Windermere Lake Water Quality Status Report

2002/2003

May 2010

Prepared by:

Alison Neufeld
Jolene Raggett
Environmental Protection Division, Kootenay Region
Ministry of Environment

Windermere Lake Water Quality Status Report

In 2002/2003, a study was undertaken near the headwaters of the Columbia River to provide an overview of water quality in this area. This study included the following components:

- Windermere Lake beaches. Samples were collected to ensure water quality was safe for recreational use, such as swimming and wading.
- Windermere Lake water intakes. Samples were collected to determine if water was safe for drinking water use and to protect aquatic life.
- Toby Creek by Mountain Minerals Mine. Samples were collected to monitor potential impacts to water quality from this abandoned mine site.
- Upper Columbia River sewage treatment plants (Radium, Edgewater, Fairmont). Sampling was undertaken to monitor potential impacts to water quality related to sewage effluent discharges.

This report summarizes the results of the Windermere Lake sampling at beaches and water intakes. Results of the Toby Creek and Upper Columbia River sampling are presented in separate reports.

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Acronyms

CFU	Colony Forming Units
DO	Dissolved Oxygen
MDL	Method Detection Limit
MoE	Ministry of Environment
MPN	Most Probable Number
NFR	Non-filterable Residue
PSC	PSC Analytical Laboratory
QA	Quality Assurance
QC	Quality Control
RDEK	Regional District of East Kootenay
RISC	Resource Information Standards Committee
RPD	Relative Percent Difference
STP	Sewage Treatment Plant
TDP	Total Dissolved Phosphorus
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WQG	Water Quality Guideline
WQO	Water Quality Objective

1.0 Introduction

1.1 Location & Hydrology

Windermere Lake is located in the Rocky Mountain Trench in the East Kootenay Region of BC. Windermere Lake was formed during the end of the last ice age when the aggrading fan of Toby Creek dammed the Columbia River Valley, forming the shallow lake (Figure 1). The lake receives drainage from Columbia Lake, the headwaters of the Columbia River, and is bound to the west by the Purcell Range of the Columbia-Omineca Mountains and to the east by the Kootenay Ranges of the Rocky Mountains. To the north and south are the Columbia River wetlands, which received Ramsar designation in 2005 as a wetland of international importance for providing critical habitat for migratory birds and many other species of wildlife.

Windermere Lake is a shallow lake with an average depth of 3.4 m and a maximum depth of 6.4 m. The lake drains a watershed of approximately 1,325 km^2 and has a surface area of approximately 1,800 ha. The lake has a rapid flushing rate of approximately 8 times per year, which means that the lake volume is replaced every 47 days (McKean and Nordin, 1985). Due to regular winds within the Columbia River Valley, combined with the shallow lake depth, Windermere Lake remains well mixed with little stratification during the ice-free season (Urban Systems, 2001).

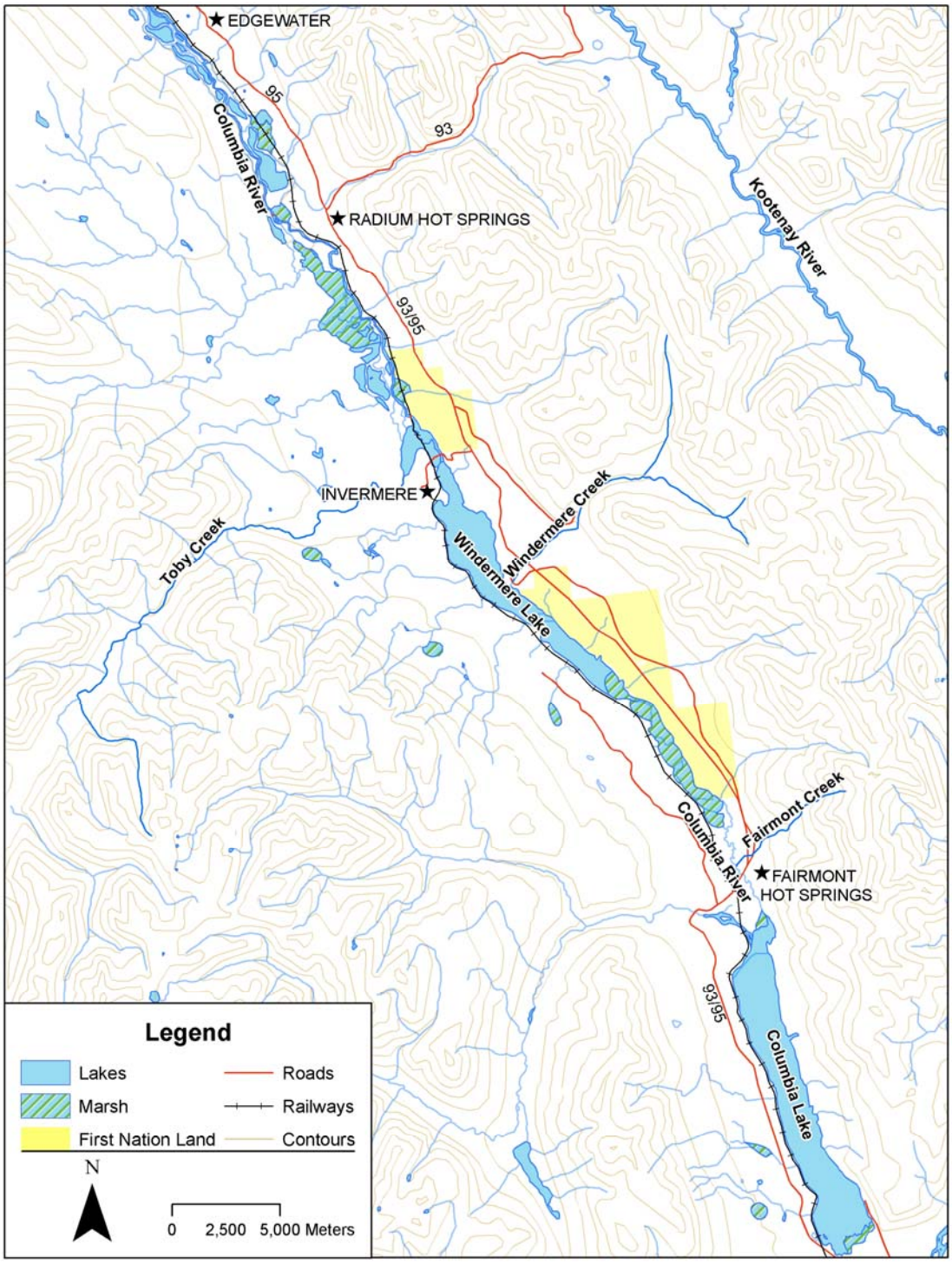

Figure 1. Windermere Lake and surrounding area.

1.2 Water Use

Windermere Lake is an important area for water-based recreation, including fishing, boating, and swimming and also provides water for domestic, irrigation, and industrial uses (McKean and Nordin, 1985). There are several public and private recreational beaches located along the shoreline of Windermere Lake, most of which are located at the north end of the lake. Both Athalmer and Invermere Beaches were sampled as part of this study. These public beaches are heavily used during the summer months.

Windermere Lake is heavily used by different types of watercraft, including: power boats, power boats with electric motors, personal watercrafts (e.g. sea-doos, jet skis) and non-motorized watercrafts. A survey of lake use conducted in 2005 found that the 449 respondents to the survey owned a collective total of 838 watercraft. The majority of these are non-motorized watercraft and power boats (Fedrigo, 2006).

As of 2004, Windermere Lake had 43 current water licenses. Together, these water licenses authorize the withdrawal of approximately 1,150 million gallons of water per year from Windermere Lake. Additional details on water licenses are provided in Appendix A.

There are three community water systems that draw water from Windermere Lake (Figure 2). These are: Parr Utilities, Timber Ridge and Windermere water intakes. Parr Utilities is privately operated and has 100 connections primarily to seasonal residences, only providing water to approximately 20 people year round, with demand increasing during the summer months to a maximum of 300 individuals (Brown, W. pers. comm., 2005). Both Timber Ridge and Windermere water intakes are operated by the Regional District of East Kootenay (RDEK) and supply primarily seasonal residences. During the summer peak season, with an average of 2.5 people per residence, Timber Ridge water intake has 365 connections and supplies approximately 913 people. Windermere water intake has 575 connections and supplies approximately 1,438 people (Brown, W. pers. comm., 2005).

All three water intakes provide a minimum level of treatment to the water taken from Windermere Lake. Chlorine is added primarily for disinfection, but it also effectively reduces tastes and odours. The amount of chlorine added to the water depends on many factors, including lake temperature and water quality, which can all vary greatly at different times of the year and during prolonged weather events, such as heavy rainfall, or snowmelt (Brown, W. pers. comm., 2005).

Figure 2. Windermere Lake water quality sampling sites, including: Athalmer and Invermere Beaches, Parr Utilities Water Intake, Timber Ridge Water Intake and Windermere Water Intake.

1.3 Discharges

There are currently no point source discharges directly entering Windermere Lake. However, there is concern about pollution from non-point sources, including inputs from golf courses, forestry operations, agriculture, and particularly from domestic wastewater, which is predominantly disposed of in septic fields. Septic leachate has been a concern, as previous soil investigations around Windermere Lake found many developed areas unsuitable for septic discharges due to soil permeability, drainage, erosion processes, steep slopes, high water table, and the potential to contaminate groundwater (McKean and Nordin, 1985). In addition to nitrogen being mobile in soils, some of the soils were found to have low phosphorus retention capability, which may result in phosphorus from septic leachate entering the lake via groundwater. As a result, there is concern these inputs may lead to contamination and eutrophication of Windermere Lake (McKean and Nordin, 1985).

Based on these concerns, along with recommendations provided in a study prepared for the District of Invermere, the RDEK has investigated community sewage strategies for the east side of Windermere Lake. One of the strategies is the development of private water and sewer utilities within the populated area of the east shore using spray irrigation to dispose of treated sewage, rather than discharge to Windermere Lake. Alternatively, the RDEK has investigated connecting new and existing developments along the east shore into the Kinbasket sewer system through a trunk main located adjacent to Highway 93 (Sharpe, E. pers. comm., 2006).

In 2006, Ministry of Environment (MoE) and the RDEK initiated discussions about the creation of a liquid waste management plan (LWMP) for the east shore of Windermere Lake. This is a community driven exercise and has received little buy-in from seasonal residents who primarily occupy the east shore. The development of a LWMP will be addressed in the Lake Management Strategy for Windermere Lake.

1.4 Previous Studies

In 1985, the MoE completed a review of existing Windermere Lake data and assessed existing and future risks to water quality. At that time, there were two key activities of concern: increasing urban and rural development and the Kootenay Diversion project, which proposed diversion of water from the Kootenay River into Columbia Lake. This project would increase flushing rates of both Columbia and Windermere Lakes, thus increasing the hydroelectric potential of downstream facilities (McKean and Nordin, 1985). Results showed that Windermere Lake had reasonably good water quality and was not demonstrating any definitive signs of eutrophication or serious bacterial contamination.

This report recommended monitoring sites, frequency, and site-specific water quality objectives (WQOs) for both Columbia and Windermere Lakes (McKean and Nordin, 1985), which loosely formed the basis of the 2002/2003 studies. The WQOs designated protective levels of specific parameters based on water use, such as drinking water,

recreation, or to protect aquatic life and were based on BC and national guidelines, ambient conditions, and scientific literature. Since the WQO report was published, most of the guidelines and scientific literature used to calculate these values have since been updated. Therefore, for the most part, more recent BC water quality guidelines (WQGs) have been used in this report.

In 1999, a water quality study of Windermere Lake was commissioned by the RDEK to assess whether there had been any changes in water quality since the 1985 MoE review, and if so, whether or not the changes could be linked to increased lakeshore development (Courtney, 1999). Samples were collected from three lake sites to establish general lake chemistry and eight shoreline sites, including two beaches and six water intakes. This study found some evidence that Windermere Lake was becoming eutrophic as a result of shoreline development at the north end of the lake.

Increased eutrophication was also noted in an MoE study conducted in 2000 (McDonald, 2000). This study assessed historic changes in water quality within the lake using diatoms, plant pigments and chemical analyses from sediment cores extracted from the lake bottom. Results of this study found a slow deterioration in water quality and slight eutrophication of Windermere Lake beginning around 1950, concurrent with population growth around the lake.

1.5 Objectives

Windermere Lake is an important regional resource, providing drinking water and recreational opportunities for residents. However, there are concerns about increasing shoreline development, potential septic failure and related contamination and eutrophication of the lake. This study was undertaken to contribute to the existing knowledge of Windermere Lake water quality and to assess changes related to increased development pressures surrounding the lake.

The specific objectives of this component of the 2002/2003 study were to:

- Assess water quality at public beaches. Microbial indicators were assessed at beaches during the summer and compared to WQGs to protect people involved in primary contact recreation, such as swimming or wading; and
- Assess water quality at water intakes. Parameters were assessed at three water intakes and data were compared to current WQGs to protect drinking water (with disinfection) and aquatic life.

2.0 Methods

2.1 Sampling Protocol

Water samples were collected at two public beaches located at the north end of Windermere Lake: Athalmer and Invermere Beaches (Figure 2). Grab samples were collected approximately 1 m from shore near the surface to minimize contamination from bottom sediments. A total of 10 samples were collected in 2002 between August 6, and September 4, 2002.

Water samples were also collected at three water intakes on Windermere Lake: Parr Utilities, Timber Ridge, and Windermere (Figure 2). Samples were collected from each intake prior to chlorination over three separate time periods: August/September 2002, January/February 2003, and April/May 2003. During each of these periods, 5 to 10 samples were collected over an approximate 30-day period.

On each sampling trip, field measurements were obtained for temperature, dissolved oxygen (DO), conductivity, and pH using an Aquacheck multimeter manufactured by National Instruments. Water samples were then collected according to standard Resource Information Standards Committee (RISC) methodology (RISC, 1997). Samples for microbiological indicators were collected at all sites. In addition to fecal coliform, *E. coli* and *Enterococci* were monitored since these bacteria are more reliable indicators of sewage contamination and potential gastrointestinal illness than fecal or total coliforms alone (Health and Welfare Canada, 1992). Total coliform bacteria were not analyzed as they may occur naturally in soil, vegetation and water, in addition to feces, which makes them less reliable indicators of fecal pollution (Health Canada, 1988).

Additional parameters were analyzed at the water intakes only, including non-filterable residue (NFR), total sulphide, dissolved sulphate, nitrogen (total-N, ammonia-N, nitrate-N, nitrite-N), and phosphorus (ortho-phosphate, total-P, and dissolved-P).

All samples were placed on ice and shipped within recommended holding times to either PSC Analytical Laboratory (PSC) or Cantest Analytical Laboratory (Cantest) for analyses. Both labs are located in Burnaby, BC.

2.2 Quality Assurance and Quality Control

Quality assurance (QA) and quality control (QC) samples and procedures were undertaken as part of the water quality sampling program.

QA procedures followed RISC (1997) protocols. Some of these included:

- Analyte appropriate, pre-cleaned sample bottles and preservatives provided by PSC and Cantest were used for all water sampling;

- All bottles were appropriately labelled using waterproof ink prior to sampling, including: date, site identification, name of sampler, and type of analysis required; and,
- Samples were kept cool using ice and coolers following collection and were sent to the appropriate laboratory within recommended holding times.

