PROVINCE OF BRITISH COLUMBIA

B.C. MINISTRY OF ENVIRONMENT

COQUITLAM-PITT RIVER AREA

TRIBUTARIES TO THE LOWER FRASER RIVER ALONG THE NORTH SHORE

WATER QUALITY ASSESSMENT AND OBJECTIVES TECHNICAL APPENDIX

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Page

LIST OF FIGURES

LIST OF TABLES

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1.0 INTRODUCTION

1.1 BACKGROUND

The B.C. Ministry of Environment (MOE) is preparing water quality assessments and objectives in priority water basins in British Columbia. This report proposes water quality objectives for use by environmental managers and by the Greater Vancouver Regional District in preparing a liquid waste management plan. This report describes the water quality within that part of the Pitt-Coquitlam area downstream from Kanaka Creek and includes Kanaka Creek, the Coquitlam River, the Pitt River, and the Brunette River, as well as their tributaries (Figure 1). Presented within this report are data collected to about June 1986.

Some of the data are summarized as mean values, or often as median values. The reason for this difference is that many data were collected over long time-periods during which many detection limits have existed. The author has used whichever of these two statistics had more meaning. Median values are usually reported for fecal coliforms and pH.

1.2 PROVISIONAL WATER QUALITY OBJECTIVES - BASIC PHILOSOPHY

Water quality objectives are to be established in British Columbia for waterbodies on a site-specific basis[1]. The objective can be a physical, chemical, or biological characteristic of water, biota, or sediment, which will protect the most sensitive designated water use at a specific location with an adequate degree of safety[1]. The objectives are designed to protect the most sensitive designated water use on a site-specific basis with due regard to ambient water quality, aquatic life, waste discharges, and socio-economic factors[1].

Water quality objectives are based upon both working and approved water quality criteria which are characteristics of water, biota or sediment[1] that must not be exceeded in order to prevent specified detrimental effects from occurring to a water use[1]. The working criteria come from the literature, and are referenced in the following chapters. Usually, the Canadian Water Quality Guidelines, prepared by a task force of the Canadian Council of Resource and Environment Ministers, are used[2]. Approved criteria are those that have been developed by the B.C. Ministry of Environment, and which supersede the working criteria. At the time of writing, approved criteria have been developed for ten characteristics, with a similar number in preparation.

Generally, objectives will only be set in reaches where man-made influences threaten a designated water use, either now or in the foreseeable future. Provisional objectives are proposed in this report, and are to be reviewed as more monitoring information becomes available and as the Ministry of Environment establishes additional approved water quality criteria.

The provisional objectives take into account the use of the water to be protected and the existing water quality. They allow for changes from background which the Ministry of Environment feels can be tolerated, or for upgrading of water quality which may be required. Any change from background which is allowed indicates that some waste assimilative capacity can be used while still maintaining a good margin of safety to protect designated water uses. In cases of water quality degradation, objectives will set the goal to be met by necessary corrective measures.

The objectives do not apply to initial dilution zones of effluents, an area set aside for initial mixing of effluent and receiving water. These zones are defined as extending up to 100 m downstream (and up to 100 m upstream at times of tide reversal) from a discharge, and occupying no more than 25 to 50 percent of the width of the river, from its bed to the surface.

The severity of conditions within initial dilution zones is controlled by permits issued pursuant to the Waste Management Act. In practice, small volume discharges or discharges with low levels of contaminants will require mixing zones much smaller than the maximum initial dilution zone allowed to meet the objectives. Conversely, large volume discharges could cause water quality objectives to be exceeded beyond 100 m. The concentrations of contaminants permitted in effluents are such that levels in the initial dilution zones normally will not be acutely toxic to aquatic life or create objectionable or nuisance conditions. Processes such as chemical changes, precipitation, absorption, volatilization, oxidation, photolysis, and microbiological action as well as dilution take place in these zones, normally ensuring that objectives will be achieved at their borders.

When dealing with limited data bases, natural variability can be noted, and comments made on whether extremes exceed water quality criteria. This doesn't necessarily mean that there is a problem since these extremes may by inherent in the drainage in question. These are factors which must be understood before specific objectives can be finalized.

2. KANAKA CREEK

Kanaka Creek is 18 km long and enters the Fraser River from the east upstream from Haney (Figure 2). It has a drainage area of about 50 km^2.

