Attainment of Water Quality Objectives for the Smithers Lakes (Kathlyn, Seymour, Tyhee and Round Lakes)

Second Update (2002/03)

A.J. Downie and Julia Kokelj

Environmental Quality Section
Environmental Protection Division
Skeena Region
British Columbia Ministry of Water, Land and Air Protection

June 2004

Summary

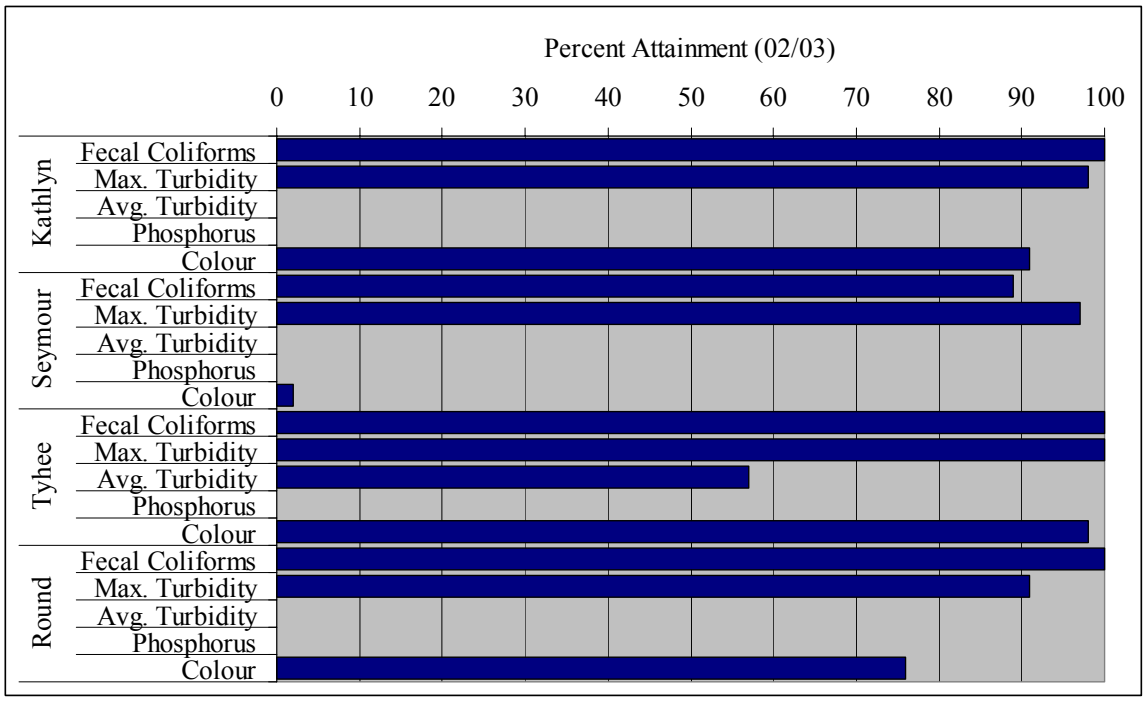
Designated water uses for the Smithers Lakes (Kathlyn, Seymour, Tyhee and Round Lakes) include drinking, recreation, aquatic life, irrigation, livestock and industrial use. Water quality objectives were set in 1985 to protect these designated uses, and this report summarizes levels of attainment in 2001 and 2002/03, and provides recommendations for updating the objectives.

Monitoring was completed at the Smithers Lakes in 2001 and 2002/03 to check attainment of established water quality objectives. The 2001 sampling program was limited to October sampling of drinking water intakes around the lakes. The 2002/03 sampling program included:

- Deep station water quality sampling in April 2003
- Beach monitoring (at Kathlyn and Tyhee Lakes only) of microbiological indicators in August 2002.
- Drinking water monitoring of colour, turbidity, and microbiological indicators at three intakes around each lake, in August 2002, October 2002 and April 2003.

Although the 2001 results are included, we focus on objectives attainment in 2002/03. Fecal coliforms and maximum turbidity objectives were met most of the time, however, average turbidity, phosphorus and colour objectives were frequently not met (Figure 1).

Figure 1: Attainment of Each Objective in 2002/03 at Kathlyn, Seymour, Tyhee and Round Lakes



Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) values were calculated for each lake to describe the current state of water quality. Attainment percentages and index values are summarized in Table 1. Seymour Lake calculations are performed both *with* and *without* the colour objective.

Table 1: 2001 and 2002/03 Objectives Attainment and 2002/03 WQI

Water Body	2001 Attainment	2002/03 Attainment	2002/03 WQI Index Value	2002/03 WQI Rating
Kathlyn	86%	86%	**39**	Poor
Seymour (with colour)	39%	40%	**12**	Poor
Seymour (without colour)	62%	67%	**17**	Poor
Tyhee	86%	95%	**55**	Marginal
Round	72%	78%	**26**	Poor

Overall, sampling results indicate that periodic water quality concerns exist at the Smithers Lakes and the designated uses are not always protected. Domestic water users should be warned that fecal coliform and maximum turbidity objectives are occasionally exceeded, indicating that disinfection alone may not be sufficient to ensure that the water is safe for drinking.

Two additional water quality objectives are proposed to evaluate microbiological water quality in the Smithers Lakes:

1. The concentration of *E. coli* in the Smithers Lakes should not exceed 10 CFU/100mL in 90% of the samples at drinking water intakes, and the geometric mean should not exceed 77 CFU/100mL in samples from recreational beaches.

2. The concentration of *Enterococci* in the Smithers Lakes should not exceed 3 CFU/100mL in 90% of the samples at drinking water intakes, and the geometric mean should not exceed 20 CFU/100mL in samples from recreational beaches.

Consistently meeting these objectives indicates that no water treatment in addition to disinfection is required to protect drinking water supplies from bacteria, and that the risk of bacteria-caused gastrointestinal disease through primary-contact recreation at beaches is minimized. Meeting these objectives does not ensure protection from other contaminants such as blue-green algal toxins; treatment beyond disinfection may still be required for these contaminants.

In addition, it is recommended that the water quality objective for colour be eliminated for Seymour Lake only, and that consideration be given to revising the phosphorus objective for all lakes when sufficient data is available.

Contents

Table of Contents

List of Tables

List of Figures

1.0 Introduction

Water quality objectives are established for water bodies in British Columbia to protect sensitive designated water uses at specific locations. Attainment monitoring and reporting allows us to check whether the objectives are being met and is useful for preparing waste management plans, issuing waste management permits, pollution prevention orders and water licenses.

1.1 Purpose

The purpose of this report is to assess the current state of Kathlyn, Seymour, Tyhee and Round Lakes (the Smithers Lakes) as it relates to designated uses. Water quality objectives were prepared by Boyd *et. al*. in 1985 for the four Smithers Lakes, and they were updated by the Ministry of Environment, Lands and Parks (MELP) Water Quality Branch in 1996 (Table 4). In this report we present the results of monitoring completed in 2001 and 2002/03 to assess attainment of water quality objectives for the Smithers Lakes. The 2002/03 sampling program was more comprehensive than the 2001 program and this report focuses on 2002/03 data. We include calculation of a Water Quality Index value and ranking for each lake and determine if the water quality objectives are still valid or need to be updated.

1.2 Water Quality Index (WQI)

The Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) is a tool for simplifying the reporting of water quality data. The index is used to assess the state of water quality in a water body, relative to its desirable state (as defined by water quality objectives) and to provide insight into the degree to which water quality is affected by human activity.

