Ministry of Environment Lands and Parks

QUATSE LAKE

WATER QUALITY ASSESSMENT AND OBJECTIVES

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Water Quality Assessment and Objectives for Quatse Lake

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Summary

THIS DOCUMENT is one in a series that presents ambient water quality objectives for British Columbia. It has two parts: an overview—which is available as a separate document—and the report. The overview provides general information about water quality in Quatse Lake. It is intended for both technical readers and for readers who may not be familiar with the process of setting water quality objectives. It includes tables listing water quality objectives and required monitoring. The main report presents the details of the water quality assessment for the lake, and forms the basis of the recommendations and objectives presented in the overview.

Quatse Lake has low fisheries productivity, resulting in limited appeal for this type of recreational activity. The lake and its outlet stream (Quatse River) are used as drinking water supplies for the Mount Waddington Regional District. The water is currently treated with large amounts of chlorine to disinfect the water and reduce the concentration of colour present.

Most water contamination seems to come from past forestry activities, with about 25% of the watershed having been logged. However, it is difficult to completely isolate impacts which may have arisen due to logging activities.

Water quality objectives are recommended to protect aquatic life, wildlife, and drinking water supplies with disinfection only. The objectives have been prepared for Environment Managers for use in determining compliance with the Forest Practices Code of B.C..

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PREFACE

Purpose of Water Quality Objectives

WATER QUALITY OBJECTIVES are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the future.

How Objectives Are Determined

WATER QUALITY OBJECTIVES are based on scientific guidelines called water quality criteria.* Water quality criteria are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the criteria by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial water supplies

* The process for establishing water quality objectives is outlined more fully in *Preparing Water Quality Objectives in British Columbia*. Copies of this document are available from the Water Quality Section, Water Management Branch.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical, or biological characteristics affecting that water body.

How Objectives Are Used

WATER QUALITY OBJECTIVES have no legal standing at this time and are not directly enforced. However, they do provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licenses and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular water body can be checked, and help to determine whether basin-wide water quality studies should be initiated. Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a water body. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at the critical time, then they also will be protected at other times when the threat is less. The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water. For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (i.e., mean value, maximum value).

INTRODUCTION

Quatse Lake is located on the north-eastern end of Vancouver Island, approximately three kilometres north from Coal Harbour (see Figure 1), and is the primary source of drinking water for the town. Currently, the water is treated with large amounts of chlorine prior to drinking to disinfect the water and reduce the concentration of colour. Recent logging activity in the lake watershed has raised concerns that the water quality might be affected.

The purpose of this report was to provide Environment Managers water quality objectives for Quatse Lake for use in determining compliance with the Forest Practices Code of B.C..

QUATSE LAKE-PROFILE

Hydrology

Quatse Lake watershed has a contributory area of 15 km^2. The lake has a surface area of 1, 500, 000 m^2, a volume of 11,760,00 m^3, resulting in an exchange rate of about one and one-half times per year.

Flows into Quatse Lake come from Bluebell Creek to the west, with estimated flows from 0.037 to 0.124 m^3/s in the April to September period and to as high as 1.03 m^3/s in January. Return periods could not be calculated since these flows were estimates based upon precipitation measurements.

Water Uses

Water uses in Quatse Lake are for aquatic life, wildlife and drinking water supplies. Mount Waddington Regional District is allowed a withdrawal of 10, 642 m^3 per year from the lake, with an additional licence for water from the Quatse River, the outflow from the lake.

Aquatic biological productivity in the lake is low, resulting in a small amount of recreational fishing.

Waste Discharges

There are no permitted refuse sites or waste water discharges into the Quatse Lake watershed. Approximately 25% of the watershed was logged in the 1970's and 1980's, including a large area of about 300 ha north from the lake.

There are also several mining claims in the watershed; however, none are currently mined actively.

WATER QUALITY ASSESSMENT AND OBJECTIVES

Water Quality Assessment

Quatse Lake is a coastal lake and is typical in being poorly-buffered to acidic inputs, having low alkalinity and therefore low hardness. The mean pH (6.3) is below the criteria range for drinking water (6.5-8.5). An objective of pH 6.0 is set in light of the naturally low pH.

Metal concentrations in Quatse Lake were usually below the B.C. approved or working water quality criteria except for occasional higher concentrations for iron or aluminum. This is typical in coastal lakes and no objectives were set.

Phosphorus concentrations were low enough to not cause excessive algal growth but watershed disturbance may cause an increase in phosphorus. For this reason, an objective is set in order to monitor this aspect of water quality.

Dissolved oxygen concentrations were usually satisfactory, but late summer concentrations in the deep water were low enough to be of some concern. Since these levels should not decrease (potentially by future anthropogenic activities, including logging), further, an objective is set to protect aquatic life.

The natural colour of the lake is very high, typically in the range of 50 to 100 true colour units, as a consequence of input of organic acids from watershed vegatation. The mean colour value (82 true colour units) exceeds the criteria for drinking water (75 units). A long term objective of 75 units is set for raw drinking water recognizing that some management efforts may be needed to achieve this.

Turbidity values are typically low (<1 NTU) but there are times during high runoff and summer algal blooms when this may be exceeded. The objective set is for 1 NTU.

Fecal coliform concentrations are generally very low , below criteria and the objective set (10 /cL). Fecal coliforms are very important indicators that need to be included in an objectives monitoring program.

Trihalomethanes (THM's) were found to be in relatively high concentrations for samples taken of treated water (after chlorination) at the tap. The high THM's are due to high amounts of natural organic material in the water (which are measured as total organic carbon and colour). Monitoring of THM's at the tap should be undertaken by the appropriate health authority as they may represent a significant human health risk.

The remainder of the general ion chemistry values are low and of little concern.

Water Quality Objectives

Water quality objectives proposed for Quatse Lake are summarized in Table 1. The objectives are based on B.C. approved and working criteria and the Canadian Drinking Water Guidelines for water quality and on available data on ambient water quality, waste discharges, and water uses. The objectives will be modified as necessary by new data from receiving water monitoring programs.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified waterbodies. They will guide the evaluation of water quality, the issuing of permits, licenses, and orders, and the management of the fisheries and of the Province's land base. They will also provide a reference against which the state of water quality in a particular water body can be checked, and serve to make decisions on whether to initiate basin-wide water quality studies.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by human activity now and in the foreseeable future.

Designated water uses for all three waterbodies are for the protection of aquatic life, wildlife, and drinking water supplies with disinfection only.

Water quality objectives which are based on approved B.C. water quality criteria are proposed for microbiological indicators, turbidity, dissolved oxygen, pH, and phosphorus. The objective for colour is based on the Canadian Drinking Water Guidelines.

Monitoring Recommendations

At least three years of monitoring is recommended to check whether the objectives are being achieved. The extent of the monitoring after that will depend on results, as well as on regional priorities and available funding. A recommended monitoring design is included as Table 2.

