BRITISH COLUMBIA | Ministry of Environment

ENVIRONMENTAL PROTECTION DIVISION
ENVIRONMENTAL SUSTAINABILITY DIVISION
MINISTRY OF ENVIRONMENT

Water Quality Assessment and Objectives for the Brash Creek Community Watershed

TECHNICAL REPORT

April 2013

EXECUTIVE SUMMARY

This document presents a summary of the ambient water quality of Brash Creek, British Columbia, and proposes water quality objectives designed to protect existing and future water uses. The water quality assessment for the river and an evaluation of the watershed form the basis for the objectives.

The Brash Creek watershed is approximately 3,370 ha in area with the community watershed portion comprising the majority (3,093 ha) of this. The creek is approximately 12.7 km in length from the upper watershed to its confluence with the Shuswap River. Brash Creek is used as a backup source of domestic water for the City of Enderby. Other designated water uses include irrigation, livestock watering, wildlife, and aquatic life.

Water quality samples were collected from Brash Creek at an upstream background site and at the water intake site between 1996 and 1999. Microbiological indicator (*E. coli*) and turbidity levels were generally low and below guideline levels but elevated concentrations did occasionally occur. Water temperatures were within the acceptable range for drinking waters (for aesthetic purposes) at most times although the data show that water quality guidelines can be exceeded during hot summer months at the water intake. Water colour is naturally elevated and frequently exceeds the drinking water guideline, which can affect the aesthetic quality of the drinking water. Other water quality parameters measured and found to be well within acceptable levels include pH, suspended solids (total and dissolved), nutrients (nitrogen and phosphorus) and dissolved oxygen. Metal levels were below method detection limits, however it is recommended that future monitoring include low-level metal analyses to obtain a more accurate estimate of dissolved and total metal concentrations in Brash Creek.

The proposed water quality objectives for Brash Creek are summarized in the following table. To determine if these objectives are being attained, it is recommended that monitoring be conducted during freshet (early May to mid-June) and low-flow (mid-September to late October) conditions, and consist of a minimum of 5 weekly samples collected over a 30-day period.

Summary of proposed water quality objectives for the Brash Creek community watershed.

Variable	Objective Value
***E. coli* bacteria**	• $\leq$ 10 CFU/100ml (90th percentile based on a minimum of 5 samples collected within a 30-day period)
Turbidity	• 5 NTU maximum; • $\leq$ 1 NTU increase downstream of disturbance (based on 5 samples over 30 day period).
Temperature	• 15 °C maximum (long term)
True colour	• $\leq$20% increase (induced) in colour downstream of any site of concern
Total suspended solids	• 30 mg/L maximum within a 24-hour period (lower site); • $<$ 5 mg/L increase over background (average of minimum 5 samples collected within a 30-day period).

ACKNOWLEDGEMENTS

The Ministry of Environment gratefully acknowledges the work of Burke Phippen (BWP Consulting Inc.) in developing the original draft of this report.

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1.0 INTRODUCTION

Community watersheds are defined under the *Forest and Range Practices Act of BC* as "the drainage area above the downstream point of diversion which are licensed under the *Water Act* for waterworks purposes". These watersheds are generally small (<500 km^2) with short stream response times and minimal opportunities for dilution or settling. The Ministry of Environment, with funding from the Resource Inventory Program of Forest Renewal BC, conducted a program to assess water quality in select designated community watersheds between 1994 and 2002. The purpose of these assessments was to expedite and accumulate the baseline data necessary to assess water quality and to establish ambient water quality objectives on an individual community watershed basis. Water quality objectives provide site-specific water quality guidance for issuing permits, licenses, and orders by the Ministry of Environment; establish benchmarks for future assessments; and offer the basis for assessing the Ministry's performance in protecting water quality. Protecting community drinking water is a shared responsibility between local users or purveyors, Health Authorities, the Ministry of Environment, and other land management agencies.

Brash Creek is a third-order stream, located approximately 8 km east of Enderby, B.C. It is a tributary to the Shuswap River, which eventually flows into Mara Lake. The watershed has provided domestic water to the community of Enderby in the past, and may do so again in the future, but is not currently used as a source of domestic water (D. Kutney, pers. comm., 2010). Land uses within the watershed include timber harvesting, range use, agriculture, and recreation. These activities, as well as natural erosion and the presence of wildlife, all potentially affect water quality in Brash Creek.

This report describes pertinent hydrologic and biogeoclimatic aspects of the Brash Creek watershed, provides information on water use and land use activities that may influence water quality, and assesses the available water quality data. This report recommends water quality objectives for the Brash Creek watershed based on potential impacts and water quality parameters of concern at the time of the original draft. The report concludes by recommending a monitoring program for future assessment of water quality objectives attainment.

This report provides water quality and relevant water and land use information up to 2004. Only changes in relevant statutes, guidelines, names, and other readily available information, have been incorporated into this final document. Release of this information at this time serves to provide a lasting record of the water quality of Brash Creek between 1996 and 2000, and establishes a baseline condition for future assessments and supports increasing interest in water quality and water resource management within the Shuswap drainage.

2.0 WATERSHED PROFILE AND HYDROLOGY

2.1 BASIN PROFILE

The Brash Creek watershed (Figure 1) is approximately 3,370 ha in area with the community watershed portion comprising the majority (3,093 ha) of this. Elevation in the watershed ranges from approximately 1,850 m in the headwaters, to about 365 m at its confluence with the Shuswap River. The creek is approximately 12.7 km in length from the upper watershed to its confluence with the Shuswap River. The Enderby intake is located at approximately 460 m elevation, 2.3 km upstream from the Shuswap River confluence. There are no lakes located in the Brash Creek watershed.

The biogeoclimatic zones within the Brash Creek watershed include Englemann Spruce – Sub-alpine Fir (ESSFwc2) in the upper watershed, progressing to Interior Cedar Hemlock (ICHmk1) and finally Interior Douglas Fir (IDFxh1) in the lower portion of the watershed (Lloyd *et al*., 1990).

2.2 HYDROLOGY AND PRECIPITATION

The nearest climate station to the watershed is the valley-bottom station at Enderby (elevation 354 m) (Environment Canada Climate Station 1162680). Average daily temperatures range from –5.7 ^{o}C in January to 19.4 ^{o}C in July. Average total annual precipitation is 502.4 mm, with 156.7 mm (water equivalent) of this falling as snow (Figure 2). A larger portion of the annual total precipitation occurs as snowfall in the higher-elevation terrain of the watershed.

Water Survey Canada (WSC) operated a hydrometric station on Brash Creek for 11 years between 1915 and 1968 near Enderby (WSC Station #08LC004). Figure 3 shows the daily mean discharge values for each month calculated from the period of record, as well as daily maximum and minimum values recorded during this period. Peak flows occur during spring freshet (May and June), while minimum flows occur during the winter (between December and February). Average daily flows range from 0.069 m^3/s in January and February to 1.46 m^3/s in May and June.

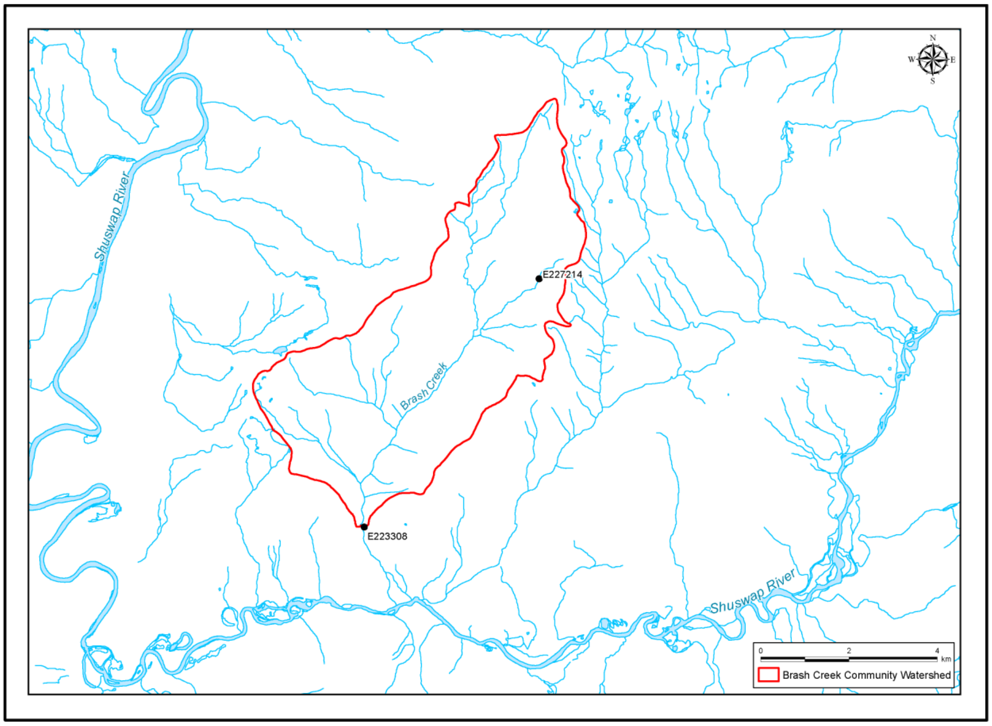

Figure 1. Brash Creek community watershed.

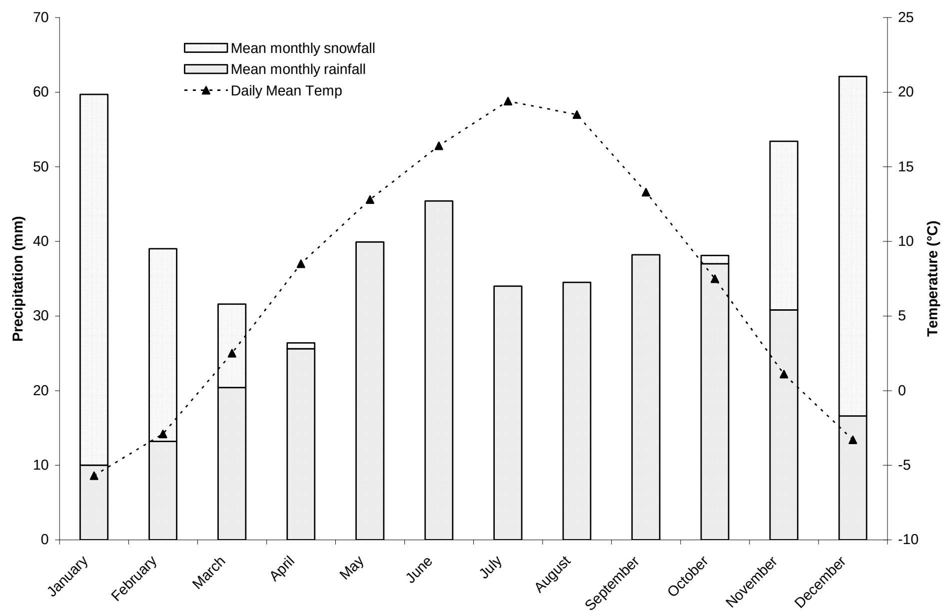

Figure 2. Climate data for the valley-bottom station at Enderby (Environment Canada Climate Station 1162680).