The WQI for a water body is based on attainment of water quality objectives, and it incorporates three elements:

- *F1* ***scope*** – the number of variables not meeting water quality objectives

$$\text{where} \quad F1 = \left(\frac{Number\ of\ Failed\ Variables}{Total\ Number\ of\ Variables} \right) \times 100$$

- *F2* ***frequency*** – the number of times these objectives are not met

$$\text{where} \quad F2 = \left(\frac{Number\ of\ Failed\ Tests}{Total\ Number\ of\ Tests} \right) \times 100$$

- *F3* ***amplitude*** – the amount by which objectives are not met

$$\text{where} \quad excursion_i = \left(\frac{FailedTestValue_i}{Objective} \right) - 1$$

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{\#\ of\ tests}$$

$$F3 = \left(\frac{nse}{0.01nse + 0.01} \right)$$

The elements are then combined according to the following equation:

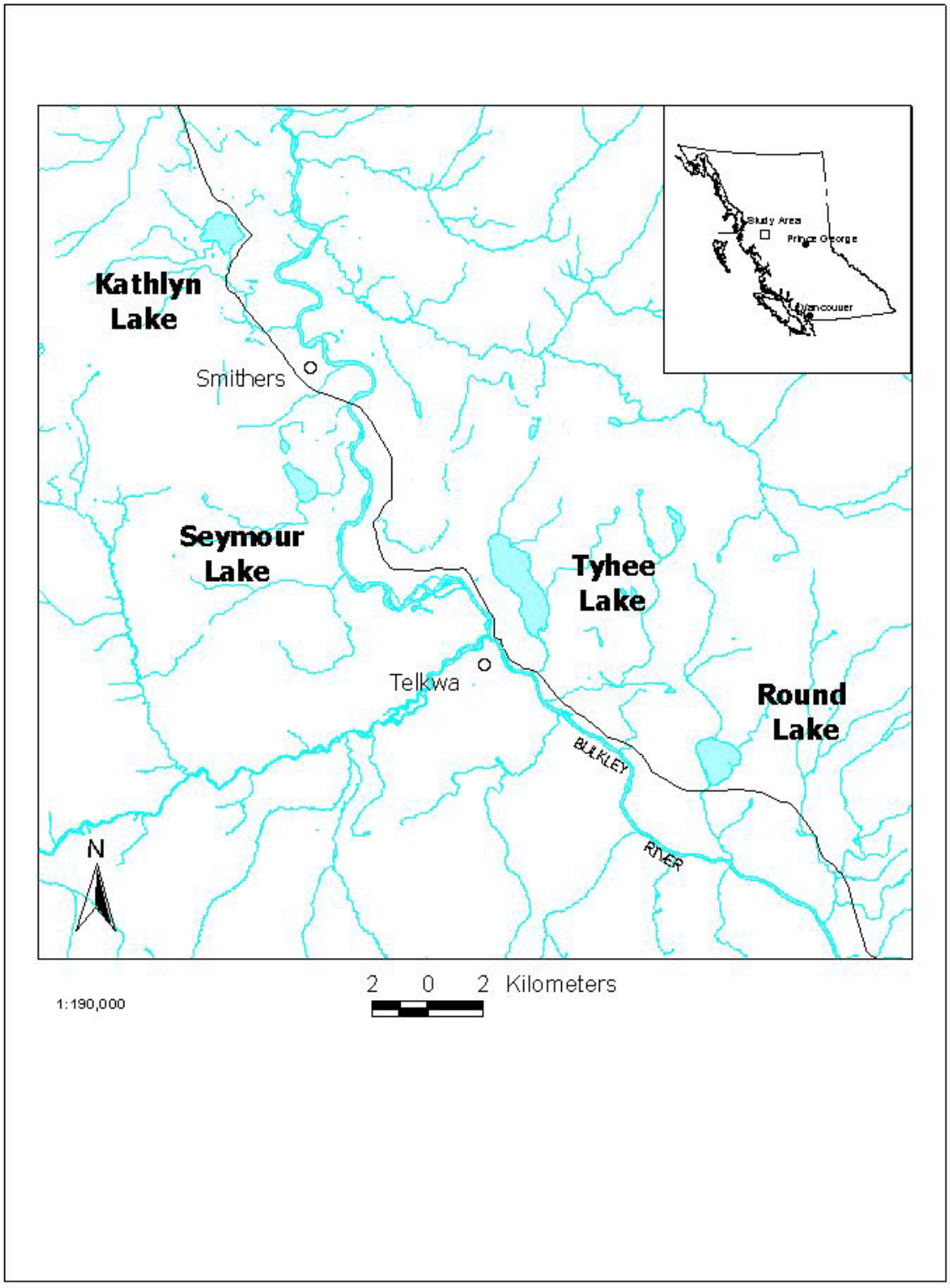
$$CCMEWQI = 100 - \left(\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \right)$$

The index calculation produces a number between 0 (worst water quality) and 100 (best water quality), which can then be related to one of the following categories:

- Excellent: (95-100) – water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
- Good: (80-94) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
- Fair: (65-79) – water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
- Marginal: (45-64) – water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
- Poor: (0-44) – water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

For additional information about the CCME WQI and details of calculation of the index value, refer to the CCME website (CCME, 2001).

Figure 2: Map of the Smithers Lakes



2.0 Overview of the Study Area

2.1 Location

The Smithers Lakes are all located along the Highway 16 corridor of North-Central British Columbia, near to the Town of Smithers (Figure 2). The lakes vary in size from approximately 90 hectares (Seymour Lake) to 318 hectares (Tyhee Lake) and have depth profiles characteristic of eutrophic lakes (Table 2).

Table 2: Summary of Morphometric Data for the Smithers Lakes

Water Body	Area (hectares)	Maximum Depth (metres)	Mean Depth (metres)
Kathlyn	170	9.5	4.6
Seymour	89.5	9.2	5.7
Tyhee	318	22.2	11.1
Round	182	20.4	9.6

Additional information pertaining to the four Smithers Lakes is contained in Boyd *et al*. (1985), Maclean (1985), the Lake Kathlyn Management Plan (Rysavy and Sharpe, 1995a) and Tyhee Lake Management Plan (Rysavy and Sharpe, 1995b).

2.2 Water Uses

Designated uses for the Smithers Lakes have not changed significantly since 1985, and include drinking, recreation, irrigation and aquatic life. Wildlife was added as a use for all lakes in 1996, and livestock is recognized as a designated use at Lake Kathlyn and Round Lake. The primary water uses that the Smithers Lakes objectives were set to protect include raw drinking water supply and recreation.

Licensed withdrawals from the lakes have remained relatively stable and low for domestic and stock watering, but have varied considerably for conservation works and industrial uses (Table 3).

Table 3: Water Licensing (2002 data from Province of B.C., 2003)

Water Body	Use Description	1985 (Objectives Est.)	1996 (First Update)	2002 (Second Update)
Lake Kathlyn	Domestic	50.3 m^3/d	45.5 m^3/d	45.5 m^3/d
	Irrigation	1700 m^3	495 m^3	493 m^3
	Industrial	478 m^3/d	22.8 m^3/d	
	Stock Watering			2.27 m^3/d
Seymour Lake	Domestic	59.8 m^3/d	59.1 m^3/d	54.6 m^3/d
	Conservation works	0 m^3/d	2446 m^3/d	1247.8 m^3/d
Round Lake	Domestic	6.8 m^3/d	9.1 m^3/d	9.1 m^3/d
	Irrigation	0 dam^3	86.3 dam^3	86.3 dam^3
	Stock watering	0 m^3/d	6.82 m^3/d	6.82 m^3/d
	Waterworks	36 m^3/d	36 m^3/d	36 m^3/d
Tyhee Lake	Domestic	13.8 m^3/d	29.5 m^3/d	25 m^3/d
	Industrial	27 m^3/d	27 m^3/d	27 m^3/d
	Waterworks	50 m^3/d	27 m^3/d	27 m^3/d

2.3 Potential Sources of Contamination

Although there are no permitted waste discharges that would affect water quality within the Smithers lakes, contamination exists in the form of non-point sources. These sources include residential and agricultural development around the lakes and likely are responsible in part for the relatively high levels of total phosphorus in the lakes. For additional details about these and other potential sources of contamination at Kathlyn and Tyhee Lakes, refer to the Lake Management Plans for these lakes (Rysavy and Sharpe, 1995a; Rysavy and Sharpe, 1995b).