QC samples were also collected and analyzed as part of the program, including field blanks and replicate samples. Field blanks were prepared by the laboratory and consisted of sample bottles filled with deionized water. These samples were exposed to the field environment, resealed, and handled in the same manner as regular samples (i.e., preserved) to provide information on contamination resulting from handling and exposure to the atmosphere. Two field blanks were exposed at Parr Utilities (January 28 and May 22, 2003) and one each at Timber Ridge and Windermere water intakes (January 14 and January 21, 2003, respectively).

Replicates were collected as independent samples as close as possible to the same point in space and time as the regular sample to assess precision and variability of the entire sampling and analytical process. Replicates with high variability may indicate that contamination occurred during collection or analysis or that field conditions are highly variable (RISC, 1998). Replicates were collected at Parr Utilities (January 28 and May 22, 2003) and Timber Ridge (January 14 and May 12, 2003).

The relative percent difference (RPD) between regular and replicate samples was calculated in order to determine precision using the following formula:

$$\text{RPD (A, B) \%} = \frac{100 \times |A - B|}{[(A+B)/2]}$$

Ideally, the RPD should be close to 0%. As a general rule, replicate values exceeding an RPD of 25% are considered imprecise (RISC, 1998).

3.0 Results and Discussion

3.1 Beaches

Improperly treated, or untreated sewage (e.g., from failing septic systems) can increase the risk of infectious water-borne disease, which can be contracted during recreational activities. As a result, water samples were collected at Invermere and Athalmer beaches and analyzed for microbial indicators. Results were compared to existing BC Water Quality Guidelines (WQGs) for primary contact recreation, which include activities where there is a high risk of ingesting water or extensive bodily contact with water, such as swimming (Appendix B). WQGs for microbial indicators were calculated using the geometric mean of a minimum of five samples collected over a 30-day period.

Both beaches had levels of microbial indicators below their respective WQGs (Table 1). However, elevated levels of all three microbial indicators were found at both beaches on August 19 and 20 (Figure 3). These values decreased by the next monitoring period the following week. The cause of elevated bacterial levels on this date is unclear, but could be related to waterfowl contamination and/or increased use of summer residences and a corresponding increase in septic leachate.

Table 1. Microbial indicators at public beaches on Windermere Lake sampled August/September, 2002. Summary statistics based on 10 samples collected over a 30-day period. CFU=colony forming units.

Parameter	Units	WQG	Invermere Beach			Athalmer Beach		
			Min	Max	Geometric Mean	Min	Max	Geometric Mean
Microbial Indicators								
Fecal coliform	CFU/100 mL	200	<1	34	2	<1	94	4
E.coli	CFU/100 mL	77	<1	22	2	<1	68	3
Enterococcus	CFU/100 mL	20	<1	11	3	<1	45	7

These results were consistent with those of previous studies, which found water quality at public beaches was safe for primary contact recreation. McKean and Nordin (1985) determined the geometric mean of fecal coliform was 3.3 MPN/100 mL (most probable number) based on beach samples collected by both the Ministry of Health and MoE between 1973 and 1982. Courtney (1999) noted some variability in fecal coliform levels collected from the same beaches between May and August 1999, with levels ranging from $\leq$ 1 MPN/100 mL to 6 MPN/100 mL. Both studies concluded that results were below the primary contact recreation WQG.

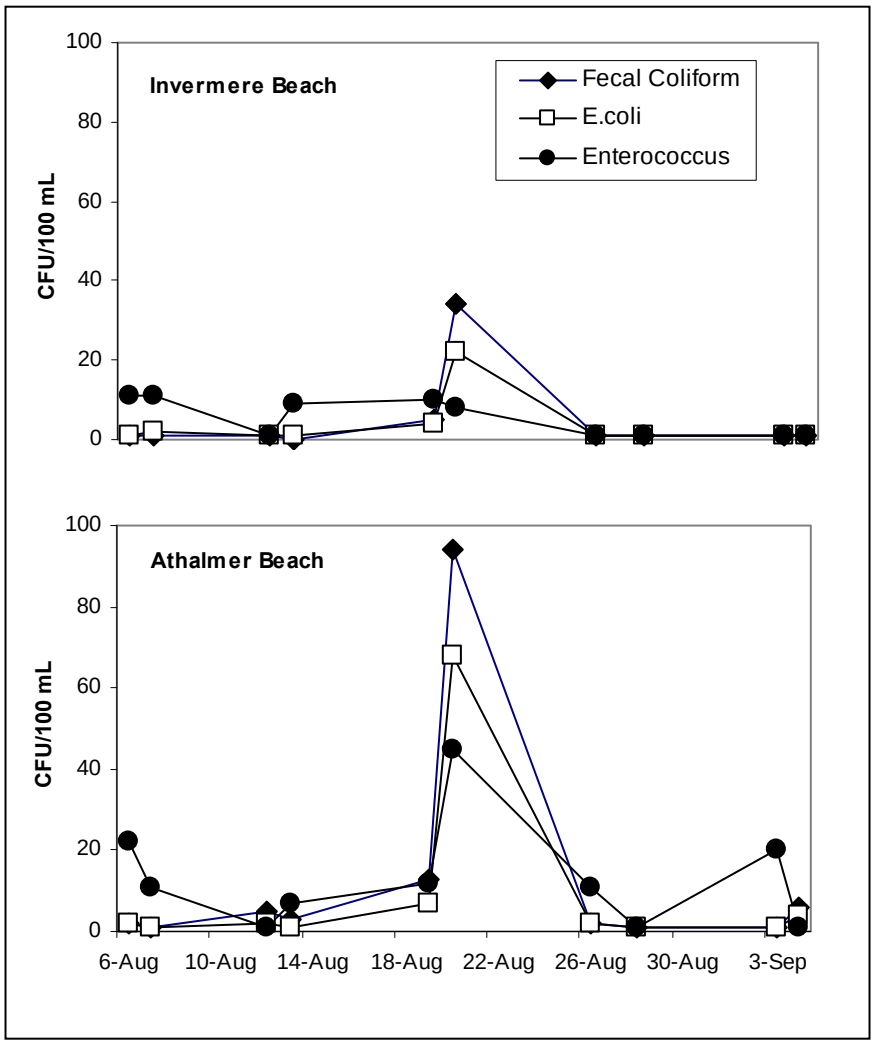

Figure 3. Level of microbial indicators at public beaches on Windermere Lake sampled August/September, 2002.

In 2004, the Interior Health Authority conducted monitoring for fecal coliforms approximately every two weeks from May to September at public and some private beaches on Windermere Lake, with sampling frequency dependent upon weather and recreational use. The 2004 monitoring program also found fecal coliform levels below WQGs for recreational use (Plotnikoff, C. pers. comm., 2004).

3.2 Water Intakes

Water samples were collected from three Windermere Lake water intakes (Parr Utilities, Timber Ridge and Windermere) during three time periods: summer (August/September 2002), winter (January/February 2003), and spring freshet (April/May 2003). Samples were analyzed for field parameters (dissolved oxygen, pH, temperature, and conductivity), microbial indicators, nutrients, sulphate and sulphide. Water quality data from the Windermere Lake water intakes are provided in Appendices C through E and are summarized in Appendix F. Details on specific parameters are provided in the following sections.

Where possible, results were compared with current BC WQGs to protect drinking water with disinfection (MoE, 1998a; 1998b). In addition, results were also compared to WQGs to protect freshwater aquatic life. Where available, data was also compared to results of previous studies to assess changes in water quality over time. As water samples were collected from water intakes and not directly from Windermere Lake, it is noted that some results may vary from actual water quality conditions within the lake.

3.2.1 Field Measurements

Dissolved Oxygen (DO) and Temperature
Both DO and temperature were measured on most sampling trips and were very similar at all three intakes during each specific time period (Figure 4). DO is essential to life in lakes and enters water by wind action and plant photosynthesis and is consumed by respiration of plants and animals. As productivity increases and lakes become more eutrophic, there is an increase in plants and animals that respire and decay, resulting in higher oxygen consumption, particularly near the bottom of the lake. DO is typically found at sufficient levels to support life at all depths throughout the year in Windermere Lake.

The 30-day average DO levels in August/September and April/May were below the minimum required WQG to protect freshwater aquatic life (8 mg/L), which may suggest the lake is becoming eutrophic. However, these samples were taken from the water intakes and may not represent ambient conditions within Windermere Lake so the ecological significance of the low levels is difficult to determine.

Temperature met WQGs for drinking water during the January/February and April/May monitoring periods. However, it exceeded the WQG of 15^{o}C established for the protection of aquatic life in August/September at all three water intakes, ranging from 17.7^{o}C to 18.4^{o}C.

DO and temperature are closely linked parameters and oxygen solubility is affected nonlinearly by temperature and increases considerably in cold water (Wetzel, 2001). Many lakes stratify and form layers of water with different temperatures and DO. This

occurs due to the large differences in density between warm and cold water. However, Windermere Lake does not generally stratify and remains well mixed during the ice-free season due to its shallow depth and the wind action through the Columbia River Valley. As expected, an inverse relationship was observed between DO and temperature (Figure 4).

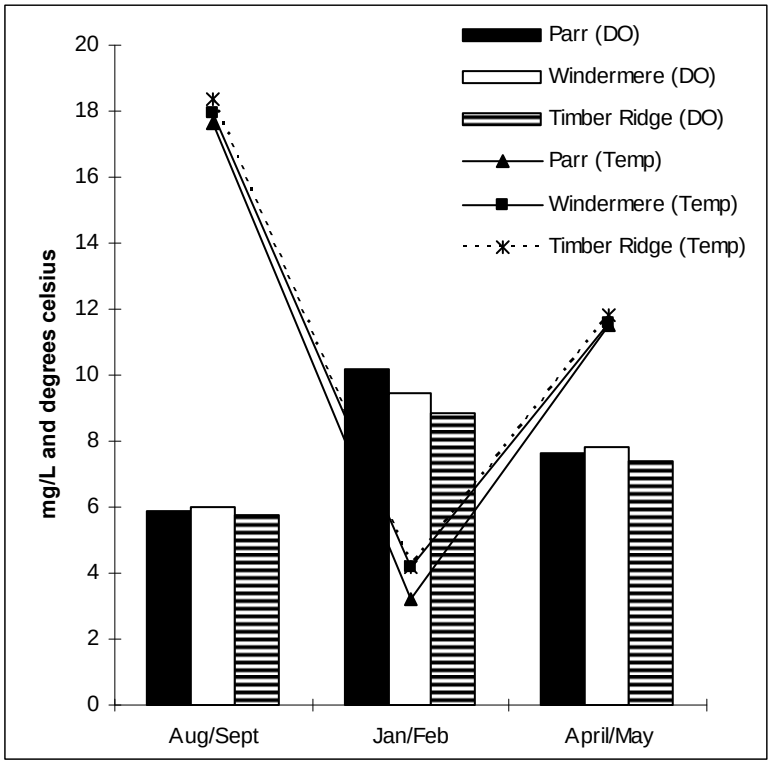

Figure 4. Temperature and DO (30-day average) at Windermere Lake water intakes sampled 2002/2003.

Conductivity

Conductivity was similar at each water intake on most sampling trips and showed a steadily increasing trend throughout all the sampling periods (Figure 5). All measurements were below the WQG for drinking water (700 μs/cm). Conductivity is a measure of ionized materials in water and is generally a function of geology and climate. It is closely related to total dissolved solids (TDS), a measure of both dissolved inorganic and organic particles.

TDS was assessed by Courtney (1999), who also noted levels peaked in late winter and early spring before freshet. This trend is likely associated with levels of dissolved ions, which are typically higher in groundwater than in surface water. Consequently, as the relative input of groundwater (as opposed to contribution from rainfall or snow melt in the spring) increases from late summer through pre-freshet, the conductivity and TDS of the lake will increase correspondingly (Jensen, V. pers. comm., 2005).

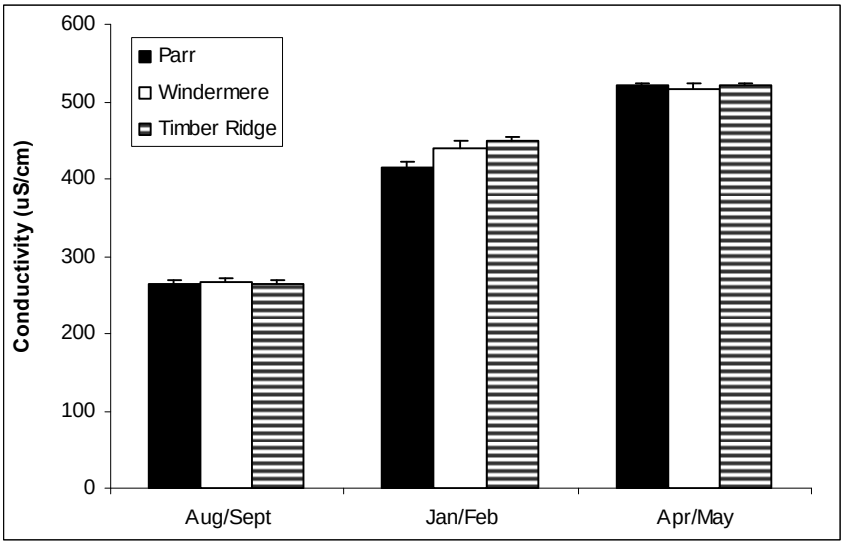

Figure 5. Conductivity (*µ*s/cm) (30-day average) at Windermere Lake water intakes sampled 2002/2003. WQG for drinking water 700 *µ*s/cm. Error bars represent standard error.

pH

pH measures the relative acidity of water and was measured in the field at the water intakes on most sampling trips. pH remained relatively constant at all intakes throughout the three sampling periods, ranging from 8.00 to 8.57. All measurements were within the range recommended for drinking water (6.5 to 8.5), with the exception of Parr Utilities, in January/February, with a 30-day average of 8.57. However, this WQG was derived to minimize solubility of metals and salts and maximize effectiveness of chlorination (MoE, 1998a), so this minor exceedance does not represent a significant health concern. All values were within WQGs for the protection of aquatic life (6.5 to 9.0).

pH measurements fell within the range previously reported by Courtney (1999). However, the 1999 review also reported a strong increasing trend in pH at the north lake station over time, with no significant trend observed mid lake, although no data was collected between 1982 and 1999. This study hypothesized that the increase may be due to eutrophication and nutrient enrichment at the north end of the lake, with increased photosynthesis decreasing CO_2 and resulting in a subsequent increase in pH.

3.2.2 Non-filterable residue

Non-filterable residue (NFR) is a measure of undissolved particles in a water sample, typically comprised of fine particles of organic and inorganic matter, soluble organic compounds, plankton, and other microscopic organisms (Caux et al., 1997). This fraction is also referred to as total suspended sediments (TSS). NFR was measured at the water intakes on most sampling trips and was below detection limits (4 mg/L) in almost all samples. This is not surprising as samples were collected from water intakes after settling had occurred.

There does not appear to be previous data available for NFR in Windermere Lake. However, there are several years of turbidity data, which is a measure of transparency in a water sample. As noted by Caux et al. (1997), NFR and turbidity are related, although turbidity is affected by site-specific factors such as the concentration, size, shape, and refractive index of suspended sediments. Courtney (1999) found no consistent trend with turbidity measurements and concluded that the water quality of Windermere Lake was not declining with regard to turbidity.