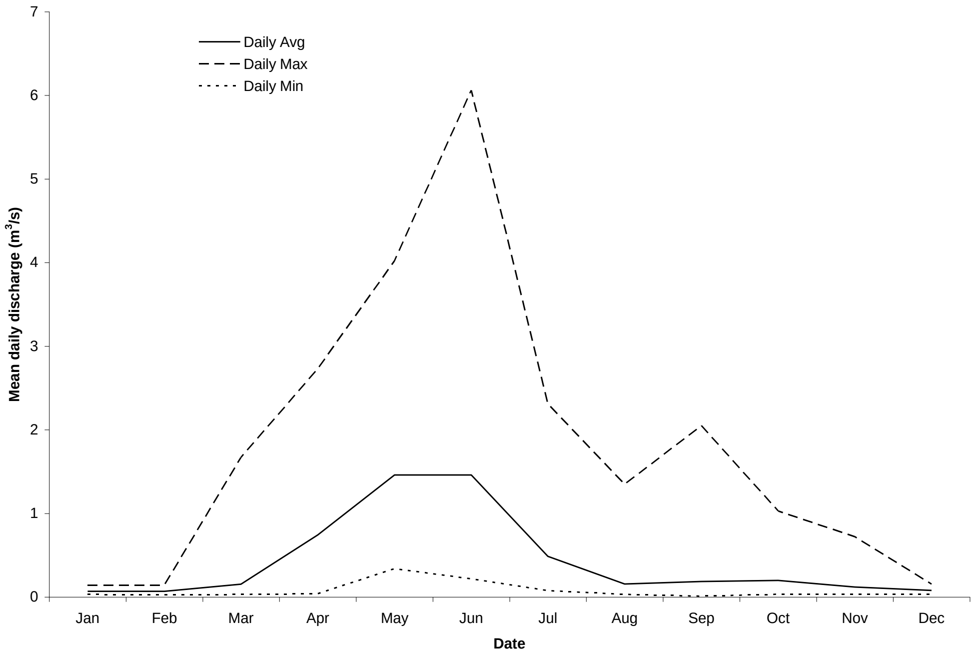

Figure 3. Minimum, maximum and average daily flow at Brash Creek near Enderby (WSC 1915 - 1968).

3.0 WATER USES

3.1 WATER LICENSES

One water license has been issued for Brash Creek within the community portion of the watershed, to the City of Enderby. It allows the withdrawal of 830 dam^3/year for the purpose of waterworks – local authority. The city does not currently use Brash Creek as a drinking water source; when active, the city chlorinates the water before distribution (D. Kutney, pers. comm., 2010). Two other water licenses have been issued for the lower portion of Brash Creek below the community watershed boundary. These are for domestic and irrigation uses, and permit the total withdrawal of 57 dam^3/year.

3.2 FISHERIES

The Brash Creek watershed is known to contain rainbow trout (FISS Database, 2004). In addition, the extreme lower portion of the watershed likely serves as rearing habitat for chinook and possibly coho salmon (Harding, pers. comm., 2004). However, this habitat would be located well below the community watershed boundary, due to impassable barriers in the lower portions of the creek.

3.3 RECREATION

There are no forest-recreation sites located in the Brash Creek watershed and no specific studies have been conducted to determine the recreational use of the Brash Creek watershed. However, snowmobilers utilize the watershed from late fall through early spring to access Hunters Range, in the upper reaches of the watershed, and local landowners also utilize trails in the watershed for horseback riding (D. Kutney, pers. comm., 2011).

3.4 DESIGNATED WATER USES

Designated water uses, are sensitive water uses that are designated for protection in a watershed or waterbody. Water quality objectives are then designed to protect the most sensitive designated water use so that attainment of the objectives will protect all of the designated uses. The water uses to be protected in the Brash Creek watershed include drinking water, irrigation, livestock watering, wildlife, and aquatic life.

4.0 INFLUENCES ON WATER QUALITY

The majority of the Brash Creek watershed is located on Crown Land, with the lower 12% of the watershed (below the intake) located on private land. There are no licensed discharges within the watershed. Logging roads in the upper watershed allow recreational access to much of this area. Timber harvest and silviculture activities also rely on this network of roads to access cut-blocks. Road construction can result in changes in the movements of water over the surface of the land, and are generally addressed through the construction of drainage ditches alongside the roads and culverts or bridges over areas of significant flow. The proximity of the roads to running water increases the potential for erosion or runoff increasing suspended sediment and turbidity concentrations in the creek. This also allows easy access for cattle or wildlife to enter the creek which can contribute to stream bank erosion, fecal contamination of the creek, and increased nutrient levels (nitrogen and phosphorus).

4.1 LICENSED WATER WITHDRAWALS

As mentioned in Section 3.1, there is one licensed water withdrawal within the community watershed boundaries of Brash Creek, with an overall maximum volume of 830 dam^3/year. Assuming water was withdrawn from Brash Creek at a constant rate throughout the year (an unlikely scenario), this would result in an average withdrawal rate of 0.026 m^3/s. As average daily flows range from 0.069 m^3/s in January and February to 1.46 m^3/s in May and June, and water consumption is highest during the summer months, it does not appear that water licenses should have a significant effect on flow downstream from the intake in an average year. In very dry years, downstream flow may be affected during some parts of the year.

4.2 FOREST HARVESTING AND FOREST ROADS

The Brash Creek watershed lies primarily within the forest tenure of Tolko Industries Ltd., with a small section of the northern watershed managed by BC Timber Sales. A watershed assessment was completed in November, 1998 (High Country and Dobson, 1998), and therefore information presented in this section pertains to that period. Table 1 lists projections of forest development proposed in 1998. At that time, a total of 12% of the watershed had been harvested, and the overall equivalent-clearcut-area (ECA) was 7%. The vast majority of this harvesting had occurred above the H_{60} line[1]. The total area proposed at that time for harvest beyond 2003 was 16%, resulting in an increased ECA of 12.9% at that time. The road density was also proposed to almost double the 1998 level, to 1.53 km/km^2. The density of roads on potentially unstable slopes was predicted to increase to 3.11 km/km^2, the number of stream crossings was to increase to 21, and the length of stream logged to the streambank was to increase to 0.05 km/km^2.

The road density within the watershed in 1998 was 0.81 km/km^2, with 2.4 km located on potentially unstable slopes, 15 landslides, and 12 stream crossings. The length of stream logged to the streambank was 0.03 km, while the length of stream with an unstable stream channel was 0.7 km. Problematic roads within the watershed were primarily the portions situated on west-facing slopes in the middle of the watershed, along Brash Canyon. This portion of the road has since been deactivated, and a new access road situated away from the Brash Creek canyon has been built.

4.3 RANGE TENURES

There are three overlapping range tenures that include the Brash Creek watershed. Two of the tenures access the watershed through the Blurton Creek (or north) side of the Brash Creek watershed, while the remaining tenure accesses the watershed from the Ashton Creek (or east) side. Brash Creek is used as a natural barrier for the western side of each of these tenures. Due to the topography of the watershed, direct access to the creek itself is limited, as is actual range land within the Brash Creek watershed. The three tenures allow for a total of 331 cow/calf pairs between May 15 and October 31, but perhaps only a quarter of the total number of cattle are within the Brash Creek watershed during this period. This results in an estimate of about 450 animal-unit months annually in the Brash Creek watershed. The estimated nutrient contributions for this number of cow/calf pairs is approximately 305 kg of phosphorus and 2,618 kg of nitrogen, based on the number of

[1] The H_{60} is the elevation at which 60% of the watershed area lies above. In the Brash Creek watershed, the H_{60} line is located at 1120 m. This is an important characteristic because in the interior of B.C., snow typically covers the upper 60% of a watershed when streamflow levels begin to rise in the spring.

cattle and dates mentioned above (Table 2). This assumes that 100% of the nutrients are transported into the creek, a scenario that is extremely unlikely.

Table 1. Forest development information proposed in 1998 IWAP (from High Country and Dobson, 1998).

Watershed Inventory Category	1998 Watershed Information	Proposed Watershed Information for 1998 to 2003	Proposed Watershed Information Beyond 2003
Area of unit (ha)	3,370	3,370	3,370
Total area harvested (%)	7	11	16
ECA (%)	7.0	10.0	12.9
ECA (%) above H60 (unweighted)	7.0	10.0	12.2
Total road density (km/km^2)	0.81	1.07	1.53
Density of road on potentially unstable slopes (km/km^2)	2.4	2.4	3.11
Number of stream crossings	12	16	21
Length of stream logged to the streambank (km/km)	0.03	0.05	0.05

Table 2. Projected nutrient production of cattle utilizing range tenure in Brash Creek watershed (based on Bangay, 1976).

	Phosphorus (kg/year)	**Nitrogen (kg/year)**
Cow	297	2550
Calf	8.3	67.9

4.4 RECREATION

Recreational activities can affect water quality in a number of ways. Erosion associated with 4-wheel drive and ATV vehicles, direct contamination of water from gasoline outboard motors on boats, and fecal contamination from human and domestic animal wastes (*e.g.*, dogs or horses) are typical examples of potential effects. Although no specific studies have been conducted on recreation within the Brash Creek watershed, year round access enables snowshoeing and snowmobiling in winter and hiking, horseback riding and ATV access in summer.

4.5 WILDLIFE

Wildlife can influence water quality because warm-blooded animals can carry pathogens such as *Giardia lamblia*, which causes giardiasis or "beaver fever", and *Cryptosporidium* oocysts which cause the gastrointestinal disease, cryptosporidiosis. In addition, the presence of wildlife can lead to elevated levels of microbiological indicators, such as *Escherichia coli*. Fecal contamination of water by animals is generally considered to be less of a concern to human health than contamination by humans because there is less risk of inter-species transfer of pathogens. However, without specific source-tracking methods, it is impossible to determine the origins of coliforms.