3.0 Water Quality Objectives

Water quality objectives for the Smithers Lakes (Kathlyn, Seymour, Tyhee and Round Lakes) were originally set in 1984 for parameters related to potential sources of contamination. These included: fecal coliforms, turbidity, total phosphorus and colour (Boyd *et al*. 1985). The phosphorus and colour objectives were not recommended for Seymour Lake. When the objectives were updated by the Ministry of Environment, Lands and Parks (MELP) Water Quality Branch in 1996 (Table 4), it was recommended that a long-term colour objective of 15 TCU (maximum) and a long-term phosphorus objective of ≤ 10 µg/L (average) be adopted for Seymour Lake.

Table 4: Current (1996) Water Quality Objectives for the Smithers Lakes

Variable	Water Quality Objective
Fecal Coliforms	Near Intakes: ≤ 10/100mL (90^{th} percentile) At Beaches: ≤ 200/100mL (geometric mean); ≤ 400/100mL (90^{th} percentile)
Turbidity	≤ 1 NTU (average); ≤ 5 NTU (maximum)
Total Phosphorus (at spring overturn)	Short Term Objective: ≤ 15 µg/L (average) Long Term Objective: ≤ 10 µg/L (average)
Colour (near water intakes)	Long Term Objective: 15 TCU (maximum)

Objectives for microbiological indicators such as fecal coliforms are important because bacteria are good indicators of the risk of gastrointestinal disease. There are three water quality objectives for fecal coliform bacteria. Consistently meeting the first objective indicates that no water treatment in addition to disinfection is required to protect drinking water supplies from bacteria, and the second two objectives ensure that the risk of bacteria-caused gastrointestinal disease through primary-contact recreation at beaches is minimized. . These objectives are based on *British Columbia Water Quality Guidelines (Criteria): 1998 Edition*.

Turbidity is most commonly an aesthetic consideration, but it is correlated with algae growth and bacterial contamination. The water quality objectives for turbidity have been set to ensure that the water is suitable for domestic water supply (the most sensitive use) with no water treatment in addition to disinfection (i.e., no removal of turbidity or suspended residues is required). The turbidity objective for the Smithers Lakes includes a maximum acceptable level (which applies to any water sample taken from or near a domestic water intake) and a desirable level (which is the mean of at least 5 weekly samples from a 30-day period).

Total phosphorus objectives are established to protect lakes from nuisance algal growth. Algae growth in lakes is usually the result of excessive phosphorus in a lake. High levels of algal growth can cause undesirable taste and odour in drinking water, aesthetic problems, poor water clarity and hypolimnetic oxygen depletion which results in loss of fisheries habitat and possible winter and summer fish kills (Nordin, 1985). A short-term objective of ≤ 15 µg/L (at spring overturn) has been put in place to manage the potential for nuisance algal growth. The long-term objective of ≤ 10 µg/L is the drinking water

guideline listed in the *British Columbia Water Quality Guidelines (Criteria): 1998 Edition*.

The water use most sensitive to colour is drinking water supply, and the objective of 15 True Colour Units (maximum) reflects the guideline listed in the *British Columbia Water Quality Guidelines (Criteria): 1998 Edition*. Colour is largely an aesthetic concern, but it can be influenced by algae, organics and other dissolved minerals.

4.0 Methods

4.1 Sampling

Water quality sampling at the four Smithers Lakes was conducted at deep station sites, public beaches (Kathlyn and Tyhee Lakes only) and at three drinking water intakes on each lake.

The following deep station sites were sampled:

- Kathlyn (EMS# 1131007; 54.8233ºN, 127.2028°W) was sampled April 23 and April 30, 2003 at the surface, 4 m and 9.5 m depths.
- Seymour (EMS# 1131010; 54.7425ºN, 127.1583°W) was sampled April 23 and April 30, 2003 at the surface, 4 m and 7 m depths.
- Tyhee (EMS# E216924; 54.7161ºN, 127.0400°W) was sampled April 23 and April 30, 2003 at the surface, 5 m, 10 m and 20 m depths.
- Round (EMS# 1131008; 54.6567ºN, 126.9236°W) was sampled April 27, April 30 and May 5, 2003 at the surface, 4 m and 20 m depths.

On each date, temperature and dissolved oxygen profiles (using a Oxyguard Handy Mk II Temperature/DO meter) were obtained and secchi depth was measured. Surface water samples were collected from the side of the boat and a Van Dorn sampler was used to obtain water samples from the middle and bottom depths. At each depth the following analyses were performed: true colour, pH, specific conductance, turbidity, total and dissolved metals, and various forms of nitrogen and phosphorus. Analyses were conducted by PSC Analytical Services in Burnaby.

Grab samples for microbiological indicators were collected from the swimming area of the public beaches on Kathlyn Lake (EMS# E207548; 54.8200ºN, 127.2092°W) and Tyhee Lake (EMS# E207559; 54.7086ºN, 127.0356°W). The samples were collected once per week for five weeks beginning on August 6, 2002. They were analysed by Cantest Ltd. (JR Laboratories Inc. in 2003) for fecal coliforms, *E. coli*, and *Enterococci*.

Three drinking water intakes on each lake were monitored as part of MoWLAP's 2002-03 Expanded Water Quality Monitoring Program. Five weekly samples were collected from each site in the summer (beginning August 6, 2002), fall (beginning October 7, 2002) and spring (beginning April 7, 2003). Two sets of samples from Round Lake #3 site were discarded when changes were made to the shoreline intake. All samples were analyzed for colour and turbidity by PSC Analytical Services and for the three microbiological indicators by Cantest Ltd. (JR Laboratories Inc. in 2003). For additional details about drinking water quality and the intake sampling sites refer to *Drinking Water Source Quality Monitoring Program Skeena Region: Bulkley Valley* (Downie, in prep.).

4.2 Data Analysis

Attainment of the fecal coliform objectives at water intakes was judged once in 2001 and three times over the 2002/03 period. 90^{th} percentiles were calculated for each set of samples from drinking water intakes and compared to the objective. 90^{th} percentiles and geometric means were calculated for the set of five samples collected in the summer of 2002 from the beaches on Kathlyn and Tyhee Lakes.

The turbidity objective includes a maximum acceptable level [5 Nephelometric Turbidity Units (NTU)] for individual samples and a desirable level (1 NTU) based on the average of at least 5 samples. Attainment of the turbidity objective was judged by comparing individual samples to the 5 NTU maximum and averaging all samples from each site during each sampling season and comparing them to the average guideline of 1 NTU.

The phosphorus objective used (for all lakes) in this report is the short-term average of ≤15 µg/L. Attainment was judged by averaging samples taken from the surface, middle, and bottom of the water column on the spring 2003 sampling date when physical and chemical properties of the water column suggested spring overturn conditions (relatively uniform profiles for temperature and dissolved oxygen, and similar chemical properties in the samples from varying depths). In some cases, the bottom water phosphorus concentrations were higher than those at other depths, indicating that complete turnover may not have occurred in 2003. The samples were included in the calculation because this phosphorus is present in the water and may become available for photosynthesis when/if the lake mixes completely. The complete set of spring 2003 phosphorus data is presented in Appendix 2.

