from 0 to 14, pH 7 is neutral; less than 7 is acid; more than 7 is alkaline.
Protozoan	A small, single-celled animal.
QA/QC (Quality assurance /Quality control):	QA is the overall verification program which provides producers and users of data the assurance that predefined standards of quality were met. QC is the system of guidelines, procedures and practices intended to regulate and control the quality of the data from collection through to analysis.

Specific conductance:	A measure of the ability of water to conduct an electric current; the greater the content of ions (dissolved metals and other materials) in the water, the more current the water can carry. Reported in microsiemens per centimetre (µS/cm).
Total metal:	A measure of metals in the dissolved state and those sorbed to particulate matter in suspension.
Turbidity:	A measure of the suspended particulate matter in a water body, which interferes with the passage of a beam of light through the water. Materials that contribute to turbidity include clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms. Reported in nephelometric turbidity units (NTU).
Water quality guideline (criteria):	A numerical value(s) for a physical, chemical, or biological characteristic of water, biota, or sediment which must not be exceeded to prevent specified detrimental effects from occurring to water use; the safe level of a substance for the protection of a given water use.
Water quality objective:	A water quality criterion or guideline adapted to protect the most sensitive designated water use at a specific location with an adequate degree of safety, taking local circumstances into account.
Watershed:	A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

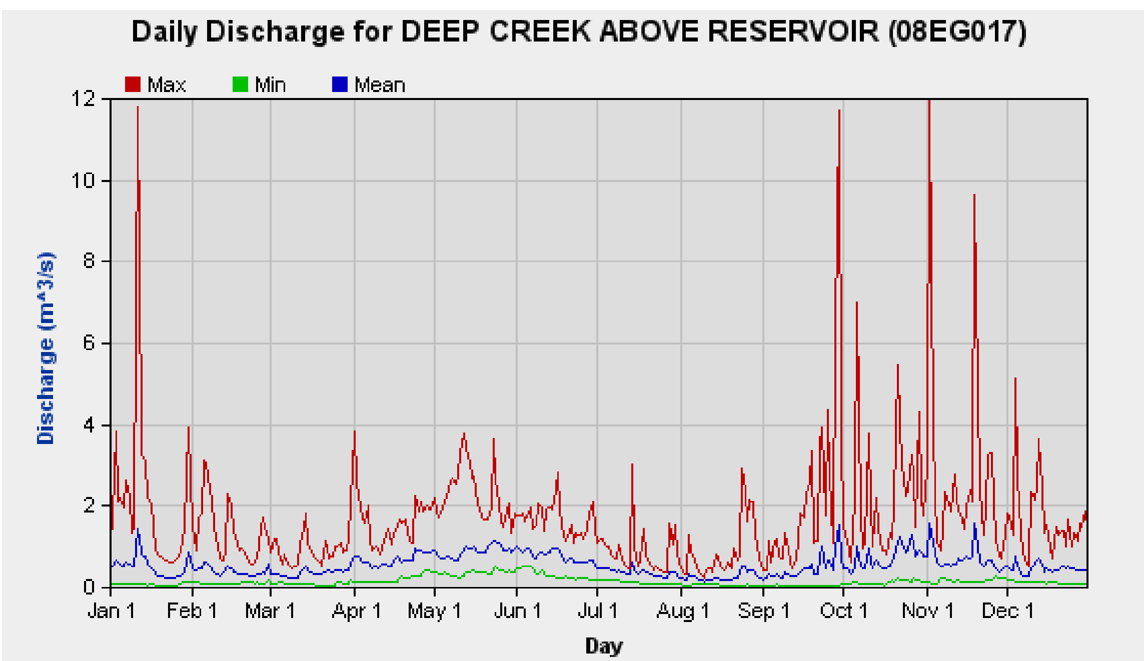
APPENDIX 1

Discharge Curves for River and Creek Sampling Sites (WSC, 2004c)