Report Prepared by:
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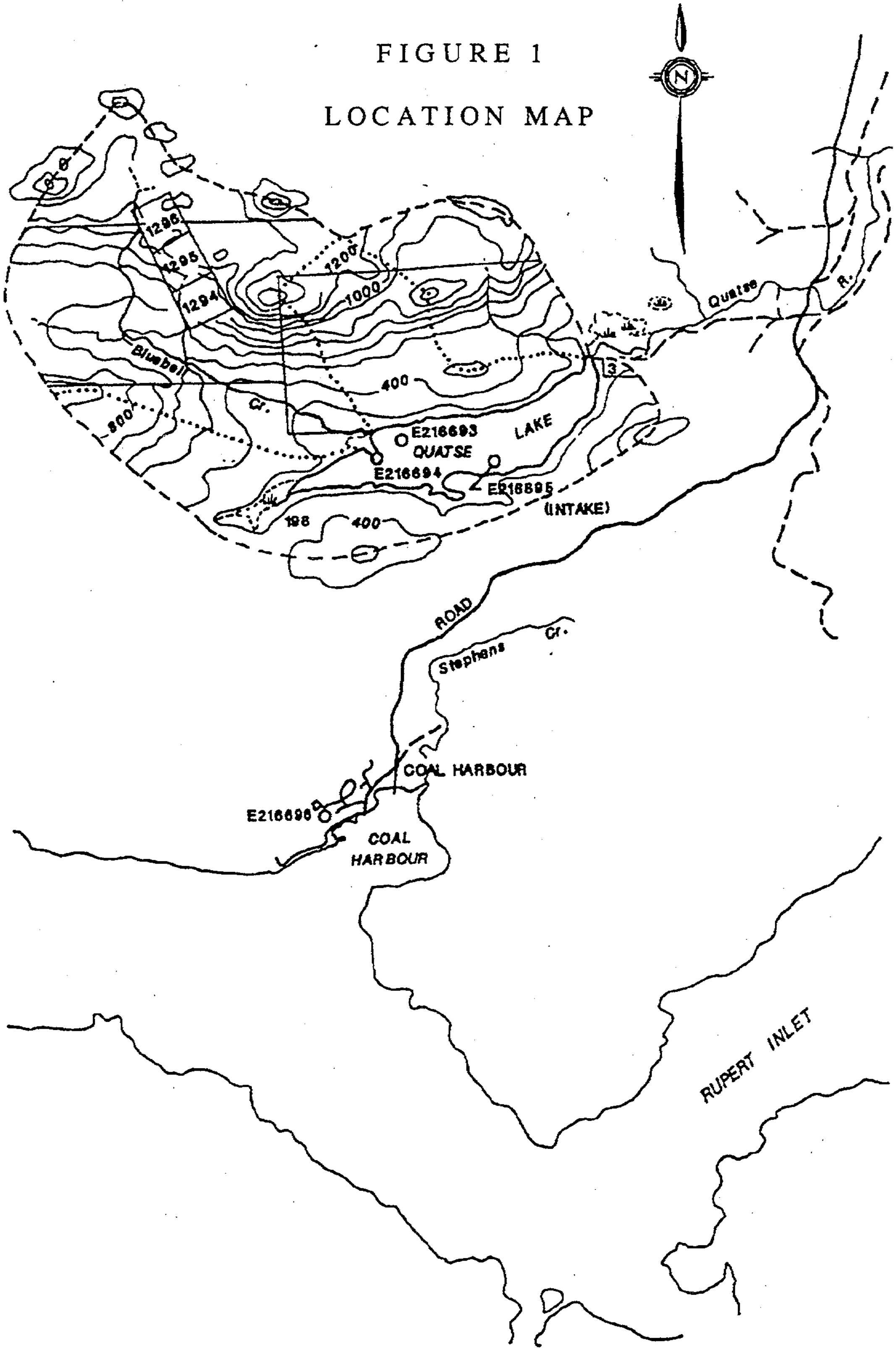
LOCATION AND MONITORING SITES MAPS

FIGURE 1

LOCATION MAP



WATER QUALITY OBJECTIVES AND MONITORING TABLES

THE FOLLOWING TABLES provide a summary of the objectives data and monitoring recommendations.

To protect water uses in a water body, objectives specify a range of values for characteristics (variables) that may affect these uses. These values are maximum and/or minimum values that are not to be exceeded.

Some readers may be unfamiliar with terms such as: maximum concentration, 30-day average concentration, 90th percentile, and not applicable (NA). Maximum concentration means that a value for a specific variable should not be exceeded; 30-day average concentration means that a value should not be exceeded during a period of 30 days, when five or more samples are collected at approximately equal time intervals. The term 90th percentile indicates that 9 out of 10 values should be less a particular variable. Not applicable (NA) means that water uses are not threatened for that particular variable.

TABLE 1
WATER QUALITY OBJECTIVES FOR QUATSE LAKE

	Quatse Lake
Designated Water Uses	aquatic life, wildlife, drinking water (disinfection only)
Characteristics	
Fecal coliforms[1]	10/cL geometric mean
Turbidity	1 NTU maximum
Phosphorus	15µg/L maximum
Colour - true	75 units maximum
Dissolved oxygen	>5mg/L
pH	>6.0

[1]The geometric mean is calculated from at least five weekly samples in a period of thirty days. For values recorded as less than the detection limit, the detection limit itself should be used in calculating the statistic.

TABLE 2
RECOMMENDED WATER QUALITY MONITORING FOR QUATSE LAKE

Site Number	Location	Frequency/Date	No.	Variables
E216693	Quatse Lake at deepest point	During Spring overturn (surface, mid-water and bottom)	3	Total Phosphorus
E216695	Quatse Lake at water intake	Four times per year: January, April, July and October	4	pH, True Colour, Turbidity
E216695	Quatse Lake at water intake	5 samples in 30 days, preferably in summer (July or August)	5	Fecal Coliforms
E216693	Quatse Lake at deepest point	August	1	Dissolved oxygen at one metre above sediments

GLOSSARY

Ambient	Refers to conditions in the surrounding environment.
Anthropogenic	Relates to, or involves, the impact of man.
Contaminant	A substance that infects by contact or association.
Designated water use	A water use that is to be protected at a specific location.
Disinfection	The process of destroying microorganisms in water by the application of a chemical agent (disinfectant) such as chlorine.
Initial Dilution zone	Areas adjacent to a wastewater discharge wherein Water Quality Objectives (except those in fish) do not apply.
Nutrient	Substance (element or compound) necessary for the growth and development of plants and animals.
pH	Negative of the logarithm (base 10) of the hydrogen ion concentration. Quantitative expression for acidity or alkalinity of solution. Scale ranges from 0 to 14, pH 7 is neutral; less than 7 is acid; more than 7 is alkaline.
Water Quality Criteria	Numerical value(s) for a physical, chemical, or biological characteristic of water, biota, or sediment which must not be exceeded to prevent specified detrimental effects from occurring to water use.
Water Quality Objective	A Water Quality Criterion or Guideline adapted to protect the most sensitive designated water use at a specified location with an adequate degree of safety, taking local circumstances into account.

QUATSE LAKE

WATER QUALITY ASSESSMENT AND OBJECTIVES

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ACKNOWLEDGMENTS

Paul Getman collected the water quality samples at Quatse Lake for this study. Michael Moore of the Port Hardy Marine Resources Management Society generously made available the data collected for Quatse Lake as part of their study of lake netpen aquaculture. Gerry Acorn of the Upper Island Health Unit obtained some of the samples and provided the data. The Mount Waddington Regional District provided part of the funding for the study and Tim Fox and Bill Shepherd have provided help and guidance for the study.

1.0 INTRODUCTION

Quatse Lake is located on the north-eastern end of Vancouver Island, approximately 3 km north of Coal Harbour (Figure 1), and is the primary source of drinking water for that town. Currently, the water supply is treated with large amounts of chlorine prior to drinking to both disinfect the water and reduce the concentration of colour. Recent logging activity in the lake watershed has raised concerns that water quality might be affected, resulting in problems with the drinking water supply to Coal Harbour.

This study was undertaken at the request of the Mount Waddington Regional District. Initial contact was with the Ministry regional office in Nanaimo in 1990, at which time the Water Quality Branch was asked to design a monitoring program for the lake. In late 1991, contact was initiated among a number of agencies and a cooperative program was agreed upon by the Regional District, the Upper Island Health Unit in Port Hardy, the Ministry regional office in Nanaimo and the Water Quality Branch.