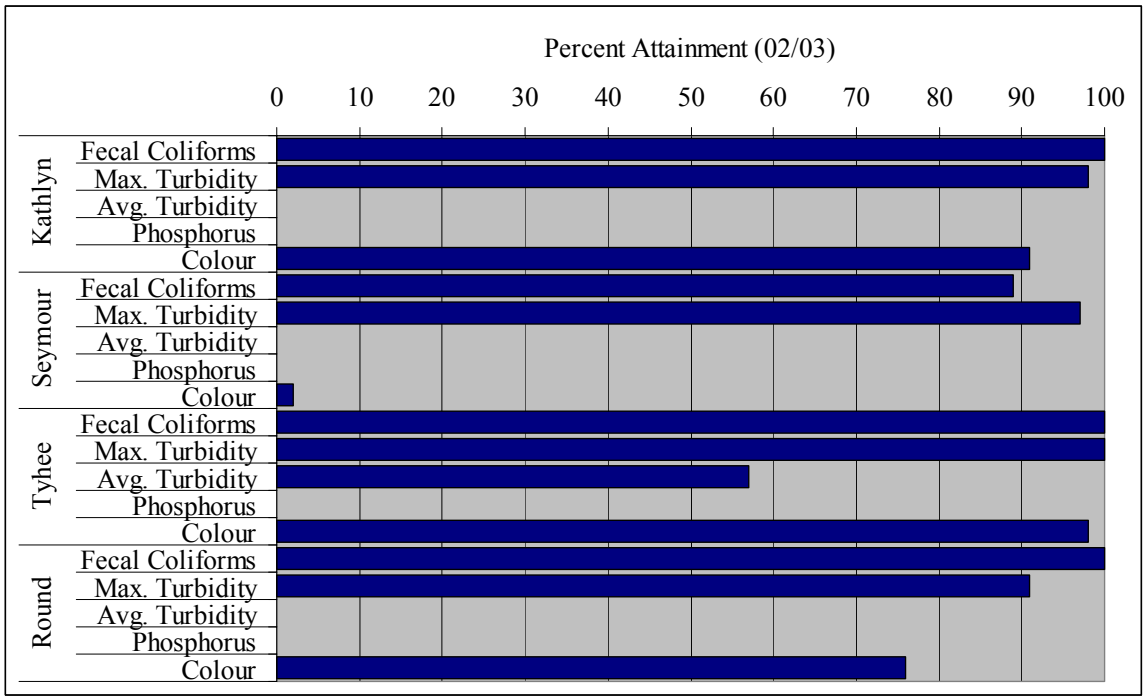
Attainment of the colour objective was judged by comparing individual samples to the 15 TCU maximum guideline.

5.0 Results and Discussion

Fecal coliform, turbidity, phosphorus, and colour data are provided in Appendix 1 (Tables 7a to 7d (2002/03 results) and Tables 8a to 8d (2001 results)). All water quality data collected is available in the MoWLAP's EMS database.

Fecal coliforms and maximum turbidity objectives were met most of the time, however average turbidity, phosphorus and colour objectives were frequently not met (Figure 3).

Figure 3: Attainment of Each Objective in 2002/03 at Kathlyn, Seymour, Tyhee and Round Lakes



5.1 Fecal Coliforms

The fecal coliform objective at drinking water intakes is ≤ 10 CFU/100mL in 90% of the samples. This objective was met 30 of 31 times at drinking water intakes on the Smithers lakes in 2002/03 and 11 of 12 times in 2001. The objective was not met 2 times:

Intake Site	90th percentile concentration (CFU/100mL)	Date
Seymour Lake #1	16.4	August 2002
Kathlyn Lake #3	106.2	October 2001

Three additional sets of samples had indefinite results because fewer than five samples were collected.

The Water Quality Objectives First Update (Province of B.C., 1996) stated that the fecal coliform objective was met consistently between 1991 and 1994. This remains the case in 2002/03 for most sites:

- Non-attainment at Kathlyn Lake #3 was due to high fecal coliform concentrations on October 14 and 22 only. Other samples from this site had much lower concentrations.
- Non-attainment at Seymour Lake #1 may indicate a site-specific concern. Seymour Lake #1 had substantially higher fecal coliform and turbidity values in both 2001 and 2002, compared to other the other Seymour Lake sampling sites. It was learned that the landowner at this site has been feeding grain to several hundred ducks and geese near his water intake every fall for several years (Remington, 2002b pers. comm.). The landowner has been advised of the sampling results and has discontinued this practice.

The fecal coliform objective at public beaches is ≤ 200 CFU/100mL (geometric mean) and ≤ 400 CFU/100mL (90^{th} percentile). In 2002/03 the geometric mean concentration calculated from the five weekly samples at the Kathlyn Lake beach was 5.9 CFU/100mL, and the 90^{th} percentile was 51.0 CFU/100mL. At the Tyhee Lake beach the geometric mean was 4.0 CFU/100mL and the 90^{th} percentile was 78.8 CFU/100mL. The objectives were met at both sites in 2002/03. The beaches were not sampled in 2001.

Although the fecal coliform drinking water objective has been met most of the time over the past decade at the Smithers Lakes, sampling in 2001-2003 illustrates that the possibility of fecal contamination from non-point sources still exists. The fecal coliform objectives should remain unchanged to protect human health.

5.2 Turbidity

The turbidity objective is a maximum acceptable level of 5 NTU in individual samples, and a desirable level of ≤ 1 NTU (average of five samples collected in a 30-day period). In 2002/03 the maximum acceptable level (5 NTU) was exceeded in 1 of 45 samples from Lake Kathlyn, 11 of 45 samples from Seymour Lake, and 3 of 34 samples from Round Lake. None of the 40 samples from Tyhee Lake had turbidity values greater than 5 NTU. In 2001, the maximum acceptable level was exceeded in 6 of 15 samples from Seymour Lake, 2 of 15 samples from Tyhee Lake, and 1 of 15 samples from Round Lake. All turbidity values from Lake Kathlyn were less than 5 NTU.

In 2002/03 average turbidity exceeded 1 NTU in all sample sets from Kathlyn, Seymour and Round Lakes. This objective was exceeded in 3 of 7 sample sets from Tyhee Lake. In 2001, average turbidity exceeded the desirable level at all 3 sites on Kathlyn and Round Lakes, at 2 of 3 sites on Seymour, and 1 of 3 on Tyhee Lake.

In the past, Seymour and Round Lakes have always shown significant departures from acceptable turbidity levels (Province of B.C., 1996). In 2001-2003 this continued, with Lake Kathlyn also exhibiting high values for average turbidity. To assist in managing these lakes for drinking water as a designated use, the turbidity objective for the Smithers Lakes should remain unchanged.

5.3 Total Phosphorus

Complete phosphorus data from spring 2003 monitoring is included in Table 9 (Appendix 2). Boyd *et al*. (1985) established a short-term objective of ≤15 µg/L for total phosphorus at spring overturn. Phosphorus concentrations in all the Smithers exceeded the short term objective in 2003:

Water Body	Phosphorus Concentration (µg/L)
Kathlyn	18
Seymour	22
Tyhee	33
Round	40

The First Update (Province of B.C., 1996) states the total phosphorus objective was never met in Kathlyn, Round and Tyhee lakes between 1991 and 1995 (and it was not applicable to Seymour Lake at that time), and past data from MoWLAP's EMS database (1985-1993) shows phosphorus concentrations consistently above the objective. At Kathlyn and Tyhee Lakes the 2003 data lies within the historical range, and is close to the historical average (see below). Seymour Lake and Round Lake concentrations were lower in 2003 than they were in past; however, there is insufficient data to confirm if this indicates a trend towards better water quality.