Kanaka Creek is generally undeveloped along its length, and in its lower reaches has a grassy shoreline which at times is flooded. Its upper reaches are in rugged terrain, with some housing and hobby farms. The GVRD has established a Regional Park in the upper reaches.

2.1 HYDROLOGY

Flows in Kanaka Creek are typical of creek flows in the Lower Mainland, reflecting the influence of wet autumns, winters, and springs and drier summer periods. Low flows usually occur from July to September, while peak flows occur from November through March. The mean flow for the period 1960 to 1982 was 2.89 m^3/s. Seven-day low flows were 0.148 m^3/s for a 2-year return period and 0.086 m^3/s for a 10-year return period.

2.2 WATER USES

Kanaka Creek is used for swimming, boating, canoeing, and rafting. It contains populations of coho and chum salmon, and is being stocked with cutthroat and steelhead trout from hatcheries. A large set of waterfalls 8 km upstream from the mouth prevents migration further upstream. Spawning of coho occurs throughout the upper reaches up to the falls, while pink and chum salmon spawn throughout the central and lower reaches[28].

Mean escapements for these salmon are provided below:

MEAN YEARLY ESCAPEMENTS

	COHO	CHUM	PINK
1950-1959	213	1 255	-
1960-1969	63	123	-
1970-1979	278	975	-
1980-1983	188	1 200	-
1981-1985 (odd years only)	-	-	50

Coho salmon spawn between late October and late January with the peak in late November, while chum salmon spawn between mid-October and mid-November[(28)]. Pink salmon spawn in mid to late October. Heavy rains in 1955 and 1956 caused severe damage to both chum and coho spawning. Escapement levels only returned to those of the 1950's in the 1970's.

Rearing habitat is distributed evenly downstream from the falls. A small fish hatchery is present in Kanaka Creek Regional Park about one kilometre upstream from the waterfalls which uses Kanaka Creek as the water supply. Fish are transported by truck and released downstream from the waterfalls. In 1987, the hatchery was scheduled to produce 100 000 each of chum and pink salmon, 60 000 coho salmon, 19 000 cutthroat trout, and 9 500 steelhead trout. The success of the hatchery program, as measured by spawning escapement, was to be evaluated in 1987/1988. The hatchery is operated through support from the Save the Salmon Society, the Salmonid Enhancement Program, the B.C. Ministry of Environment (Fisheries), the GVRD Parks Department, and the B.C. Attorney General (Corrections Branch).

Consumptive licensed water uses include three withdrawals totalling 6.8 m^3/d for drinking water, two withdrawals totalling 12.6 dam^3/year for irrigation, and one withdrawal of 3 914 m^3/d for the fish hatchery.

2.3 WASTE DISCHARGES

Two sources of contaminants with permits are in this watershed: a landfill and the discharge of treated sewage from a dog kennel. These sites can be referred to on Figure 2 by their waste management permit numbers. Water from the hatchery, which is an incubation/early release type, would constitute a discharge which occurs to the creek without a permit.

2.3.1 BOCHEE KENNELS (PE 3874)

This company operates a kennel to the west from North Kanaka Creek. Wastewater is kennel washdown water which is treated in a 4.5 m^3 septic tank. The treated effluent is discharged to 114 m of tile field which is located about 150 m from North Kanaka Creek.

Permit PE 3874 allows the discharge of a maximum of 3.2 m^3/d. No data on the treated effluent exist.

Effluent from this operation should not cause any problems in the creek due to its small volume, and the fact that the effluent is discharged to a soil disposal system nearly 150 m from the creek.

2.3.2 CORPORATION OF THE DISTRICT OF MAPLE RIDGE (PR 1710)
(Cottonwood Drive Site)

The District of Maple Ridge operates a landfill, located about 3 km from Haney. An unnamed creek, which is a tributary to Kanaka Creek, is about 100 m to the east. This tributary supports populations of cutthroat trout.

Permit PR 1710 allows the discharge of 129 m^3/d of municipal solid waste to this site. However, the District has requested an amendment to the permit, which would increase the area of the landfill slightly, but would decrease the amount of waste disposed to 70 t/d.

Leachate from the site is collected in a pond and is pumped to the sewage collection system, for subsequent treatment at the Annacis Island Sewage Treatment Plant (STP). The leachate volume would depend on rainfall volumes. Surface water entering the site is diverted from the site by a series of drains.