Although no consistent trends in either NFR or turbidity have been found, turbidity and/or NFR can be useful as a QC check to ensure bottom sediments in lake samples are not influencing results. It is likely that levels may increase slightly during summer months due to increased algal growth. Since the results from the 2002/2003 study reflect conditions after settling had occurred, these results do not reflect raw lake water quality. Additional data would be required to assess trends in Windermere Lake.

3.2.3 Microbiological Indicators

Each water intake was tested for indicators of fecal contamination and the presence of enteric pathogens, including fecal coliforms, *E. coli*, and *Enterococci*. Fecal coliform bacteria provide an indication of fecal contamination in surface water. *E.coli* is the only total coliform bacteria that is exclusively associated with human and animal feces. It's presence in surface water indicates recent fecal contamination, as well as the potential presence of intestinal disease-causing bacteria, viruses and protozoa (Health Canada, 2004). *Enterococci* are also good indicators of fecal contamination, as they are more resistant than other bacteria to common disinfection techniques and environmental stresses (Health Canada, 2004).

Results from the water intakes over the three sampling periods found *E. coli* and fecal coliform counts below detectable levels (< 1 CFU/100 mL) in most samples. For these two parameters, all three water intakes met the WQG for drinking water with disinfection, which states that no more than 10% of raw water samples taken in a 30-day period (i.e., 90^{th} percentile) should exceed 10 CFU/100 mL.

Enterococci counts were generally higher than *E. coli* or fecal coliforms. This is likely because fecal coliforms, such as *E. coli*, are generally more sensitive to environmental stresses, therefore decreasing their survival and persistence in the environment (Health Canada, 1988). Ninetieth percentile *Enterococci* counts exceeded the WQG (3 CFU/100 mL) on a few occasions, including August/September at Parr and Timber Ridge intakes (6 CFU/100 mL at both sites) and April/May at Windermere intake (5 CFU/100 mL) (Figure 6). These results indicate source water may be subject to fecal contamination. However, it should be noted that these samples were collected prior to disinfection (i.e., chlorination) and monitoring of water post-treatment would be required to more fully assess health risks associated with the presence of microbial indicators.

Fecal coliform bacteria have been sampled in Windermere Lake on numerous occasions in the past 30 years and counts at water intakes have been variable, ranging from 2 CFU/100 mL to greater than 100 CFU/100 mL in samples collected between 1987 and 1990 (Courtney, 1999). Note that two different methods were used during this time, including multiple tube filtration, which reports results as the most probable number (MPN) and membrane filter method, which reports results as colony forming units (CFU). For the purpose of water quality assessment, results obtained by these different methods for fecal coliforms and *Enterococci* are considered comparable (Jagals, 2001).

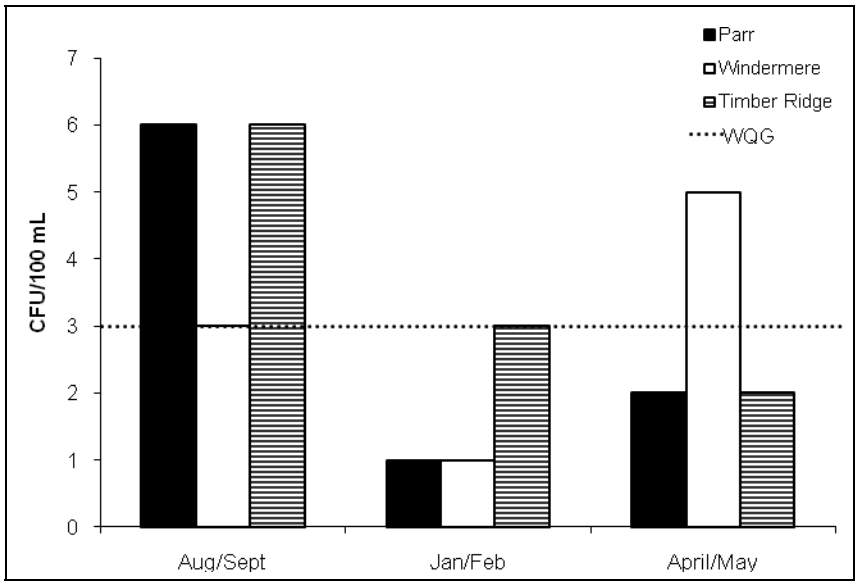

Figure 6. Ninetieth percentile *Enterococci* (CFU/100 mL) at Windermere Lake water intakes sampled 2002/2003 (n = 10 for each intake). WQG (90th percentile) for raw drinking water with disinfection only < 3 CFU/100 mL.

3.2.4 Nutrients

Total Phosphorous

In most lakes, phosphorus is the limiting factor for plant growth. Eutrophication is usually associated with increased phosphorus related to human activities and inputs such as sewage, lawn fertilizer, and/or agricultural wastes. There is a well-defined relationship between phosphorous and algal biomass within lakes during the growing season, particularly during spring turnover (MoE, 1985). Algal biomass can be monitored by measuring chlorophyll *a* (mg/L) content in water samples. Algae can cause poor water clarity and hypolimnetic oxygen depletion, which can impact aquatic organisms. It can also cause taste and odour problems in drinking water.

Site-specific WQOs were set for total phosphorus in Windermere Lake during spring turnover to protect against nuisance algal growth (McKean and Nordin, 1985). To achieve a mean summer chlorophyll *a* level of 0.002 mg/L and maintain the current oligotrophic state of the lake, a provisional objective of $\leq$0.010 mg/L total phosphorus

was proposed. This objective applies to an average of three samples taken at the surface, mid-depth, and near the bottom during spring turnover. This value is consistent with the current total phosphorus WQG for lakes used as a drinking water source to minimize treatment costs and reduce risk of taste and odour from algae.

Results from all water intakes found 30-day average total phosphorus ranged from 0.004 mg/L to 0.015 mg/L, although individual values of up to 0.057 mg/L were found. As the WQO applies to samples collected during spring turnover, only results from the April/May period were compared to this value. Note that the WQO is calculated using the average of three samples collected at varying depths, while the 2002/2003 results only represent total phosphorus concentrations near the lake bottom, where intake pipes are located. Samples collected from the water intakes are collected after settling has occurred, so may not reflect actual total phosphorus levels in the lake.

Total phosphorus concentrations during spring turnover are higher than those reported by McKean and Nordin (1985), who found total phosphorus concentration of 0.0098 mg/L in Windermere Lake during spring turnover in 1983. McKean and Nordin (1985) also reported an annual average total phosphorus level of 0.0073 mg/L at all stations. The average total phosphorus concentration at all three intakes during spring turnover (April/May 2003) was 0.0123 mg/L. It is noted that this value represents conditions after settling has occurred at the water intakes and it is likely that these results underestimate the actual total phosphorus concentrations in Windermere Lake.

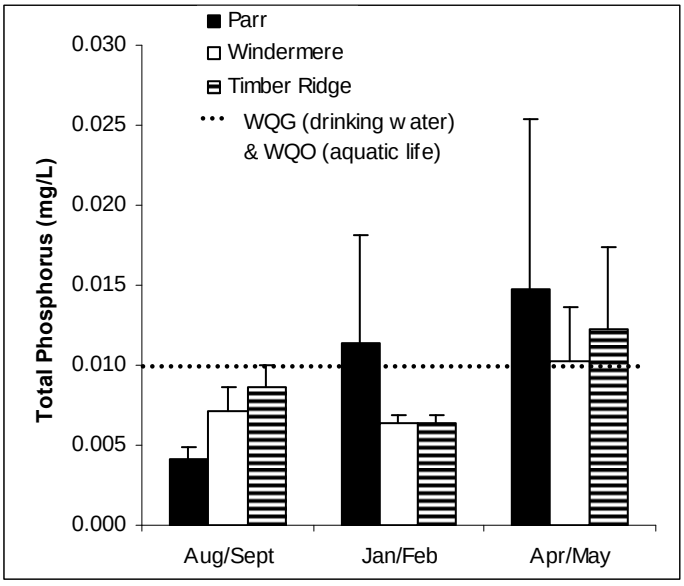

Figure 7. Total phosphorus (30-day average) at Windermere Lake water intakes sampled 2002/2003. WQO during spring turnover and WQG for drinking water ≤ 0.010 mg/L. Error bars represent standard error.

Total Dissolved Phosphorus

Total dissolved phosphorus (TDP) is composed of ortho-phosphate, polyphosphates and a fraction of dissolved organic phosphorus from cellular contents and breakdown products of biota (Nordin, 1985). Higher levels of TDP are commonly associated with increasing eutrophication (Courtney, 1999). There are currently no WQGs for TDP. The 30-day average TDP concentrations were relatively consistent throughout the sampling periods at all three water intakes, ranging from 0.002 mg/L to 0.005 mg/L.

These results were similar to those found from previous sampling between 1971 and 1989, in which many results were at or below detection limits (0.003 mg/L to 0.005 mg/L). However, based on levels ranging from 0.003 mg/L to 0.02 mg/L Courtney (1999) concluded that TDP is increasing over time and provides evidence that Windermere Lake is becoming increasingly eutrophic.

Ortho-Phosphate

There is currently no WQG for drinking water or the protection of aquatic life for ortho-phosphate. However, monitoring is important as ortho-phosphate (also called dissolved inorganic phosphate, or soluble reactive phosphorus) is the most bioavailable form of phosphorus, as it is dissolved and directly available for uptake (McKean and Nordin, 1985). Ortho-phosphate levels were highest at all three water intakes in August/September and declined through April/May (Figure 8). This differs from trends noted for total phosphorus (lowest values in August/September, highest in April/May).

Elevated ortho-phosphate levels may be caused by increased discharge from heavy rainfall events, snowmelt, and/or pollution sources, such as agricultural runoff and sewage inputs. A review of climatic data collected by Environment Canada in Invermere (http://www.climate.weatheroffice.ec.gc.ca) found no indication of heavy rainfall in August/September. The increased use of summer residences during the summer months likely increases septic leachate, resulting in increased levels of ortho-phosphate. Ortho-phosphate was not assessed in previous Windermere Lake studies, so it is not possible to compare these results.

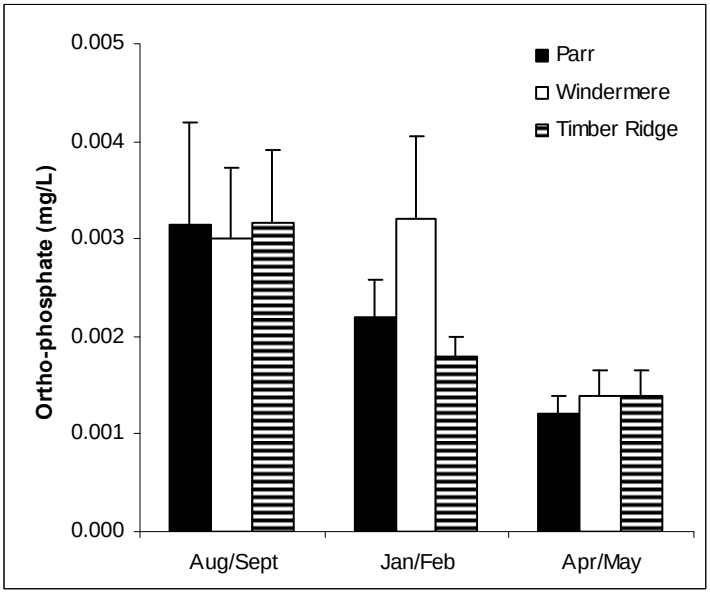

Figure 8. Ortho-phosphate (30-day average) at Windermere Lake water intakes sampled 2002/2003. Error bars represent standard error.

Nitrogen

Nitrogen occurs in freshwater in many forms, including the un-combined dissolved molecular form (N_2), organic, and inorganic compounds. Sources of nitrogen in lakes include precipitation, nitrogen fixation in water and sediments, and inputs from surface and ground water drainage (Wetzel, 2001). Nitrogen (e.g., ammonia, nitrate, and nitrite) may be elevated in waters polluted by sewage and agriculture (Wetzel, 2001). Samples collected from all three water intakes were analyzed for several forms of nitrogen, including: total nitrogen, ammonia, nitrite, and nitrate.

Total and Organic Nitrogen

Concentrations of total nitrogen were relatively consistent at all three water intakes, ranging from 0.19 mg/L to 0.32 mg/L (30-day averages, all sites). Previous studies found that most nitrogen in Windermere Lake was present in the organic form, which contains compounds resistant to decomposition (Courtney, 1999). Total nitrogen levels were considerably higher than inorganic nitrogen in this study, which confirms the occurrence of predominantly organic nitrogen in Windermere Lake water samples.

The 2002/2003 results showed slightly higher levels of total (and organic) nitrogen than previous studies, ranging from 0.19 mg/L to 0.32 mg/L (30-day averages from all sites over all sampling periods). McKean and Nordin (1985) reported organic nitrogen concentration at spring turnover was 0.14 mg/L. Based on a review of previous studies, Urban Systems (2001) reported the concentration of organic nitrogen in Windermere Lake as 0.16 mg/L at the south end of the lake and 0.15 mg/L at the mid and north lake stations (mean all results). An increasing trend in total organic nitrogen over time was also noted by Courtney (1999), which was attributed to a number of influences such as photosynthetic activity, the Columbia River inflow water quality, seasonal influences and lakeshore development.

Inorganic Nitrogen

Ammonia is present primarily as NH_4^+ and un-dissociated NH_4OH, with the latter being highly toxic to many aquatic organisms. The ammonia concentration of oxygenated waters is generally low because it is oxidized to nitrite and nitrate, which are then reduced by algal assimilation (Courtney, 1999). The dissociation dynamics between NH_4^+ and NH_4OH are influenced by pH and temperature, therefore the toxicity of ammonia is dependent on these variables (Wetzel, 2001). There is no guideline for ammonia to protect drinking water quality, but there is a WQG for ammonia to protect aquatic life. For this study, the 30-day average ammonia WQG ranged from 0.200 mg/L to 0.396 mg/L, depending on pH and temperature. Ammonia concentrations were below these levels during all sampling periods, ranging from 0.008 mg/L to 0.116 mg/L (30-day average, all sites).

Like total nitrogen, ammonia results from the 2002/2003 study appeared slightly higher than those found in previous studies. Samples collected between 1973 and 1983 ranged from 0.010 mg/L to 0.013 mg/L (McKean and Nordin, 1985). Urban Systems (2001) found that the mean concentration of ammonia nitrogen within the lake ranged from 0.007 mg/L to 0.011 mg/L based on a review of previous studies. Courtney (1999) also noted that ammonia levels were lowest after the freshet runoff. This was consistent with the 2002/2003 data that found results were lowest during the spring sampling period, which may be due to increased runoff.

It was noted that samples for previous studies were collected within the lake, while the 2002/2003 samples were collected directly from the water intakes. It is possible that these results reflect greater near shore influence and may not reflect ambient lake trends.

For nitrate, 30-day average concentrations ranged from 0.003 mg/L to 0.021 mg/L at all three intakes during the August/September and April/May sampling periods. However, concentrations were considerably greater at all sites in January/February, ranging from 0.039 mg/L to 0.074 mg/L (Figure 9). It is likely that due to low temperatures, ammonia was quickly oxidized to nitrite and nitrate. Decreased dilution during the winter months, as well as reduced uptake by plants and algae could also account for the elevated nitrate levels during the winter months. All values were below the WQG for drinking water (10 mg/L) and to protect aquatic life (30-day average, 40 mg/L, note that the nitrate guideline level is under review and pending change).