Water Body	Average Spring Phosphorus Concentrations (µg/L), based on 1986 to 1999 data		
	# years with data	Range	Average
Kathlyn	9	17 - 28	22
Seymour	5	21 - 47	36
Tyhee	7	5 - 40	26
Round[1]	6	46 - 83	61

The short and long-term objectives for total phosphorus should remain unchanged, and potential remediation options to lower phosphorus concentrations should be considered. Kathlyn and Tyhee Lakes have undergone a lake management planning exercise to identify sources of water quality degradation and potential remediation actions to improve water quality. Recommendations listed in the Lake Kathlyn Management Plan

[1] Average spring phosphorus concentrations were calculated from upper and middle water column samples only. Bottom water samples were not included because it is not known if high sample concentrations were a result of sample contamination from the sediment, or reducing conditions that cause liberation of phosphorus into the water at the sediment-water interface.

(Rysavy and Sharpe, 1995a) and Tyhee Lake Management Plan (Rysavy and Sharpe, 1995b) should be considered to help lower phosphorus levels to objective standards. Knowledge of historical phosphorus concentrations for Round and Seymour Lakes is needed before remediation actions for these lakes should be considered. Round Lake is undergoing a lake management planning exercise in 2003/04. A sediment core analysis to determine historical concentrations, and a tributary sampling program to identify current sources of phosphorus, will be included in the planning process. Seymour Lake would benefit from a similar exercise. No specific remediation actions are recommended for Round and Seymour Lakes until the management planning process is complete.

5.4 Colour

The colour objective in the Smithers Lakes is ≤ 15 True Colour Units (TCU). Colour values during 2001-2003 ranged from <5 to 120 TCU. In 2002/03 colour values exceeded the 15 TCU maximum in 4 of 45 samples from Lake Kathlyn, 44 of 45 samples from Seymour Lake, 1 of 40 samples from Tyhee Lake, and 8 of 34 samples from Round Lake. In 2001, colour exceeded the objective in 1 of 15 samples from Lake Kathlyn, 14 of 15 samples from Seymour Lake, 2 of 15 samples from Tyhee Lake and 6 of 15 samples from Round Lake.

When the objective was set in 1984, average colour values were slightly above the colour objective in Kathlyn, Round and Tyhee Lakes, and far above the objective in Seymour Lake. At that time, Boyd *et al*. (1985) commented that the colour of Seymour Lake is "typical of bogs, although not as brown…and may originate from within the lake or from the watershed." Colour in the remaining lakes appears to be derived from within the lakes. When the objectives were assessed in 1996 (Province of B.C., 1996), colour was exceeded between 1991 and 1995, and the greatest departures were in Seymour and Round Lakes. This continues to be the case in 2001 and 2002/03.

Since Seymour Lake is naturally high in organic acids, it is likely that colour values in will continue to exceed the water quality objective by a large margin. We recommend that the colour objective, which was added for Seymour Lake in 1996, be eliminated in future checks of objectives attainment.

6.0 Conclusions and Recommendations

6.1 Objectives Attainment Summary

Overall attainment of water quality objectives in 2001 and 2002/03 suggests that water quality in the Smithers Lakes was similar in 2001 and 2002/03, with minor variations likely resulting from differences in sampling frequency and season (Table 5). Because high colour values in Seymour Lake represent natural levels and do not indicate water quality degradation due to human activities, attainment at this lake is judged both *with* and *without* the colour results.

Table 5: Overall Objectives Attainment at the Smithers Lakes (2001 and 2002/03)

Water Body	2001 Attainment	2002/03 Attainment
Kathlyn	86%	86%
Seymour (with colour)	39%	40%
Seymour (without colour)	62%	67%
Tyhee	86%	95%
Round	72%	78%

The CCME Water Quality Index (WQI) has been used to summarize overall water quality in the Smithers Lakes in 2002/03. Seymour Lake water quality index calculations were performed both *with* and *without* the colour results (Table 7). When colour is removed from the calculation, overall attainment increases from 39% to 62% in 2001, and from 40% to 67% in 2002/03. The index value also increases, but the rating remains poor.

Table 6: WQI Elements and Index Values at the Smithers Lakes (2002/03)

Water Body	WQI Element			Index Value	Rating
	F1	F2	F3		
Kathlyn	57	14	87	**39**	Poor
Seymour (with colour)	100	60	99	**12**	Poor
Seymour (without colour)	100	33	98	**17**	Poor
Tyhee	43	5	64	**55**	Marginal
Round	80	22	97	**26**	Poor

According to the CCME WQI, water quality at the Smithers Lakes was not very good in 2002/03. The relatively low index values and ratings reflect high values for the amplitude *(f3)* variable – indicating that when objectives were exceeded, they were exceeded by a large margin. This is especially apparent in the case of Tyhee Lake, where attainment was 95%, but the index rating is "Marginal" because the phosphorus objective was exceeded by such a large margin. Overall, Smithers Lakes sampling results indicate that periodic water quality concerns exist and the designated uses are not always protected. Domestic water users should be warned that fecal coliform and maximum turbidity objectives are occasionally exceeded, indicating that disinfection alone may not be sufficient to ensure that the water is safe for drinking.

6.2 Final Recommendations

Current water quality sampling results and lake conditions indicate that most Smithers Lakes objectives are still valid, however, a few changes are recommended:

- Phosphorus concentrations at all lakes are consistently above the recommended level, in many cases by a large margin. Historical phosphorus concentrations should be identified for all of the lakes using sediment cores, and major current sources of phosphorus must be identified. After this information is available, consideration should be given to adjusting the objectives.
- High colour values in Seymour Lake likely represent natural conditions and do not indicate water quality degradation due to human activities. This objective should be eliminated for Seymour Lake only.
- Two additional water quality objectives are proposed to evaluate microbiological water quality in the Smithers Lakes[2].

Proposed Water Quality Objectives for the Smithers Lakes:

The concentration of E. coli in the Smithers Lakes should not exceed 10 CFU/100mL in 90% of the samples at drinking water intakes, and the geometric mean should not exceed 77 CFU/100mL in samples from recreational beaches.

The concentration of Enterococci in the Smithers Lakes should not exceed 3 CFU/100mL in 90% of the samples at drinking water intakes, and the geometric mean should not exceed 20 CFU/100mL in samples from recreational beaches.

Consistently meeting these objectives indicates that no water treatment in addition to disinfection is required to protect drinking water supplies from bacteria, and that the risk of bacteria-caused gastrointestinal disease through primary-contact recreation at beaches is minimized. Meeting these objectives does not ensure protection from other contaminants such as blue-green algal toxins; treatment beyond disinfection may still be required for these contaminants.

[2] Fecal coliforms have historically been the microbiological indicator of choice, but many agencies are now using other indicators such as *Enterococci* and *E. coli* in their water quality monitoring programs. Although complete results have not been reported in this document, Skeena Region sampling in 2001-2003 has included *Enterococci* and *E. coli* in addition to fecal coliforms (see Downie, in prep.). Results are suggesting that the indicators behave differently and may not be correlated. Until new source tracking technologies are developed to enhance the ability of specific indicators to predict the health risks associated with bacterial pollution, sampling for multiple indicators is recommended for future monitoring programs.

References

Boyd, I., C. McKean, R. Nordin and B. Wilkes. 1985. Kathlyn, Seymour, Round, and Tyhee Lakes water quality assessment and objectives, technical appendix. Water Management Branch, Ministry of Environment, Victoria.