Little specific information regarding the wildlife resources of the Brash Creek watershed is available. Warm-blooded wildlife species known to occur in the study area include: whitetail deer, black bear, wolf, cougar, fox, coyote, lynx, beaver, river otter, red squirrels, ermine, eagles, hawks, owls, grouse and numerous other species of small birds. The mid and lower portions of the Brash Creek watershed provide high-value deer wintering range.

5.0 WATER QUALITY

5.1 WATER SAMPLING PROCEDURES

Drinking water is the most sensitive water use in Brash Creek. Given the potential anthropogenic impacts to the watershed (generally associated with forestry and recreation), and the lack of discharge licenses within the watershed, the water quality parameters most likely to change should impacts occur are: microbiological indicators, turbidity, colour, pH, phosphorus, nitrate, nitrite and specific conductivity. Nutrients (nitrate, nitrite and phosphorus) and dissolved oxygen concentrations are also considered for the protection of fisheries and wildlife values.

Two water quality monitoring sites were selected within the Brash Creek watershed: EMS Site E227214, Brash Creek Upper Watershed, and E223308, Brash Creek upstream from the Enderby Intake (Figure 1). These sites were selected to characterize water quality in the upper watershed and identify changes in water quality prior to the intake. Samples were collected above the intake reservoir, rather than in the reservoir itself, to determine the water quality before the effects of settling could occur within the reservoir, which in itself represents partial treatment.

Water samples were generally collected biweekly between March and October of each year, with sampling frequencies increasing to weekly between mid-May and mid-June (the period which approximates the spring freshet). During the winter months, (November through February) when snow and ice cover keep water quality relatively stable, samples were collected on a monthly basis. On occasion, snow cover restricted access to the sites (especially the upper site) and sampling frequencies were slightly lower than discussed above. Samples were collected according to Resources Information Standards Committee (RISC) protocols (Cavanagh *et al.* 1994).

The BC Water Quality Guidelines and Health Canada Drinking Water Guidelines were used to assess the water quality of Brash Creek.

5.2 Quality Assurance / Quality Control

Quality assurance and quality control was verified by collecting field blanks, and duplicate and triplicate samples. Field blanks are collected by transporting deionized water and filling sample bottles at each site in a manner consistent with how regular samples are collected. The samples are handled in exactly the same way as regular samples, and give an indication of contamination from the sample bottles or sample handling. Duplicate and triplicate samples are collected by filling two (or three) sample bottles in as close to the same time period as possible (concurrently or one right after the other) at a monitoring location to assess overall variability.

For blank samples, contamination has occurred when 5% or more of the blanks show any levels above the method detection limit. If the results are below method detection limits, the data is considered clean and the real sample data are to be treated as uncontaminated (Cavanagh *et al*., 1998). The precision of co-located duplicate samples is measured using the relative percent difference between the two samples and is calculated using the following equation:

$$\frac{Sample\ 1 - Sample\ 2}{mean\ of\ Samples\ 1, 2} \times 100$$

The maximum acceptable relative percent difference between duplicate samples is 25%.

The precision of co-located triplicate samples is measured using the percent relative standard deviation, and is calculated using the following equation:

$$\frac{Standard\ Deviation\ of\ samples}{Mean\ of\ samples} \times 100$$

The maximum acceptable percent relative standard deviation is 18%.

Precision is influenced by how close the analytical value is to the method detection limit (MDL). The MDL is the level above which there is a high probability (e.g., 95 %) that a substance can be detected. The percent relative standard deviation increases rapidly as the analytic value approaches the MDL. Consequently, the use of percent mean difference or percent relative standard deviation is limited to analytical values that are at least five times the MDL.

Four sets of duplicate samples and five sets of triplicate samples (Appendix I - Table 3), as well as 2 field blanks (Appendix I - Table 4), were collected at the lower site between June 29, 1998 and May 4, 2000. One set of duplicate samples was collected at the upper site on October 22, 1998 (Appendix I - Table 5). Most QA/QC samples were found to be within acceptable limits, or rejected due to because of concentrations less than 5 times the MDC as discussed. With except of one NO3+NO2 sample, field blanks submitted for this study were near or below detection limits.

6.0 WATER QUALITY ASSESSMENT AND OBJECTIVES

6.1 COLIFORM BACTERIA

Coliform bacteria are present in large numbers in the feces of warm-blooded animals, and although rarely pathogenic themselves, they are used as indicators of potential health risk to drinking water sources. Fecal coliforms are quite specific to the feces of warm-blooded animals and *E. coli* are even more specific, whereas total coliforms have many non-fecal sources (*e.g.* soils, plants), and thus are less indicative of fecal contamination. Coliforms generally do not survive long in cold, fresh water (Brettar and Höfle, 1992), but can survive for prolonged periods in stream sediment, soils or fecal material, when associated with particulate matter, or in warmer water (Howell *et al.*, 1996; Tiedemann *et al.*, 1987). Disturbance of these sediments can therefore result in coliforms appearing in overlying water for extended periods (Jawson *et al.*, 1982; Stephenson and Rychert, 1982). The inclusion of a small piece of fecal matter in a sample can result in extremely high concentrations (>1,000 CFU/100 mL), which can skew the overall results for a particular site. It is therefore important to consider the range of values, as well as the standard deviation, to determine if numbers are consistently high or if one value "artificially" inflated the mean. For this reason, the 90th percentile is generally used to determine if the water quality guideline is exceeded, as extreme values would have less effect on the data. The BC guideline to protect drinking water sources, for waters receiving disinfection only, is that the 90th percentile of at least five, and ideally 10 samples collected in a 30-day period should not exceed 10 CFU/100 mL for both fecal coliforms and *E. coli*. Increasingly, *E. coli* is considered the primary indicator; however as both parameters were collected they are discussed below.

Fecal coliform concentrations at the upper site were generally below detection limits, with concentrations of < 1 CFU/100 mL in 23 of 35 samples collected between 1997 and 1999. The maximum concentration however, was relatively high (470 CFU/100 mL) occurring on September 17, 1997; the next highest value recorded at this site was 56 CFU/100 mL. Concentrations were slightly lower at the intake site, with values ranging from below detectable limits (< 1 CFU/100 mL; 42 of 59 samples) to 28 CFU/100 mL.

There was one instance at the upper site where at least five fecal coliform samples were collected in a 30-day period (a condition which must be met to calculate an accurate 90th percentile value), and four instances at the lower site. All of the percentile values at both sites met the drinking water guideline, with a 90th percentile of 8.8 CFU/100 mL at the upper site and 90th percentile values ranging from 1.6 CFU/100 mL to 8.8 CFU/100 mL at the lower site.

E. coli concentrations followed a similar pattern to those of fecal coliforms, with 27 of 35 samples at the upper site below detectable limits (< 1 CFU/100 mL), a maximum concentration of 360 CFU/100 mL (also recorded on September 17, 1997) and a 90th percentile of 2 CFU/100 mL. At the lower site, 43 of 60 values were below detectable limits, the maximum concentration was 20 CFU/100 mL, and the 90th percentile of all values was 2.2 CFU/100 mL. As with fecal coliforms, there were four instances at the lower site and one instance at the upper site when the sampling frequency required to assess guideline attainment was met (at least five samples in a 30-day period). Three of the four values at the lower site, as well as the single value at the upper site, were below the guideline of 10 CFU/100 mL (<1 CFU/100 mL to 3.8 CFU/100 mL at the lower site; 7.6 CFU/100 mL at the upper site). The guideline was exceeded by one set of five-in-30 day samples, with a 90th percentile of 12.4 CFU/100 mL between May 19 and June 15, 1998.

Elevated coliform values at both the upper and lower site occurred between the months of June and September each year. On the date when the maximum coliform values were recorded at the upper site, turbidity levels were slightly elevated (1.99 NTU versus an average of 0.57 NTU for the clear-flow period), suggesting that rainfall may have contributed to the elevated coliform levels. Cattle presence in the watershed during the period when the maximum concentration was recorded suggests that they may potentially contribute to the elevated levels of coliforms. Wildlife or recreational activities however, cannot be ruled out as potential coliform sources. Nevertheless, Brash Creek water is normally low in coliform bacteria. ***A water quality objective is proposed for* E. coli *in Brash Creek. The objective is that the 90th percentile of a minimum of 5 samples collected within a 30-day period should not exceed 10 CFU/100 mL.*** This objective is consistent with the BC drinking water guidelines for raw water receiving only treatment by chlorination.

6.2 TURBIDITY

Turbidity is a measure of the clarity or cloudiness of water, and is measured by the amount of light scattered by the particles in the water. The BC drinking water guideline for raw water that does not receive treatment to remove turbidity, is a maximum of 5 NTU (nephelometric turbidity unit) at any time or an increase of no more than 1 NTU downstream of anthropogenic activity.

Brash Creek water is generally low in turbidity. Turbidity measured at the upper site ranged from 0.15 NTU to 4.3 NTU, with an average of 0.54 NTU for 37 samples collected between 1997 and 1999. Analyzing turbidity measurements on the basis of clear-flow and turbid-flow periods (defined as April 1 to June 30 for turbid flow and July 1 to March 31 for clear flow, based on the hydrograph) shows a clear-flow average of 0.46 NTU, versus a turbid flow average of 0.88 NTU. The maximum value occurred on June 16, 1999, during the turbid-flow period.

At the intake site, turbidity values ranged from 0.09 to 14.3 NTU, with an average of 2.4 NTU. The turbid-flow average was 4.3 NTU, with values ranging from 0.92 NTU to 11 NTU, while the clear flow average was 1.7 NTU with values ranging from 0.09 NTU to 14.3 NTU. Therefore, although the extremes during the two periods were similar, the overall average turbidity during the clear-flow period was less than half that measured during the turbid-flow period.

In summary, turbidity values at both the upper and lower sites are often well below the guideline to protect drinking water sources (5.0 NTU). Values occasionally exceeded this guideline during both the turbid-flow and clear-flow periods at the lower site. As there are no automated sensors employed in the Brash Creek watershed, the duration of these periods of elevated turbidity cannot be determined. Nevertheless, given the normally low turbidity, ***the water quality objective proposed for turbidity in the Brash Creek watershed is that induced turbidity should not exceed 1NTU and total turbidity***

should not exceed 5 NTU at any time. This is consistent with the BC Guideline to protect drinking water distributed without treatment to reduce turbidity.