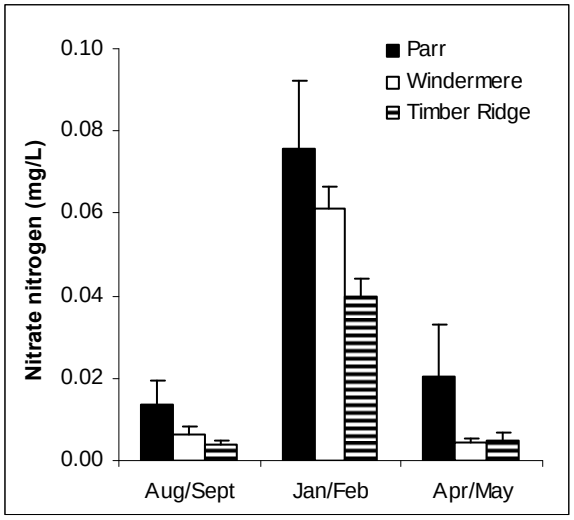

Figure 9. Nitrate nitrogen (30-day average) at Windermere Lake water intakes sampled 2002/2003. Error bars represent standard error.

Previous studies in Windermere Lake found nitrate concentrations generally below 0.02 mg/L, similar to those found in this study for the August/September and April/May sampling periods. Courtney (1999) found that often in summer nitrate plus nitrite concentrations in Windermere Lake were below detectable limits (0.02 mg/L), typical of summer conditions in most lakes. The 1985 water quality assessment (McKean and Nordin, 1985) also found nitrate nitrogen was always less than 0.02 mg/L.

Nitrite levels at all sites were mostly below the method detection limit (MDL) (0.002 mg/L) and were also well below the WQG for drinking water (1 mg/L) and to protect aquatic life (0.02 mg/L where chloride < 2 mg/L).

3.2.5 Sulphate/Sulphide

Windermere Lake receives large quantities of sulphur from the hot springs upstream and from gypsum ($CaSO_4$) deposits in Windermere Creek (McDonald, 2000; McKean and Nordin, 1985). Consequently, total sulphide and dissolved sulphate were measured in water samples. Sulphur reacts with oxygen to produce sulphate, which is the predominant form of dissolved sulphur in water. Sulphide is a product of the decomposition of organic matter. In aerated lakes, sulphide is rapidly oxidized (MoE, 1998b).

Total sulphide levels at all three intakes were consistently at or below the detection limit (0.005 mg/L), except during the month of April. During this time, concentrations increased slightly at all three water intakes, but were well below the WQG for drinking water ($\leq$0.05 mg/L). The WQG for the protection of aquatic life is 0.002 mg/L, however this is below the MDL for sulphide (0.005 mg/L). There is some uncertainty surrounding

all sulphide data as results are either very close to, or less than the MDL. Future monitoring of sulphide using an analytical method with a lower MDL is recommended to determine whether or not total sulphide is exceeding the WQG for the protection of aquatic life.

Dissolved sulphate was higher than sulphide in all water samples, ranging from 24.0 mg/L – 72.3 mg/L (30-day average). The higher concentration of sulphate relative to sulphide is likely because decomposition of organic matter (e.g., in bottom sediments) releases sulphur largely as hydrogen sulphide, which is rapidly oxidized to dissolved sulphate under oxygenated conditions (Wetzel, 2001). Sulphate concentrations were similar at each water intake during each sampling period and an increasing trend was noted throughout the sampling periods (Figure 10).

Sulphate was well below the WQG for drinking water of 500 mg/L (aesthetic objective) and was also below the maximum WQG to protect aquatic life (100 mg/L). However, concentrations exceeded the alert level for aquatic life (50 mg/L) at all three intakes during the January/February and April/May sampling periods. This alert level is recommended to protect aquatic mosses, which may be more sensitive to the toxic effects of sulphate (MELP, 2000).

Figure 10. Total sulphate (mg/L) at Windermere Lake water intakes sampled 2002/2003. WQG is alert level for aquatic life (50 mg/L), maximum WQG is 100 mg/L. Error bars represent standard error.

3.3 QA/QC Results

Four blank samples were collected at water intakes as part of the QC sampling program (Appendix G). The first was collected at Parr Utilities on January 28, 2003, and reported 0.003 mg/L total phosphorus, while the regular sample on this date was 0.038 mg/L. The second blank sample was collected May 22, 2003, at Parr Utilities and was analyzed for bacteriological parameters (fecal coliforms, *E. coli* and *Enterococci*). All results were less than the MDL. Blank samples were analyzed for total sulphide at Timber Ridge on January 14, 2003, and Windermere on January 21, 2003. Both results were less than the MDL. Results from the blank samples showed that contamination of samples as a result of handling and exposure to the atmosphere in the field is unlikely.

For replicates, there were seven instances where RPD exceeded the 25% guideline, suggesting potential field and/or laboratory contamination (Appendix G). However, RPD increases as analytic values approach the MDL, therefore, the use of RPD is limited to analytical values that are at least five times the MDL (RISC, 1998). In all of the instances where RPD exceeded 25%, the analytic values were less than five times the MDL, suggesting that these differences may be a laboratory artefact and not indicative of field or laboratory contamination. Consequently, replicate data from this study with RPD exceeding 25% are unlikely to be environmentally significant.

4.0 Conclusions and Recommendations

Windermere Lake is an important area for water-based recreation, including fishing, boating, and swimming and also provides water for domestic, irrigation, and industrial uses. Results from 2002/2003 and previous studies suggest that water quality in Windermere Lake may be changing, possibly due to inputs from ground water contaminated by septic fields, nutrients from lawns and gardens, logging and agricultural activity, among others. Changing trophic status is a concern as increased eutrophication has the potential to affect recreation on Windermere Lake due to an increase in weed and algal growth. This also has the potential to affect drinking water quality by changing the taste and odour, decreasing water clarity and causing aesthetic problems. Changes in water quality caused by septic field leachate may also increase health risks, as concentrations of disease-related organisms increase.

The rapid flushing rate (47 days) and shallow mean depth (3.4 m) cause Windermere Lake to remain well mixed throughout most of the year. These factors contribute to the water quality of Windermere Lake and its ability to assimilate nutrients without major impact on water quality.

Given the concern about pollution from non-point source inputs entering Windermere Lake, long-term monitoring is important to assess trends in water quality, develop management decisions, and ensure the safety of water quality for drinking water and aquatic life.

Beaches
Water monitoring at Windermere Lake public beaches found water quality met guidelines for primary contact recreation, although microbial indicators were elevated during one sampling period. It is recommended that microbial indicators, including fecal coliforms, *E. coli*, and *Enterococci* continue to be monitored during periods of recreational use to ensure water quality continues to be safe for recreation.

Water Intakes
Water quality at water intakes met most WQGs to protect drinking water with disinfection, with the exception of pH, temperature, and *Enterococci*. Of these parameters, *Enterococci* may be of some concern to water users. However, it is important to note samples were collected prior to disinfection (i.e., chlorination) and monitoring of water post-treatment would be required to more fully assess health risks associated with the presence of microbial indicators. It is recommended that continued monitoring be conducted by the purveyors, as required under the *Drinking Water Protection Act* to ensure water quality is safe for human consumption.

It is also recommended that water, post treatment, be analyzed at the intakes for trihalomethanes (THM). THMs are disinfection by-products formed when chlorine, or bromine used to disinfect drinking water reacts with organic matter in the water being treated (Health Canada, 2006). The interim maximum allowable concentration is 0.1 mg/L of total THMs (Health Canada, 2006). This is a health-based guideline. The guideline is based on the risk associated with chloroform, as it is the THM most often present in drinking water and in the greatest concentrations.

Lake Stations

This study did not assess water quality at lake stations. However, water quality from water intakes was compared with WQGs to protect aquatic life within Windermere Lake. It was noted that water quality samples from the intakes may not represent water quality conditions within the lake itself. Most parameters met available WQOs and WQGs, with the exception of dissolved oxygen, total phosphorus and dissolved sulphate.

Given the concern about pollution from non-point source inputs entering Windermere Lake, long-term monitoring is important to assess trends in water quality, develop management decisions, and ensure the safety of water quality for drinking water and aquatic life. As resources allow, it is recommended that monitoring be undertaken within Windermere Lake at the three lake sites established by MoE. Data collected from these sites can be compared to previous data to evaluate longer-term trends in water quality. Monitoring at these sites should include dissolved oxygen, pH, temperature, conductivity, NFR and/or turbidity, total and organic nitrogen, nitrate, nitrite, and ammonia, dissolved sulphate, total sulphide, total phosphorous, ortho-phosphate and total dissolved phosphorus. In addition, it is recommended that monitoring include chlorophyll *a* to assess lake productivity and Secchi monitoring to assess lake clarity.

5.0 References

Caux, P. Y., Moore, D.R.J. and MacDonald, D. 1997. Ambient Water Quality Guidelines (Criteria) for Turbidity, Suspended and Benthic Sediments. Technical Appendix. Prepared for the Water Management Branch, BC Ministry of Environment, Lands and Parks, Victoria, BC

Courtney, R. 1999. 1999 Windermere Lake Water Quality Monitoring Program. Prepared for the Regional District of East Kootenay by EnviResource Consulting. Calgary, AB

Fedrigo, A. 2006. Findings of the 2005 Lake Use Survey. The Lake Windermere Project. Invermere, BC

Health Canada 1988. Updated January 2002. Guidelines for Canadian Drinking Water Quality: Supporting Documentation. Bacteriological Quality. Federal – Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environmental and Occupational Health, Ottawa, ON: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc

Health Canada 2001. Summary of Guidelines for Canadian Drinking Water Quality. Federal – Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environmental and Occupational Health, Ottawa, ON

Health Canada 2004. Guidelines for Canadian Drinking Water Quality: Supporting Documentation. Enteric Viruses. Federal – Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environmental and Occupational Health, Ottawa, ON: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/enteric-enterovirus/index-eng.php

Health Canada 2006. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Trihalomethanes. Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment, Ottawa, ON

Health and Welfare Canada 1992. Guidelines for Canadian Recreational Water Quality. Minister of Supply and Services Canada, Canadian Government Publishing Center, Ottawa, ON

Jagals, P., Grabow, W. O. K., Griesel, M., Jagals, C. 2000. Evaluation of Selected Membrane Filtration and Most Probable Number Methods for the Enumeration of Faecal Coliforms, *Escherichia coli* and *Enterococci* in Environmental Waters. Quantitative Microbiology 2, 129-140, 2000.

Land and Water BC: http://www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input

McDonald, L.E. 2000. Water Quality Changes Over The Past 300 Years As Determined From A Bottom Sediment Core. BC Ministry of Environment, Land and Parks, Cranbrook, BC

McKean, C.J.P, Nordin, R.N. 1985. Upper Columbia River Area - Columbia and Windermere Lakes Sub-basin Water Quality Assessment and Objectives (Technical Appendix). BC Ministry of Environment, Victoria, BC

Ministry of Environment (MoE). 1985. Water Quality Criteria for Nutrients and Algae (Technical Appendix). BC Water Management Branch, Victoria, BC

Ministry of Environment (MoE). 1998a, updated 2006. WQ Criteria British Columbia Approved Water Quality Guidelines (Criteria): 1998 Edition. Water Quality Section, BC Ministry of Environment, Lands and Parks, Victoria, BC: http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html

Ministry of Environment (MoE). 1998b, updated 2006. A Compendium of Working Water Quality Guidelines for British Columbia: 1998 Edition. Water Quality Section, BC Ministry of Environment, Lands and Parks, Victoria, BC: http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html

Ministry of Environment, Land and Parks (MELP). 2000. Ambient Water Quality Guidelines for Sulphate (Technical Appendix). Water Management Branch. Victoria, BC: http://www.env.gov.bc.ca/wat/wq/BCguidelines/sulphate/index.html

Nordin, R.N. 1985. Water Quality Criteria for Nutrients and Algae (Technical Appendix). BC Ministry of Environment. Victoria, BC

Resource Information Standards Committee (RISC). 1997. Ambient Fresh Water and Effluent Sampling Manual. Resources Inventory Committee Publications: http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/ambient/index.htm

Resource Information Standards Committee (RISC). 1998. Guidelines for Interpreting Water Quality Data (Field Test Edition). BC Ministry of Environment, Lands and Parks, Victoria, BC: http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/interp/index.htm

Urban Systems. 2001. Lake Windermere Management Strategy. District of Invermere. Invermere, BC

Wetzel, R. G. 2001. Limnology; Lake and River Ecosystems, Third Edition. Academic Press, Elsevier Science, USA.

Personal Communications

Brown, W. Utilities Superintendent. Regional District of East Kootenay, Cranbrook, BC

Jensen, V. Environmental Impact Assessment Biologist. BC Ministry of Environment, Penticton, BC

Plotnikoff, C. Public Health Inspector. Interior Health Authority, Invermere, BC

Sharpe, E. Manager of Engineering and Environmental Services. Regional District of East Kootenay, Cranbrook, BC

Appendices

Appendix A: Table 1. Water Intake Licenses on Windermere Lake.
Source; Land and Water BC Website (http://www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input)

Licence No[1]	WR Map/Point Code	Stream Name	Purpose	Quantity	Units[2]	Qty Flag[3]	Licensee	Licence Status	Process Status	Priority Date[4]	Issue Date[5]
C027766	2962B R3 (PD24871)	Windermere Lake	Waterworks Local Auth	36500000	GY	T	REGIONAL DISTRICT OF EAST KOOTENAY 19 24TH AVE S CRANBROOK BC V1C3H8	Current	N/A	19620413	0
C032043	2962C P (PD24974)	Windermere Lake	Domestic	500	GD	T	MARSHALL H DAVIDSON 936 KERFOOT CRESCENT SW CALGARY AB T2V2M7	Current	N/A	19651221	0
C032369	2962A VV (PD24930)	Windermere Lake	Waterworks Local Auth	182500000	GY	T	PARR UTILITIES LTD BOX 711 WINDERMERE BC V0B2L0	Current	N/A	19660406	0
C041285	2962A D3 (PD24924)	Windermere Lake	Waterworks Local Auth	16425000	GY	T	OWNERS OF TERRAVISTA-STRATA PLAN N-9 BOX 401 WINDERMERE BC V0B1L0	Current	N/A	19711109	0
C043520	2963 Y (PD24852)	Windermere Lake	Waterworks Local Auth	6570000	GY	T	LARCH POINT INDUSTRIES LTD 6918 LEFROY CRT SW CALGARY AB T3E6G9	Current	N/A	19731017	0
C045200	2962A D3 (PD24924)	Windermere Lake	Waterworks Local Auth	2920000	GY	T	OWNERS OF TERRAVISTA-STRATA PLAN N-9 BOX 401 WINDERMERE BC V0B1L0	Current	N/A	19750221	0
C045211	2962A D3 (PD24924)	Windermere Lake	Waterworks Local Auth	3832500	GY	T	OWNERS OF TERRAVISTA-STRATA PLAN N-9 BOX 401 WINDERMERE BC V0B1L0	Current	N/A	19750221	0
C048008	2962A E3 (PD24926)	Windermere Lake	Domestic	3500	GD	T	WINDERMERE HOLDINGS LTD C/O M E HOPKINS SECRETARY 5032 BARRON DR NW CALGARY AB T2L1T6	Current	N/A	19740715	0
C052423	2962A J3 (PD24921)	Windermere Lake	Land Improve	0	TF	M	AKISKINOOK HOLDINGS LTD BOX 2471 INVERMERE BC V0A1K0	Current	N/A	19780824	0
"	2962A K3 (PD24919)	Windermere Lake	Land Improve	0	TF	M	AKISKINOOK HOLDINGS LTD BOX 2471 INVERMERE BC V0A1K0	Current	N/A	19780824	0
C054508	2962C U (PD24970)	Windermere Lake	Domestic	500	GD	T	DOUGLAS R & ANITA L BROCKWAY 4107 VARSITY RD NW CALGARY AB T3B2Y5	Current	N/A	19780928	0
							HEATHER G GIUFFRE				