Canadian Council of Ministers of the Environment (CCME). 2001. Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, Technical Report. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Downie, A. (in prep). Drinking Water Source Quality Monitoring Program: Bulkley Valley. Ministry of Water Land and Air Protection, Skeena Region, Smithers, BC.

Maclean, D. 1985. Seymour Lake: 1984 Data Summary and Recommendation. Waste Management Branch, Ministry of Environment, Smithers.

Noble, R. T., M. K. Leecaster, D. F. Moore, K. C. Schiff and S. B. Weisberg. 2000. Relationships among bacterial indicators during a regional survey of microbiological water quality along the shoreline of the Southern California Bight. In Southern California Coastal Water Research Project 1999-2000 Annual Report. http://www.sccwrp.org/pubs/annrpt/99-00/table_of_contents.htm

Nordin, R. 2003. Personal Communication. Limnologist, University of Victoria, Victoria, BC.

Nordin, R. and C. McKean. 1984. Shawnigan Lake Water Quality Study. Water Management Branch, Ministry of Environment, Victoria, BC.

Nordin, R. 1985. Water Quality Criteria for Nutrients and Algae. Resource Quality Section, Water Management Branch, Ministry of Environment, Victoria, BC.

Province of British Columbia (Ministry of Sustainable Resource Management). 2003. Water Licences Query Website. http://www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input

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

Province of British Columbia. 1996. Water Quality Objectives: Kathlyn, Seymour, Round and Tyhee Lakes First Update, Draft. Water Quailty Branch, Ministry of Environment, Lands and Parks, Victoria, BC.

Remington, D. 2002a. Drinking Water Source Quality Monitoring: Skeena Region 2001. Ministry of Water Land and Air Protection, Skeena Region, Smithers, B.C.

Remington, D. 2002b. Personal communication. Consulting biologist, Remington Environmental, Smithers, BC.

Rysavy, S. and I. Sharpe. 1995a. Lake Kathlyn Management Plan (Draft #1). Ministry of Environment, Lands and Parks, Smithers, BC.

Rysavy, S. and I. Sharpe. 1995b. Lake Tyhee Management Plan (Draft #1). Ministry of Environment, Lands and Parks, Smithers, BC.

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

Appendix 1

Table 7a: Kathlyn Lake Water Quality Objectives – 2002/03

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL ninetieth percentile (np) Beaches: ≤200/100mL geometric mean (gm) ≤400/100mL ninetieth percentile (np)	Kathlyn Lake #1 (beach) E207548	Aug 6 – Sept 3	5	<1 – 59/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	gm = 5.9/100 mL	Objective met
		Aug 6, 12, 19, 27, Sept 3	1	np = 51.0/100mL	Objective met
	Kathlyn Lake #2 E207549	Aug 6 – May 6	15	<1 – 2/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	np = 1.2/100 mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = 1.6/100 mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100 mL	Objective met
	Kathlyn Lake #3 E207550	Aug 6 – May 6	15	<1 – 13/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	np = 2.2/100 mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = 9.8/100 mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100 mL	Objective met
	Kathlyn Lake #4 E207551	Aug 6 – May 6	15	<1 – 12/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	np = 8.4/100 mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = <1/100 mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100 mL	Objective met
Turbidity ≤5 NTU maximum (max) ≤1 NTU average (av)	Kathlyn Lake #2 E207549	Aug 6 – May 6	15	0.88 – 5.1 NTU	**Max objective not met (1x)**
		Aug 6, 12, 19, 27, Sept 3	1	av = 2.66 NTU	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 1.16 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 1.50 NTU	**Objective not met**
	Kathlyn Lake #3 E207550	Aug 6 – May 6	15	0.74 – 2.3 NTU	Max objective met
		Aug 6, 12, 19, 27, Sept 3	1	av = 1.86 NTU	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 1.15 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 1.50 NTU	**Objective not met**
	Kathlyn Lake #4 E207551	Aug 6 – May 6	15	0.8 – 3.3 NTU	Max objective met
		Aug 6, 12, 19, 27, Sept 3	1	av =1.96 NTU	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 1.11 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 1.19 NTU	**Objective not met**
Total Phosphorus Short Term: ≤15 µg/L average (av)	Kathlyn Lake DS 1131007	Apr 23 (samples at 0 m, 4 m, and 9 m)	3		
			1	av = 18.0 µg/L	**Objective not met**
Colour ≤15 TCU maximum (max)	Kathlyn Lake #2 E207549	Aug 6, 12, 19, 27, Sept 3 October 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	<5 – 20 TCU	**Objective not met (2x)**
	Kathlyn Lake #3 E207550	Aug 6, 12, 19, 27, Sept 3 October 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	<5 – 20 TCU	Objective met
	Kathlyn Lake #4 E207551	Aug 6, 12, 19, 27, Sept 3 October 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	<5 – 20 TCU	**Objective not met (2x)**

Table 7b: Seymour Lake Water Quality Objectives – 2002/03

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL ninetieth percentile (np)	Seymour Lake #1 E207552	Aug 6 – May 6	15	<1 – 22/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	np = 16.4/100 mL	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	np = 5.2/100 mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100 mL	Objective met
	Seymour Lake #2 E207553	Aug 6 – May 12	15	<1 – 3/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	np = <1/100 mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = 2.2/100 mL	Objective met
		Apr 14, 22, 29, May 6, 12	1	np = 2.4/100 mL	Objective met
	Seymour Lake #3 E207554	Aug 6 – May 6	15	<1 – 1/100 mL	
		Aug 6, 12, 19, 27, Sept 3	1	np = 1.0/100 mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = <1/100 mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100 mL	Objective met
Turbidity ≤5 NTU maximum (max) ≤1 NTU average (av)	Seymour Lake #1 E207552	Aug 6 – May 6	15	2.15 – 26 NTU	**Max objective not met (11x)**
		Aug 6, 12, 19, 27, Sept 3	1	av = 15.45 NTU	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 6.11 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 5.30 NTU	**Objective not met**
	Seymour Lake #2 E207553	Aug 6 – May 12	15	0.26 – 4.32 NTU	Max objective met
		Aug 6, 12, 19, 27, Sept 3	1	av = 1.11 NTU	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 2.10 NTU	**Objective not met**
		Apr 14, 22, 29, May 6, 12	1	av = 2.17 NTU	**Objective not met**
	Seymour Lake #3 E207554	Aug 6 – May 6	15	0.89 – 3.19 NTU	Max objective met
		Aug 6, 12, 19, 27, Sept 3	1	av = 1.43 NTU	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 1.79 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 1.69 NTU	**Objective not met**
Total Phosphorus Short Term: ≤15 µg/L average (av)	Seymour Lake DS 1131010	Apr 30 (samples at 0 m, 4 m, and 7 m)	3		
			1	av = 22.0 µg/L	**Objective not met**
Colour ≤15 TCU maximum (max)	Seymour Lake #1 E207552	Aug 6, 12, 19, 27, Sept 3 Oct 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	5 - 120 TCU	**Objective not met (14x)**
	Seymour Lake #2 E207553	Aug 6, 12, 19, 27, Sept 3 Oct 7, 15, 21, 28, Nov 3 Apr 14, 22, 29, May 6, 12	15	20 - 100 TCU	**Objective not met (15x)**
	Seymour Lake #3 E207554	Aug 6, 12, 19, 27, Sept 3 Oct 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	20 - 50 TCU	**Objective not met (15x)**