Data are in Table 1 for samples collected in a nearby ditch. Other data for samples collected at about the same time are not in this report, since they are similar to those in Table 1. It is important that children not play in these contaminated waters. If the ditchwater is typical of leachate quality, the impact on the Annacis STP could be estimated if leachate flows were known.

In terms of past impacts on Kanaka Creek, the data indicate that the leachate from the landfill often had high concentrations of several contaminants (see Table 1), especially copper, ammonia and fecal coliforms. These could have had a significant impact on the receiving water, depending on the degree of dilution.

2.3.3 NON-POINT SOURCES

Major non-point sources of contaminants to Kanaka Creek are from septic tanks and agriculture. The amount of land in the agricultural land reserve is depicted in Figure 3. The reserve area draining to Kanaka Creek amounts to about 12.3 km^2. Based on a yearly rainfall of 1 900 mm and concentrations from Ferguson and Hall[14] of 3000 MPN/100 mL fecal coliforms, 3 mg/L each of suspended solids and BOD_5, 2 mg/L total nitrogen, 0.1 mg/L total phosphorus, and 0.003 mg/L each of total copper, lead, and zinc, the following annual loadings were calculated:

Potential Loadings (per year) to Kanaka Creek Drainage From Agricultural Sources

BOD_5	70 110 kg
Suspended Solids	70 110 kg
Total Nitrogen	46 740 kg
Total Phosphorus	2 340 kg
Total Copper	70 kg
Total Lead	70 kg
Total Zinc	70 kg
Fecal Coliforms	7×10^8 Organisms

The number of septic tanks in this watershed is about 900, based on the number in the Serpentine and Little Campbell River drainages[13] with interpolation on the basis of land area. This interpolation would only be valid if rural population densities are the same. Assuming that 10% of the loading to each septic tank could reach Kanaka Creek due to outflow or septic tank failure, and that a flow of 2.3 m^3/d per residence would occur at suspended solids and BOD_5 concentrations of 250 mg/L, 25 mg/L of ammonia, and 24×10^6 fecal coliform organisms/100 mL, the following yearly loadings could occur:

Potential Loadings (per year) to Kanaka Creek
from Septic Tanks

BOD_5	18 900 kg
Suspended Solids	18 900 kg
Ammonia	1 890 kg
Fecal Coliforms	1.8×10^{13} organisms

Increases due to non-point sources in Kanaka Creek could be signficant. The impact on the water quality in the creek would depend upon the actual release period, creek flow, and the actual amount reaching the creek. However, since the majority of these loadings would reach the creek during periods of higher flow, their impact was estimated by use of the mean flow (Section 2.1) of 2.89 m^3/s. Potential increases would be 0.2 mg/L for each of BOD_5 and suspended solids, 0.02 mg/L for ammonia, and 20 MPN/100 mL fecal coliforms. These increases are not particularly high, considering the crude estimates used.

Whitfield and Dalley [3] have found that the acidity of rainfall on Kanaka Creek can have severe impacts. This is discussed more fully in Section 2.4.1.

Swain [20] reported on the quality of precipitation in discrete samples collected during a one year period in 1980 and 1981 in Vancouver. Mean values (based on 150 to 300 measurements) were: pH, 4.85; total cadmium, 0.0012 mg/L; total copper, 0.011 mg/L; total lead, 0.033 mg/L; total zinc, 0.056 mg/L; ammonium-nitrogen, 0.20 mg/L; nitrate-nitrogen, 0.96 mg/L; and nitrite-nitrogen, 0.033 mg/L. These data reflect the acidic nature of rainfall in the lower mainland and the potential for the rainfall to influence metals and nutrients in the receiving waters.

2.4 AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

A data summary for the water quality of Kanaka Creek is in Table 2 for Site 0300024 near the mouth and Site 0300025 further upstream. A study conducted by B.C. Research for the GVRD in 1979 had results similar to those reported herein[34]. Therefore, no further references will be made to the GVRD study. Inland Waters has operated a continuous recording monitoring station on Kanaka Creek since August 1984, which records pH at 15-minute time intervals at the fish hatchery, about seven kilometres upstream from the mouth. This would be near Site 0300025.

Designated water uses for Kanaka Creek are aquatic life and wildlife, irrigation and livestock watering, primary-contact recreation, and drinking water supplies (complete treatment).