6.3 pH

pH measures the concentration of hydrogen ions (H^+) in water. The concentration of hydrogen ions in water can range over 14 orders of magnitude, so pH is defined on a logarithmic scale between 0 and 14. A pH between 0 and 7 is acidic (the lower the number, the more acidic the water) and a pH between 7 and 14 is basic (the higher the number, the more basic the water). The BC guideline to protect the aesthetic quality of drinking water is a pH between 6.5 and 8.5. Corrosion of metal plumbing may occur at both low and high pH outside of this range, while scaling or encrustation of metal pipes may occur at high pH. The effectiveness of chlorine as a disinfectant is also reduced outside of this range.

pH values at the upper site showed a relatively high degree of variation, ranging from 7.17 to 9.20 pH units and averaged 7.57 $\pm$0.39. The maximum value occurred on October 22, 1998, and the next highest value (8.7 pH units) occurred on October 26, 1999. At the lower site, pH values ranged from 6.2 to 8.41 pH units and averaged 7.88 $\pm$0.34. The minimum value occurred on April 29, 1999. However, a second sample collected on the same day had a pH value of 7.2. Therefore, the few pH values which fell outside of the drinking water guideline range could represent the normal variation of Brash Creek water, or perhaps a measurement error. As it is unlikely that any of the anthropogenic activities within the watershed are having a significant effect on pH, an objective is not proposed for pH.

6.4 Temperature

Brash Creek stream temperature could be affected by changes in riparian vegetation or changes in the proportion of groundwater contributing to stream flow. Temperature is considered in drinking water for aesthetic reasons. Water temperature is also important to aquatic life protection. The aesthetic guideline is 15 °C; temperatures above this level are considered to be too warm to be aesthetically pleasing. For salmonids, the water quality guidelines are set as mean weekly maximum water temperatures depending on the species and life stage of the fish. For example, the optimum rearing temperature range rainbow trout is 16-18 °C and for spawning, the maximum weekly temperature average is 10-15.5 °C.

Water temperature was measured in the field each time the sites were visited. As expected, temperatures were strongly seasonally correlated, with near-freezing temperatures occurring during the winter months and the warmest temperatures occurring towards the end of summer. Temperatures at the upper site ranged from 0.5 °C to 12.7 °C, while those at the lower site ranged from 0.9 °C to 18.8 °C. In general, water temperatures increase in a downstream direction as the exposure time to warmer ambient air increases.

The aesthetic drinking water guideline was exceeded during one of the four summers on record at the lower intake site (1998), with a maximum temperature of 18.8°C. Rainbow trout spawning in the creek are unlikely to be adversely affected by elevated water temperatures, as they spawn in the early spring and late fall, when water temperatures are below the critical range. While the aesthetic drinking water guideline is occasionally exceeded these temperatures may represent normal conditions given the relatively intact riparian corridor and lack of impoundment. In the absence of more detailed information, a long-term temperature objective is proposed which is consistent with the BC water quality guideline. ***The long term objective is that water temperatures at the Enderby intake not exceed 15 °C between July and September of each year.*** Further monitoring will be required to better define stream specific temperature objectives to address both drinking water, and aquatic life protection.

6.5 COLOUR

Colour in water is caused by dissolved and particulate organic and inorganic matter. True colour is a measure of the dissolved colour in water after the particulate matter has been removed, while apparent colour is a measure of the dissolved and particulate matter in water. Colour can affect the aesthetic acceptability of drinking water, and the aesthetic objective is a maximum of 15 true colour units (TCU). Colour is also an indicator of the amount of organic matter in water, which can produce disinfection by-products such as trihalomethanes (THMs) when chlorinated.

Colour at the upper site ranged from below detectable limits (<5 TCU) to 40 TCU, with an average of 11 TCU for 37 samples collected. At the intake site, values ranged from below detectable limits (<5 TCU) to 45 TCU, with an average of 15 TCU for 59 samples collected. Three values at the upper site exceeded the aesthetic guideline of 15 TCU (values ranging from 18 TCU to 40 TCU), while 18 of 59 values at the intake exceeded this guideline. Therefore, colour is occasionally an aesthetic concern in the Brash Creek system.

As colour levels in the Brash Creek watershed are almost certainly associated with natural events, it is unlikely that true colour in Brash Creek will consistently meet the 15 TCU guideline maximum for drinking water. Nevertheless, given the averages of colour measurements at the intake during clear and turbid flow are only slightly above the guideline, a long-term water quality objective consistent with the guideline is reasonable**.** ***In the interim the water quality objective proposed is that the maximum induced colour should not be greater than 20% from upstream to downstream from any area of anthropogenic influence.***

In addition, due to potential chlorination at the Enderby diversion, trihalomethanes and other by-products of reactions between organic matter and chlorine may pose a health risk. This compound should therefore be measured in the finished water (after chlorination has occurred) to ensure that the Health Canada guideline of 0.1 mg/L is not being exceeded.

6.6 CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS

Conductivity refers to the ability of a substance to conduct an electric current. The conductivity of a water sample gives an indication of the amount of dissolved ions in the water. The more ions dissolved in a solution, the greater the electrical conductivity. Water temperature affects conductivity (a 1ºC increase in temperature results in approximately a 2% increase in conductivity). Specific conductivity is conductivity normalized to 25 °C to account for the variation caused by water temperature. Coastal systems, with high annual rainfall values and typically short water retention times, generally have low specific conductivity (<80 μS/cm), while interior watersheds generally have higher values. Increased flows resulting from precipitation events or snowmelt tends to dilute the ions, resulting in decreased specific conductivity levels with increased flow levels. Therefore, water level and specific conductivity tend to be inversely related. However, in situations such as landslides where high levels of dissolved and suspended solids are introduced to the stream, specific conductivity levels tend to increase. As such, significant changes in specific conductivity can be used as an indicator of potential impacts.

At the upper site, specific conductivity values ranged from 18 µs/cm to 63 µs/cm, with an average of 37 µs/cm. The lower site had values ranging from 40 µs/cm to 213 µs/cm, with an average of 119 µs/cm. Values were closely correlated with flows, with the highest conductivity occurring during low flows (when dilution was lowest) and conductivity values dropping during freshet (when dilution from snowmelt runoff was highest). Due to its natural variability, there are no water quality guidelines for specific conductance. In terms of drinking water quality, high specific conductance levels are aesthetically unpleasing. There is an aesthetic drinking water guideline of 500 mg/L for total dissolved solids (TDS) for finished water (Health and Welfare Canada, 2008), and this would be an appropriate guideline value for source waters used for drinking that receive no treatment for dissolved solids removal. This equates to a specific conductance of approximately 700 μS/cm (BC Ministry of Environment, 1997). As all values were well below the drinking water guideline, no objective is proposed for specific conductivity.

Total dissolved solids (also referred to as filterable residue) includes all of the substances that are dissolved in a sample. The value for TDS should be strongly correlated with the specific conductivity of a sample. To determine TDS, a quantity of water is filtered to remove all particulate matter, and the filtrate is left so that all of the water evaporates, leaving the dissolved substances as crystals. The crystals are then weighed and a ratio of the mass of dissolved particles to water volume is determined. The Canadian aesthetic drinking water guideline for TDS is 500 mg/L.

Dissolved solids concentrations were only measured on four occasions in the upper watershed, with values ranging from 30 mg/L to 50 mg/L. At the intake site, dissolved solids concentrations were measured 12 times, with values ranging from 70 mg/L to 110 mg/L. As all values were well below the aesthetic drinking water guideline, no site specific objective is proposed.

6.7 TOTAL SUSPENDED SOLIDS

Total suspended solids (TSS), also referred to as non-filterable residue (NFR) includes all of the particulate matter in a sample. This value should be closely correlated with the turbidity value, however, unlike turbidity, it is not measured by optics. Instead, a quantity of the sample is filtered, and the residue is dried and weighed so that a weight of residue per volume is determined. No guideline has been established for drinking water at this time, however there are guidelines for the protection of aquatic life which vary with background conditions.

Concentrations of total suspended solids at the upper site were generally below detectable limits (35 of 37 measurements were < 5 mg/L) with a maximum value of 17 mg/L. At the lower site, the majority of values were also below detectable limits (53 of 60 values were < 5 mg/L), with a maximum value of 33 mg/L. There were 34 instances where TSS was measured at both the upper and lower site and thus a comparison of the increase above background levels could be calculated. In 33 of those cases there was no increase, while in the remaining instance, TSS increased by 16 mg/L. This increase (which occurred on June 16, 1999) was above the acceptable level for the protection of aquatic life, which allows a maximum increase of 10 mg/L.

Given that Brash Creek is normally low in suspended solids (<5 mg/L), and supports aquatic life along its length, an objective consistent with the provincial water quality guidelines is proposed. ***The objective is a maximum concentration of 30 mg/L (background of 5 mg/L + 25 mg/L increase) at the lower site, and a 30-day average of no more than 5 mg/L over background (upstream) conditions.***

6.8 NUTRIENTS (NITRATE, NITRITE AND PHOSPHORUS)

The concentrations of nitrogen (including nitrate and nitrite) and phosphorus are important parameters, as they tend to be the limiting nutrients in biological systems. Productivity is therefore directly proportional to the availability of these parameters. Nitrogen is usually the limiting nutrient in terrestrial systems, while phosphorus tends to be the limiting factor in aquatic systems. In watersheds where drinking water is a priority, it is desirable that nutrient levels remain low to avoid algal blooms and foul tasting water. Similarly, to protect aquatic life, nutrient levels should not be too high or the resulting plant and algal growth can deplete oxygen levels when it dies and begins to decompose, as well as during periods of low productivity when plants consume oxygen (*i.e.*, at night and during the winter under ice cover). The guideline for the maximum concentration for nitrate in drinking water is 10 mg/L and the guideline for nitrite is a maximum of 1 mg/L. When both nitrate and nitrite are present, their combined concentration must not exceed 10 mg/L. For the protection of aquatic life the maximum concentration of nitrate is 31.3 mg/L and the 30-day average concentration is 3.0 mg/L. The maximum concentration of nitrite for aquatic life protection is 0.06 mg/L and the 30 day average is 0.020 mg/L in low chloride water. There are no proposed guidelines for phosphorus in streams.