Table 7c: Tyhee Lake Water Quality Objectives – 2002/03

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL ninetieth percentile (np) Beaches: ≤200/100mL geometric mean (gm) ≤400/100mL ninetieth percentile (np)	Tyhee Lake #1 (beach) E207559	Aug 6 – Sept 3	5	<1 – 130/100mL	
		Aug 6, 14, 20, 27, Sept 3	1	gm = 4.0/100 mL	Objective met
		Aug 6, 14, 20, 27, Sept 3	1	np = 78.8/100mL	Objective met
	Tyhee Lake #2 E207560	Aug 6 – Nov 3	15	<1 - 7/100mL	
		Aug 6, 14, 20, 27, Sept 3	1	np = 1.0/100mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = 4.6/100mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100mL	Objective met
	Tyhee Lake #3 E207561	Aug 6 – Oct 28	10	<1 - 1/100mL	
		Aug 6, 14, 20, 27, Sept 3	1	np = <1/100mL	Objective met
		Oct 7, 15, 21, 28	1	np = <1/100mL	Indefinite result
		Apr 22	1	np = ?/100mL	Indefinite result
	Tyhee Lake #4 E207562	Aug 6 – Nov 3	15	<1 - 1/100mL	
		Aug 6, 14, 20, 27, Sept 3	1	np = 1.0/100mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = 1.0/100mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100mL	Objective met
Turbidity ≤5 NTU maximum (max) ≤1 NTU average (av)	Tyhee Lake #2 E207560	Aug 6 – Nov 3	15	<0.1 – 1.78 NTU	Max objective met
		Aug 6, 14, 20, 27, Sept 3	1	av = 0.54 NTU	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	av = 0.42 NTU	Objective met
		Apr 7, 14, 22, 29, May 6	1	av = 1.01 NTU	**Objective not met**
	Tyhee Lake #3 E207561	Aug 6 – Oct 28	10	0.28 – 2.16 NTU	Max objective met
		Aug 6, 14, 20, 27, Sept 3	1	av = 1.10 NTU	**Objective not met**
		Oct 7, 15, 21, 28	1	av = 0.43 NTU	Indefinite result
		Apr 22	1	av = 1.33 NTU	Indefinite result
	Tyhee Lake #4 E207562	Aug 6 – Nov 3	15	0.43 – 2.72 NTU	Max objective met
		Aug 6, 14, 20, 27, Sept 3	1	av = 0.82 NTU	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	av = 1.14 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 0.73 NTU	Objective met
Total Phosphorus Short Term: ≤15 µg/L average (av)	Tyhee Lake DS E216924	Apr 23 (samples at 0m, 5m 10m and 20m)	4		
			1	av = 33.5 µg/L	**Objective not met**
Colour ≤15 TCU maximum (max)	Tyhee Lake #2 E207560	Aug 6, 14, 20, 27, Sept 3 October 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	<5 – 20 TCU	**Objective not met (1x)**
	Tyhee Lake #3 E207561	Aug 6, 14, 20, 27, Sept 3 October 7, 15, 21, 28 Apr 22	10	<5 – 10 TCU	Objective met
	Tyhee Lake #4 E207562	Aug 6, 14, 20, 27, Sept 3 October 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	<5 – 15 TCU	Objective met

Table 7d: Round Lake Water Quality Objectives – 2002/03

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL ninetieth percentile (np)	Round Lake #3 E207557	Aug 6 – May 6	15	<1 – 160/100mL	
		Aug 6, 14, 20, 28, Sept 3	1	np = 4.4/100mL	Objective met
	Round Lake #4 E207558	Aug 6 – May 6	15	<1 – 1/100mL	
		Aug 6, 14, 20, 28, Sept 3	1	np = <1/100mL	Objective met
		Oct 7, 15, 21, 28, Nov 3	1	np = 1.0/100mL	Objective met
		Apr 7, 14, 22, 29, May 6	1	np = <1/100mL	Objective met
	Round Lake #5 E249107	Aug 6 –May 12	14	<1 – 2/100mL	
		Aug 6, 14, 20, 28, Sept 3	1	np = 1.6/100mL	Objective met
		Oct 7, 15, 21, 28	1	np = <1/100mL	Indefinite result
		Apr 14, 22, 29, May 6, 12	1	np = <1/100mL	Objective met
Turbidity ≤5 NTU maximum (max) ≤1 NTU average (av)	Round Lake #3 E207557	Aug 6 – Sept 3	5	0.72 – 8.25 NTU	**Max objective not met (1x)**
		Aug 6, 14, 20, 28, Sept 3	1	av = 2.29 NTU	**Objective not met**
	Round Lake #4 E207558	Aug 6 – May 6	15	0.8 – 44.0 NTU	**Max objective not met (1x)**
		Aug 6, 14, 20, 28, Sept 3	1	av = 10.16 NTU *	**Objective not met**
		Oct 7, 15, 21, 28, Nov 3	1	av = 1.73 NTU	**Objective not met**
		Apr 7, 14, 22, 29, May 6	1	av = 1.95 NTU	**Objective not met**
	Round Lake #5 E249107	Aug 6 –May 12	14	0.81 – 6.53 NTU	**Max objective not met (1x)**
		Aug 6, 14, 20, 28, Sept 3	1	av = 1.41 NTU	**Objective not met**
		Oct 7, 15, 21, 28	1	av = 2.56 NTU	Indefinite result
		Apr 14, 22, 29, May 6, 12	1	av = 1.10 NTU	**Objective not met**
Total Phosphorus Short Term: ≤15 µg/L average (av)	Round Lake DS 1131008	May 5 (samples at 0m, 4m and 20m)	3		
			1	av = 40.0 µg/L	**Objective not met**
Colour ≤15 TCU maximum (max)	Round Lake #3 E207557	Aug 6, 14, 20, 28, Sept 3	5	5 – 30 TCU	**Objective not met (1x)**
	Round Lake #4 E207558	Aug 6, 14, 20, 28, Sept 3 Oct 7, 15, 21, 28, Nov 3 Apr 7, 14, 22, 29, May 6	15	5 – 40 TCU	**Objective not met (4x)**
	Round Lake #5 E249107	Aug 6, 14, 20, 28, Sept 3 Oct 7, 15, 21, 28 Apr 14, 22, 29, May 6, 12	14	<5 – 20 TCU	**Objective not met (3x)**

* September 3 sample was 44.0 NTU. Without this sample, average = 1.70 NTU (objective still not met)

Table 8a: Kathlyn Lake Water Quality Objectives - 2001

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL (np) Beaches: ≤200/100mL (gm) ≤400/100mL (np)	Kathlyn Lake #1 (beach) E207548	2001	0	No data collected	Omitted 2001
	Kathlyn Lake #2 E207549	Oct 3 – 29	5	<1 – 7/100mL	
		Oct 3, 8, 14, 22, 29	1	np = 5.0/100mL	Objective met
	Kathlyn Lake #3 E207550	Oct 3 - 29	5	<1 – 139/100mL	
		Oct 3, 8, 14, 22, 29	1	np = 106.2/100mL	**Objective not met**
	Kathlyn Lake #4 E207551	Oct 3 - 29	5	<1 – 5/100mL	
		Oct 3, 8, 14, 22, 29	1	np = 4.6/100mL	Objective met
Turbidity ≤5 NTU (max) ≤1NTU (av)	Kathlyn Lake #2 E207549	Oct 3 - 29	5	1.42 – 2.25 NTU	Max objective met
		Oct 3, 8, 14, 22, 29	1	av = 1.93 NTU	**Objective not met**
	Kathlyn Lake #3 E207550	Oct 3 - 29	5	1.05 – 3.31 NTU	Max objective met
		Oct 3, 8, 14, 22, 29	1	av = 2.07 NTU	**Objective not met**
	Kathlyn Lake #4 E207551	Oct 3 - 29	5	1.13 – 1.6 NTU	Max objective met
		Oct 3, 8, 14, 22, 29	1	av = 1.41 NTU	**Objective not met**
Total Phosphorus Short Term: ≤15 µg/L (av)	Kathlyn Lake DS 1131007	2001	0	No data collected	Omitted 2001
Colour ≤15 TCU (max)	Kathlyn Lake #2 E207549	October 3, 8, 14, 22, 29	5	11 - 16 TCU	**Objective not met (1x)**
	Kathlyn Lake #3 E207550	October 3, 8, 14, 22, 29	5	11 - 13 TCU	Objective met
	Kathlyn Lake #4 E207551	October 3, 8, 14, 22, 29	5	11 - 13 TCU	Objective met