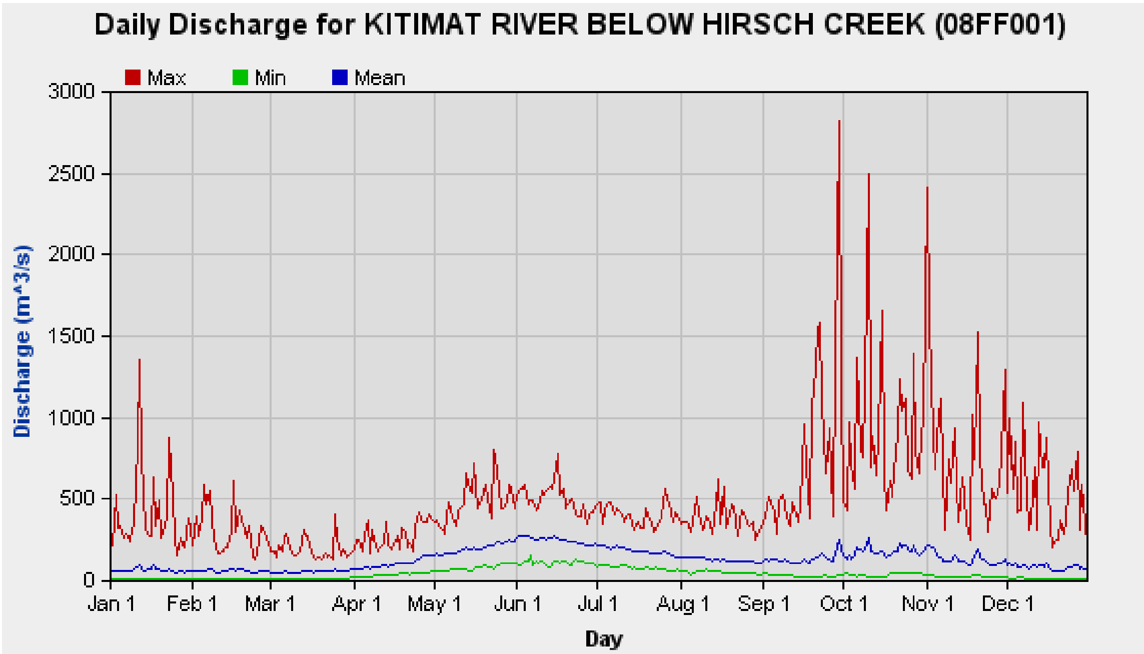
Skeena River Annual Flows



Deep Creek Annual Flows



Kitimat River Annual Flows



APPENDIX 2

Water Quality Analysis

Water Quality Analysis – Woodworth Lake Intake, Prince Rupert Water System (EMS #E253653)
(Values reported in mg/L unless noted)

	PRWS 29-Sep-03	**PRWS 14-Oct-03**	**PRWS 22-Oct-03**	**Drinking Water Guideline**		
BACTERIA						
Fecal coliforms (CFU/100mL)	< 1	3	2	≤ 10	max acceptable concentration	Met
E. coli (CFU/100mL)	< 1	< 1	1	≤ 10	max acceptable concentration	Met
Enterococci (CFU/100mL)	< 1	< 1	< 1	≤ 3	max acceptable concentration	Met
PARASITES						
Giardia (cysts/100L)	NPD	NPD	NPD	≤ 1	max acceptable concentration	Met
Cryptosporidium (oocysts/100L)	NPD	**4.7**	NPD	≤ 1	max acceptable concentration	**Not Met**
PYHSICAL						
pH (pH units)	7.1	7.1	6.8	≤ 8.5	aesthetic objective (>6.5)	Met
Colour True (Col. Units)	**30**	**40**	**20**	≤ 15	aesthetic objective	**Not Met**
Specific Conductance (uS/cm)	24	25	26	≤ 700	max acceptable concentration	Met
Residue Filterable - TDS	24	24	36	≤ 500	aesthetic objective	Met
Turbidity (NTU)	0.44	0.55	0.33	≤ 5	max acceptable concentration	Met
Hardness Total - T	9.1	9.3	9.5	≤ 500	max acceptable concentration	Met
Alkalinity Total (mg/L CaCO3)	6.3	7.2	5.6			
ANIONS						
Chloride Dissolved	1.1	1.1	1.4	≤ 250	aesthetic objective	Met
Fluoride Dissolved	< 0.01	< 0.01	< 0.01	≤ 1.5	max acceptable concentration	Met
CARBON						
Organic Carbon - Total	3.9	3.7	3.5	≤ 4	max acceptable conc. (THM)	Met
NITROGEN						
Ammonia N	< 0.005	< 0.005	< 0.005			
Nitrate Nitrogen Dissolved	< 0.02	< 0.02	< 0.02	≤ 10	max acceptable concentration	Met
Nitrate+Nitrite	0.011	0.008	0.017			
Nitrite Nitrogen	< 0.002	0.002	0.002	≤ 1	max acceptable concentration	Met
SULFATE						
Sulfate	1.4	2.3	1.9	≤ 500	aesthetic objective	Met

Woodworth Lake Intake, Prince Rupert Water System (EMS #E253653) Continued
(Values reported in mg/L unless noted)