C054510	2962C U (PD24970)	Windermere Lake	Domestic	500	GD	T	3619 12 STREET SW CALGARY AB T2T3P1	Current	N/A	19780928	0
C056093	2963 CC (PD24847)	Windermere Lake	Domestic	500	GD	T	BRUCE ALBERT SHAND 96 MCNAB STREET BROOKS AB T1R0K7	Current	N/A	19801202	0
"	"	Windermere Lake	Irrigation	2.5	AF	T	BRUCE ALBERT SHAND 96 MCNAB STREET BROOKS AB T1R0K7	Current	N/A	19801202	0
C056178	2963 CC (PD24847)	Windermere Lake	Domestic	500	GD	T	STEWART B & HEIDEMARIE ZAROWNY 259 EDGEBROOK RISE NW CALGARY AB T3C5J9	Current	N/A	19800801	0
"	"	Windermere Lake	Irrigation	2.5	AF	T	STEWART B & HEIDEMARIE ZAROWNY 259 EDGEBROOK RISE NW CALGARY AB T3C5J9	Current	N/A	19800801	0
C056277	2965 KK (PD24835)	Windermere Lake	Domestic	500	GD	T	RAYMOND D & JANIS E EVANS 4525 RUSHMERE RD INVERMERE BC V0A1K4	Current	N/A	19801119	0
"	"	Windermere Lake	Irrigation	2	AF	T	RAYMOND D & JANIS E EVANS 4525 RUSHMERE RD INVERMERE BC V0A1K4	Current	N/A	19801119	0
C056515	2965 Z (PD24841)	Windermere Lake	Domestic	500	GD	T	WILLIAM & MILDRED TAYLOR 331 CANYON CLOSE CANMORE AB T1W1H4	Current	N/A	19800804	0
"	"	Windermere Lake	Irrigation	1.25	AF	T	WILLIAM & MILDRED TAYLOR 331 CANYON CLOSE CANMORE AB T1W1H4	Current	N/A	19800804	0
C056721	2965 Y (PD24837)	Windermere Lake	Irrigation	2	AF	T	L WAYNE & PATRICIA J PEARCE 628 MALVERN DR NE CALGARY AB T2A5P5	Current	N/A	19800611	0
C058704	2965 CC (PD24836)	Windermere Lake	Domestic	500	GD	T	PETER RICHARD GARRETT 382 WILDWOOD DR SW CALGARY AB T3C3E6	Current	N/A	19810721	0
"	"	Windermere Lake	Irrigation	1.25	AF	T	PETER RICHARD GARRETT 382 WILDWOOD DR SW CALGARY AB T3C3E6	Current	N/A	19810721	0
C063516	2965 CC (PD24836)	Windermere Lake	Domestic	500	GD	T	KEVIN D MCKAY PO BOX 391 INVERMERE BC V0A1K0	Current	N/A	19810910	0
"	"	Windermere Lake	Irrigation	1.5	AF	T	KEVIN D MCKAY PO BOX 391 INVERMERE BC V0A1K0	Current	N/A	19810910	0
C063827	2962B R3 (PD24871)	Windermere Lake	Waterworks Local Auth	730000000	GY	T	REGIONAL DISTRICT OF EAST KOOTENAY 19 24TH AVE S CRANBROOK BC V1C3H8	Current	N/A	19850307	0

C067874	2962A F3 (PD24932)	Windermere Lake	Waterworks Local Auth	16060000	GY	T	REGIONAL DISTRICT OF EAST KOOTENAY 19-24 AVE S CRANBROOK BC V1C3H8	Current	N/A	19771206	0
C067875	2962A F3 (PD24932)	Windermere Lake	Waterworks Local Auth	35040000	GY	T	REGIONAL DISTRICT OF EAST KOOTENAY 19-24 AVE S CRANBROOK BC V1C3H8	Current	N/A	19750317	0
C068133	2962A H3 (PD24923)	Windermere Lake	Waterworks Local Auth	18250000	GY	T	AKISKINOOK HOLDINGS LTD BOX 2471 INVERMERE BC V0A1K0	Current	N/A	19771118	0
C068134	2962A H3 (PD24923)	Windermere Lake	Waterworks Local Auth	7482500	GY	T	AKISKINOOK HOLDINGS LTD BOX 2471 INVERMERE BC V0A1K0	Current	N/A	19790418	0
C068135	2962A H3 (PD24923)	Windermere Lake	Waterworks Local Auth	6205000	GY	T	AKISKINOOK HOLDINGS LTD BOX 2471 INVERMERE BC V0A1K0	Current	N/A	19800807	0
C069584	2962A F3 (PD24932)	Windermere Lake	Watering	10	AF	T	REGIONAL DISTRICT OF EAST KOOTENAY 19-24 AVE S CRANBROOK BC V1C3H8	Current	N/A	19871023	19910315
"	"	Windermere Lake	Waterworks Local Auth	11680000	GY	T	REGIONAL DISTRICT OF EAST KOOTENAY 19-24 AVE S CRANBROOK BC V1C3H8	Current	N/A	19871023	19910315
C100339	2962C U (PD24970)	Windermere Lake	Domestic	500	GD	T	VICTOR A & WILMA J DIDKOWSKY 200 EDELWEISS DR NW CALGARY AB T3A3R7	Current	N/A	19880906	19921214
C106516	2962C W (PD67711)	Windermere Lake	Land Improve	5	AF	T	LAKE WINDERMERE DISTRICT LIONS CLUB PO BOX 213 INVERMERE BC V0A1K0	Current	Sec. 18 Amendment	19930421	19950126
"	"	Windermere Lake	Watering	220	AF	T	LAKE WINDERMERE DISTRICT LIONS CLUB PO BOX 213 INVERMERE BC V0A1K0	Current	Sec. 18 Amendment	19930421	19950126
C109189	2962A F3 (PD24932)	Windermere Lake	Waterworks Local Auth	3650000	GY	T	REGIONAL DISTRICT OF EAST KOOTENAY 19-24 AVE S CRANBROOK BC V1C3H8	Current	N/A	19950116	19970908
C111111	2962A E3 (PD24926)	Windermere Lake	Domestic	500	GD	T	SUSAN K MCGREGOR 2411 UXBRIDGE DR NW CALGARY AB T2N3Z8	Current	N/A	19960524	20030529
C115390	2965 KK (PD24835)	Windermere Lake	Domestic	500	GD	T	DAVID E & RITA I BURKE RR 4 4552 RUSHMERE RD INVERMERE BC	Current	N/A	20000615	20020423
							ROY L BURKE				

C116238	2965 HH (PD24832)	Windermere Lake	Domestic	500	GD	T	41079 CIRCLE 5 ESTATES CALGARY AB T3Z2T4	Current	Sec. 18 Amendment	19820422	20010801
C116780	2962A E3 (PD24926)	Windermere Lake	Domestic	500	GD	T	746634 ALBERTA INC 12 CARRIAGE LANE CALGARY AB T3Z3L8	Current	N/A	19810903	20030728
C119775	2962C D (PD24972)	Windermere Lake	Domestic	500	GD	T	MATTHEW J & MARGARET E BINFET 615 WILLOW BROOK DRIVE CALGARY AB T2J1N6	Current	N/A	19580902	20041129
F045390	2962C S (PD24977)	Windermere Lake	Domestic	500	GD	T	CONSTANCE C FILICHUK 56 WOODHAVEN CRES SW CALGARY BC T2W5S3	Current	N/A	19660310	0
F045816	2962C R (PD24979)	Windermere Lake	Domestic	500	GD	T	CINDY L ROYER PLACE SW CALGARY AB T2V2T6	Current	N/A	19660301	0
F052340	2962A C3 (PD24928)	Windermere Lake	Domestic	500	GD	T	TERRY SPARKS 1416 BEVERLY PL SW CALGARY AB T2V2C6	Current	N/A	19711103	0

Notes:

All water licenses fall under the GOL-WINDERMERE water district/precinct.

1. License No:
   Cnnnnnn - Conditional Licence ("licence that authorizes the construction of works or the diversion and use of water before the issue of a final licence" *Water Act* - 1996).
   Fnnnnnn - Final Licence ("licence that authorizes the diversion and use of water, and does not authorize the construction of additional works or an extension of the use of water" *Water Act* - 1996).
2. Unit - The unit of measurement for the quantity of water authorized in the licence.
   AF (acre-feet per annum)
   GD (gallons per day)
   GY (gallons per year)
   TF (total flow) - a unit for non-consumptive purposes for which the total flow of the source is authorized to pass through the licensed works.
3. Qty Flag Desc - Description of the Quantity Flag code
   T - Total demand for purpose
   M - Maximum licensed demand for purpose
4. Priority Date - The date from which the precedence of the licence is established (YYYYMMDD).
5. Issue Date - The date on which the licence was issued (YYYYMMDD).

Appendix A: Table 2. Water Uses and Uptake Rates on Windermere Lake.
Source: Land and Water BC website (http://www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input)

Purpose	Description	# of licences	Total uptake	Units *
Land Improvement	Water diverted or impounded to protect property, facilitate development, drainage, or other land improvement, including ponds.	1	4464 of 1629255	GD GY
Watering	Water used for watering golf courses, ornamental gardens, parks, etc.	2	205331 or 74945730	GD GY
Irrigation	Water used on cultivated lands and hay meadows to nourish crops.	7	11606 or 4236063	GD GY
	Water conveyed to more than 5 dwellings by a water district.		2951000 or	GD
Domestic	Water used in a dwelling (household) where the number of dwellings on that land is 4 or less, includes gardens <.25 acres, fire protection and pets, or stock, poultry of a number sufficient only to sustain licensees family with food.	19	10500 or 3832500	GD GY

Notes:
* GY refers to Gallons per Year and GD is Gallons per Day.

Appendix B: Table 1. Water Quality Results at Public Beaches on Windermere Lake sampled August/September, 2002.

Parameter	Units	WQG[a]	06-Aug-02	07-Aug-02	12-Aug-02	13-Aug-02	19-Aug-02	20-Aug-02	26-Aug-02	28-Aug-02	03-Sep-02	04-Sep-02	Min	Max	Geometric Mean
Invermere Beach (E207050)															
Field Measurements															
Temperature	Celsius	6.5 - 9	18.2	17.8	20.1	20.7	20.8	19.1	18.8	19.9	19.7	20.8	17.8	20.8	19.6
Conductivity	uS/cm		243	242	251	259	250	255	270	269	257	255	242	270	255
Dissolved Oxygen	mg/L		5.7	5.2	5.8	5.6	6.4	6.5	6.4	5	4.7	9.1	4.7	9.1	5.9
pH	pH units		7.79	8.08	8.23	8.06	8.11	7.98	8.11	8.22	8.30	8.34	7.79	8.34	8.12
Microbial Indicators															
Fecal coliform	CFU/100 mL	200	1	1	< 1	-	5	34	< 1	1	< 1	< 1	1	34	2
E. coli	CFU/100 mL	77	1	2	< 1	< 1	4	22	< 1	< 1	< 1	< 1	1	22	2
Enterococci	CFU/100 mL	20	11	11	< 1	9	10	8	< 1	< 1	1	< 1	1	11	3
Athalmer Beach (E207051)															
Field Measurements															
Temperature	Celsius	6.5 - 9	18.5	17.3	20.5	20.3	21.0	19.2	18.5	18.1	19.9	20.6	17.3	21.0	19.4
Conductivity	uS/cm		245	249	261	266	262	274	283	280	264	264	245	283	265
Dissolved Oxygen	mg/L		5.9	5.3	6.6	6.6	6.4	6.7	5.8	5.6	5.7	14.3	5.3	14.3	6.6
pH	pH units		7.89	8.03	8.31	8.01	8.15	7.99	8.05	8.19	8.16	8.29	7.89	8.31	8.11
Microbial Indicators															
Fecal coliform	CFU/100 mL	200	2	< 1	5	3	13	94	2	< 1	1	6	1	94	4
E. coli	CFU/100 mL	77	2	< 1	2	1	7	68	2	< 1	< 1	4	1	68	3
Enterococci	CFU/100 mL	20	22	11	< 1	7	12	45	11	1	20	1	1	45	7

Notes:

[a] BC Water Quality Guideline (WQG) for primary contact recreation based on geometric mean of results (MoE, 1998a).

Appendix C: Table 1. Water Quality Results Parr Utilities Water Intake (E207048) August/September, 2002.

			DWG[a]	WQG[b]																												
Parameter	**Unit**	**MDL**		**30-Day Avg.**	**Max**	**6-Aug-02**		**7-Aug-02**		**12-Aug-02**		**13-Aug-02**		**19-Aug-02**		**20-Aug-02**		**26-Aug-02**		**28-Aug-02**		**3-Sep-02**		**4-Sep-02**		**9-Sep-02**		**10-Sep-02**		**16-Sep-02**		**17-Sep-02**	**N**	**30-Day Avg.[c]**	**Max.**	**SD**	**SE**
FIELD MEASUREMENTS																																		
Temperature	Celsius		15^				17.9		16.4		17.3		19.4		16.9		18.7		19.5		18.3		19.7		15.3		19.4		15.5		16.9		16.1	14	17.7	19.7	1.537	0.411
Conductivity	µS/cm		700*				247		247		250		256		252		258		281		276		262		262		260		292		287		286	14	265	292	15.795	4.221
Dissolved Oxygen	mg/L						6.5		6.1		5.4		6.4		6		6.1		5.1		5.8		4.5		5.4		5.5		6.7		5.9		6.8	14	5.9	6.8	0.645	0.172
pH	pH units		6.5 - 8.5^	6.5 - 9			7.67		7.93		8.02		8.13		8.07		7.88		8.11		8.17		8.12		8.15		8.04		8.32		8.22		8.27	14	8.08	8.32	0.168	0.045
PHYSICAL																																		
Residue Non-filterable	mg/L	4	-	-		<	4		-	<	4		-	<	4		-	<	4		-	<	4		-	<	4		-	<	4		-	7	< 4	< 4	0	0
NITROGEN																																		
Nitrogen (total)	mg/L	0.02	-	-	-		0.24		-		0.17		-		0.19		-		0.18		-		0.26		-		0.25		-		0.42		-	7	0.24	0.42	0.085	0.032
Ammonia (dissolved)[d]	mg/L	0.005	-	0.396	2.91		0.022		-	<	0.005		-	<	0.005		-		0.027		-		0.049		-		0.061		-		0.065		-	7	0.033	0.065	0.025	0.009
Nitrate nitrogen (NO3) (dissolved)	mg/L	0.002	10	40	200		0.026		-		0.005		-	<	0.002		-		0.005		-		0.039		-		0.003		-		0.012		-	7	0.013	0.039	0.014	0.005
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-		0.026		-		0.005		-	<	0.002		-		0.005		-		0.041		-		0.003		-		0.014		-	7	0.014	0.041	0.015	0.006
Nitrite nitrogen (dissolved)[e]	mg/L	0.002	1	0.02	0.06	<	0.002		-	<	0.002		-	<	0.002		-	<	0.002		-		0.002		-	<	0.002		-		0.002		-	7	0.002	0.002	0.000	0
PHOSPHORUS																																		
Ortho-Phosphate (dissolved)	mg/L	0.001					0.003		-		0.006		-		0.008		-	<	0.001		-	<	0.001		-		0.002		-		0.001		-	7	0.003	0.008	0.003	0.001
Phosphorus (dissolved)	mg/L	0.002					0.004		-		0.005		-		0.003		-		0.005		-		0.006		-		0.004		-		0.002		-	7	0.004	0.006	0.001	0.001
Phosphorus (total)	mg/L	0.002	0.01*		0.01~		0.005		-		0.006		-		0.004		-		0.006		-		0.009		-		0.006		-		0.009		-	7	0.004	0.009	0.002	0.001
SULPHATE																																		
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100		18.5		-		19.5		-		21.9		-		30.6		-		24.2		-		26.1		-		27.3		-	7	24.0	30.6	4.355	1.646
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		<	0.005		-	<	0.005		-	<	0.005		-	<	0.005		-	<	0.005		-	<	0.005		-	<	0.005		-	7	< 0.005	< 0.005	0	0
MICROBIAL INDICATORS			**90th percentile**																														**90th percentile**			
Fecal coliform	CFU/100 mL		10*	-	-	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1		2	<	1	14	1	2	-	-
E. coli	CFU/100 mL		10*	-	-	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1	<	1		1	<	1	14	1	1	-	-
Entercocci	CFU/100 mL		3*	-	-		5		6	<	1		1	<	1	<	1		2	<	1	<	1		3		7		3	<	1	<	1	14	6	7	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 19.7 degrees Celsius, pH 8.32)

[e] 30-Day Avg WQG based on <2mg/L chloride.