Table 8b: Seymour Lake Water Quality Objectives - 2001

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL (np) Beaches: ≤200/100mL (gm) ≤400/100mL (np)	Seymour Lake #1 E207552	Oct 3 – 29	5	<1 – 1/100mL	
		Oct 3, 8, 14, 22, 29	1	np = <1/100mL	Objective met
	Seymour Lake #2 E207553	Oct 3 – 29	5	<1 – 1/100mL	
		Oct 3, 8, 14, 22, 29	1	np = <1/100mL	Objective met
	Seymour Lake #3 E207554	Oct 3 – 29	5	all <1/100mL	
		Oct 3, 8, 14, 22, 29	1	np = <1/100mL	Objective met
Turbidity ≤5NTU (max) ≤1NTU (av)	Seymour Lake #1 E207552	Oct 3 – 29	5	7.16 – 13.0 NTU	**Max objective not met (5x)**
		Oct 3, 8, 14, 22, 29	1	av = 10.47 NTU	**Objective not met**
	Seymour Lake #2 E207553	Oct 3 – 29	5	0.64 – 6.40 NTU	**Max objective not met (1x)**
		Oct 3, 8, 14, 22, 29	1	av = 1.97 NTU	**Objective not met**
	Seymour Lake #3 E207554	Oct 3 – 29	5	0.34 – 1.41 NTU	Max objective met
		Oct 3, 8, 14, 22, 29	1	av = 0.81 NTU	Objective met
Total Phosphorus Short Term: ≤15 µg/L (av)	Seymour Lake DS 1131010	2001	0	No data collected	Omitted 2001
Colour ≤15 TCU (max)	Seymour Lake #1 E207552	Oct 3, 8, 14, 22, 29	5	55 - 90 TCU	**Objective not met (5x)**
	Seymour Lake #2 E207553	Oct 3, 8, 14, 22, 29	5	25 - 45 TCU	**Objective not met (5x)**
	Seymour Lake #3 E207554	Oct 3, 8, 14, 22, 29	5	13 - 35 TCU	**Objective not met (4x)**

Table 8c: Tyhee Lake Water Quality Objectives - 2001

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL (np) Beaches: ≤200/100mL (gm) ≤400/100mL (np)	Tyhee Lake #1 (beach) E207559	2001	0	No data collected	Omitted 2001
	Tyhee Lake #2 E207560	Oct 2 – 29	5	all <1/100mL	
		Oct 2, 8, 14, 22, 29	1	np = <1/100mL	Objective met
	Tyhee Lake #3 E207561	Oct 2 – 29	5	all <1/100mL	
		Oct 2, 8, 14, 22, 29	1	np = <1/100mL	Objective met
	Tyhee Lake #4 E207562	Oct 2 – 29	5	all <1/100mL	
		Oct 2, 8, 14, 22, 29	1	np = <1/100mL	Objective met
Turbidity ≤5 NTU (max) ≤1 NTU (av)	Tyhee Lake #2 E207560	Oct 2 – 29	5	1.02 – 13.6 NTU	**Max objective not met (2x)**
		Oct 2, 8, 14, 22, 29	1	av = 4.63 NTU	**Objective not met**
	Tyhee Lake #3 E207561	Oct 2 – 29	5	0.53 – 0.90 NTU	Max objective met
		Oct 2, 8, 14, 22, 29	1	av = 0.68 NTU	Objective met
	Tyhee Lake #4 E207562	Oct 2 – 29	5	0.49 – 0.63 NTU	Max objective met
		Oct 2, 8, 14, 22, 29	1	av = 0.56 NTU	Objective met
Total Phosphorus Short Term: ≤15 µg/L (av)	Tyhee Lake DS E216924	2001	0	No data collected	Omitted 2001
Colour ≤15 TCU (max)	Tyhee Lake #2 E207560	Oct 2, 8, 14, 22, 29	5	11 - 25 TCU	**Objective not met (2x)**
	Tyhee Lake #3 E207561	Oct 2, 8, 14, 22, 29	5	6 - 12.5 TCU	Objective met
	Tyhee Lake #4 E207562	Oct 2, 8, 14, 22, 29	5	8 - 12.5 TCU	Objective met

Table 8d: Round Lake Water Quality Objectives - 2001

Variable & Objective	Site	Date	N	Value	Conclusion
Fecal Coliforms Intakes: ≤10/100mL (np) Beaches: ≤200/100mL (gm) ≤400/100mL (np)	Round Lake #3 E207557	Oct 2 - 29	5	<1 – 1/100mL	
		Oct 2, 8, 14, 22, 29	1	np = 1.0/100mL	Objective met
	Round Lake #4 E207558	Oct 2 – 29	5	all <1/100mL	
		Oct 2, 8, 14, 22, 29	1	np = <1/100mL	Objective met
	Round Lake #2 E207556	Oct 2 – 29	5	all <1/100mL	
		Oct 2, 8, 14, 22, 29	1	np = <1/100mL	Objective met
Turbidity ≤5 NTU (max) ≤1 NTU (av)	Round Lake #3 E207557	Oct 2 – 29	5	0.91 – 4.25 NTU	Max objective met
		Oct 2, 8, 14, 22, 29	1	av = 1.41 NTU	**Objective not met**
	Round Lake #4 E207558	Oct 2 – 29	5	0.65 – 9.52 NTU	**Max objective not met (1x)**
		Oct 2, 8, 14, 22, 29	1	av = 2.92 NTU	**Objective not met**
	Round Lake #2 E207556	Oct 2 - 29	5	0.61 – 2.10 NTU	Max objective met
		Oct 2, 8, 14, 22, 29	1	av = 1.28 NTU	**Objective not met**
Total Phosphorus Short Term: ≤15 µg/L (av)	Round Lake DS 1131008	2001	0	No data collected	Omitted 2001
Colour ≤15 TCU (max)	Round Lake #3 E207557	Oct 2, 8, 14, 22, 29	5	13 - 18 TCU	**Objective not met (2x)**
	Round Lake #4 E207558	Oct 2, 8, 14, 22, 29	5	12.5 - 20 TCU	**Objective not met (3x)**
	Round Lake #2 E207556	Oct 2, 8, 14, 22, 29	5	12.5 - 18 TCU	**Objective not met (1x)**

Appendix 2

Table 9: Smithers Lakes Phosphorus Data - 2003

Lake	Sampling Date	P Concentration in µg/L		
		Surface	Middle (Depth)	Bottom (Depth)
Kathlyn	**April 23**	**18**	**17 (4m)**	**19 (9.5m)**
	April 30	13	15 (4m)	18 (9.5m)
Seymour	April 23	26	25 (4m)	54 (7m)
	April 30	**16**	**19 (4m)**	**31 (7m)**
Tyhee	**April 23**	**28**	**25 (5m) 36 (10m)**	**45 (20m)**
	April 30	9	15 (5m) 16 (10m)	35 (20m)
Round	April 27	49	46 (4m)	102 (20m)
	April 30	32	39	72 (20m)
	May 5	**33**	**38 (4m)**	**48 (20m)**

(Spring overturn dates are indicated in bold text)