		PRWS 29-Sep-03		PRWS 14-Oct-03		PRWS 22-Oct-03	Drinking Water Guideline			
METALS TOTAL										
Aluminum		0.106		0.085		0.0906	≤	0.2	max acceptable concentration	Met
Antimony		0.000005	<	0.000005	<	0.000005	≤	0.006	interim max acceptable conc.	Met
Arsenic	<	0.0001	<	0.0001	<	0.0001	≤	0.025	interim max acceptable conc.	Met
Barium		0.00751		0.00749	0	0.00751	≤	1	max acceptable concentration	Met
Beryllium	<	0.00002	<	0.00002	<	0.00002				
Bismuth	<	0.00002	<	0.00002	<	0.00002				
Boron	<	0.008	<	0.008	<	0.008	≤	5	max acceptable concentration	Met
Cadmium	<	0.00001	<	0.00001	<	0.00001	≤	0.005	max acceptable concentration	Met
Calcium		3.1		3.22		3.26				
Chromium		0.0011	<	0.0002		0.0003	≤	0.05	max acceptable concentration	Met
Cobalt		0.000086		0.000056		0.000054				
Copper		0.00222		0.00136		0.00104	≤	1	aesthetic objective	Met
Iron		0.135		0.127		0.115	≤	0.3	aesthetic objective	Met
Lead		0.00065		0.00051		0.00051	≤	0.01	max acceptable concentration	Met
Lithium		0.00009		0.00014		0.00027				
Magnesium		0.33		0.31		0.33	≤	100	aesthetic objective	Met
Manganese		0.00487		0.0034		0.00309	≤	0.05	aesthetic objective	Met
Molybdenum		0.00012	<	0.00005		0.00005	≤	0.25	max acceptable concentration	Met
Nickel		0.0004		0.00024		0.00028				
Phosphorus	<	0.1	<	0.1	<	0.1	≤	0.01	max acceptable concentration	
Potassium	<	1	<	1	<	1				
Selenium	<	0.0002	<	0.0002	<	0.0002	≤	0.01	max acceptable concentration	Met
Silver	<	0.00002	<	0.00002	<	0.00002				
Sodium		0.93		0.91		0.98	≤	200	aesthetic objective	Met
Strontium		0.0111		0.0135		0.0136				
Sulfer		0.5		0.6		0.6				
Tellurium	<	0.05	<	0.05	<	0.05				
Thallium		0.000003		0.000006		0.000051				
Tin		0.00001		0.00003		0.00003				
Titanium	<	0.003	<	0.003	<	0.003	≤	0.1	max acceptable concentration	Met
Uranium		0.000018		0.000005		0.000007	≤	0.02	interim max acceptable conc.	Met
Vanadium		0.00047		0.00018		0.00019	≤	0.1	max acceptable concentration	Met
Zinc		0.002		0.0027		0.0023	≤	5	aesthetic objective	Met
Zirconium	<	0.005	<	0.005	<	0.005				

Water Quality Analysis – Deep Creek at Intake, Terrace (EMS #E253652)
(Values reported in mg/L unless noted)

	DCT 30-Sep-03	**DCT 15-Oct-03**	**DCT 21-Oct-03**	**Drinking Water Guideline**		
BACTERIA						
Fecal coliforms (CFU/100mL)	**15**	< 1	**28**	≤ 10	max acceptable concentration	**Not Met**
E. coli (CFU/100mL)	**13**	< 1	**25**	≤ 10	max acceptable concentration	**Not Met**
Enterococci (CFU/100mL)	< 1	< 1	1	≤ 3	max acceptable concentration	Met
PARASITES						
Giardia (cysts/100L)	NPD	NPD	**4.1**	≤ 1	max acceptable concentration	**Not Met**
Cryptosporidium (oocysts/100L)	NPD	NPD	NPD	≤ 1	max acceptable concentration	Met
PYHSICAL						
pH (pH units)	7.3	7.2	6.7	≤ 8.5	aesthetic objective (>6.5)	Met
Colour True (Col. Units)	**30**	**30**	**60**	≤ 15	aesthetic objective	**Not Met**
Specific Conductance (uS/cm)	26	28	22	≤ 700	max acceptable concentration	Met
Residue Filterable - TDS	42	24	28	≤ 500	aesthetic objective	Met
Turbidity (NTU)	0.41	0.27	0.43	≤ 5	max acceptable concentration	Met
Hardness Total - T	9.6	13	9	≤ 500	max acceptable concentration	Met
Alkalinity Total (mg/L CaCO3)	9.3	10.3	4.8			
ANIONS						
Chloride Dissolved	1	0.6	0.9	≤ 250	aesthetic objective	Met
Fluoride Dissolved	0.06	0.08	0.04	≤ 1.5	max acceptable concentration	Met
CARBON						
Organic Carbon - Total	**6.2**	3.7	**10.2**	≤ 4	max acceptable conc. (THM)	**Not Met**
NITROGEN						
Ammonia N	< 0.005	< 0.005	< 0.005			
Nitrate Nitrogen Dissolved	< 0.02	< 0.02	0.02	≤ 10	max acceptable concentration	Met
Nitrate+Nitrite	0.008	0.022	0.022			
Nitrite Nitrogen	< 0.002	0.005	< 0.002	≤ 1	max acceptable concentration	Met
SULFATE						
Sulfate	1.6	1.6	1.8	≤ 500	aesthetic objective	Met

Deep Creek at Intake, Terrace (EMS #E253652) Continued
(Values reported in mg/L unless noted)