The project began in 1992, with water samples collected primarily between March and October. Other data were supplied by the Port Hardy Marine Resource Management Society (PHMRMS). The PHMRMS has been involved in a study of the effects of net pen aquaculture activities on two nearby lakes (Georgie and O'Conner), and used Quatse Lake as a control site in 1992.

1.1 Study details

Four water quality sampling sites were established, and site-specific sampling regimes were planned. A description of the sites, as well as the actual sampling schedule adhered to at each site, follows:

Quatse Lake at the deepest point, Ministry of Environment SEAM site number E216693. Sampling was to be conducted four times during the year, both at the surface and near the lake bottom, for a broad range of water chemistry characteristics. Data from these samples are given in Table 5.2.1.

Bluebell Creek at the mouth, E216694. Monthly measurements of the inflow creek were included in the original monitoring program to assess the quality of water flowing into the lake through the winter. Unfortunately, access to the creek was very difficult and it was not possible to sample at this site.

Quatse Lake at the water intake, E216695. Fecal coliform concentrations were sampled monthly at this site through the summer (Table 5.2.2).

Coal Harbour treated water supply at the school, E216696. Sampling at this site was to be conducted to evaluate the quality of the chlorinated water as it was supplied to the town of Coal Harbour. See Table 5.2.3 for the tabulated data.

2.0 LAKE CHARACTERISTICS

Lake characteristics are summarized in Table 2.0. A bathymetric map of Quatse Lake is included as Figure 2.

Table 2.0. Lake Morphometric Data

Elevation	76 m
Surface Area	1,500,000 m^2
Volume	11,760,000 m^3
Mean Depth	7.8 m
Maximum Depth	22 m
Perimeter	8,600 m
Watershed Area	15,000,000 m^2
Bluebell Creek Watershed	8,250,000 m^2

Data from Fisheries Branch survey of May 1980
NTS mapsheet 92L 12E
UTM coordinate 9.6016 56097

2.1 Hydrology

The Hydrology Branch of the Water Management Division were asked to provide estimates of the flow of Bluebell Creek. Coulson (memo of June 25 1992) made estimates of Bluebell Creek flow at the mouth as it flows into Quatse Lake (Table 2.1). Since no hydrometric data were available, precipitation (as measured at the Coal Harbour-Rupert Inlet), evapotranspiration, and a comparison to observed flows for other north-Island gauged watersheds were used to estimate flow. Mean runoff by month is given in Table 2.1 for average rainfall and for three other different rainfall years to provide an indication of variation in monthly flow. Coulson states that as these values are based on estimates they should only be considered approximate, and adds that flows should be confirmed by hydrometric measurements especially during the late-summer, low-flow period.

The average runoff (0.336 m^3/s) is equivalent to a volume of 10,596 dam^3/year from Bluebell Creek. Since the contibuting area of Bluebell Creek represents approximately 60% of the watershed, the total watershed yield would be about 17,660 dam^3/year. The lake has a volume of about 11,760 dam^3, and therefore the water exchange time would be approximately 1.5 times per year; *i.e.*, one and a half times the volume of the lake passes through it in an average year. This value ranges from 1.2 times per year in a low-flow year (see data for 1985 in Table 2.1) to 2.1 times per year in a high-flow year (e.g., 1990 in Table 2.1).

Table 2.1 Estimated runoff for Bluebell Creek associated with different precipitation.

	Mean Runoff		1990 Runoff		1985 Runoff		1980 Runoff	
Month	mm	m^3/s	mm	m^3/s	mm	m^3/s	mm	m^3/s
January	220	0.677	334	1.030	92	0.283	193	0.593
February	173	0.585	211	0.721	239	0.816	104	0.341
March	138	0.424	58	0.180	160	0.493	151	0.465
April	43	0.136	20	0.065	97	0.309	145	0.460
May	20	0.061	13	0.040	20	0.063	20	0.062
June	13	0.041	11	0.035	13	0.041	13	0.041
July	11	0.034	10	0.031	11	0.034	11	0.034
August	10	0.031	9	0.028	10	0.031	10	0.031
September	9	0.029	8	0.025	9	0.029	39	0.123
October	102	0.314	358	1.102	232	0.715	86	0.265
November	253	0.804	482	1.534	78	0.248	271	0.862
December	293	0.902	299	0.922	92	0.283	460	1.418
April-Sept	106	0.055	71	0.037	161	0.084	238	0.124
Total	1284	0.336	1815	0.475	1054	0.276	1502	0.392

The only other inflow to the lake is through a small unnamed creek located on the north side of the watershed which enters the lake near it's outflow (Figure 1). It is assumed that much of the water entering the lake from this stream flows directly through the outflow and therefore has little effect on either the water chemistry or the water exchange rates of the main body of the lake.

3.0 WATER USES

Mount Waddington Regional District holds two water licenses for use of the lake water: 47 888 000 gallons per year (10 642 m^3) to be diverted for waterworks purposes, and a storage license for 4.1 acre feet (5 055 m^3). There are no other licenses on the lake. The Regional District also holds a water license on the Quatse River, the primary outflow of the lake. The intake for the waterworks is located at a depth of 4 metres on the south side of the lake near the pumphouse (Figure 1). Designated water uses for protection include drinking water (with disinfection only), aquatic life, and wildlife. Body contact recreation does not appear to be a use in this lake.

3.1 Watershed activities

3.1.1 Vegetation cover/Logging activities

Western hemlock and amabilis fir are typically the dominant tree species in this zone, and the majority of the watershed is located in TFL #6, held by Western Forest Products. Cutting plans for the watershed are in progress with 40 ha cut blocks planned. Approximately 25% of the watershed has already been logged (primarily in the late 1970's and early 1980's), including a large area of about 300 ha north of the lake.

3.1.2 Mining claims

There are several mining claims in the watershed (Figure 3). None of these claims are being actively mined at present.

3.1.3 Recreational Uses

A very limited amount of recreational fishing occurs in Quatse Lake. Although it is not a closed watershed, it has low fisheries productivity and therefore limited appeal for this activity.

4.0 PERMITTED DISCHARGES AND NON-POINT SOURCES

There are currently no known point source discharges or permits to Quatse Lake. Non-point sources of concern are primarily the logging and mining activities discussed in Section 3.0.

5.0 AMBIENT WATER QUALITY ASSESSMENT

The purpose of the study was twofold: first, to establish a baseline for water quality in the lake since no previous data has been collected, and second, to evaluate the data collected during this study to determine which, if any, water chemistry characteristics are potentially of concern.

The general quality of the water was compared to the Guidelines for Canadian Drinking Water Quality (1989) and other criteria for the untreated water (e.g. Approved and Working Criteria for Water Quality 1991) and two potential areas of concern were revealed. The first concern was that logging or other human-based activities in the watershed might have some adverse effects on drinking water quality. As some logging has already occurred in the watershed, it is impossible to completely isolate the effects of logging and to determine the quality of the lake in its pristine condition. However, as significant amounts of logging are planned in the next few years, it would be beneficial to determine conditions as close to baseline as possible in order to recognize and mitigate potential negative effects. The other major concern pertains to natural colour. Quatse Lake, as with other lakes in the northern Vancouver Island area, has a high concentration of natural colour (50-100 true colour units). To alleviate this problem and make the water more acceptable for a source of drinking water, very high dosages of chlorine are used to reduce the colour. In so doing there is a potential for producing a variety of disinfection by-products, in particular chlorinated organics such as trichloromethanes which are known animal carcinogens.