Nitrogen concentrations were measured in terms of dissolved nitrite (NO_2), dissolved nitrate + nitrite ($NO_3 + NO_2$) and dissolved ammonia. Dissolve nitrate (NO_3) was also measured on occasion at the intake site. Concentrations of nitrate + nitrite at the upper site ranged from below detectable limits (<0.002 mg/L) to a maximum of 0.107 mg/L. The single measurement of dissolved nitrite was below detectable limits (< 0.002 mg/L). Dissolved ammonia was measured four times, with three of the values below detectable limits (< 0.005 mg/L) and the remaining value equal to 0.007 mg/L. At the lower site, concentrations of nitrate + nitrite ranged from below detectable limits (<0.002 mg/L) to a maximum of 0.058 mg/L. Dissolve nitrate concentrations were measured on seven occasions – six of these were below detectable limits (< 0.002 mg/L), and the remaining value was 0.019 mg/L. Dissolved nitrite was measured on nine occasions – six of these were below detectable limits (< 0.002 mg/L), and the maximum value was 0.003 mg/L.

Dissolved ammonia was measured twice at the intake site, and both values were below detectable limits (< 0.005 mg/L). These values are all well below the aquatic life guidelines.

Phosphorus concentrations were also generally low, with concentrations at the upper site ranging from below detectable limits (< 0.002 mg/L) to a maximum of 0.016 mg/L for 37 values (average = 0.007 mg/L). At the intake site, values ranged from 0.013 mg/L to 0.094 mg/L, with an average of 0.031 mg/L for 57 values. Phosphorus concentrations in Brash Creek are not likely to be a concern.

As concentrations of both nitrogen and phosphorus are low in Brash Creek, no objective is proposed for these parameters.

6.9 Dissolved Oxygen

Dissolved oxygen (DO) concentrations are a crucial factor in the survival of salmonids such as rainbow trout and kokanee. These species are extremely sensitive to low DO, and exposure to low levels of dissolved oxygen can quickly prove fatal. A number of factors affect DO concentrations in fresh water. First, the solubility of oxygen in water is affected a great deal by temperature. The colder the water, the higher the potential concentration of dissolved oxygen. Exposure to air also affects DO levels; atmospheric concentrations of oxygen are many times greater than that of water, and oxygen tends to diffuse into water at its surface, especially when the water is shallow and fast-flowing. Finally, the decomposition of organic material consumes oxygen, and while plants and algae produce oxygen during the day, they respire at night and consume oxygen. In this way, deeper, more stagnant water with high productivity can become depleted of oxygen, resulting in a fatal condition for salmonids termed “summer kill”. Thus shallow, cold, fast-moving water will generally have high dissolved oxygen concentrations while deep, warmer, stagnant water will generally have lower oxygen concentrations. The 30-day average guideline for DO levels is a minimum of 8 mg/L for all life stages of salmonids other than alevins, and 11 mg/L for alevins in the water column. The instantaneous minimum guideline is 5 mg/L for all life stages, 9 mg/L for alevins in the water column, and 6 mg/L for interstitial embryos or alevins.

Dissolved oxygen concentrations at the upper site ranged from 9.8 mg/L to 14.0 mg/L for 15 values, with a mean of 12.0 mg/L. At the lower site, values ranged from 10.1 mg/L to 13.9 mg/L for 22 values, with an average of 11.9 mg/L. Therefore, it does not appear that low dissolved oxygen levels are a concern in Brash Creek.

6.10 METALS

Total metals concentrations were measured on four occasions at the lower site on Brash Creek. The concentrations of most metals were below detectable limits, and well below guidelines for drinking water and aquatic life. A number of metals, including arsenic, cadmium, selenium and antimony, were measured using detection limits that exceeded the respective guidelines for these metals. While all of these metals were consistently below their respective detection limits, an accurate assessment of guideline compliance cannot be made. As there are no anthropogenic sources of any of these metals within the watershed, it is not likely that human activities will significantly impact their concentrations at the Enderby intake, and therefore no water quality objectives are recommended for any metals within the Brash Creek watershed. Future metals analyses should include more appropriate detection limits (i.e. low-level analyses), and should be sampled (five samples within 30 days) during high flow and once during low flow for both total and dissolved fractions.

7.0 SUMMARY OF PROPOSED WATER QUALITY OBJECTIVES AND MONITORING RECOMMENDATIONS

A summary of the proposed water quality objectives is provided in Table 3. To determine whether the water quality objectives are being met, a monitoring program is recommended. In order to monitor the periods when water quality concerns are most likely to occur (*i.e.*, freshet and fall low-flow) it is recommended that a minimum of five samples be collected on a weekly basis between early May and mid-June, as well as between mid-September and late October. In this way, the two critical flow periods, as well as the period when cattle and recreationalists are present within the watershed, will be monitored. Samples should be analyzed for the water quality objective parameters (Table 3). It is recommended that other water chemistry data (including pH, specific conductivity, nutrients, low-level metals analyses) and field observations (dissolved oxygen, temperature) also be gathered to provide supporting information.

Table 3. Water quality objectives for the Brash Creek community watershed.

Variable	Objective Value
***E. coli* bacteria**	• $\leq$ 10 CFU/100ml (90th percentile based on a minimum of 5 samples collected within a 30-day period)
Turbidity	• 5 NTU maximum; • $\leq$ 1 NTU increase downstream of disturbance (based on 5 samples over 30 day period).
Temperature	• 15 °C maximum (long term)
True colour	• $\leq$20% increase (induced) in colour downstream of any site of concern
Total suspended solids	• 30 mg/L maximum within a 24-hour period (lower site); • < 5 mg/L increase over background (average of minimum 5 samples collected within a 30-day period).

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APPENDIX I. SUMMARY OF WATER QUALITY ASSURANCE DATA

Table 1. Summary of duplicate and triplicate samples collected at Site E223308 (Brash Creek above Intake Reservoir). Duplicate results with relative percent differences ≤25% are accepted (A) and rejected (R) if >25%. Triplicate results with percent relative standard deviations ≤18% are accepted (A) and rejected (R) if >18%.

Sampling Date	Fecal coliforms (CFU/ 100mL)	Color True (Col.unit)	E Coli (CFU/ 100mL)	Nitrate + Nitrite Diss. (mg/L)	P--T (mg/L)	Residue Non-filterable (mg/L)	Specific Cond. (µS/cm)	Turbidity (NTU)	pH (pH units)
29/06/1998 10:40	6	8	2	<0.002	0.014	<5	87	1.3	7.75
29/06/1998 10:45	<1	10	<1	<0.002	0.014	<5	87	1.32	7.76
Mean	3.5	9.0	1.5	<0.002	0.014	<5	87	1.31	7.76
Standard Deviation	3.5	1.4	0.7	<0.002	0	<5	0	0.01	0.01
% Relative S.Dev.	143	22	67	0	0	0	0	1	0
Accept @ <25%	R	A	R	A	A	A	A	A	A
13/08/1998 14:10	8	<5	6	<0.002	0.034	<5	194	0.14	8.22
13/08/1998 14:15	8	<5	4	<0.002	0.032	<5	194	0.15	8.23
Mean	8	<5	5.0	<0.002	0.033	<5	194	0.15	8.23
Standard Deviation	0	0.0	1.4	<0.002	0.001	<5	0	0.01	0.01
% Relative S.Dev.	0	0	40	0	6	0	0	7	0
Accept @ <25%	A	A	R	A	A	A	A	A	A
07/04/1999 9:30	<1	20	<1	<0.002	0.053	<5	138	3.8	7.95
07/04/1999 9:31	<1	20	<1	<0.002	0.051	<5	138	3.9	7.97
Mean	<1	20	<1	<0.002	0.052	<5	138	3.9	7.96
Standard Deviation	0	0	0	<0.002	0.001	<5	0	0.1	0.01
% Relative S.Dev.	0	0	0	0	0	0	0	2	0
Accept @ <25%	A	A	A	A	A	A	A	A	A
13/04/1999 9:45	<2		<2						
13/04/1999 9:46	<2		<2						
Mean	<2		<2						
Standard Deviation	0		0						
% Relative S.Dev.	0		0						
Accept @ +/-25%	A		A						

31/05/1999 11:00	<2	25	2	0.005	0.028	16	54	7.1	7.64
31/05/1999 11:01	<2	25	<2	0.005	0.031	17	54	7.3	7.62
31/05/1999 11:02	2	25	<2	0.004	0.031	14	54	7	7.61
Mean	2.0	25	2.0	0.005	0.030	16	54	7.1	7.62
Standard Deviation	0.0	0	0.0	0	0	2	0	0.2	0.02
% Relative S.Dev.	0	0	0	0	0	10	0	3	0
Accept @ ≤18%	A	A	A	A	A	A	A	A	A
30/08/1999 11:30	28	10	10	<0.002	0.029	<5	148	0.3	8.17
30/08/1999 11:31	36	10	14	<0.002	0.027	<5	149	0.25	8.15
30/08/1999 11:32	30	10	10	<0.002	0.027	<5	147	0.31	8.16
Mean	31	10	11	<0.002	0.028	<5	148	0.3	8.16
Standard Deviation	4	0	2	<0.002	0.001	<5	1	0.0	0.01
% Relative S.Dev.	13	0	18	0		0	1	0	0
Accept @ ≤18%	A	A	A	A	A	A	A	A	A

Table 1 (continued)

Sampling Date	Fecal coliforms (CFU/ 100mL)	Color True (Col.unit)	E Coli (CFU/ 100mL)	Nitrate + Nitrite Diss. (mg/L)	P--T (mg/L)	Residue Non-filterable (mg/L)	Specific Cond. (µS/cm)	Turbidity (NTU)	pH (pH units)
30/11/1999 12:00	<2	12.5	2	0.005	0.025	<5	84	1.4	7.07
30/11/1999 12:01	<2	12.5	4	0.003	0.026	<5	84	1.3	7.49
30/11/1999 12:02	<2	12.5	<2	0.003	0.025	<5	84	1.3	7.66
Mean	<2	13	2.7	0.004	0.025	<5	84	1.3	7.41
Standard Deviation	0	0	1.2	0.001	0.001	<5	0	0.1	0.30
% Relative S.Dev.	0	0	44	25	4	0	0	7	4
Accept @ ≤18%	A	A	R	R	A	A	A	A	A
14/03/2000 15:45		40		<0.002	0.077	9	179	21	8.01
14/03/2000 15:46		40		<0.002	0.075	9	178	20	8.14
14/03/2000 15:47		40		<0.002	0.077	11	180	20	8.13
Mean		40		<0.002	0.076	9.7	179.0	20.3	8.09
Standard Deviation		0		<0.002	0.001	1.2	1.0	0.6	0.07
% Relative S.Dev.		0		0	2	0	1	0	1
Accept @ ≤18%		A		A	A	A	A	A	A
04/05/2000 12:00	<1	30	<1	0.005	0.063	36	58	8.18	7.12
04/05/2000 12:01	<1	30	<1	0.005	0.057	23	55	8.37	7.1
04/05/2000 12:02	<1	30	<1	0.005	0.058	39	57	7.83	7.35
Mean	<1	30	<1	0.005	0.059	32.7	56.7	8.13	7.19
Standard Deviation	0	0	0	0	0.003	8.5	1.5	0.27	0.14
% Relative S.Dev.	0	0	0	0	5	26	3	3	2
Accept @ ≤18%	A	A	A	A	A	R	A	A	A

Table 2. Summary of laboratory analyses of field blanks collected at Site E223308 (Brash Creek above Intake Reservoir).