		DCT 30-Sep-03		DCT 15-Oct-03		DCT 21-Oct-03	Drinking Water Guideline			
METALS TOTAL										
Aluminum		0.0728		0.0674		0.189	≤	0.2	max acceptable concentration	Met
Antimony		0.000006	<	0.000005		0.000005	≤	0.01	interim max acceptable conc.	Met
Arsenic	<	0.0001	<	0.0001	<	0.0001	≤	0.03	interim max acceptable conc.	Met
Barium		0.014		0.0142		0.0141	≤	1	max acceptable concentration	Met
Beryllium	<	0.00002	<	0.00002	<	0.00002				
Bismuth	<	0.00002	<	0.00002	<	0.00002				
Boron	<	0.008	<	0.008	<	0.008	≤	5	max acceptable concentration	Met
Cadmium		0.00001		0.00003		0.00001	≤	0.01	max acceptable concentration	Met
Calcium		2.88		3.97		2.7				
Chromium		0.0003	<	0.0002		0.0002	≤	0.05	max acceptable concentration	Met
Cobalt		0.000041		0.000038		0.000053				
Copper		0.00032		0.00038		0.00046	≤	1	aesthetic objective	Met
Iron		0.136		0.176		0.194	≤	0.3	aesthetic objective	Met
Lead		0.00003		0.00003		0.00005	≤	0.01	max acceptable concentration	Met
Lithium		0.00006		0.00027		0.00023				
Magnesium		0.59		0.75		0.54	≤	100	aesthetic objective	Met
Manganese		0.0124		0.0152		0.0129	≤	0.05	aesthetic objective	Met
Molybdenum		0.00639		0.00752		0.00516	≤	0.25	max acceptable concentration	Met
Nickel	<	0.00005	<	0.00005		0.00012				
Phosphorus	<	0.1	<	0.1	<	0.1	≤	0.01	max acceptable concentration	
Potassium	<	1	<	1		1				
Selenium	<	0.0002	<	0.0002	<	0.0002	≤	0.01	max acceptable concentration	Met
Silver	<	0.00002	<	0.00002	<	0.00002				
Sodium		0.93		1.14		0.95	≤	200	aesthetic objective	Met
Strontium		0.0216		0.0279		0.0236				
Sulfer		0.5		0.6		0.5				
Tellurium	<	0.05	<	0.05	<	0.05				
Thallium	<	0.000002		0.000002		0.000014				
Tin		0.00001		0.00003		0.00002				
Titanium	<	0.003	<	0.003	<	0.003	≤	0.1	max acceptable concentration	Met
Uranium		0.000354		0.000321		0.000514	≤	0.02	interim max acceptable conc.	Met
Vanadium		0.00022		0.00014		0.00019	≤	0.1	max acceptable concentration	Met
Zinc		0.0004		0.0015		0.0024	≤	5	aesthetic objective	Met
Zirconium	<	0.005	<	0.005	<	0.005				

Water Quality Analysis – Skeena River at Intake, Terrace (EMS #E253651)
(Values reported in mg/L unless noted)

	SRT 30-Sep-03	SRT 15-Oct-03	SRT 21-Oct-03	SRT DUP 21-Oct-03	Drinking Water Guideline		
BACTERIA							
Fecal coliforms (CFU/100mL)	7	4	**13**	n/a	≤ 10	max acceptable concentration	**Not Met**
E. coli (CFU/100mL)	4	< 1	10	n/a	≤ 10	max acceptable concentration	Met
Enterococci (CFU/100mL)	3	< 1	**7**	n/a	≤ 3	max acceptable concentration	**Not Met**
PARASITES							
Giardia (cysts/100L)	**28**	**24.2**	**51.3**	n/a	≤ 1	max acceptable concentration	**Not Met**
Cryptosporidium (oocysts/100L)	NPD	NPD	NPD	n/a	≤ 1	max acceptable concentration	Met
PYHSICAL							
pH (pH units)	7.8	7.8	7.8	7.8	≤ 8.5	aesthetic objective (>6.5)	Met
Colour True (Col. Units)	10	5	10	10	≤ 15	aesthetic objective	Met
Specific Conductance (uS/cm)	84	101	91	92	≤ 700	max acceptable concentration	Met
Residue Filterable - TDS	66	76	54	50	≤ 500	aesthetic objective	Met
Turbidity (NTU)	**5.16**	2	**5.89**	4.68	≤ 5	max acceptable concentration	**Not Met**
Hardness Total - T	39.6	49.8	43.9	44.9	≤ 500	max acceptable concentration	Met
Alkalinity Total (mg/L CaCO3)	32.9	41	38	38.1			
ANIONS							
Chloride Dissolved	0.9	< 0.5	< 0.5	< 0.5	≤ 250	aesthetic objective	Met
Fluoride Dissolved	0.03	0.03	0.01	0.01	≤ 1.5	max acceptable concentration	Met
CARBON							
Organic Carbon - Total	1.8	1.6	3	2.9	≤ 4	max acceptable conc. (THM)	Met
NITROGEN							
Ammonia N	< 0.005	< 0.005	< 0.005	< 0.005			
Nitrate Nitrogen Dissolved	0.03	0.02	0.03	0.03	≤ 10	max acceptable concentration	Met
Nitrate+Nitrite	0.033	0.029	0.036	0.037			
Nitrite Nitrogen	< 0.002	0.005	0.004	0.004	≤ 1	max acceptable concentration	Met
SULFATE							
Sulfate	6.7	9.5	7.7	7.5	≤ 500	aesthetic objective	Met

Skeena River at Intake, Terrace (EMS #E253651) Continued
(Values reported in mg/L unless noted)