2.4.1 pH AND ALKALINITY

Inland Waters Directorate of Environment Canada has indicated that the pH in the creek can be decreased by more than 1.0 pH unit due to the input of large volumes of precipitation[3]. As well, values as low as 6.2 have been recorded by Inland Waters[3] during low or no precipitation periods, and 4.8 during periods of high precipitation[3]. These low pH values and large fluctuations arise from the acidic nature of precipitation in the Lower Mainland, as well as from the fact that the runoff would enter the creek relatively quickly in the upper reaches. This, in turn, would reduce the amount of buffering which could be imparted to the water from contact with the soil.

Whitfield and Dalley reported on studies of Kanaka Creek between August 1984 and May 1985. They found that "during periods without rain, Kanaka Creek exhibits similar characteristics with respect to pH and flow irrespective of the season of the year"[3]. At such times, the average pH varied from 6.20 to 6.40.

In 14 storms with a maximum rainfall of greater than 20 mm/day, the largest depressions in stream pH occurred when the base flow of the stream was lowest[3]. When the stream flow was less than 0.5 m^3/s, the pH decreased by greater than 1.0 unit, but decreased from 0.8 to 1.0 unit at stream flows greater than 0.5 m^3/s.

"Each rainstorm in the Kanaka Creek area resulted in some depression of pH values within the Creek. The largest rainstorms result in the largest depressions in stream pH. On some occasions, instantaneous measurements of pH reached values as low as 4.8"[3]. Survival of fish eggs can be affected at pH values <6.0[27].

At Site 0300024, pH values have ranged from 6.2 to 7.4, while at Site 0300025, the range has been 5.9 to 7.3 (Table 2). These lower values reflect rainfall, and do not meet the range of 6.5 to 8.5 to protect drinking water supplies[4] or 6.5 to 9.0 to protect aquatic life[2]. Values at Site 0300025 would reflect conditions similar to those observed by Whitfield and Dalley, since the stations are at about the same location. The pH at Site 0300024 may not be influenced by precipitation to the same degree as upstream, due to the gentler slope of the watershed further downstream with its larger soil profile.

Agricultural practices in the watershed can contribute nitrogen to the creek. Since the toxicity of ammonia increases at higher pH values, it is desirable to maintain lower pH values in order to minimize ammonia impacts in the creek.

Since both drinking water supplies and aquatic life need to be protected, the upper value of the pH range should be 8.5 instead of the maximum of 9.0 allowed by the criteria for the protection of aquatic life[2]. In addition, due to the acidic nature of the rainfall, it is desirable that the pH regime in the Creek does not become too acidic. Therefore, a provisional objective is proposed for pH in Kanaka Creek. Since the lower pH value is not achieved, the objective will be a long-term objective. The objective is that the pH should not be outside the range 6.5 to 8.5, except in initial dilution zones of effluents should any effluents be discharged to the creek in the future. These excluded initial dilution zones are defined as extending up to 100 m downstream from the discharge point, and up to 50% across the width of the stream, from the surface to the bottom. In proposing this objective, it is recognized that during and after precipitation events the lower objective for pH in the creek may not be attained. To reduce the acidity of the precipitation and hence to reduce the impact of precipitation on the creek will require an extensive study of atmospheric sources, weather patterns, and other factors. It may be possible that the pH of precipitation falling on Kanaka Creek is not affected by emissions which can be controlled, and hence the pH itself may not be controlled.

Alkalinity values in the creek have been as low as 3.1 mg/L at Site 0300025 (Table 2). Values of this magnitude indicate that Kanaka Creek is highly sensitive to acidic inputs (<10 mg/L). The alkalinity values indicate that the creek has slightly more buffering capacity downstream toward the mouth.

2.4.2 HARDNESS AND METALS

Kanaka Creek would be classed as having "soft" water, with a maximum value of less than 40 mg/L. The toxicity of metals is increased in soft water. The creek is slightly softer further upstream than at the mouth.

Most metals were less than detection or working water quality criteria. Some exceptions to this were as follows. The maximum total chromium value of 0.005 mg/L at Site 0300024 met the criterion of 0.020 mg/L to protect fish(2), but not the criterion of 0.002 mg/L to protect phytoplankton and zooplankton(2). However, only one of 15 values was detectable, all others were <0.005 mg/L. This maximum chromium value may be background or related to leachate from the landfill.