Ambient Water Quality Results

The water quality data are reported in three sections. The first section contains temperature, oxygen and conductance data, compiled primarily from samples collected by the Port Hardy Marine Resource Management Society. These data provide an important basis for how the lake physically functions and changes on an annual basis. The second section contains more detailed water chemistry data. Relatively few water chemistry data have been collected due to cost and time constrains, but it can prove to be a very useful diagnostic tool in determining how the lake might be changing over time. The third group contains biological data which, although in the case of this study are very limited, nonetheless tend to be the best indicators of change in a lake.

5.1 Lake stratification and physiochemistry

5.1.1 Temperature

The thermal structure of the lake is an important characteristic for understanding how the lake stratifies but also has some very practical uses with regard to the quality of water drawn in at the intake. Figure 4 shows a time/depth diagram for the thermal stratification of Quatse Lake through 1992. It depicts the lake as being very weakly stratified, if at all, in the early spring. By late April, some thermal stratification begins to occur but the entire water column temperature has increased (presumably due to vertical mixing) and the hypolimion temperature is surprisingly high at 9.5-10 degrees C. By June the lake has become well stratified and is divided into two separate thermal layers. This stratification persists through mid-October when the lake surface cools down from a late July surface maximum of 22°C to vertically circulate at about 11°C. There are few temperature data for the winter period but it can be assumed that in most winters, the entire lake water column cools to between 1 and 4°C. The 1993 January data included as Appendix 2 shows the lake was isothermal at 2°, and it probably mixes top to bottom for the entire period from about October through April. In cold winters it might be expected that ice cover would persist for some period and a reverse stratification would then occur (0° C at the surface, 2-4° C at the bottom).

Since the water intake is fixed at 4 metres, the temperature of this water at any particular time of the year can be easily determined from Figure 4. The management or the operator of the water system also has the ability to raise or lower the intake to modify the depth at which water is drawn into the system. If for instance there is reason to believe that an excessive amount of algae were present in the surface waters, it might be advantageous to draw water from a deeper depth. Conversely if there is low dissolved oxygen or high concentration of decomposition products in the deeper water, it might be an advantage to draw from near-surface waters.

5.1.2 Dissolved Oxygen

Figure 5 shows a compilation of the dissolved oxygen concentrations for Quatse Lake in the form of a D.O. time/depth diagram. It reveals that the surface waters were generally near saturation but that in late summer a significant depletion was present in the hypolimnion below about 8 metres. The minimum concentration at this time was about 42% saturation. For the purposes of water supply, any decrease below 10 or 20 percent saturation would be of concern since at these levels iron or manganese production generally increases and problems with taste and odour may subsequently occur. It would also be prudent to ensure that the deep water dissolved oxygen does not decrease significantly from present levels, as this might alter the overall biological community of the lake. If the water quality is to be protected in at least its present condition without any deterioration, a stable physical, chemical and biological environment has to be maintained. Since dissolved oxygen is a major determinant of lake biological community structure, DO should not decrease any further. To this end, any activities which would cause an increase in the input of oxygen-demanding materials to the lake should be regarded as undesirable. Logging activities which might increase the input of organics (in particulate matter or as dissolved organic carbon), may contribute to increased organic loading to the lake but there are very few data from other areas concerning this, and it might be a focus of monitoring the effects of watershed logging in the future.

5.1.3 Conductivity

The third depth profile characteristic collected for the lake is specific conductance. A time-depth diagram for the data collected by the PHMRMS is shown as Figure 6. The conductance values for these data are high in comparison to the concentration of dissolved ions reflected in the chemistry data (Section 5.2.2). It is presumed that a calibration problem exists with the instrument used for collecting the data. However, the general patterns of concentration still provide some useful information. There appears to be very little vertical differences in conductance but there is a noticeable increase through the year, presumably reflecting evapotranspiration and the inflow of water higher in dissolved minerals during the summer.

5.2 Water chemistry results

5.2.1 Quality assurance /Quality control (QA/QC)

The QA/QC aspect of the program was very basic. One pair of replicated samples was collected to test the combined variability of handling in the field and analytical laboratory. The results showed that the samples were well within the variation expected, with the majority of results being very close if not identical. A field blank sample was also shipped to the lab for analysis. This consisted of a set of sample bottles filled in the field with de-ionized water at the same time as the sample bottles were being filled with lake water. For almost all of the reported characteristics, the results were below the detection limits of the characteristic being analyzed. One notable exception was for total nitrate-nitrite where the result reported (0.1 mg/L) was higher than any of the lake water results (all were below 0.020 mg/L). The reason for this single high value is not known. There appears to be no nitrate-nitrite contamination in the field samples as the other results for this characteristic are below the analytical detection limit. There were a few other characteristics where results were reported at or near the detection limit (turbidity, calcium, iron, magnesium and sodium). The complete set of data for the replicates and blanks is included in Appendix 1.

There are several groups of results for water chemistry discussed below and summarized as Table 5.2.1.

5.2.2 General Ions

Although alkalinity was only measured twice in Quatse Lake and therefore does not give a very clear picture of the actual condition of the lake over time, both measurements were very low with a mean concentration of only 5.7 mg/L (Table 5.2.1). At this concentration, the lake is considered to be highly sensitive to acid inputs (Swain, 1987). Calcium concentrations are also very low, within the range considered to be highly sensitive to acid inputs (Swain, 1987). The only two pH measurements taken were also low, with a mean value of 6.2. This value is less than the drinking water criterion range of pH 6.5 to 8.5 (McKean and Nagpal, 1991), so pH may be a concern in Quatse Lake. Since the low pH appears to be natural, ambient levels and not due to anthropogenic acitivities, a long-term objective is proposed. The objective states that pH values should be ≥ 6.5 in order to minimize solubilization of heavy metals and salts and to maximize the effectiveness of chlorination. The samples should be collected from the same depth as the water intake is located.

True colour in Quatse Lake is very high, with values ranging from 55 to 100 true colour units and a mean concentration of 82 true colour units. The majority of values exceeded the maximum water quality criteria of 75 true colour units recommended for drinking water with colour removal, and a maximum of 15 true colour units without colour removal (Health and Welfare Canada, 1989 and 1992). Logging activities in the area have the potential to raise the already-high colour levels, and therefore an objective for colour is proposed. The high levels of chlorine added to drinking water from Quatse Lake effectively acts to remove colour, so the objective states that the maximum colour concentration in Quatse Lake should not exceed 75 true colour units. The samples should be collected from the same depth as the water intake and a sample also taken from the distribution system four times per year.

Due to the high colour concentrations in Quatse Lake, large amounts of chlorine are added to the drinking water supply to remove colour and purify the water. A common concern with regards to this addition is the potential for the formation of trihalomethanes, which can be detrimental to human health at higher concentrations. Treated water samples were collected in Coal Harbour and analyzed for concentrations of trihalomethanes (Table 5.2.2). The water quality criterion for trihalomethanes is a maximum of 0.1 mg/L based on annual averages of quarterly samples (Health and Welfare Canada, 1993). The concentration of chloroform alone met or exceeded this criterion in all four samples collected. Therefore, an objective is proposed for trihalomethanes, which states that the average concentration of total trihalomethanes measured in a minimum of four quarterly samples should not exceed 0.1 mg/L. Samples to check the attainment of this objective should be collected from a standard location in the distibution system on an annual basis

Turbidity concentrations are also fairly high, with a mean value of 0.6 NTU and a maximum value of 1.6 NTU. This maximum value exceeds the approved Water Quality Criterion maximum of 1 NTU based on health considerations (Health and Welfare Canada, 1989 & 1992). However, as the majority of the values are well below this criterion, turbidity is not considered to be a major problem at this time, however there is some concern about the effects of logging on lake water quality so this parameter may provide an indication of this. An objective of 1 NTU is proposed to be monitored four times per year at the water intake.