[f] 30-Day WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix C: Table 2. Water Quality Results Parr Utilities Water Intake (E207048) January/February, 2003.

Parameter	Unit	MDL	DWG[a]	WQG[b] 30-d Ave.	WQG[b] Max	7-Jan-03	8-Jan-03	14-Jan-03	15-Jan-03	21-Jan-03	22-Jan-03	28-Jan-03	29-Jan-03	4-Feb-03	5-Feb-03	N	30-d Ave.[c]	Max	SD	SE
FIELD MEASUREMENTS																				
Temperature	Celsius		15^			-	-	2	2.8	2.8	3.2	4.9		3.3	3.3	7	3.2	4.9	0.882	0.333
Conductivity	µS/cm		700*			-	-	363	416	412	436	426		424	424	7	414	436	23.929	9.044
Dissolved Oxygen	mg/L					-	-	10.9	9.4	10.3	10.6	10.2		9.9	9.9	7	10.2	10.9	0.496	0.187
pH	pH units		6.5 - 8.5^	6.5 - 9		-	-	8.49	8.44	8.4	8.49	8.69		8.75	8.75	7	8.57	8.75	0.152	0.057
PHYSICAL																				
Residue Non-filterable	mg/L	4	-	-		-	< 4	< 4	-	< 4	-	< 4	-	-	< 4	5	< 4	< 4	0	0
NITROGEN																				
Nitrogen (total)	mg/L	0.02	-	-	-	-	0.28	0.29	-	0.3	-	0.31	-	-	0.26	5	0.29	0.31	0.019	0.009
Ammonia (dissolved)[d]	mg/L	0.005	-	0.2	1.04	-	0.054	0.100	-	0.107	-	0.032	-	-	0.035	5	0.066	0.107	0.036	0.016
Nitrate nitrogen (NO3) (dissolved)	mg/L	0.002	10	40	200	-	0.089	0.021	-	0.050	-	0.103	-	-	0.105	5	0.074	0.105	0.037	0.016
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	-	0.093	0.023	-	0.051	-	0.103	-	-	0.108	5	0.076	0.108	0.037	0.017
Nitrite nitrogen (dissolved)[e]	mg/L	0.002	1	0.02	0.06	-	0.004	0.002	-	< 0.002	-	< 0.002	-	-	0.003	5	0.003	0.004	0.001	0
PHOSPHORUS																				
Ortho-Phosphate (dissolved)	mg/L	0.001				-	0.003	0.003	-	0.002	-	0.002	-	-	0.001	5	0.002	0.003	0.001	0
Phosphorus (dissolved)	mg/L	0.002				-	0.004	0.008	-	0.003	-	0.006	-	-	0.003	5	0.005	0.008	0.002	0.001
Phosphorus (total)	mg/L	0.002	0.01*		0.01~	-	0.004	0.005	-	0.007	-	0.038	-	-	0.003	5	0.011	0.038	0.015	0.007
SULPHATE																				
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	-	62.4	61.3	-	57.3	-	53.3	-	-	55.4	5	**57.9**	62.4	3.859	1.726
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		-	< 0.005	< 0.005	-	< 0.005	-	< 0.005	-	-	< 0.005	5	< 0.005	< 0.005	0	0
MICROBIAL INDICATORS			**90th percentile**														**90th percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	10	1	1	-	-
E. coli	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	-	-
Entercocci	CFU/100mL		3*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 4.9 degrees Celsius, pH 8.75)

[e] 30d Ave WQG based on <2mg/L chloride.

[f] 30-d WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix C: Table 3. Water Quality Results Parr Utilities Water Intake (E207048) April/May, 2003.

			DWG[a]	WQG[b]																				
Parameter	**Unit**	**MDL**		**30-d Ave.**	**Max**	**22-Apr-03**	**23-Apr-03**	**28-Apr-03**	**29-Apr-03**	**5-May-03**	**6-May-03**	**12-May-03**	**13-May-03**	**20-May-03**	**22-May-03**	**N**	**30-d Ave.[c]**	**Max**	**SD**	**SE**
FIELD MEASUREMENTS																				
Temperature	Celsius		15^			10.1	10.7	9.3	9.9	12.1	10.3	13.2	13.3	12.4	13.8	10	11.5	13.8	1.634	0.517
Conductivity	µS/cm		700*			536	516	522	515	515	518	541	512	527	504	10	521	541	11.237	3.553
Dissolved Oxygen	mg/L					7.2	9.3	5.9	7.2	6.8	6.8	8.2	8.4	7.3	9.1	10	7.6	9.3	1.091	0.345
pH	pH units		6.5 - 8.5^	6.5 - 9		7.87	8.17	7.94	8.33	8.45	8.59	8.53	8.64	8.57	8.41	10	8.35	8.64	0.272	0.086
PHYSICAL																				
Residue Non-filterable	mg/L	4	-	-		< 4	-	< 4	-	< 4	-	< 4	-	< 4	-	5	< 4	< 4	0	0
NITROGEN																				
Nitrogen (total)	mg/L	0.02	-	-	-	0.22	-	0.19	-	0.18	-	0.17	-	0.17	-	5	0.19	0.22	0.021	0.009
Ammonia (dissolved)[d]	mg/L	0.005	-	0.241	1.25	0.025	-	0.005	-	< 0.005	-	< 0.005	-	< 0.005	-	5	0.009	0.025	0.009	0.004
Nitrate nitrogen (NO3) (dissolved)	mg/L	0.002	10	40	200	0.030	-	0.070	-	0.001	-	< 0.002	-	< 0.002	-	5	0.021	0.070	0.030	0.013
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	0.030	-	0.066	-	0.003	-	< 0.002	-	< 0.002	-	5	0.021	0.066	0.028	0.013
Nitrite nitrogen (dissolved)[e]	mg/L	0.002	1	0.02	0.06	0.002	-	< 0.002	-	0.002	-	< 0.002	-	< 0.002	-	5	0.002	0.002	0	0
PHOSPHORUS																				
Ortho-Phosphate (dissolved)	mg/L	0.001				0.002	-	0.001	-	< 0.001	-	0.001	-	0.001	-	5	0.001	0.002	0	0
Phosphorus (dissolved)	mg/L	0.002				0.005	-	0.003	-	0.005	-	0.003	-	0.003	-	5	0.004	0.005	0.001	0
Phosphorus (total)	mg/L	0.002	0.01*		0.01~	0.005	-	0.057	-	< 0.002	-	0.005	-	0.005	-	5	**0.015**	0.057	0.024	0.011
SULPHATE																				
Sulphate (dissolved)f	mg/L	0.5	500^	50	100	74.5	-	-	-	70.3	-	71.9	-	72.3	-	4	**72.3**	74.5	1.731	0.774
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		-	-	-	-	< 0.005	-	-	-	< 0.005	-	2	< 0.005	< 0.005	0	0
MICROBIAL INDICATORS			**90th percentile**														**90th percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 1	< 1	< 1	< 2	10	< 2	< 2	-	-
E. coli	CFU/100mL		10*	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 1	< 1	< 1	< 2	10	< 2	< 2	-	-
Entercocci	CFU/100mL		3*	-	-	< 2	< 2	< 2	< 2	< 2	< 2	1	< 1	2	< 2	10	< 2	2	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 13.8 degrees Celsius, pH 8.64)

[e] 30d Ave WQG based on <2mg/L chloride.

[f] 30-d WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix D: Table 1. Water Quality Results Windermere Water Intake (E207044) August/September, 2002.

			DWG[a]	WQG[b]																					
Parameter	**Unit**	**MDL**		**30-d Ave.**	**Max**	**12-Aug-02**	**13-Aug-02**	**19-Aug-02**	**20-Aug-02**	**26-Aug-02**	**28-Aug-02**	**3-Sep-02**	**4-Sep-02**	**9-Sep-02**	**10-Sep-02**	**16-Sep-02**	**17-Sep-02**	**N**	**30-d Ave.[c]**	**Max**	**SD**	**SE**
FIELD MEASUREMENTS																						
Temperature	Celsius		15^			21.6	19.3	17.3	19.6	19	18.6	19.2	18.2	16.4	16.4	13.5	16.1	12	17.9	21.6	2.121	0.612
Conductivity	µS/cm		700*			257	261	258	261	279	284	263	264	285	286	206	288	12	266	288	22.454	6.482
Dissolved Oxygen	mg/L					5.1	5.9	6.3	5.3	6	6.6	4.7	5.3	5.6	6	8.2	6.8	12	6.0	8.2	0.933	0.269
pH	pH units		6.5 - 8.5^		6.5 - 9	8.1	8.04	8.08	7.98	8.03	8.14	8	8.3	8.27	8.32	7.94	8.31	12	8.1	8.32	0.139	0.040
PHYSICAL																						
Residue Non-filterable	mg/L	4	-	-		< 4	-	< 4	-	< 4	-	< 4	-	< 4	-	< 4	-	6	< 4	< 4	0	0
NITROGEN																						
Nitrogen (total)	mg/L	0.02	-	-	-	0.18	-	0.21	-	0.22	-	0.26	-	0.54	-	0.48	-	6	0.32	0.54	0.154	0.063
Ammonia (dissolved)[d]	mg/L	0.005	-	0.396	2.91	0.017	-	0.011	-	0.036	-	0.087	-	0.087	-	0.092	-	6	0.055	0.092	0.038	0.015
Nitrate (NO3) (dissolved)	mg/L	0.002	10	40	200	0.005	-	< 0.002	-	0.004	-	0.005	-	0.007	-	0.012	-	6	0.006	0.012	0.003	0.001
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	0.005	-	< 0.002	-	0.004	-	0.007	-	0.007	-	0.014	-	6	0.007	0.014	0.004	0.002
Nitrogen - Nitrite (dissolved)	mg/L	0.002	1	0.02	0.06	< 0.002	-	< 0.002	-	< 0.002	-	0.002	-	< 0.002	-	0.002	-	6	0.002	0.002	0	0
PHOSPHORUS																						
Ortho-Phosphate (dissolved)	mg/L	0.001				0.006	-	0.003	-	0.004	-	0.002	-	0.002	-	0.001	-	6	0.003	0.006	0.002	0.001
Phosphorus (dissolved)	mg/L	0.002				0.004	-	0.003	-	0.009	-	0.003	-	0.007	-	0.003	-	6	0.005	0.009	0.003	0.001
Phosphorous (total)	mg/L	0.002	0.01*		0.01~	0.006	-	0.004	-	0.014	-	0.004	-	0.008	-	0.007	-	6	0.007	0.014	0.004	0.002
SULPHATE																						
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	21	-	23.1	-	25.9	-	26.1	-	27.2	-	27.7	-	6	25.2	27.7	2.592	1.058
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		< 0.005	-	< 0.005	-	< 0.005	-	< 0.005	-	< 0.005	-	0.007	-	6	0.005	0.007	0.001	0
MICROBIAL INDICATORS			**90th percentile**																**90th percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	1	2	1	2	< 1	< 1	1	< 1	12	2	2	-	-
E. coli	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	1	1	< 1	2	< 1	< 1	< 1	< 1	12	1	2	-	-
Entercocci	CFU/100mL		3*	-	-	< 1	4	3	1	< 1	< 1	< 1	< 1	3	< 1	< 1	2	12	**3**	4	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 21.6 degrees Celsius, pH 8.32)

[e] 30d Ave WQG based on <2mg/L chloride.

f 30-d WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix D: Table 2. Water Quality Results Windermere Water Intake (E207044) January/February, 2003.

Parameter	Unit	MDL	DWG[a]	30-d Ave.	WQG[b] Max	7-Jan-03	8-Jan-03	14-Jan-03	15-Jan-03	21-Jan-03	22-Jan-03	28-Jan-03	29-Jan-03	4-Feb-03	5-Feb-03	N	30-d Ave.[c]	Max	SD	SE
FIELD MEASUREMENTS						-	-													
Temperature	Celsius		15^			-	-	6.5	3.1	5.9	3.9	3.6	4.6	2.6	3.2	10	4.2	6.5	1.392	0.492
Conductivity	µS/cm		700*			-	-	396	436	431	435	472	443	466	441	10	440	472	23.201	8.203
Dissolved Oxygen	mg/L					-	-	9.7	-	9.2	9.2	9	9.3	9.4	10.3	10	9.4	10.3	0.435	0.165
pH	pH units		6.5 - 8.5^		6.5 - 9	-	-	8.25	8.38	7.73	8	8.38	7.83	7.93	8.43	10	8.12	8.43	0.276	0.098
PHYSICAL																				
Residue Non-filterable	mg/L	4	-	-		< 4	-	8	-	< 4	-	< 4	-	-	< 4	5	5	8	1.789	0.800
NITROGEN																				
Nitrogen (total)	mg/L	0.02	-	-	-	0.22	-	0.26	-	0.27	-	0.30	-	-	0.27	5	0.26	0.30	0.029	0.013
Ammonia (dissolved)[d]	mg/L	0.005	-	0.396	2.91	0.044	-	0.052	-	0.043	-	0.095	-	-	0.069	5	0.061	0.095	0.022	0.010
Nitrate (NO3) (dissolved)	mg/L	0.002	10	40	200	0.040	-	0.053	-	0.068	-	0.067	-	-	0.066	5	0.059	0.068	0.012	0.005
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	0.042	-	0.057	-	0.070	-	0.069	-	-	0.068	5	0.061	0.070	0.012	0.005
Nitrogen - Nitrite (dissolved)	mg/L	0.002	1	0.02	0.06	< 0.002	-	0.004	-	0.002	-	0.002	-	-	0.002	5	0.002	0.004	0.001	0
PHOSPHORUS																				
Ortho-Phosphate (dissolved)	mg/L	0.001				0.002	-	0.004	-	0.006	-	< 0.001	-	-	0.003	5	0.003	0.006	0.002	0.001
Phosphorus (dissolved)	mg/L	0.002				0.006	-	0.006	-	0.006	-	0.005	-	-	0.004	5	0.005	0.006	0.001	0
Phosphorous (total)	mg/L	0.002	0.01*		0.01~	0.007	-	0.006	-	0.008	-	0.005	-	-	0.006	5	0.006	0.008	0.001	0.001
SULPHATE																				
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	53.8	-	52.5	-	58.6	-	51.2	-	-	55.8	5	**54.4**	58.6	2.907	1.300
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		0.005	-	0.006	-	< 0.005	-	< 0.005	-	-	< 0.005	5	0.005	0.006	0	0
MICROBIAL INDICATORS			**90th percentile**														**90th percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	-	-
E. coli	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	-	-
Entercocci	CFU/100mL		3*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	< 1	10	1	2	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 6.5 degrees Celsius, pH 8.43)

[e] 30d Ave WQG based on <2mg/L chloride.

f 30-d WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix D: Table 3. Water Quality Results Windermere Water Intake (E207044) April/May, 2003.