	SRT 30-Sep-03	SRT 15-Oct-03	SRT 21-Oct-03	SRT DUP 21-Oct-03	Drinking Water Guideline		
METALS TOTAL							
Aluminum	0.125	0.072	0.113	0.115	≤0.2	max acceptable concentration	Met
Antimony	0.000051	0.000048	0.000044	0.000041	≤0.01	interim max acceptable conc.	Met
Arsenic	0.0002	0.0001	0.0002	0.0002	≤0.03	interim max acceptable conc.	Met
Barium	0.0194	0.0206	0.0237	0.0241	≤1	max acceptable concentration	Met
Beryllium	<0.00002	<0.00002	<0.00002	<0.00002			
Bismuth	<0.00002	<0.00002	<0.00002	<0.00002			
Boron	<0.008	<0.008	<0.008	<0.008	≤5	max acceptable concentration	Met
Cadmium	<0.00001	<0.00001	<0.00001	0.00007	≤0.01	max acceptable concentration	Met
Calcium	12.7	15.9	14	14.3			
Chromium	0.001	0.0005	<0.0002	<0.0002	≤0.05	max acceptable concentration	Met
Cobalt	0.000062	0.000024	0.000061	0.000067			
Copper	0.00078	0.00066	0.00113	0.00112	≤1	aesthetic objective	Met
Iron	0.264	0.12	0.274	**0.333**	≤0.3	aesthetic objective	**Not Met**
Lead	0.0001	0.00006	0.00011	0.00012	≤0.01	max acceptable concentration	Met
Lithium	0.00031	0.00039	0.00032	0.00028			
Magnesium	1.92	2.44	2.16	2.23	≤100	aesthetic objective	Met
Manganese	0.00683	0.00369	0.0083	0.00855	≤0.05	aesthetic objective	Met
Molybdenum	0.00086	0.00084	0.00081	0.00079	≤0.25	max acceptable concentration	Met
Nickel	0.00013	<0.00005	<0.00005	0.00008			
Phosphorus	<0.1	<0.1	<0.1	<0.1	≤0.01	max acceptable concentration	
Potassium	<1	<1	<1	<1			
Selenium	<0.0002	<0.0002	<0.0002	0.0002	≤0.01	max acceptable concentration	Met
Silver	<0.00002	<0.00002	<0.00002	<0.00002			
Sodium	1.34	1.78	1.63	1.69	≤200	aesthetic objective	Met
Strontium	0.0716	0.0968	0.0906	0.0918			
Sulfer	2.6	3.4	2.7	2.7			
Tellurium	<0.05	<0.05	<0.05	<0.05			
Thallium	0.000002	0.000002	<0.000002	<0.000002			
Tin	<0.00001	<0.00001	0.00002	0.00001			
Titanium	0.006	<0.003	0.005	0.008	≤0.1	max acceptable concentration	Met
Uranium	0.000053	0.000059	0.000083	0.000074	≤0.02	interim max acceptable conc.	Met
Vanadium	0.00067	0.00039	0.00031	0.0003	≤0.1	max acceptable concentration	Met
Zinc	0.0006	0.0012	0.002	0.0028	≤5	aesthetic objective	Met
Zirconium	<0.005	<0.005	<0.005	<0.005			

Water Quality Analysis – Kitimat River Infiltration Gallery, Kitimat (EMS #E253649)
(Values reported in mg/L unless noted)

	KRK 30-Sep-03	**KRK DUP 30-Sep-03**	**KRK 15-Oct-03**	**KRK 21-Oct-03**	**Drinking Water Guideline**		
BACTERIA							
Fecal coliforms (CFU/100mL)	**23**	n/a	2	**165**	≤10	max acceptable concentration	**Not Met**
E. coli (CFU/100mL)	**26**	n/a	<1	**78**	≤10	max acceptable concentration	**Not Met**
Enterococci (CFU/100mL)	**5**	n/a	**4**	**140**	≤3	max acceptable concentration	**Not Met**
PARASITES							
Giardia (cysts/100L)	**12.5**	n/a	**43.6**	**23.8**	≤1	max acceptable concentration	**Not Met**
Cryptosporidium (oocysts/100L)	NPD	n/a	NPD	**4.8**	≤1	max acceptable concentration	**Not Met**
PYHSICAL							
pH (pH units)	7.4	7.4	7.4	7.1	≤8.5	aesthetic objective (>6.5)	Met
Colour True (Col. Units)	10	10	5	**50**	≤15	aesthetic objective	**Not Met**
Specific Conductance (uS/cm)	35	35	43	26	≤700	max acceptable concentration	Met
Residue Filterable - TDS	38	32	30	26	≤500	aesthetic objective	Met
Turbidity (NTU)	**5.09**	5.47	1.76	**37.5**	≤5	max acceptable concentration	**Not Met**
Hardness Total - T	13.8	13.8	16.1	18.7	≤500	max acceptable concentration	Met
Alkalinity Total (mg/L CaCO3)	12.4	11.9	15.1	9			
ANIONS							
Chloride Dissolved	0.7	0.7	0.9	0.7	≤250	aesthetic objective	Met
Fluoride Dissolved	0.01	0.01	0.04	0.01	≤1.5	max acceptable concentration	Met
CARBON							
Organic Carbon - Total	2.5	2.3	1.2	**5.1**	≤4	max acceptable conc. (THM)	**Not Met**
NITROGEN							
Ammonia N	0.012	0.012	<0.005	<0.005			
Nitrate Nitrogen Dissolved	0.06	0.06	0.05	0.07	≤10	max acceptable concentration	Met
Nitrate+Nitrite	0.064	0.064	0.046	0.077			
Nitrite Nitrogen	0.005	0.004	<0.002	0.004	≤1	max acceptable concentration	Met
SULFATE							
Sulfate	2	2.1	3.1	1.6	≤500	aesthetic objective	Met