The remainder of the general ions measured (including total organic carbon, dissolved chloride, potassium, silica, and total and suspended solids) are well below their respective criteria, and no objectives are proposed for these characteristics. Chloride concentrations are noticeably higher in the Coal Harbour sample than in the ambient lake water (9.7 mg/L compared to a maximum of 2.7 in the lake) due to the high levels of chlorination, but levels are still well below all water quality criteria for dissolved chloride (250 mg/L for drinking water (Health and Welfare Canada, 1989 and 1992)).

5.2.3 Metals

The majority of metals measured in Quatse Lake are present in concentrations well below the applicable water quality criteria. Exceptions to this include aluminum and iron, which both occasionally exceed the maximum concentrations recommended for drinking water. As there does not appear to be any anthropogenic contribution to either metal concentration in Quatse Lake and the high concentrations appear to be due to natural sources, no objective is proposed for these metals.

5.3 Biological data

Limited amounts of biological data were collected from Quatse Lake. These data consist of four measurements each of chlorophyll a and fecal coliform concentrations (Table 5.2.1). Coliform concentrations were also measured at the water intake (Site E216695) on three occasions between May and October, 1992 (Table 5.2.2).

5.3.1 Chlorophyll a

Two of the four chlorophyll a measurements exceeded the water quality guideline of 2.5 µg/L for the protection of drinking water, with a maximum concentration of 5.8 mg/L. These samples were collected in May and August, 1992. The two concentrations which fell below the guideline were measured in October, outside the range of time specified under the guideline. Phosphorus levels were generally low, with all values below the water quality criteria of 0.005 to 0.015 mg/L maximum concentrations for the protection of drinking water (Nordin, 1985). However, logging activities in the watershed could increase levels of phosphorus, leading to an increase in algal production and subsequent negative effects on the quality of water for drinking. The ratio of mean total nitrogen:mean total phosphorus is about 31:1, which indicates that the system is fairly strongly phosphorus-limited and supports the possiblity of increased phosphorus leading to algal problems. Therefore, an objective for phosphorus is proposed, which states that the maximum concentration of total phosphorus in any discrete measurement should be ≤ 0.015 mg/L.

5.3.2 Fecal Coliforms

Fecal coliform concentrations were generally low, with only one of four values measured at the centre of Quatse Lake (Site E216693) exceeding the water quality criterion of 10 CFU/cL (Warrington, 1988). This value (190 CFU/cL) was measured at a depth of 20 metres on the same date that the surface concentration was only 8 CFU/cL, suggesting that the coliforms may have been associated with sediment material and would therefore not affect the quality of the drinking water (as the water intake is located at a depth of four metres). Measurements taken at the water intake support this hypothesis, with a measurement of 11 CFU/cL recorded at the intake on the day that the maximum value occurred at Site E216693. This value slightly exceeds the water quality criterion of 10 CFU/cL for raw drinking water with disinfection only. The remainder of the values collected at this site were well below this criterion. There are no obvious sources of these coliforms but as some contamination is occurring, an objective is proposed for this characteristic in Quatse Lake. The proposed objective states that the geometric mean concentration of at least five samples collected in a 30-day period should not exceed 10 CFU/cL. It is expected that the high level of chlorination that is applied to the drinking water due to true colour concentrations is sufficient to deal with pathogens.

6.0 FUTURE MONITORING

The following schedule is recommended in order to monitor parameters for which water quality objectives have been set.

Table 6.1 Monitoring Schedule.

Site Number	Location	Frequency/Date	N	Parameter
E216693	Quatse Lake at Deepest Point	During Spring overturn (surface, mid-water and bottom)	3	Total Phosphorus
E216695	Quatse Lake at Water Intake	Four times per year: January, April, July and October	4	pH, True Colour, Turbidity
E216695	Quatse Lake at Water Intake	5 samples in 30 days, preferably in summer (July or August)	5	Fecal Coliforms
E216696	Treated water supply	Four times per year: January, April, July, and October	4	True Colour, Trihalomethanes

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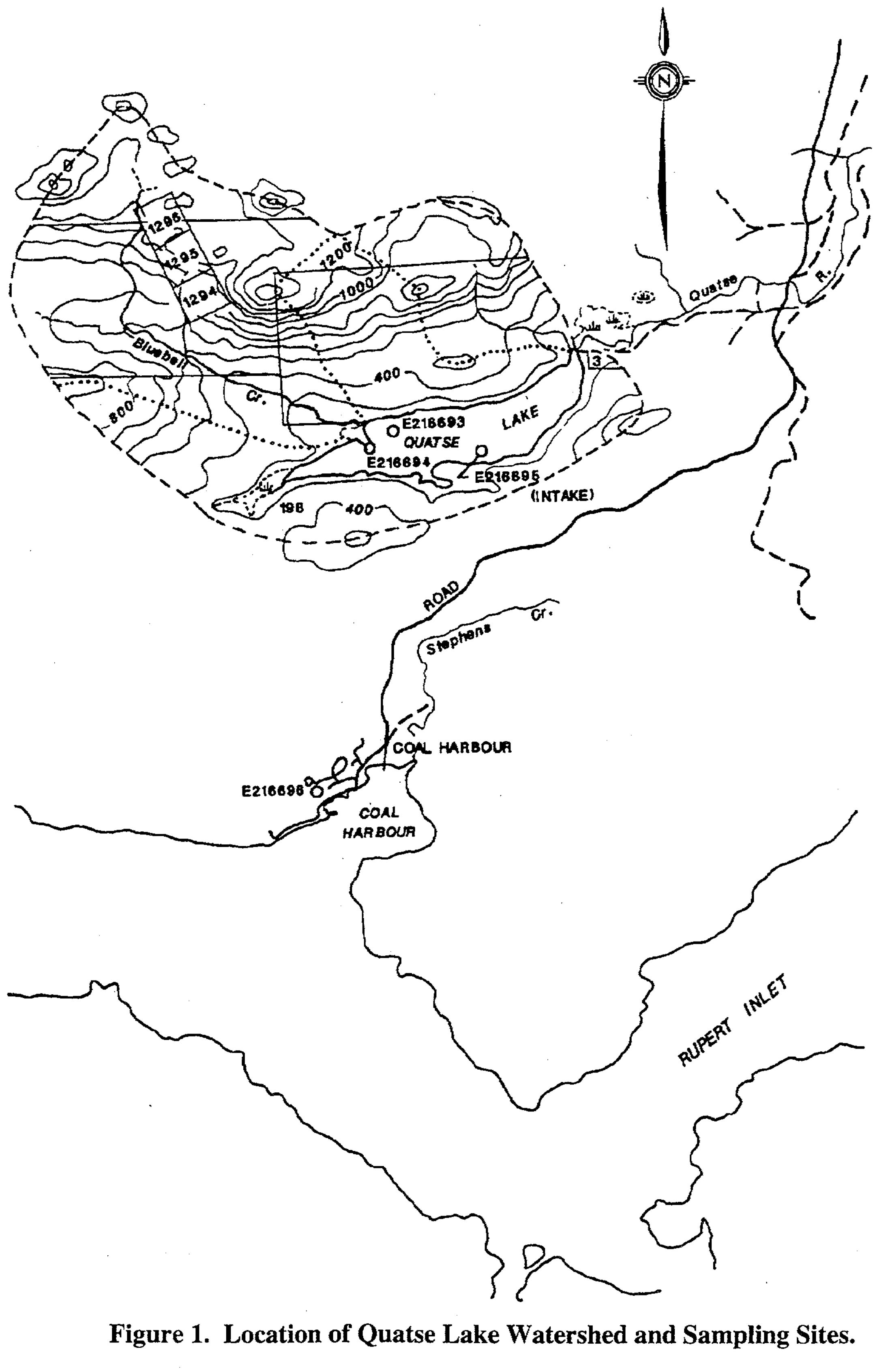

Figure 1. Location of Quatse Lake Watershed and Sampling Sites.