Parameter	Unit	MDL	DWG[a]	WQG[b] 30-Day Avg.	WQG[b] Max	22-Apr-03	23-Apr-03	28-Apr-03	29-Apr-03	5-May-03	6-May-03	12-May-03	13-May-03	20-May-03	22-May-03	N	30-Day Avg.[c]	Max	SD	SE
FIELD MEASUREMENTS																				
Temperature	Celsius		15^			10.6	11	10	11.5	10.8	12.9	11.4	12.4	11.5	13.4	10	11.6	13.4	1.063	0.336
Conductivity	µS/cm		700*			565	534	519	512	491	504	526	527	491	492	10	516	565	23.431	7.409
Dissolved Oxygen	mg/L					8.4	8.4	6.6	7.2	7.2	7.6	7.5	10.6	7.7	7.2	10	7.8	10.6	1.116	0.353
pH	pH units		6.5 - 8.5^		6.5 - 9	7.21	8.49	8.07	8.31	8.47	8.43	8.18	8.53	8.54	8.23	10	8.25	8.54	0.398	0.126
PHYSICAL																				
Residue Non-filterable	mg/L	4	-	-		< 4	-	< 4	-	< 4	-	4	-	< 4	-	5	4	4	0	0
NITROGEN																				
Nitrogen (total)	mg/L	0.02	-	-	-	0.23	-	0.21	-	0.22	-	0.22	-	0.21	-	5	0.22	0.23	0.008	0.004
Ammonia (dissolved)[d]	mg/L	0.005	-	0.366	1.91	0.011	-	0.005	-	< 0.005	-	< 0.005	-	0.016	-	5	0.008	0.016	0.005	0.002
Nitrate (NO3) (dissolved)	mg/L	0.002	10	40	200	< 0.002	-	< 0.002	-	0.006	-	< 0.002	-	0.004	-	5	0.003	0.006	0.002	0.001
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	0.004	-	0.004	-	0.008	-	< 0.002	-	0.004	-	5	0.004	0.008	0.002	0.001
Nitrogen - Nitrite (dissolved)	mg/L	0.002	1	0.02	0.06	0.002	-	< 0.002	-	0.002	-	< 0.002	-	< 0.002	-	5	0.002	0.002	0	0
PHOSPHORUS																				
Ortho-Phosphate (dissolved)	mg/L	0.001				0.002	-	< 0.001	-	< 0.001	-	0.002	-	0.001	-	5	0.001	0.002	0.001	0
Phosphorus (dissolved)	mg/L	0.002				0.003	-	0.002	-	< 0.002	-	0.002	-	< 0.002	-	5	0.002	0.003	0	0
Phosphorous (total)	mg/L	0.002	0.01*		0.01~	0.005	-	0.012	-	0.002	-	0.01	-	0.022	-	5	**0.010**	0.022	0.008	0.003
SULPHATE																				
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	75.6	-	76.3	-	69.9	-	71.3	-	63.7	-	5	**71.4**	76.3	5.079	2.271
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		-	-	-	-	< 0.005	-	-	-	< 0.005	-	2	< 0.005	< 0.005	0	0
MICROBIAL INDICATORS			**90th percentile**														**90th percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 1	< 1	< 2	< 1	10	< 2	< 2	-	-
E. coli	CFU/100mL		10*	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 1	< 1	< 2	< 1	10	< 2	< 2	-	-
Entercocci	CFU/100mL		3*	-	-	4	< 2	< 2	< 2	< 2	< 2	1	4	< 2	9	10	**5**	9	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 13.4 degrees Celsius, pH 8.54)

[e] 30-Day Avg WQG based on <2mg/L chloride.

f 30-Day WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix E: Table 1. Water Quality Results Timber Ridge Water Intake (E207049) August/September, 2002.

Parameter	Unit	MDL	DWG[a]	WQG[b] 30-d Ave.	WQG[b] Max	12-Aug-02	13-Aug-02	19-Aug-02	20-Aug-02	26-Aug-02	28-Aug-02	3-Sep-02	4-Sep-02	9-Sep-02	10-Sep-02	16-Sep-02	17-Sep-02	N	30-d Ave.[c]	Max	SD	SE
FIELD MEASUREMENTS																						
Temperature	Celsius		15^			19.9	20	19.4	18.9	18.8	17.7	18.8	17.8	18.8	17.2	16.1	16.9	12	18.4	20.0	1.219	0.352
Conductivity	µS/cm		700*			250	252	250	251	252	286	259	258	251	282	291	289	12	264	291	17.163	4.955
Dissolved Oxygen	mg/L					5.3	5.9	5.9	6.1	5.9	6.3	4.4	5.7	5.5	6	6.1	6.1	12	5.8	6.3	0.512	0.148
pH	pH units		6.5 - 8.5^	6.5 - 9		8.11	8.06	8.19	7.98	8.03	8.14	8.12	8.22	8.07	8.39	8.26	8.29	12	8	8.39	0.119	0.034
PHYSICAL																						
Residue Non-filterable	mg/L	4	-	-		< 4	-	< 4	-	< 4	-	< 4	-	< 4	-	< 4	-	6	< 4	< 4	0	0
NITROGEN																						
Nitrogen (total)	mg/L	0.02	-	-	-	0.2	-	0.19	-	0.21	-	0.25	-	0.4	-	0.33	-	6	0.263	0.4	0.084	0.034
Ammonia (dissolved)[a]	mg/L	0.005	-	0.321	2.36	0.006	-	< 0.005	-	0.035	-	0.065	-	0.062	-	0.084	-	6	0.043	0.084	0.033	0.013
Nitrate (NO3) (dissolved)	mg/L	0.002	10	40	200	< 0.002	-	< 0.002	-	0.003	-	0.004	-	0.005	-	0.008	-	6	0.004	0.008	0.002	0.001
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	< 0.002	-	< 0.002	-	0.003	-	0.004	-	0.005	-	0.008	-	6	0.004	0.008	0.002	0.001
Nitrogen - Nitrite (dissolved)	mg/L	0.002	1	0.02	0.06	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	< 0.002	-	6	< 0.002	< 0.002	0	0
PHOSPHORUS																						
Ortho-Phosphate (dissolved)	mg/L	0.001				0.006	-	0.002	-	0.004	-	0.004	-	0.002	-	< 0.001	-	6	0.003	0.006	0.002	0.001
Phosphorus (dissolved)	mg/L	0.002				0.004	-	0.003	-	0.007	-	0.003	-	0.004	-	0.003	-	6	0.004	0.007	0.002	0.001
Phosphorous (total)	mg/L	0.002	0.01*		0.01~	0.009	-	0.006	-	0.012	-	0.005	-	0.007	-	0.013	-	6	0.009	0.013	0.003	0.001
SULPHATE																						
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	20	-	22.1	-	23.5	-	24	-	26.8	-	27.7	-	6	24	27.7	2.877	1.175
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		< 0.005	-	< 0.005	-	< 0.005	-	< 0.005	-	0.005	-	< 0.005	-	6	0.005	0.005	0	0
MICROBIAL INDICATORS			**90[th] percentile**																**90[th] percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	12	1	2	-	-
E. coli	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	12	1	1	-	-
Entercocci	CFU/100mL		3*	-	-	3	2	< 1	5	< 1	4	< 1	< 1	3	19	5	3	12	**6**	19	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[u] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 20.0 degrees Celsius, pH 8.39)

[c] 30d Ave WQG based on <2mg/L chloride.

[f] 30-d WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix E: Table 2. Water Quality Results Timber Ridge Water Intake (E207049) January/February, 2003.

Parameter	Unit	MDL	DWG[a]	WQG[b] 30-d Ave.	WQG[b] Max	7-Jan-03	8-Jan-03	14-Jan-03	15-Jan-03	21-Jan-03	22-Jan-03	28-Jan-03	29-Jan-03	4-Feb-03	5-Feb-03	N	30-d Ave.[c]	Max	SD	SE
FIELD MEASUREMENTS						-	-													
Temperature	Celsius		15^			-	-	5.5	3.8	5.1	3.9	4.3	4.4	3.1	3.3	10	4.2	5.5	0.8294	0.2623
Conductivity	µS/cm		700*			-	-	442	430	431	452	451	456	482	456	10	450	482	16.5874	5.2454
Dissolved Oxygen	mg/L					-	-	9.4	8.1	8.3	9.2	8.4	9.2	9.1	9.1	10	8.9	9.4	0.4986	0.1577
pH	pH units		6.5 - 8.5^		6.5 - 9	-	-	8.15	8.26	8.28	8.34	8.44	8.27	8.37	8.37	10	8.31	8.44	0.0891	0.0282
PHYSICAL																				
Residue Non-filterable	mg/L	4	-	-		< 4	-	< 4	-		-	< 4	-	-	< 4	4	< 4	< 4	0	0
NITROGEN																				
Nitrogen (total)	mg/L	0.02	-	-	-	0.3	-	0.33	-	0.34	-	0.32	-	-	0.31	5	0.32	0.34	0.0158	0.0071
Ammonia (dissolved)[u]	mg/L	0.005	-	0.38	1.98	0.092	-	0.12	-	0.114	-	0.144	-	-	0.108	5	0.116	0.144	0.0190	0.0085
Nitrate (NO3) (dissolved)	mg/L	0.002	10	40	200	0.030	-	0.034	-	0.035	-	0.041	-	-	0.055	5	0.039	0.055	0.0098	0.0044
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	0.028	-	0.037	-	0.035	-	0.043	-	-	0.055	5	0.040	0.055	0.0101	0.0045
Nitrogen - Nitrite (dissolved)	mg/L	0.002	1	0.02	0.06	0.002	-	0.003	-	< 0.002	-	0.002	-	-	< 0.002	5	0.002	0.003	0.0004	0.0002
PHOSPHORUS																				
Ortho-Phosphate (dissolved)	mg/L	0.001				0.002	-	0.002	-	0.002	-	0.001	-	-	0.002	5	0.002	0.002	0.0004	0.0002
Phosphorus (dissolved)	mg/L	0.002				0.005	-	0.005	-	0.004	-	0.003	-	-	0.005	5	0.004	0.005	0.0009	0.0004
Phosphorous (total)	mg/L	0.002	0.01*		0.01~	0.006	-	0.007	-	0.005	-	0.008	-	-	0.006	5	0.006	0.008	0.0011	0.0005
SULPHATE																				
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	60.2	-	66.6	-	57.3	-	58.9	-	-	70.5	5	**62.7**	70.5	5.6103	2.5090
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		-	-	< 0.005	-	< 0.005	-	< 0.005	-	-	0.006	4	0.005	0.006	0.0005	0.0003
MICROBIAL INDICATORS			**90th percentile**														**90th percentile**			
Fecal coliform	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	-	-
E. coli	CFU/100mL		10*	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	10	< 1	< 1	-	-
Entercocci	CFU/100mL		3*	-	-	< 1	< 1	< 1	< 1	2	< 1	10	< 1	1	< 1	10	3	10	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[u] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 5.5 degrees Celsius, pH 8.44)

[e] 30d Ave WQG based on <2mg/L chloride.

[f] 30-d WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
# (boxed)	value > maximum WQG
# (shaded)	value > DWG

Appendix E: Table 3. Water Quality Results Timber Ridge Water Intake (E207049) April/May, 2003.

Parameter	Unit	MDL	DWG[a]	30-Day Avg.	WQG[b] Max	22-Apr-03	23-Apr-03	28-Apr-03	29-Apr-03	5-May-03	6-May-03	12-May-03	13-May-03	20-May-03	22-May-03	N	30-Day Avg.[c]	Max	SD	SE
FIELD MEASUREMENTS																				
Temperature	Celsius		15^			9.5	10.4	11.3	12.8	11.5	11.3	12	13.5	12.4	13.4	10	11.8	13.5	1.278	0.404
Conductivity	µS/cm		700*			530	526	518	511	518	517	525	519	512	536	10	521	536	7.927	2.507
Dissolved Oxygen	mg/L					8	7.8	7	7.1	6	7.2	7.8	9.2	6.8	7	10	7.39	9.2	0.862	0.273
pH	pH units		6.5 - 8.5^		6.5 - 9	8.16	8.36	7.9	6.86	8.56	8.51	8.53	8.58	8.59	8.45	10	8.25	8.59	0.536	0.169
PHYSICAL																				
Residue Non-filterable	mg/L	4	-	-		4	-	10	-	< 4	-	< 4	-	< 4	-	5	5	10	2.683	1.200
NITROGEN																				
Nitrogen (total)	mg/L	0.02	-	-	-	0.26	-	0.32	-	0.21	-	0.20	-	0.17	-	5	0.23	0.32	0.059	0.026
Ammonia (dissolved)[d]	mg/L	0.005	-	0.296	1.54	0.416	-	0.014	-	< 0.005	-	< 0.005	-	< 0.005	-	5	0.089	0.416	0.183	0.082
Nitrate (NO3) (dissolved)	mg/L	0.002	10	40	200	0.014	-	< 0.002	-	0.002	-	< 0.002	-	< 0.002	-	5	0.004	0.014	0.005	0.002
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	< 0.002	-	0.012	-	0.004	-	< 0.002	-	0.005	-	5	0.005	0.012	0.004	0.002
Nitrogen - Nitrite (dissolved)	mg/L	0.002	1	0.02	0.06	0.006	-	< 0.002	-	0.002	-	< 0.002	-	< 0.002	-	5	0.003	0.006	0.002	0.001
PHOSPHORUS																				
Ortho-Phosphate (dissolved)	mg/L	0.001				0.002	-	0.001	-	< 0.001	-	0.002	-	< 0.001	-	5	0.001	0.002	0.001	0
Phosphorus (dissolved)	mg/L	0.002				0.007	-	0.005	-	0.007	-	< 0.002	-	< 0.002	-	5	0.005	0.007	0.003	0.001
Phosphorous (total)	mg/L	0.002	0.01*		0.01~	0.008	-	0.032	-	< 0.002	-	0.012	-	0.007	-	5	**0.012**	0.032	0.012	0.005
SULPHATE																				
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	71.8	-	72.2	-	70.7	-	62.2	-	71.7	-	5	**69.7**	72.2	4.240	1.896
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		< 0.005	-	-	-	< 0.005	-	-	-	< 0.005	-	3	< 0.005	< 0.005	0	0
MICROBIAL INDICATORS			**90th percentile**														**90th percentile**			
Fecal coliform	CFU/100 mL		10*	-	-	< 2	< 2	< 2	< 2	< 2	2	< 1	< 1	< 1	< 1	10	< 2	2	-	-
E. coli	CFU/100 mL		10*	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 1	< 1	< 1	< 1	10	< 2	< 2	-	-
Entercocci	CFU/100 mL		3*	-	-	< 2	< 2	< 2	< 2	6	2	1	1	1	1	10	2	6	-	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = D

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 13.5 degrees Celsius, pH 8.5

[e] 30-Day Avg WQG based on <2mg/L chloride.