Kitimat River Infiltration Gallery, Kitimat (EMS #E253649) Continued
(Values reported in mg/L unless noted)

	KRK 30-Sep-03	KRK DUP 30-Sep-03	KRK 15-Oct-03	KRK 21-Oct-03	Drinking Water Guideline		
METALS TOTAL							
Aluminum	0.164	0.189	0.0629	**0.672**	≤0.2	max acceptable concentration	**Not Met**
Antimony	0.000017	0.000019	0.000005	0.000007	≤0.01	interim max acceptable conc.	Met
Arsenic	<0.0001	<0.0001	<0.0001	0.0002	≤0.03	interim max acceptable conc.	Met
Barium	0.0135	0.0137	0.0133	0.021	≤1	max acceptable concentration	Met
Beryllium	<0.00002	<0.00002	<0.00002	<0.00002			
Bismuth	<0.00002	<0.00002	<0.00002	<0.00002			
Boron	<0.008	<0.008	<0.008	<0.008	≤5	max acceptable concentration	Met
Cadmium	<0.00001	<0.00001	<0.00001	0.00002	≤0.01	max acceptable concentration	Met
Calcium	4.57	4.54	5.34	4.7			
Chromium	0.0009	0.0008	0.0003	0.0003	≤0.05	max acceptable concentration	Met
Cobalt	0.00011	0.000114	0.000052	0.000511			
Copper	0.00083	0.00087	0.0009	0.00273	≤1	aesthetic objective	Met
Iron	**0.325**	0.332	0.225	**3.3**	≤0.3	aesthetic objective	**Not Met**
Lead	0.00008	0.00009	0.0001	0.00037	≤0.01	max acceptable concentration	Met
Lithium	<0.00005	0.00008	0.00014	0.00025			
Magnesium	0.59	0.59	0.67	1.69	≤100	aesthetic objective	Met
Manganese	0.0122	0.0127	0.0115	0.0469	≤0.05	aesthetic objective	Met
Molybdenum	0.00052	0.00056	0.00057	0.00022	≤0.25	max acceptable concentration	Met
Nickel	0.00015	0.00014	<0.00005	0.00047			
Phosphorus	<0.1	<0.1	<0.1	0.2	≤0.01	max acceptable concentration	
Potassium	<1	1	<1	2			
Selenium	<0.0002	<0.0002	<0.0002	<0.0002	≤0.01	max acceptable concentration	Met
Silver	<0.00002	<0.00002	<0.00002	<0.00002			
Sodium	1.11	1.11	1.56	1.24	≤200	aesthetic objective	Met
Strontium	0.0239	0.0247	0.0336	0.0259			
Sulfer	0.8	0.7	0.9	0.5			
Tellurium	<0.05	<0.05	<0.05	<0.05			
Thallium	0.000002	0.000002	0.000005	<0.000002			
Tin	0.00001	<0.00001	0.00002	<0.00001			
Titanium	0.014	0.012	<0.003	**0.129**	≤0.1	max acceptable concentration	**Not Met**
Uranium	0.000089	0.000089	0.000082	0.000288	≤0.02	interim max acceptable conc.	Met
Vanadium	0.00093	0.00085	0.0004	0.0018	≤0.1	max acceptable concentration	Met
Zinc	0.0006	0.0007	0.0016	0.0032	≤5	aesthetic objective	Met
Zirconium	<0.005	<0.005	<0.005	<0.005			

Water Quality Analysis – Kitimat River Pumphouse #7 Tap, Kitimat (EMS #E253650)
(Values reported in mg/L unless noted)