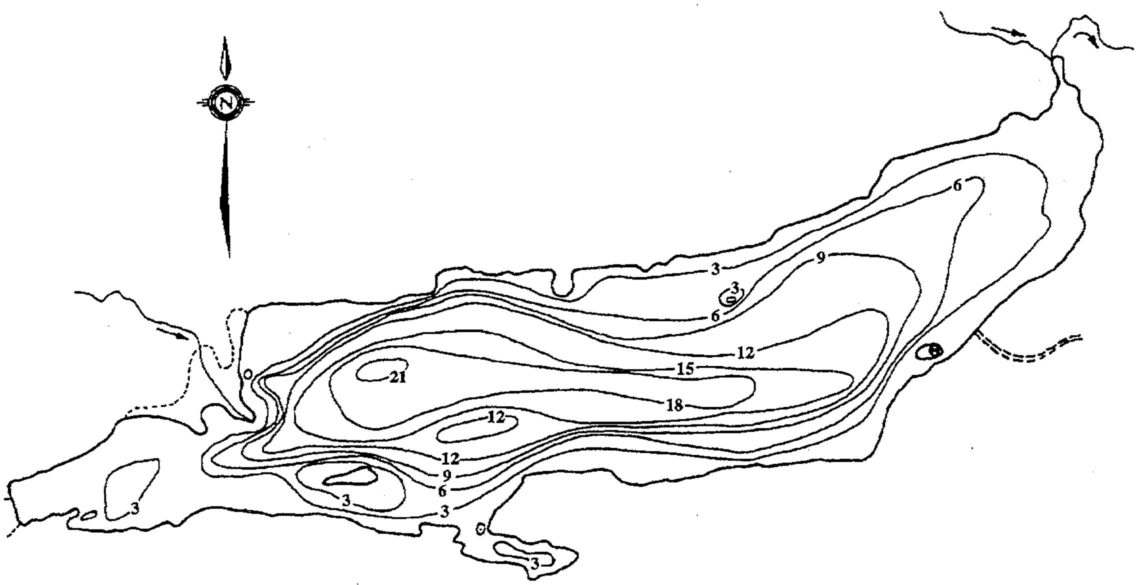

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Figure 2. Bathymetric Map of Quatse Lake