Sampling Date	Color True (Col.unit)	Nitrate + Nitrite Diss. (mg/L)	P--T (mg/L)	Residue Non-filterable (mg/L)	Specific Conductance (uS/cm)	Turbidity (NTU)	pH (pH units)
13/04/1999 9:46	<5	0.038	<0.002	<5	<2	0.05	5.77
20/09/1999 13:46	5	<0.002	<0.002	<5	<2	0.15	5.8

Table 3. Summary of duplicate sample collected at Site E227214 (Brash Creek Upstream). Duplicate results with relative percent differences ≤25% are accepted (A) and rejected (R) if >25%.

Sampling Date	Alk. 4.5/4.2 (mg/L)	Ammonia Diss. (mg/L)	Fecal coliforms (CFU/ 100mL)	Color True (Col.unit)	E Coli (CFU/ 100mL)	Nitrate + Nitrite Diss. (mg/L)	P--T (mg/L)	Res:Tot (mg/L)
22/10/1998 11:00	16	<0.005	<1	10	<1	0.044	0.005	<55
22/10/1998 11:01	16	<0.005	<1	7	<1	0.043	0.007	<45
Mean	16	<0.005	<1	8.5	<1	0.044	0.006	50
Standard Deviation	0	0	<1	2.1	<1	0.001	0.001	7
% Relative S.Dev.	0	0	0	35	0	2	33	20
Accept @ ≤25%	A	A	A	R	A	A	R	A

Sampling Date	Residue Filterable 1.0u (mg/L)	Residue Non-filterable (mg/L)	Specific Conductance (uS/cm)	Turbidity(NTU)	pH (pH units)
22/10/1998 11:00	50	<5	44	0.22	7.42
22/10/1998 11:01	40	<5	44	0.21	7.41
Mean	45.0	<5	44	0.22	7.42
Standard Deviation	7.1	<5	0	0.01	0.01
% Relative S.Dev.	22	0	0	5	0
Accept @ ≤25%	A	A	A	A	A

APPENDIX II. SUMMARY OF WATER QUALITY DATA

Table 1. Summary of general water chemistry at Site E227214, Brash Creek upper watershed.

	Minimum	Maximum	Average	Std Dev	Count	Turbid Min	Turbid Max	Turbid Average	Turbid Count	Clear Min	Clear Max	Clear Average	Clear Count
Alkalinity pH 4.5/4.2 (mg/L)	16	26.9	20.7	5.6	3				0	16	26.9	20.7	3
Amonia Dissolved (mg/L)	<0.005	0.007	0.0055	0.001	4				0	<0.005	0.007	0.006	4
Coli:Fec (CFU/100mL)	<1	470	18.5	79.2	35	<1	14	4.3	7	<1	470	22.1	28
Coli:Tot (CFU/100mL)	28	28	28	0.0	1				0	28	28	28	1
Color True (Col.unit)	<5	40	10.8	6.7	37	5	18	10	7	5	40	11.0	30
Diss Oxy (mg/L)	9.81	14	12.03	1.28	15	11.8	13.61	12.78	6	9.81	14	11.52	9
E Coli (CFU/100mL)	<1	360	12.0	60.6	35	<1	12	2.9	7	<1	360	14.3	28
Hardness Total (T) (mg/L)	14.9	26.7	18.2	5.6	4				0	14.9	26.7	18.2	4
Nitrate + Nitrite Diss. (mg/L)	<0.002	0.107	0.0194	0.0255	37	0.005	0.025	0.0147	7	<0.002	0.107	0.020	30
Nitrogen - Nitrite Diss. (mg/L)	<0.002	<0.002	<0.002	0	1				0	<0.002	<0.002	<0.002	1
P--T (mg/L)	<0.002	0.016	0.007	0.003	37	0.003	0.016	0.006	7	<0.002	0.013	0.008	30
pH (pH units)	7.17	9.2	7.57	0.39	37	7.2	7.71	7.46	7	7.17	9.2	7.60	30
Res:Tot (mg/L)	<35	<55	47.5	9.6	4				0	<35	<55	47.5	4
Residue Filterable 1.0u (mg/L)	30	50	42.5	9.6	4				0	30	50	42.5	4
Residue Non-filterable (mg/L)	<5	17	5.4	2.0	37	5	17	6.7143	7	<5	6	5.0	30
Specific Conductance (µS/cm)	18	63	37.1	10.4	36	18	32	26.5	6	25	63	39.2	30
Temp (C)	0.5	12.7	5.5	3.4	26	2.4	6.7	4.7271	7	0.5	12.7	5.8	19
Turbidit (NTU)	0.15	4.3	0.54	0.71	37	0.3	4.3	0.9	7	0.15	1.99	0.46	30

Table 2. Summary of general water chemistry at Site E223308, Brash Creek upstream from Enderby intake.

	Minimum	Maximum	Average	Std Dev	Count	Turbid Min	Turbid Max	Turbid Average	Turbid Count	Clear Min	Clear Max	Clear Average	Clear Count
Alkalinity pH 4.5/4.2 (mg/L)	81.7	81.7	81.7	0	1				0	81.7	81.7	81.7	1
Amonia Dissolved (mg/L)	<0.005	<0.005	<0.005	0	2				0	<0.005	<0.005	<0.005	2
Coli:Fec (CFU/100mL)	<1	28	3.2	4.9	59	<1	14	2.6	15	1	28	3.5	44
Coli:Tot (CFU/100mL)	1.0	41.0	9.3	11.4	11				0	1.0	41.0	9.3	11
Color True (Col.unit)	<5	45	14.8	9.6	59	7	40	19.5	15	<5	45	13.2	44
Diss Oxy (mg/L)	10.1	13.9	11.9	1.1	22	11.2	13.8	12.2	12	10.1	13.9	11.6	10
E Coli (CFU/100mL)	<1	20	2.1	3.0	60	<1	20	2.7	16	<1	10	1.9	44
Hardness Total (T) (mg/L)	46.9	50.9	48.3	2.2	3				0	46.9	50.9	48.3	3
Nitrate (NO3) Dissolved (mg/L)	<0.002	0.019	0.007	0.008	7				0	<0.002	0.019	0.007	7
Nitrate + Nitrite Diss. (mg/L)	<0.002	0.058	0.005	0.008	57	<0.002	0.008	0.003	15	<0.002	0.058	0.006	42
Nitrogen - Nitrite Diss. (mg/L)	<0.002	0.003	0.002	0.000	9				0	<0.002	0.003	0.002	9
pH (pH units)	6.2	8.41	7.88	0.34	56	6.2	8.1	7.6	15	7.07	8.41	7.98	41
P--T (mg/L)	0.013	0.094	0.031	0.017	59	0.014	0.086	0.034	15	0.013	0.094	0.030	44
Res:Tot (mg/L)	<75	<115	99.2	17.3	12				0	<75	<115	99.2	12
Residue Filterable 1.0u (mg/L)	70	110	94.2	17.3	12				0	70	110	94.2	12
Residue Non-filterable (mg/L)	<5	33	6.2	4.5	60	<5	33	8.2	15	<5	23	5.6	45
Specific Conductance (uS/cm)	40	213	118.9	42.8	61	40	138	78.5	15	66	213	132.0	46
Temp (C)	0.9	18.8	8.4	4.6	48	3.4	12.1	7.0	14	0.9	18.8	9.0	34
Temp(Air) (C)	15	28	22.3	5.1	8				0	15	28	22.3	8
Turbidit (NTU)	0.09	14.3	2.4	3.0	60	0.92	11	4.3	15	0.09	14.3	1.7	45
Wtr Lev (m)	0.15	0.25	0.18	0.04	7				0	0.15	0.25	0.18	7

Table 3. Metals concentrations for -samples collected at Site E227214, Brash Creek upper watershed.

Sampling Date	18/11/1997	18/11/1997	24/09/1998	29/09/1999
Requisition ID	50011365	50011365	50023614	50036656
Lab Temp	4	4	3	2
Ag-T (mg/L)	<0.01	<0.01	<0.01	<0.01
Al-T (mg/L)	<0.06	<0.06	0.15	0.08
As-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Ba-T (mg/L)	0.008	0.01	0.026	0.01
Be-T (mg/L)	<0.001	<0.001	<0.001	<0.001
B--T (mg/L)	<0.01	<0.01	<0.01	<0.01
Ca-T (mg/L)	5	5.1	8.7	4.8
Cd-T (mg/L)	<0.006	<0.006	<0.006	<0.006
Co-T (mg/L)	<0.006	<0.006	<0.006	<0.006
Cr-T (mg/L)	0.007	<0.006	0.012	0.014
Cu-T (mg/L)	<0.006	<0.006	<0.006	<0.006
Fe-T (mg/L)	0.041	0.21	0.12	0.057
K--T (mg/L)	0.5	0.6	1	0.6
Mg-T (mg/L)	0.7	0.8	1.2	0.7
Mn-T (mg/L)	0.002	0.007	0.003	0.003
Mo-T (mg/L)	<0.01	<0.01	<0.01	<0.01
Na-T (mg/L)	0.4	0.6	1.1	0.6
Ni-T (mg/L)	<0.02	<0.02	<0.02	<0.02
Pb-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Sb-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Se-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Si-T (mg/L)	3.87	4.23	4.66	3.64
Sn-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Sr-T (mg/L)	0.033	0.034	0.052	0.032
S--T (mg/L)	0.76	0.79	1.52	0.74
Ti-T (mg/L)	0.006	0.017	0.012	0.004
V--T (mg/L)	<0.01	<0.01	<0.01	<0.01
Zn-T (mg/L)	<0.002	<0.002	0.025	<0.002

Table 3. Metals concentrations for samples collected at Site E223308, Brash Creek upstream from Enderby intake.