	KPH7 30-Sep-03	KPH7 15-Oct-03	KPH7 21-Oct-03	Drinking Water Guideline		
BACTERIA						
Fecal coliforms (CFU/100mL)	< 1	< 1	5	≤ 10	max acceptable concentration	Met
E. coli (CFU/100mL)	< 1	< 1	4	≤ 10	max acceptable concentration	Met
Enterococci (CFU/100mL)	1	< 1	**6**	≤ 3	max acceptable concentration	**Not Met**
PARASITES						
Giardia (cysts/100L)	NPD	NPD	NPD	≤ 1	max acceptable concentration	Met
Cryptosporidium (oocysts/100L)	NPD	NPD	NPD	≤ 1	max acceptable concentration	Met
PYHSICAL						
pH (pH units)	7.3	7.2	7.1	≤ 8.5	aesthetic objective (>6.5)	Met
Colour True (Col. Units)	5	5	15	≤ 15	aesthetic objective	Met
Specific Conductance (uS/cm)	39	40	36	≤ 700	max acceptable concentration	Met
Residue Filterable - TDS	32	30	34	≤ 500	aesthetic objective	Met
Turbidity (NTU)	0.5	0.43	1.22	≤ 5	max acceptable concentration	Met
Hardness Total - T	14.7	14.7	13.9	≤ 500	max acceptable concentration	Met
Alkalinity Total (mg/L CaCO3)	13.2	14	11.8			
ANIONS						
Chloride Dissolved	0.7	0.9	0.8	≤ 250	aesthetic objective	Met
Fluoride Dissolved	< 0.01	0.03	< 0.01	≤ 1.5	max acceptable concentration	Met
CARBON						
Organic Carbon - Total	2.3	0.6	2.9	≤ 4	max acceptable conc. (THM)	Met
NITROGEN						
Ammonia N	0.026	< 0.005	< 0.005			
Nitrate Nitrogen Dissolved	0.17	0.12	0.21	≤ 10	max acceptable concentration	Met
Nitrate+Nitrite	0.172	0.118	0.212			
Nitrite Nitrogen	0.005	< 0.002	0.003	≤ 1	max acceptable concentration	Met
SULFATE						
Sulfate	2.2	2.8	2.2	≤ 500	aesthetic objective	Met

Kitimat River Pumphouse #7 Tap, Kitimat (EMS #E253650) Continued
(Values reported in mg/L unless noted)

		KPH7 30-Sep-03		KPH7 15-Oct-03		KPH7 21-Oct-03	Drinking Water Guideline			
METALS TOTAL										
Aluminum		0.038		0.0228		0.0756	≤	0.2	max acceptable concentration	Met
Antimony		0.00006		0.000105		0.000047	≤	0.01	interim max acceptable conc.	Met
Arsenic	<	0.0001	<	0.0001	<	0.0001	≤	0.03	interim max acceptable conc.	Met
Barium		0.0122		0.0122		0.0118	≤	1	max acceptable concentration	Met
Beryllium	<	0.00002	<	0.00002	<	0.00002				
Bismuth	<	0.00002	<	0.00002	<	0.00002				
Boron	<	0.008	<	0.008	<	0.008	≤	5	max acceptable concentration	Met
Cadmium	<	0.00001	<	0.00001		0.00001	≤	0.01	max acceptable concentration	Met
Calcium		4.96		4.96		4.66				
Chromium		0.0008		0.0005	<	0.0002	≤	0.05	max acceptable concentration	Met
Cobalt		0.000049		0.000024		0.000047				
Copper		0.00464		0.00175		0.00608	≤	1	aesthetic objective	Met
Iron		0.076		0.05		0.123	≤	0.3	aesthetic objective	Met
Lead		0.00088		0.00022		0.00059	≤	0.01	max acceptable concentration	Met
Lithium	<	0.00005		0.0001	<	0.00005				
Magnesium		0.57		0.57		0.56	≤	100	aesthetic objective	Met
Manganese		0.0241		0.0198		0.022	≤	0.05	aesthetic objective	Met
Molybdenum		0.00042		0.00041		0.0004	≤	0.25	max acceptable concentration	Met
Nickel		0.00006	<	0.00005	<	0.00005				
Phosphorus	<	0.1	<	0.1	<	0.1	≤	0.01	max acceptable concentration	
Potassium	<	1	<	1	<	1				
Selenium	<	0.0002	<	0.0002	<	0.0002	≤	0.01	max acceptable concentration	Met
Silver	<	0.00002	<	0.00002	<	0.00002				
Sodium		1.12		1.25		1.1	≤	200	aesthetic objective	Met
Strontium		0.0272		0.0321		0.0297				
Sulfer		0.8		0.8		0.7				
Tellurium	<	0.05	<	0.05	<	0.05				
Thallium	<	0.000002		0.000005	<	0.000002				
Tin		0.00007		0.00003	<	0.00001				
Titanium	<	0.003	<	0.003	<	0.003	≤	0.1	max acceptable concentration	Met
Uranium		0.000047		0.000034		0.000096	≤	0.02	interim max acceptable conc.	Met
Vanadium		0.00046		0.00029		0.00022	≤	0.1	max acceptable concentration	Met
Zinc		0.0257		0.0225		0.0247	≤	5	aesthetic objective	Met
Zirconium	<	0.005	<	0.005	<	0.005				