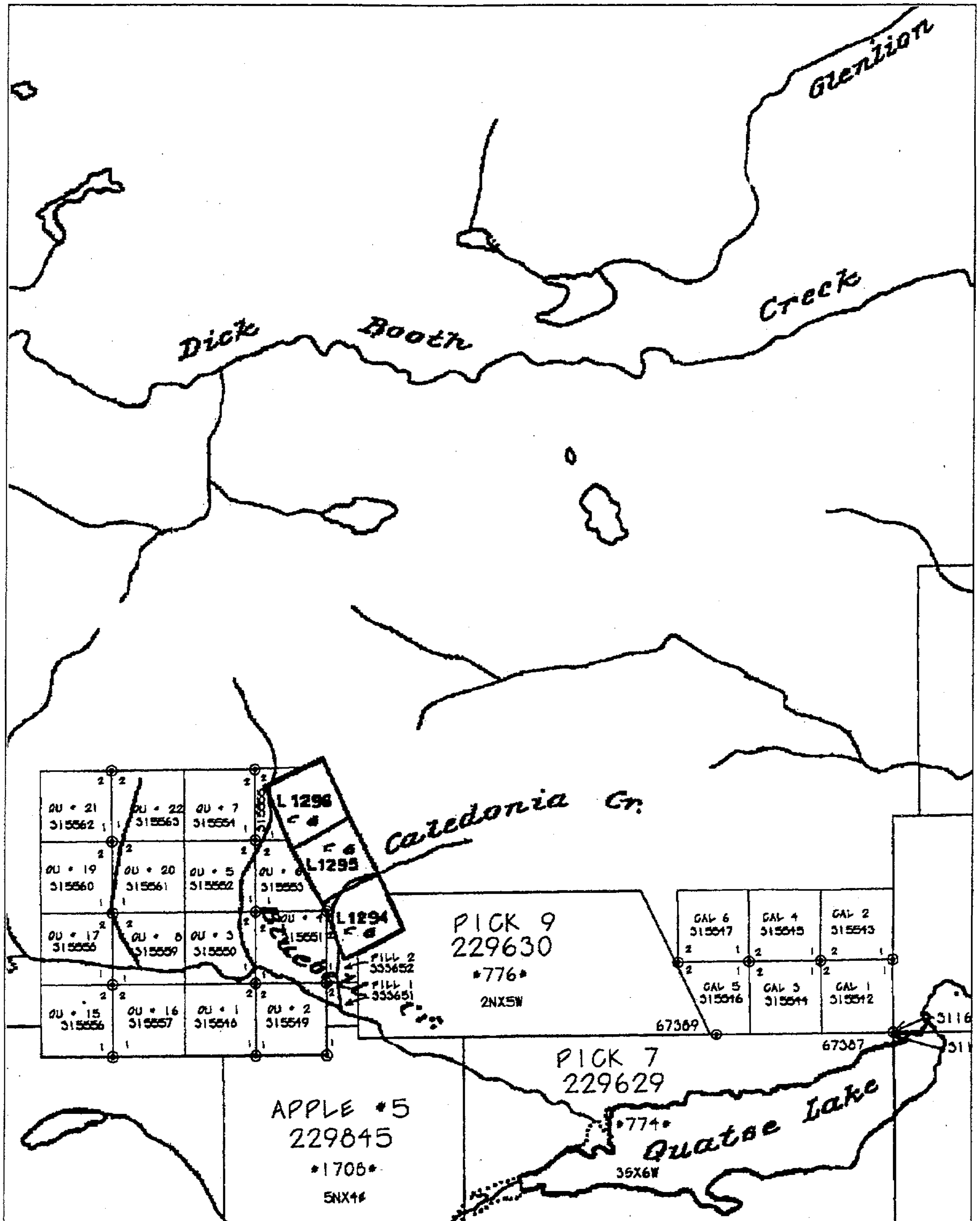

Figure 3. Mining Claims in Quatse Lake Watershed

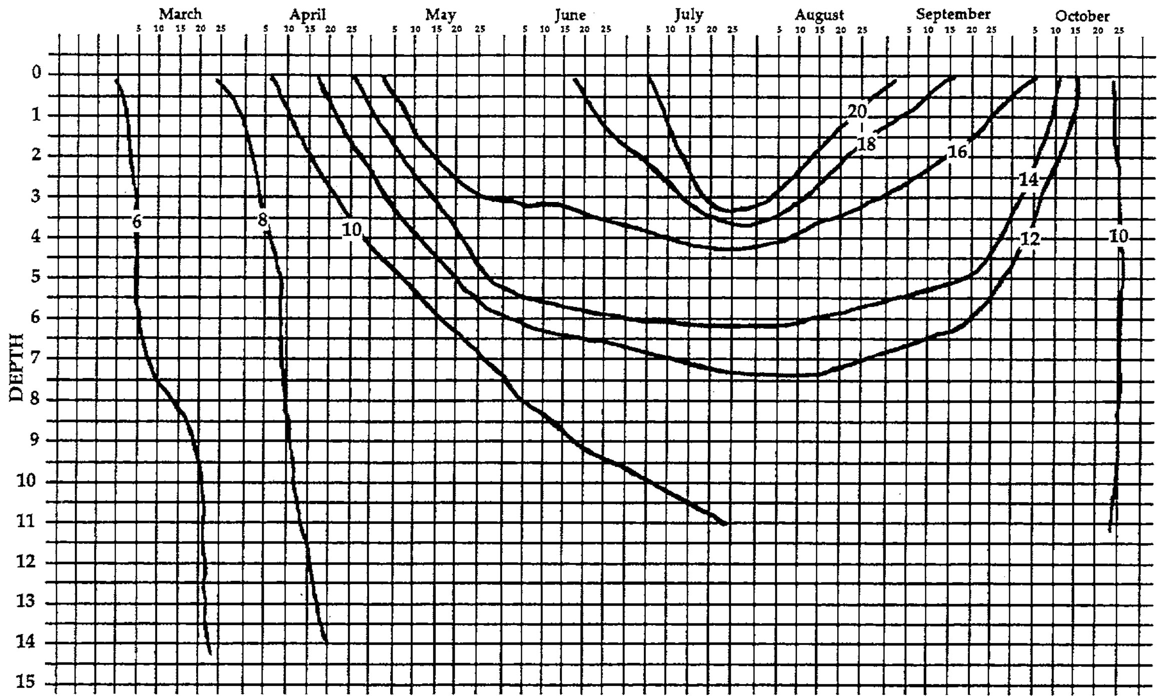

Figure 4. Time-Depth Diagram - Temperature (in degrees C) Stratification of Quatse Lake, 1992

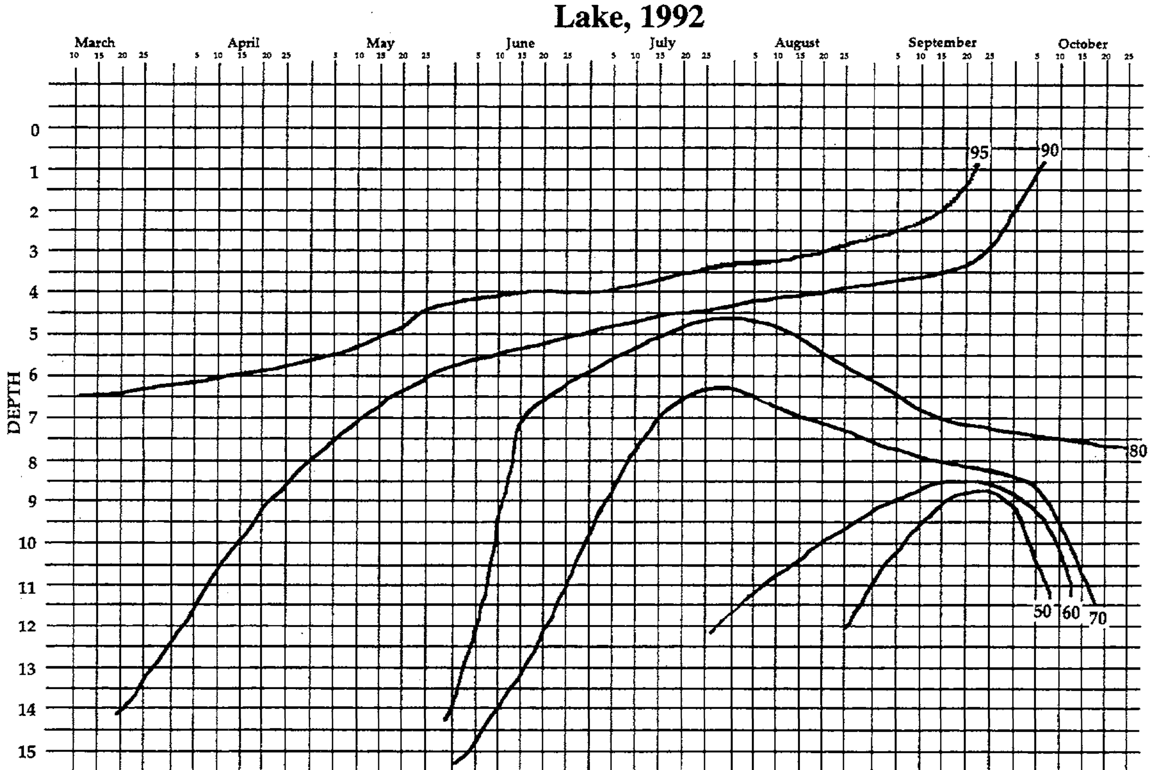

Figure 5. Time-Depth Diagram - Dissolved Oxygen Stratification (percent saturation) of Quatse Lake in 1992.

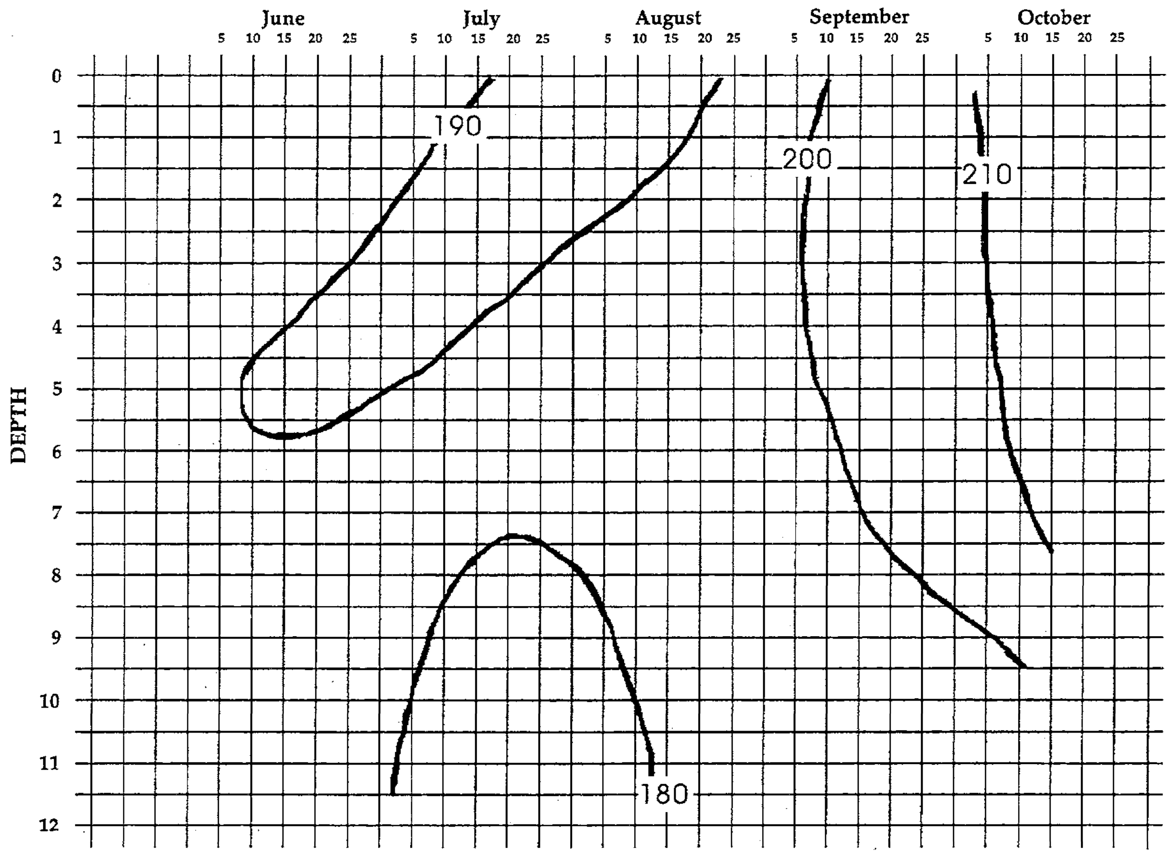

Figure 6. Time-Depth Diagram - Specific Conductance (in uS/cm) in Quatse Lake, 1992.