Sampling Date	18/11/1997	18/11/1997	24/09/1998	29/09/1999
Requisition ID	50011365	50011365	50023614	50036656
Lab Temp	4	4	3	2
Ag-T (mg/L)	<0.01	<0.01	<0.01	<0.01
Al-T (mg/L)	<0.06	<0.06	0.15	0.08
As-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Ba-T (mg/L)	0.008	0.01	0.026	0.01
Be-T (mg/L)	<0.001	<0.001	<0.001	<0.001
B--T (mg/L)	<0.01	<0.01	<0.01	<0.01
Ca-T (mg/L)	5	5.1	8.7	4.8
Cd-T (mg/L)	<0.006	<0.006	<0.006	<0.006
Co-T (mg/L)	<0.006	<0.006	<0.006	<0.006
Cr-T (mg/L)	0.007	<0.006	0.012	0.014
Cu-T (mg/L)	<0.006	<0.006	<0.006	<0.006
Fe-T (mg/L)	0.041	0.21	0.12	0.057
K--T (mg/L)	0.5	0.6	1	0.6
Mg-T (mg/L)	0.7	0.8	1.2	0.7
Mn-T (mg/L)	0.002	0.007	0.003	0.003
Mo-T (mg/L)	<0.01	<0.01	<0.01	<0.01
Na-T (mg/L)	0.4	0.6	1.1	0.6
Ni-T (mg/L)	<0.02	<0.02	<0.02	<0.02
Pb-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Sb-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Se-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Si-T (mg/L)	3.87	4.23	4.66	3.64
Sn-T (mg/L)	<0.06	<0.06	<0.06	<0.06
Sr-T (mg/L)	0.033	0.034	0.052	0.032
S--T (mg/L)	0.76	0.79	1.52	0.74
Ti-T (mg/L)	0.006	0.017	0.012	0.004
V--T (mg/L)	<0.01	<0.01	<0.01	<0.01
Zn-T (mg/L)	<0.002	<0.002	0.025	<0.002

APPENDIX III. RAW WATER QUALITY DATA

Table 1. Raw water quality data collected at Site E227214, Brash Creek upper watershed.

Sampling Date	Requisition ID	Lab Temp	Alk pH 4.5/4.2 (mg/L)	Amonia Dissolved (mg/L)	Fec coli (CFU/ 100mL)	Tot coli (CFU/ 100mL)	Color True TCU	Diss Oxy (mg/L)	E Coli (CFU/100mL)	Hardness Total (T) (mg/L)	Nitrate + Nitrite Diss. (mg/L)	Nitrogen - Nitrite Diss. (mg/L)	P--T (mg/L)	Total solids (mg/L)	FR (mg/L)	NFR (mg/L)	Sp. Cond. (uS/cm)	Temp (C)	Turbidit (NTU)	pH (pH units)
09/07/1997	50005060	7		0.007			15				<0.002	<0.002	0.01	<35	30	<5	27		0.45	7.32
09/07/1997	50005063	9			19	28			2											
21/07/1997	50005654	6					10				0.002		0.008			<5	31		0.55	7.41
21/07/1997	50005659	7			<1				1											
06/08/1997	50006315	6					7				<0.002		0.009			<5	37		0.39	7.46
18/08/1997	50006669	7					<5				0.003		0.005			<5	38		0.48	7.57
04/09/1997	50007886	5					25				<0.002		0.009			<5	43		0.69	7.46
04/09/1997	50007878				56				1											
17/09/1997	50008317	6					40				<0.002		0.013			<5	32		1.99	7.27
17/09/1997	50008321				470				360											
02/10/1997	50009065	5					15				0.002		0.007			<5	37		0.48	7.49
02/10/1997	50009063				6				1											
16/10/1997	50009883	6					15				0.005		0.008			<5	34		0.31	7.37
16/10/1997	50009881				2				1											
30/10/1997	50010505	5					10				0.011		0.009			<5	37		0.54	7.52
30/10/1997	50010501				<1				1											
18/11/1997	50011365	4					5			15.3676	0.018		0.002			<5	38		0.51	7.5
18/11/1997	50011366				<1															
18/11/1997	50011365	4					5			16.0291	0.018		<0.002			<5	38		0.42	7.38
18/11/1997	50011366				2				1											
18/11/1997	50011366								1											
19/05/1998	50016825	6					15	13.61			0.022		0.004			<5	18	2.93	0.34	7.71
19/05/1998	50016829				<1				1											
25/05/1998	50016297	4					10	13.25			0.025		0.008			<5		3.76	0.31	7.42
25/05/1998	50016301				<1				1											
03/06/1998	50017111	4					7	13.2			0.015		0.004			<5	27	4.9	0.256	7.4
03/06/1998	50017046				<1				1											
08/06/1998	50017479	5					<5				0.011		0.003			<5	28	6.7	0.39	7.5
08/06/1998	50017490				<1				1											
15/06/1998	50017938	5					10	12.82			0.007		0.003			<5	31	5.8	0.26	7.5
15/06/1998	50017942				14				12											
29/06/1998	50018510	5					<5	11.8			0.005		0.004			<5	32	6.6	0.33	7.5
29/06/1998	50018514				10				2											
13/07/1998	50018882	4					<5	11.5			0.009		0.004			<5	37	7.5	0.28	7.7
13/07/1998	50018898				<1				1											
27/07/1998	50019753	4					<5	10.9			0.049		0.008			<5	46	12.7	0.37	7.7
27/07/1998	50019784				4				1											
13/08/1998	50021112	8					<5	10.8			0.041		0.011			<5	56	12.7	0.45	7.8

Sampling Date	Requisition ID	Lab Temp	Alk pH 4.5/4.2 (mg/L)	Amonia Dissolved (mg/L)	Fec coli (CFU/ 100mL)	Tot coli (CFU/ 100mL)	Color True TCU	Diss Oxy (mg/L)	E Coli (CFU/100mL)	Hardness Total (T) (mg/L)	Nitrate + Nitrite Diss. (mg/L)	Nitrogen - Nitrite Diss. (mg/L)	P--T (mg/L)	Total solids (mg/L)	FR (mg/L)	NFR (mg/L)	Sp. Cond. (uS/cm)	Temp (C)	Turbidit (NTU)	pH (pH units)
13/08/1998	50021134				<1				1											
31/08/1998	50021749	6					7				0.081		0.011			6	59	10	1.18	7.7
31/08/1998	50022121				<2				1											
09/09/1998	50022589	4					5				0.107		0.009			<5	63	8	0.71	7.74
09/09/1998	50022603				24				2											
24/09/1998	50023614	3	26.9	<0.005			<5			26.6655	0.035		0.005	<55	50	<5	60.5	7	0.31	7.57
24/09/1998	50023620				<1				1											
06/10/1998	50024017	3	19.1	<0.005			10				0.011		0.006	<45	40	<5	52.1		0.28	7.57
06/10/1998	50024020				2				2											
22/10/1998	50025201	6	16	<0.005			10				0.044		0.005	<55	50	<5	44	2.4	0.22	9.2
22/10/1998	50025206				<1				1											
02/11/1998	50025490	4					8				<0.002		0.01			<5	40	0.9	0.32	7.38
02/11/1998	50025477				4				1											
15/02/1999	50025945	4					10				0.089		0.006			<5	39	0.5	0.25	7.54
15/02/1999	50025953				<2				1											
16/06/1999	50033117	6					18	12			0.018		0.016			17	23	2.4	4.3	7.2
16/06/1999	50033148				<2				<2											
05/07/1999	50033757	5					12				0.002		0.005			<5	25	5.1	0.37	7.17
05/07/1999	50033762				<2				<2											
21/07/1999	50030637	5					15				0.002		0.006			<5	28	6	0.26	7.3
21/07/1999	50030682				<2				<2											
24/08/1999	50035380	5					12.5				0.01		0.009			<5	32	7.5	0.25	7.44
24/08/1999	50035386				<2				<2											
30/08/1999	50035571	5					12.5	11.5			0.002		0.007			<5	37	7.5	0.3	7.48
30/08/1999	50035576				<2				<2											
20/09/1999	50036411	2					12.5	13			0.011		0.009			<5	32	6.5	0.16	8.2
20/09/1999	50036415				<2				<2											
29/09/1999	50036656	2					10	14		14.8682	0.007		0.01			<5	34	2.3	0.17	7.49
29/09/1999	50036661				<2				<2											
18/10/1999	50037690	4					12.5				0.006		0.007			<5	33	2	0.61	7.4
18/10/1999	50037695				<2				<2											
26/10/1999	50037915	4					10	10.1			0.013		0.008			<5	34	1.7	0.15	8.7
26/10/1999	50037927				<2				<2											
30/11/1999	50038667	5					10	12.1			0.026		0.008			<5	32	1.3	0.22	7.2
30/11/1999	50038675				<2				<2											

Table 2. Raw water quality data collected at Site E223308, Brash Creek upstream from Enderby intake.