QA/QC Analysis

	MDL	BLANK 15-Oct-03	KRK 30-Sep-03	KRK DUP 30-Sep-03	RPD (%)	SRT 21-Oct-03	SRT DUP 21-Oct-03	RPD (%)
BACTERIA								
Fecal coliforms (CFU/100mL)			**23**	n/a		**13**	n/a	
E. coli (CFU/100mL)			**26**	n/a		10	n/a	
Enterococci (CFU/100mL)			**5**	n/a		**7**	n/a	
PARASITES								
Giardia (cysts/100L)			**12.5**	n/a		**51.3**	n/a	
Cryptosporidium (oocysts/100L)			NPD	n/a		NPD	n/a	
PYHSICAL								
pH (pH units)	0.1	6.9	7.4	7.4	0.0	7.8	7.8	0.0
Colour True (Col. Units)	5	5	10	10		10	10	
Specific Conductance (uS/cm)	1	1	35	35	0.0	91	92	-1.1
Residue Filterable - TDS	10	<10	38	32		54	50	
Turbidity (NTU)	0.1	0.19	**5.09**	**5.47**	-7.2	**5.89**	4.68	22.9
Hardness Total - T	0.3	<0.3	13.8	13.8	0.0	43.9	44.9	-2.3
Alkalinity Total (mg/L CaCO3)	0.5	2.3	12.4	11.9	4.1	38	38.1	-0.3
ANIONS								
Chloride Dissolved	0.5	<0.5	0.7	0.7		<0.5	<0.5	
Fluoride Dissolved	0.01	<0.01	0.01	0.01		0.01	0.01	
CARBON								
Organic Carbon - Total	0.5	<0.5	2.5	2.3		3	2.9	3.4
NITROGEN								
Ammonia N	0.005	<0.005	0.012	0.012		<0.005	<0.005	
Nitrate Nitrogen Dissolved	0.02	<0.02	0.06	0.06		0.03	0.03	
Nitrate+Nitrite	0.002	0.004	0.064	0.064	0.0	0.036	0.037	-2.7
Nitrite Nitrogen	0.002	0.003	0.005	0.004		0.004	0.004	
SULFATE								
Sulfate	0.5	<0.5	2	2.1		7.7	7.5	2.6

QA/QC Analysis Continued

	MDL	BLANK 15-Oct-03	KRK 30-Sep-03	KRK DUP 30-Sep-03	RPD (%)	SRT 21-Oct-03	SRT DUP 21-Oct-03	RPD (%)
METALS TOTAL								
Aluminum	0.0003	<0.0003	0.164	0.189	-14.2	0.113	0.115	-1.8
Antimony	0.000005	<0.000005	0.000017	0.000019		0.000044	0.000041	7.1
Arsenic	0.0001	<0.0001	<0.0001	<0.0001		0.0002	0.0002	
Barium	0.00002	<0.00002	0.0135	0.0137	-1.5	0.0237	0.0241	-1.7
Beryllium	0.00002	<0.00002	<0.00002	<0.00002		<0.00002	<0.00002	
Bismuth	0.00002	<0.00002	<0.00002	<0.00002		<0.00002	<0.00002	
Boron	0.008	<0.008	<0.008	<0.008		<0.008	<0.008	
Cadmium	0.00001	<0.00001	<0.00001	<0.00001		<0.00001	0.00007	
Calcium	0.05	<0.05	4.57	4.54	0.7	14	14.3	-2.1
Chromium	0.0002	<0.0002	0.0009	0.0008		<0.0002	<0.0002	
Cobalt	0.000005	<0.000005	0.00011	0.000114	-3.6	0.000061	0.000067	-9.4
Copper	0.00005	0.00044	0.00083	0.00087	-4.7	0.00113	0.00112	0.9
Iron	0.005	<0.005	**0.325**	**0.332**	-2.1	0.274	**0.333**	-19.4
Lead	0.00001	0.00004	0.00008	0.00009	-11.8	0.00011	0.00012	-8.7
Lithium	0.00005	0.00011	<0.00005	0.00008		0.00032	0.00028	13.3
Magnesium	0.05	<0.05	0.59	0.59	0.0	2.16	2.23	-3.2
Manganese	0.000008	<0.000008	0.0122	0.0127	-4.0	0.0083	0.00855	-3.0
Molybdenum	0.00005	<0.00005	0.00052	0.00056	-7.4	0.00081	0.00079	2.5
Nickel	0.00005	<0.00005	0.00015	0.00014		<0.00005	0.00008	
Phosphorus	0.1	<0.1	<0.1	<0.1		<0.1	<0.1	
Potassium	1	<1	<1	1		<1	<1	
Selenium	0.0002	<0.0002	<0.0002	<0.0002		<0.0002	0.0002	
Silver	0.00002	<0.00002	<0.00002	<0.00002		<0.00002	<0.00002	
Sodium	0.05	<0.05	1.11	1.11	0.0	1.63	1.69	-3.6
Strontium	0.000005	0.000006	0.0239	0.0247	-3.3	0.0906	0.0918	-1.3
Sulfer	0.1	<0.1	0.8	0.7	13.3	2.7	2.7	0.0
Tellurium	0.05	<0.05	<0.05	<0.05		<0.05	<0.05	
Thallium	0.000002	<0.000002	0.000002	0.000002		<0.000002	<0.000002	
Tin	0.00001	0.00001	0.00001	<0.00001		0.00002	0.00001	
Titanium	0.003	<0.003	0.014	0.012		0.005	0.008	
Uranium	0.000002	<0.000002	0.000089	0.000089	0.0	0.000083	0.000074	11.5
Vanadium	0.00006	<0.00006	0.00093	0.00085	9.0	0.00031	0.0003	
Zinc	0.0001	0.0008	0.0006	0.0007	-15.4	0.002	0.0028	-33.3
Zirconium	0.005	<0.005	<0.005	<0.005		<0.005	<0.005	

RPD > 25%