Table 5.2.1. Ambient Water Quality Data Summary
Quatse Lake Site E216693 (lake centre) for 1992

Characteristics*	Number of	Minimum	Maximum	Mean	Std. Dev.
GENERAL IONS					
Alkalinity	2	5.5	5.9	5.7	0.3
Carbon - total	2	12	16	14	2.8
Chloride	2	2.6	2.7	2.65	0.07
Colour (true) TCU	9	55	100	82	17
pH (pH units)	2	6.1	6.3	6.2	0.14
Potassium	7	all <0.4			-
Silica	2	3.1	3.2	3.15	0.07
Sodium	9	1.50	1.9	1.67	0.14
Solids - dissolved	1	54			-
Solids - suspended	9	<1	13	2.6	3.9
Specific cond (µS/cm)	2	22	23	22.5	0.7
Sulphate	2	both 4.1			0
Turbidity	9	0.1	1.6	0.6	0.38
METALS (total)					
Aluminum	9	0.21	0.41	0.26	0.06
Arsenic	9	all <0.04			0
Calcium	9	1.29	2.34	1.63	0.34
Fluoride	2	both <0.1			0
Iron	9	0.15	0.56	0.28	0.13
Magnesium	9	0.38	0.57	0.46	0.07
Manganese	9	0.01	0.04	0.016	0.01
Nickel	9	all <0.01			0
Silver	9	eight @ <0.01	one @ 0.03	median <0.01	
NUTRIENTS					
N - ammonia	9	<0.005	0.012	<0.0087	0.003
N - Kjeldahl	9	0.150	0.220	0.185	0.02
N - nitrate + nitrate	9	all <0.020			0
P - tot. diss.	9	<0.003	0.004	0.003	0.0003
P - total	9	<0.003	0.014	0.0059	0.003
BIOLOGICAL					
Chlorophyll a	4	1.7	5.8	3.2	1.9
Fecal coliforms	4	two@<2, one@8	190	50.5	93

*all units mg/L except as noted

Table 5.2.2. Fecal Coliform Concentrations at Water Intake (Site E216695)

Date	Depth (m)	Fecal Coliforms CFU/cL
92/05/26	0.5	<2
92/08/11	0.5	1
92/10/21	0.5	11

Table 5.2.3. Water Quality Summary for Coal Harbour Treated Water Supply Site E216696

Characteristic	Units	Value
Color TC	Col.unit	50
pH	pH units	6.3
Dissolved Solids	mg/L	54
Suspended Solids	mg/L	1
Specific	uS/cm	48
Turbidity	NTU	1.1
Alkalinity	mg/L	5.4
Chloride:D	mg/L	9.7
FluordeD	mg/L	<0.1
NO.NO.:D	mg/L	<0.02
Sulphate:D	mg/L	3.1
Hardness	mg/L	5.1
Aluminum	mg/L	0.25
Arsenic	mg/L	<0.001
Barium	mg/L	<0.01
Boron	mg/L	<0.01
Cadmium	mg/L	<0.0005
Calcium	mg/L	1.35
Chromium	mg/L	<0.01
Cobalt	mg/L	<0.1
Copper	mg/L	0.05
Cyanide (SAD)	mg/L	0.022
Iron	mg/L	0.32
Lead	mg/L	0.001
Magnsium	mg/L	0.41
Mangnese	mg/L	<0.01
Mercury	ug/L	<0.05
Molybdenum	mg/L	<0.01
Nickel	mg/L	<0.05
Potasium	mg/L	0.1
Silver	mg/L	<0.0005
Sodium	mg/L	7.3
Uranium	mg/L	<0.0002

Table 5.2.4. Trihalomethane Concentrations in Samples Collected at Various Sites in Coal Harbour (all from treated water supply).

Characteristic*	Coal Harbour Treated Water Supply	Tap - Coal Harbour		Tap - Getman Residence (next to school)
Date	92/01/28	92/03/03	92/09/29	
Color TC	50	60	30	40
bromodichloromethan	0.001	0.002	0.002	0.002
bromoform	<0.001	<0.001	<0.001	<0.001
chloroform	0.14	0.1	0.16	0.16
chlorodibromomethan	<0.001	<0.001	<0.001	<0.001

*all units mg/L except colour (colour units)

Appendix 1. QA/AC Replicates and Blank Collected at Site E216693

Characteristic	Units	Replicates							Blank
Date		92/03/11	92/03/11	92/03/11	92/03/11	92/03/11	92/08/11	92/08/11	92/03/11
Time		00:00	00:00	00:00	12:01	12:02	00:00	00:00	00:00
Lower		20	20	0.5	0.5	0.5	0.5	0.5	0
Color TC	Col.unit	100			100	100		55	<5
pH	pH units								
Suspended Solids	mg/L	1			<1	1		2	<1
Specific Conductance	uS/cm								
Turbidity	NTU	0.7			0.6	0.7		0.4	0.1
Alkalinity	mg/L								
Cyanide	mg/L								
Kjeldahl N	mg/L	0.17			0.19	0.19		0.18	<0.04
Inorganic Carbon	mg/L								
Chlorophyll a	ug/L						3.3		
Fecal Coliforms	CFU/cL		<2	<2					
Chloride:D	mg/L								
Fluoride:D	mg/L								
Ammonia:D	mg/L	0.006			<0.005	0.006		0.008	0.005
NO_2NO_3:D	mg/L	<0.02			<0.02	<0.02		<0.02	0.1
Silica:D	mg/L								
Sulphate:D	mg/L								
Silver:T	mg/L	<0.01			<0.01	<0.01		<0.01	<0.01
Aluminum:T	mg/L	0.25			0.24	0.25		0.21	<0.02
Arsenic:T	mg/L	<0.04			<0.04	<0.04		<0.04	<0.04
Boron:T	mg/L	<0.008			<0.008	0.035		0.079	<0.008
Barium:T	mg/L	0.003			0.003	0.004		0.003	<0.001
Beryllium:T	mg/L	<0.001			<0.001	<0.001		<0.001	<0.001
Bismuth:T	mg/L	<0.02			<0.02	<0.02		<0.02	<0.02
Carbon:T	mg/L								
Calcium:T	mg/L	1.24			1.29	1.68		1.52	0.07
Cadmium:T	mg/L	<0.002			<0.002	<0.002		<0.002	<0.002
Cobalt:T	mg/L	<0.003			<0.003	<0.003		<0.003	<0.003
Chromium:T	mg/L	<0.002			<0.002	<0.002		<0.002	<0.002
Copper:T	mg/L	<0.001			0.001	<0.001		0.002	<0.001
Iron:T	mg/L	0.251			0.238	0.245		0.154	0.009
Potassium:D	mg/L								
Potassium:T	mg/L	<0.4			<0.4	<0.4		<0.4	<0.4
Magnesium:T	mg/L	0.38			0.38	0.47		0.44	<0.02
Manganese:T	mg/L	0.011			0.01	0.011		0.011	<0.002
Molybdenum:T	mg/L	<0.004			<0.004	<0.004		<0.004	<0.004
Sodium:D	mg/L								
Sodium:T	mg/L	1.51			1.5	1.57		1.78	0.03
Nickel:T	mg/L	<0.008			<0.008	<0.008		<0.008	<0.008
Phosphorus:D	mg/L	0.003			0.003	0.003		<0.003	<0.003
Phosphorus:T	mg/L	0.006			0.005	0.005		<0.003	<0.003
Lead:T	mg/L	<0.02			<0.02	<0.02		<0.02	<0.02
Uranium:T	mg/L								
Zinc:T	mg/L	0.009			0.004	0.007		0.004	0.003