Sampling Date	Requisition ID	Lab Temp	Alk pH 4.5/4.2 (mg/L)	Amonia-D (mg/L)	Fec coli (CFU/ 100mL)	Tot coli (CFU/ 100mL)	Color TCU	Diss Oxy (mg/L)	E Coli (CFU/ 100mL)	Hardness (T) (mg/L)	Nitrate (NO3) Dissolved (mg/L)	Nitrate + Nitrite Diss. (mg/L)	Nitrogen - Nitrite Diss. (mg/L)	P--T (mg/L)	Total Solids (mg/L)	FR (mg/L)	NFR (mg/L)	Sp. Cond. (uS/cm)	Temp (C)	Turb (NTU)	pH (pH units)
15/07/1996	10068668	6			<1	1															
15/07/1996	10068668	6							<1												
25/07/1996	10067923	10			<1	6			<1												
25/07/1996	20000719	8					10				<0.003	0.005	0.002	0.022	<115	110	<5	133		0.45	8.1
25/07/1996								10.1										120	13.5		
30/07/1996	10068670	6			<1	4			<1												
30/07/1996	20000722	6					7				<0.005	0.007	0.002	0.039	<105	100	<5	147		4.9	8.12
06/08/1996	10068675	10			<1	10			<1												
06/08/1996	20000725	4					15					<0.002	0.002	0.021	<105	100	<5	129		0.4	8.06
13/08/1996	10068692	7			6	10			<1												
13/08/1996	20000729	5					7				<0.002	<0.002	0.003	0.024	<115	110	<5	149		0.26	8.1
20/08/1996	10068688	8			<1	10			<1												
20/08/1996	20000733	4					7				<0.019	0.021	0.002	0.02	<115	110	<5	162		0.15	8.15
26/08/1996	10068686	9			<1	2			<1												
26/08/1996	20005948	6					5				0.005	0.007	0.002	0.021	<115	110	<5	173		0.09	8.15
03/09/1996	10068683	5			2	2			<1												
04/09/1996	10069494	10			<1	14			2												
09/09/1996	10068676	9			<1	2			2												
23/09/1996	10025380	5					15							0.021	<75	70	<5	92		0.45	
23/09/1996								12.2											6		
12/11/1996	10025375	4					40				>0	<0.002	0.002	0.052	<75	70	<5	76		5.7	
26/11/1996	10026554	2					10							0.034	<85	80	<5	96		1.9	
10/12/1996	10026568	4					7				<0.016	0.018	0.002	0.028	<95	90	<5	116		0.98	
09/07/1997	50005062	9			<1	41			<1												
09/07/1997	50005055	6		<0.005			35					<0.002	0.002	0.032	<75	70	<5	66		2.6	7.75
21/07/1997	50005658	7			4				1												
21/07/1997	50005624	6					25					<0.002		0.034			<5	99		3.9	7.87
06/08/1997	50006314	6					10					<0.002		0.034			<5	126		1.5	7.94
18/08/1997	50006670	7					7					<0.002		0.025			<5	141		0.78	8.11
18/08/1997								10.34										170.19	13.37	5.41	7.74
04/09/1997	50007877	0			4				1												
04/09/1997	50007885	5					25					0.002		0.028			<5	118		2.31	7.97
17/09/1997	50008320	0			23				1												
02/10/1997	50009062	0			2																
02/10/1997	50009064	5					15					<0.002		0.023			<5	93		1.71	7.93
06/10/1997	50009062	0							1												
16/10/1997	50009880	0			2				<1												
16/10/1997	50009882	6					15					0.004		0.022			<5	79		1.5	7.8
30/10/1997	50010500	0			<1				<1												
30/10/1997	50010504	6					20					<0.002		0.028			<5	90		2.63	7.95
18/11/1997	50011367	0			<1				<1												

Sampling Date	Requisition ID	Lab Temp	Alk pH 4.5/4.2 (mg/L)	Amonia-D (mg/L)	Fec coli (CFU/ 100mL)	Tot coli (CFU/ 100mL)	Color TCU	Diss Oxy (mg/L)	E Coli (CFU/ 100mL)	Hardness (T) (mg/L)	Nitrate (NO3) Dissolved (mg/L)	Nitrate + Nitrite Diss. (mg/L)	Nitrogen - Nitrite Diss. (mg/L)	P--T (mg/L)	Total Solids (mg/L)	FR (mg/L)	NFR (mg/L)	Sp. Cond. (uS/cm)	Temp (C)	Turb (NTU)	pH (pH units)
18/11/1997	50011367	0			<1				<1												
18/11/1997	50011364	4					7			46.9133		0.003		0.013			<5	102		1.44	7.92
18/11/1997	50011364	4					7			47.163		0.002		0.013			<5	102		1.51	7.93
10/02/1998	50002867	4			<1				<1												
10/02/1998	50001557	7					25					0.01		0.065			8	168	2	7.5	8.07
09/03/1998	50012953	0			<1				<1												
09/03/1998	50012956	5					7					0.007		0.063			<5	191	3	2.7	8.05
30/04/1998	50016300				<1				<1												
30/04/1998	50016296	7					25	13.83				0.008		0.037			8	59	4.9	8.78	7.68
19/05/1998	50016830				<1				<1												
19/05/1998	50016826	6					20	12.54				0.003		0.016			<5	45	8.05	1.96	7.71
25/05/1998	50016946				<1				<1												
25/05/1998	50016960	4					20	11.8				<0.002		0.018			<5	64	8.5	1.47	7.6
03/06/1998	50017045				<1				<1												
03/06/1998	50017110	4					10	11.7				<0.002		0.016			<5	80	9.4	1.12	7.8
08/06/1998	50017491				<1				<1												
08/06/1998	50017478	5					10					0.002		0.019			<5	91	12.1	1.09	7.83
15/06/1998	50017941				14				20												
15/06/1998	50017937	5					7	11.17				0.002		0.015			<5	100	10.7	0.92	8
29/06/1998	50018513				6				2												
29/06/1998	50018513				<1				<1												
29/06/1998	50018509	4					8	11.8				<0.002		0.014			<5	87	11.3	1.3	7.8
29/06/1998	50018509	4					10					<0.002		0.014			<5	87		1.32	7.76
13/07/1998	50016953				10																
13/07/1998	50016953								10												
13/07/1998	50018881	4					5	11.4				<0.002		0.014			<5	121	12.8	0.64	7.94
27/07/1998	50019783				2				<1												
27/07/1998	50019750	4					5	10.3				0.007		0.022			<5	163	18.8	0.31	8.1
13/08/1998	50021120				8				4												
13/08/1998	50021120				8				6												
13/08/1998	50021109	8					5	10.1				<0.002		0.034			<5	194	18	0.14	8.2
13/08/1998	50021109	8					5					<0.002		0.032			<5	194		0.15	8.23
31/08/1998	50022119				2				<1												
31/08/1998	50021748	6					5					<0.002		0.032			<5	204	14	0.17	8.19
09/09/1998	50022591				<1				<1												
09/09/1998	50022588	4					5					0.005		0.024			<5	213	14.12	0.14	8.41
24/09/1998	50023618				<1				2												
06/10/1998	50024018				2				<1												
22/10/1998	50025204				<1				<1												
22/10/1998	50025199	6	81.7	<0.005			5					<0.002		0.021	<115	110	<5	172	5.8	0.16	8
02/11/1998	50025480				<1				<1												
02/11/1998	50025488	4					8					0.058		0.021			<5	154	5.6	0.17	8.04
17/11/1998	50025950				<1				<1												

Sampling Date	Requisition ID	Lab Temp	Alk pH 4.5/4.2 (mg/L)	Amonia-D (mg/L)	Fec coli (CFU/ 100mL)	Tot coli (CFU/ 100mL)	Color TCU	Diss Oxy (mg/L)	E Coli (CFU/ 100mL)	Hardness (T) (mg/L)	Nitrate (NO3) Dissolved (mg/L)	Nitrate + Nitrite Diss. (mg/L)	Nitrogen - Nitrite Diss. (mg/L)	P--T (mg/L)	Total Solids (mg/L)	FR (mg/L)	NFR (mg/L)	Sp. Cond. (uS/cm)	Temp (C)	Turb (NTU)	pH (pH units)
17/11/1998	50025939	2					25					0.002		0.035			<5	116	3.9	2.41	7.3
02/12/1998	50026503	5					14					0.006		0.035			<5	130	2.4	1.36	7.97
02/02/1999	50028192				<1				<1												
02/02/1999	50028188	4					11	13.7				0.018		0.038			<5	180	1.5	0.8	7.7
15/02/1999	50028508				<2				<1												
15/02/1999	50028510	4					10					0.014		0.033			<5	188	0.9	0.66	8.1
24/03/1999	50029463				<5				<5												
24/03/1999	50029458	3					45					0.004		0.094			9	120	3	14.3	8.1
07/04/1999	50029799				<1				<1												
07/04/1999	50029810	4					20	12.4				<0.002		0.053			<5	138	3.6	3.8	7.7
13/04/1999	50030416				<2				<2												
13/04/1999	50030416								<2												
13/04/1999	50030406	4					22	12.4				<0.002		0.061			<5	115	3.4	4.9	8.1
20/04/1999	50030681				<2				<2												
20/04/1999	50030638	4					40	12.3				0.006		0.086			11	71	4.2	10	7.2
29/04/1999	50031202				<2				<2												
29/04/1999	50031196	5					25	12.5				0.006		0.048			<5	78	3.8	4.3	6.2
03/05/1999	50031296				<2				<2												
03/05/1999	50031280	3					25	12.6				0.006		0.052			<5	68	4.5	5.3	8.1
31/05/1999	50032338				<2				2												
31/05/1999	50032333	7					25					0.005		0.028			16	54	5.2	7.1	7.64
16/06/1999	50033149				<2				<2												
16/06/1999	50033128	6					25	11.8				0.002		0.036			33	40	8.1	11	7.3
05/07/1999	50033763				<2				<2												
05/07/1999	50033758	5					15					<0.002		0.019			<5	67	9.8	1.9	7.78
21/07/1999	50020163				<2				<2												
21/07/1999	50020322	5					15					0.003		0.028			<5	93	11.8	1.2	7.9
24/08/1999	50035387				<2				2												
24/08/1999	50035381	5					12.5					<0.002		0.028			<5	142	11.8	0.25	8.07
30/08/1999	50035577				28				10												
30/08/1999	50035572	5					10	11.7				<0.002		0.029			<5	148	12.5	0.3	8.17
20/09/1999	50036416				8				2												
20/09/1999	50036412	2					12.5					<0.002		0.026			<5	115	11.2	0.37	8.06
29/09/1999	50036660				<2				<2												
29/09/1999	50036655	2					10	12		50.9085		<0.002		0.024			<5	120	6.6	0.26	8.02
18/10/1999	50037696				<2				<2												
18/10/1999	50037691	4					12.5					<0.002		0.02			<5	104	4.5	0.32	7.96
26/10/1999	50037934				<2				<2												
26/10/1999	50037917	4					10					<0.002		0.02			<5	114	5.1	0.25	8
30/11/1999	50038676				<2				2												
30/11/1999	50038668	5					12.5	13.9				0.005		0.025			<5	84	2.5	1.4	7.07