The maximum total copper value of 0.005 mg/L at Site 0300024 (Table 2) exceeded the draft B.C. criteria of 0.002 mg/L as a 30-day average value and 0.0027 mg/L as a maximum value at a hardness of 7 mg/L(5). However, the other 15 copper values did not exceed 0.002 mg/L. Copper concentrations in rainfall have been measured (mean value: 0.011 mg/L) at levels higher than this maximum (Section 2.3.3).

Iron values were as high as 4.9 mg/L at Site 0300024 (Table 2). All iron values equalled or exceeded the working criteria of 0.3 mg/L for drinking water (aesthetics)(4) and aquatic life(2). Manganese values were as high as 0.14 mg/L, and exceeded the drinking water criterion for aesthetics of 0.05 mg/L(4) on 5 of 20 occasions at Site 0300024 and 2 of 14 occasions at Site 0300025. If suspended solids are removed prior to using the water for drinking, these high levels may be reduced.

The maximum total lead values of 0.028 mg/L at Site 0300024 (Table 2) and 0.012 mg/L at Site 0300025 exceeded the B.C. criterion for a maximum (and average) value of 0.0034 mg/L to protect aquatic life(25). However, only 4 of 33 values exceeded this criterion level at both sites combined. These high levels could not be correlated to precipitation events, and the maximum values at the two sites were measured on two different occasions. However, it has been shown that high lead concentrations (mean = 0.033 mg/L) have been measured in rainfall (Section 2.3.3). This implies the possibility of an error in measurement. However, stormwater runoff from the Lougheed Highway near Site 0300024 could carry lead into the creek.

Swain and Walton reported on a sediment sample collected from Site 0300024 in November 1987(30). The particle size gradation of the sediments was approximately the same as for sediments collected at the same time from Still Creek. This is an important consideration in examining data for sediments since finer sized particles will sorb considerably higher concentrations of contaminants than will coarser particles. Levels (dry-weight) for the following metals were considerably lower in Kanaka Creek compared to Still Creek as follows:

	VALUE (µg/g : dry-weight)	
METAL	KANAKA CR.	STILL CR.
Boron	1.94	3.14
Cadmium	<0.10	1.18
Chromium	19.1	32.9
Copper	17.6	122.0
Lead	3.93	238.0
Mercury	0.018	0.12
Molybdenum	<5.0	26.0
Nickel	15.7	24.3
Tin	3.0	5.31
Zinc	45.2	256.0

Still Creek has been impacted significantly by anthropogenic activities. These data indicate that by comparison, sediments in Kanaka Creek have not been exposed to significant impacts.

Sediment samples collected in 1979 by B.C. Research for the GVRD(34) were very fine textured near the mouth (30% <0.063 mm) at Site 51 but much coarser at Sites 53, 55, and 58 (over 65% > 4 mm). Cadmium, copper, lead, and mercury concentrations at the mouth were about twice those at the other three sites. Values found in 1987 at the mouth were about the same as found earlier at Sites 53, 55, and 58. It is not known if the lower values in 1987 reflect actual decreased concentrations or the fact that two different laboratories performed the analyses.

2.4.3 NUTRIENTS

The maximum nitrite, nitrate, and ammonia values (Table 2) were well below approved B.C. water quality criteria[6] for the protection of freshwater aquatic life. The maximum ammonia-nitrogen was 0.149 mg/L, while the maximum nitrite-nitrogen was 0.009 mg/L, both at Site 0300024. The maximum nitrate of 1.28 mg/L at Site 0300024 is ample to support periphyton growth if other factors are not limiting. As will be discussed later in this section, there are some high phosphorus levels and therefore it may be desirable to have an objective for periphyton growth.

Agricultural practices within the watershed can contribute some nitrogen to the creek, but at present, there do not appear to be elevated ammonia or nitrite levels in the creek for the protection of freshwater aquatic life.

To ensure that nitrogen levels remain within an acceptable range, provisional objectives are proposed for nitrite and ammonia levels along the length of Kanaka Creek. The proposed objectives are that the maximum nitrite-nitrogen should not exceed 0.06 mg/L while the 30-day average should not exceed 0.02 mg/L. The maximum ammonia-nitrogen should not exceed the values listed in Table 3, and the 30-day average should not exceed the values listed in Table 4. The objectives apply outside the initial dilution zones of effluents, described in Section 2.4.1. The 30-day averages are to be calculated from at least five weekly samples taken in a period of 30 days.