[f] 30-Day WQG for sulphate = alert level.

[g] Sulphide as H_2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix F: Table 1. Water Quality Results Summary Data. Water Intake Sites. August/September, 2002.

			DWG[a]	WQG[b]		Parr				Windermere				Timber Ridge			
Parameter	**Unit**	**MDL**		**30-Day Avg.**	**Max**	**N**	**30-Day Avg.[c]**	**Max.**	**SE**	**N**	**30-Day Avg.[c]**	**Max**	**SE**	**N**	**30-Day Avg.[c]**	**Max**	**SE**
FIELD MEASUREMENTS																	
Temperature	Celsius		15^			14	17.7	19.7	0.411	12	17.9	21.6	0.612	12	18.4	20.0	0.352
Conductivity	µS/cm		700*			14	265	292	4.221	12	266	288	6.482	12	264	291	4.955
Dissolved Oxygen	mg/L					14	5.9	6.8	0.172	12	6.0	8.2	0.269	12	5.8	6.3	0.148
pH	pH units		6.5 - 8.5^	6.5 - 9		14	8.08	8.32	0.045	12	8.1	8.32	0.040	12	8	8.39	0.034
PHYSICAL																	
Residue Non-filterable	mg/L	4	-	-		7	< 4	< 4	0	6	< 4	< 4	0	6	< 4	< 4	0
NITROGEN																	
Nitrogen (total)	mg/L	0.02	-	-	-	7	0.24	0.42	0.032	6	0.32	0.54	0.063	6	0.263	0.4	0.034
Ammonia (dissolved)[d]	mg/L	0.005	-	0.396	2.91	7	0.033	0.065	0.009	6	0.055	0.092	0.015	6	0.043	0.084	0.013
Nitrate nitrogen (NO3) (dissolved)	mg/L	0.002	10	40	200	7	0.013	0.039	0.005	6	0.006	0.012	0.001	6	0.004	0.008	0.001
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	7	0.014	0.041	0.006	6	0.007	0.014	0.002	6	0.004	0.008	0.001
Nitrite nitrogen (dissolved)[e]	mg/L	0.002	1	0.02	0.06	7	0.002	0.002	0	6	0.002	0.002	0	6	< 0.002	< 0.002	0
PHOSPHORUS																	
Ortho-Phosphate (dissolved)	mg/L	0.001				7	0.003	0.008	0.001	6	0.003	0.006	0.001	6	0.003	0.006	0.001
Phosphorus (dissolved)	mg/L	0.002				7	0.004	0.006	0.001	6	0.005	0.009	0.001	6	0.004	0.007	0.001
Phosphorus (total)	mg/L	0.002	0.01*		0.01~	7	0.004	0.009	0.001	6	0.007	0.014	0.002	6	0.009	0.013	0.001
SULPHATE																	
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	7	24.0	30.6	1.646	6	25.2	27.7	1.058	6	24	27.7	1.175
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		7	< 0.005	< 0.005	0	6	0.005	0.007	0	6	0.005	0.005	0
MICROBIAL INDICATORS			**90th percentile**				**90th percentile**				**90th percentile**				**90th percentile**		
Fecal coliform	CFU/100 mL		10*	-	-	14	1	2	-	12	2	2	-	12	1	2	-
E Coli	CFU/100 mL		10*	-	-	14	1	1	-	12	1	2	-	12	1	1	-
Entercoccus	CFU/100 mL		3*	-	-	14	6	7	-	12	3	4	-	12	6	19	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2003), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (WLAP, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 19.7 degrees Celsius, pH 8.32)

[e] 30-Day Avg WQG based on <2mg/L chloride.

[f] 30-Day WQG for sulphate = alert level.

[g] Sulphide as H2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix F: Table 2. Water Quality Results Summary Data. Water Intake Sites. January/February, 2003.

			DWG[a]	WQG[b]		Parr				Windermere				Timber Ridge			
Parameter	**Unit**	**MDL**		**30-d Ave.**	**Max**	**N**	**30-d Ave.[c]**	**Max**	**SE**	**N**	**30-d Ave.c**	**Max**	**SE**	**N**	**30-d Ave.c**	**Max**	**SE**
FIELD MEASUREMENTS																	
Temperature	Celsius		15^			7	3.2	4.9	0.333	10	4.2	6.5	0.492	10	4.175	5.5	0.2623
Conductivity	µS/cm		700*			7	414	436	9.044	10	440	472	8.203	10	450	482	5.2454
Dissolved Oxygen	mg/L					7	10.2	10.9	0.187	10	9.4	10.3	0.165	10	8.85	9.4	0.1577
pH	pH units		6.5 - 8.5^	6.5 - 9		7	8.57	8.75	0.057	10	8.12	8.43	0.098	10	8.31	8.44	0.0282
PHYSICAL																	
Residue Non-filterable	mg/L	4	-	-		5	< 4	4	0	5	5	8	0.800	5	< 4	< 4	0.0000
NITROGEN																	
Nitrogen (total)	mg/L	0.02	-	-	-	5	0.29	0.31	0.009	5	0.26	0.30	0.013	5	0.320	0.34	0.0071
Ammonia (dissolved)[d]	mg/L	0.005	-	0.2	1.04	5	0.066	0.107	0.016	5	0.061	0.095	0.010	5	0.116	0.144	0.0085
Nitrate nitrogen (NO3) (dissolved)	mg/L	0.002	10	40	200	5	0.074	0.105	0.016	5	0.059	0.068	0.005	5	0.039	0.055	0.0044
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	5	0.076	0.108	0.017	5	0.061	0.070	0.005	5	0.040	0.055	0.0045
Nitrite nitrogen (dissolved)[e]	mg/L	0.002	1	0.02	0.06	5	0.003	0.004	0	5	0.002	0.004	0	5	0.002	0.003	0.0002
PHOSPHORUS																	
Ortho-Phosphate (dissolved)	mg/L	0.001				5	0.002	0.003	0	5	0.003	0.006	0.001	5	0.002	0.002	0.0002
Phosphorus (dissolved)	mg/L	0.002				5	0.005	0.008	0.001	5	0.005	0.006	0	5	0.004	0.005	0.0004
Phosphorus (total)	mg/L	0.002	0.01*		0.01~	5	0.011	0.038	0.007	5	0.006	0.008	0.001	5	0.006	0.008	0.0005
SULPHATE																	
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	5	**57.9**	62.4	1.726	5	**54.4**	58.6	1.300	5	**62.7**	70.5	2.5090
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		5	< 0.005	< 0.005	0	5	0.005	0.006	0	4	0.005	0.006	0.0003
MICROBIAL INDICATORS			**90th percentile**				**90th percentile**				**90th percentile**				**90th percentile**		
Fecal coliform	CFU/100mL		10*	-	-	10	1	1	-	10	< 1	< 1	-	10	< 1	< 1	-
E Coli	CFU/100mL		10*	-	-	10	< 1	< 1	-	10	< 1	< 1	-	10	< 1	< 1	-
Entercoccus	CFU/100mL		3*	-	-	10	< 1	< 1	-	10	1	2	-	10	**3**	10	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2003), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (WLAP, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 4.9 degrees Celsius, pH 8.75)

[e] 30d Ave WQG based on <2mg/L chloride.

[f] 30-d WQG for sulphate = alert level.

[g] Sulphide as H2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix F: Table 3. Water Quality Results Summary Data. Water Intake Sites. April/May, 2003.

			DWG[a]	WQG[b]		Parr				Windermere				Timber Ridge			
Parameter	**Unit**	**MDL**		**30-d Ave.**	**Max**	**N**	**30-d Ave.[c]**	**Max**	**SE**	**N**	**30-d Ave.[c]**	**Max**	**SE**	**N**	**30-d Ave.[c]**	**Max**	**SE**
FIELD MEASUREMENTS																	
Temperature	Celsius		15^			10	11.5	13.8	0.517	10	11.6	13.4	0.336	10	11.8	13.5	0.404
Conductivity	µS/cm		700*			10	521	541	3.553	10	516	565	7.409	10	521	536	2.507
Dissolved Oxygen	mg/L					10	7.6	9.3	0.345	10	7.8	10.6	0.353	10	7.4	9.2	0.273
pH	pH units		6.5 - 8.5^	6.5 - 9		10	8.35	8.64	0.086	10	8.25	8.54	0.126	10	8	8.59	0.169
PHYSICAL																	
Residue Non-filterable	mg/L	4	-	-		5	< 4	4	0	5	4	4	0	5	5	10	1.200
NITROGEN																	
Nitrogen (total)	mg/L	0.02	-	-	-	5	0.19	0.22	0.009	5	0.22	0.23	0.004	5	0.232	0.32	0.026
Ammonia (dissolved)[d]	mg/L	0.005	-	0.241	1.25	5	0.009	0.025	0.004	5	0.008	0.016	0.002	5	0.089	0.416	0.082
Nitrate nitrogen (NO3) (dissolved)	mg/L	0.002	10	40	200	5	0.021	0.070	0.013	5	0.003	0.006	0.001	5	0.004	0.014	0.002
Nitrate + Nitrite (dissolved)	mg/L	0.002	-	-	-	5	0.021	0.066	0.013	5	0.004	0.008	0.001	5	0.005	0.012	0.002
Nitrite nitrogen (dissolved)[e]	mg/L	0.002	1	0.02	0.06	5	0.002	0.002	0	5	0.002	0.002	0	5	0.003	0.006	0.001
PHOSPHORUS																	
Ortho-Phosphate (dissolved)	mg/L	0.001				5	0.001	0.002	0	5	0.001	0.002	0	5	0.001	0.002	0
Phosphorus (dissolved)	mg/L	0.002				5	0.004	0.005	0	5	0.002	0.003	0	5	0.005	0.007	0.001
Phosphorus (total)	mg/L	0.002	0.01*		0.01~	5	0.015	0.057	0.011	5	0.010	0.022	0.003	5	0.012	0.032	0.005
SULPHATE																	
Sulphate (dissolved)[f]	mg/L	0.5	500^	50	100	4	**72.3**	74.5	0.774	5	**71.4**	76.3	2.271	5	**70**	72.2	1.896
Sulphide (total)[g]	mg/L	0.005	0.05^	0.002		2	< 0.005	< 0.005	0	2	< 0.005	< 0.005	0	3	< 0.005	< 0.005	0
MICROBIAL INDICATORS			**90th percentile**				**90th percentile**				**90th percentile**				**90th percentile**		
Fecal coliform	CFU/100mL		10*	-	-	10	< 2	< 2	-	10	2	2	-	10	2	2	-
E Coli	CFU/100mL		10*	-	-	10	< 2	< 2	-	10	2	2	-	10	< 2	< 2	-
Entercoccus	CFU/100mL		3*	-	-	10	< 2	2	-	10	**5**	9	-	10	2	6	-

Notes:

[a] Drinking Water Guidelines (DWG) maximum acceptable concentration from Health Canada (2001), unless otherwise noted. (*) = BC DWG, (^) = aesthetic objective.

[b] Water Quality Guideline (WQG) for protection of aquatic life (MoE, 1998). (~) = site specific WQO (MoE, 1985).

[c] To calculate mean concentration for parameters < detection limit (DL), concentration assumed to be = DL

[d] WQG for ammonia calculated as a function of highest temp and highest pH over sampling time (temp. 13.8 degrees Celsius, pH 8.64)

[e] 30d Ave WQG based on <2mg/L chloride.

[f] 30-d WQG for sulphate = alert level.

[g] Sulphide as H2S; all values exceed WQG for protection of aquatic life as guideline is less than MDL

#	value > 30-day average WQG
#	value > maximum WQG
#	value > DWG

Appendix G: Table 1. Quality Control Data Water Intakes.

			Parr Utilities Water Intake (E207048)												Timber Ridge Water Intake (E207049)										Windermere Water Intake (E207047)		
			28-Jan-03					22-May-03							14-Jan-03					12-May-03					21-Jan-03		
Parameter	Unit	MDL	REG		REP	RPD	BLANK	REG		REP	RPD	BLANK			REG		REP	RPD	BLANK		REG		REP	RPD		REG		BLANK
PHYSICAL																												
Residue Non-filterable	mg/L	4	<	4	<	4	-								<	4	<	4	-		<	4	<	4	-	<	4		
NITROGEN																												
Nitrogen (total)	mg/L	0.02		0.31		0.33	6									0.33		0.31	6			0.2		0.21	5		0.27		
Ammonia (dissolved)	mg/L	0.005		0.032		0.037	14									0.12		0.119	1		<	0.005	<	0.005	0		0.043		
Nitrate (NO3) (dissolved)	mg/L	0.002		0.103		0.097	6									0.034		0.041	19		<	0.02	<	0.02	-		0.068		
Nitrate + Nitrite (dissolved)	mg/L	0.002		0.103		0.099	4									0.037		0.043	15		<	0.002	<	0.002	-		0.07		
Nitrogen - Nitrite (dissolved)	mg/L	0.002	<	0.002		0.002	0									0.003		0.002	40		<	0.002	<	0.002	-		0.002		
PHOSPHORUS																												
Ortho-Phosphate (dissolved)	mg/L	0.001		0.002		0.001	67									0.002		0.006	100			0.002	<	0.001	67		0.006		
Phosphorus (dissolved)	mg/L	0.002		0.006		0.004	40									0.005		0.008	46		<	0.002	<	0.002	0		0.006		
Phosphorous (total)	mg/L	0.002		0.038		0.007	138		0.003							0.007		0.009	25			0.012		0.014	15		0.008		
SULPHATE																												
Sulphate (dissolved)	mg/L	0.5		53.3		51.6	3									66.6		65.3	2			62.2		66.5	7		58.6		
Sulphide Total	mg/L	0.005	<	0.005	<	0.005	-								<	0.005	<	0.005	-	<	0.005	<	0.005	<	0.005	-	<	0.005	<	0.005
MICROBIAL INDICATORS																												
Fecal Coliform	CFU/100 mL		<	1	<	1	-	<	2	<	1	-	<	1	<	1	<	1	-		<	1	<	1	-	<	1		
E Coli	CFU/100 mL		<	1	<	1	-	<	2	<	1	-	<	1	<	1	<	1	-		<	1	<	1	-	<	1		
Entercoccus	CFU/100 mL		<	1	<	1	-	<	2		2	0	<	2	<	1	<	1	-			1	<	1	0	<	1		

Notes:

RPD = absolute value x (100 x [sample-duplicate]/[sample+duplicate]/2)

To calculate RPD for values <DL, DL was used. If both values were <DL, RPD was not calculated "-".

#	RPD exceeds 25% (field replicates)
#	RPD exceeds 25% due to values = DL (field replicates)
#	RPD exceeds 25%, although analytic values < 5xMDL (see note below)

note: The percent relative standard deviation increases rapidly as the analytic value approaches the MDL.