The maximum total phosphorus value of 0.087 mg/L was recorded at Site 0300025 (Table 2), while the maximum dissolved phosphorus (0.041 mg/L) and dissolved orthophosphorus (0.03 mg/L) were recorded at Site 0300024. The high phosphorus values can be a concern with regard to periphyton growth in Kanaka Creek, especially in the lower reaches where the channel slope is significantly less than in the upper reaches.

Swain and Walton[30], in a comparison of lower Fraser River tributaries, reported that except for one site on the Brunette River, phosphorus levels were the lowest for sediment at the site (0300024) on Kanaka Creek compared to eleven other sites. This may indicate that significant levels of phosphorus are not entering Kanaka Creek, or it may be related to the fact that the Kanaka Creek sediment particle size distribution was such (i.e., larger sized particles than in other sediments except Still Creek) that the relatively small surface area could not sorb as much phosphorus.

Measurements of periphyton chlorophyll-*a* have not been made in Kanaka Creek. The B.C. criteria to protect aquatic life and to provide good areas for recreation are that the maximum value should not exceed 100 mg/m² and 50 mg/m², respectively[12]. Recognizing that there are no data on which to base an objective, but taking into account the fact that primary-contact recreation requires the low concentrations of chlorophyll-*a*, <u>a provisional objective is proposed for periphyton chlorophyll-*a*. The objective is that the average of at least five randomly located periphyton chlorophyll-*a* values from any site on the same day from natural substrate should not exceed 50 mg/m²</u>. The objective applies in all areas of the creek, except initial dilution zones of effluents, described in Section 2.4.1.

2.4.4 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

The question of what is an adequate dissolved oxygen level to support aquatic life has been addressed by many researchers and reviewers, including the CCREM[2], Davis[7], Sigma Resource Consultants (for the Department of Fisheries and Oceans)[8], and most recently by the Environmental Protection Agency[26].

Davis[7] expressed dissolved oxygen requirements of fish in terms of percent saturation. This can result in unnecessarily stringent criteria in cold months and potentially unprotective criteria with high ambient temperatures[26]. The criteria document[8] prepared for DFO by Sigma Consultants provided information and the rationale to use a single concentration of oxygen (7.8 mg/L) based on Davis[7] for the carefully controlled environment of a fish hatchery.

The EPA[26] determined that expressing criteria in terms of the concentration of dissolved oxygen available is more direct and easier to administer. This approach was evidently supported by the Research Advisory Board of the International Joint Commission (IJC) which concluded that such criteria were scientifically sound because the rate of oxygen transfer across fish gills is directly dependent on the mean difference in oxygen partial pressure across the gill[26]. The total amount of oxygen delivered to the gill is a more specific limiting factor than is oxygen pressure per se[26].

The Canadian Council of Resource and Environment Ministers (CCREM)[2] has developed criteria for dissolved oxygen, based on the EPA criteria[26]. The criteria are based on warm-water or cold-water biota being present in a system. Cold-water systems were defined as any with at least one salmonid species present. In British Columbia, this definition for cold-water systems covers virtually the entire Province.

The EPA[26] had based its criteria, and discussed its findings, on the basis of salmonids and non-salmonids. The EPA[26] indicated that for salmonids there was no impairment at 11.0 mg/L when embryo and larvae were present or 8.0 mg/L for other life stages, and slight impairment at 9.0 mg/L and 6.0 mg/L, respectively. The EPA[26] based its criteria (accepted by CCREM[2]) on the slight impairment levels, and then arbitrarily added 0.5 mg/L to arrive at the criteria. In British Columbia, we are fortunate enough to generally have high quality waters, and there is no need to accept the slight impairment level.

Therefore, the limits which will be used as criteria in this document will be based on salmonids and should provide for no impairment (i.e., 8.0 mg/L and 11.0 mg/L minima).

Dissolved oxygen values have been good in the upper reaches of the creek, with values between 8.3 and 13.2 mg/L at Site 0300025. At this site, percent saturation values were within 20% of 100% saturation, an acceptable level of variation which will not normally cause stress to aquatic life.

Values for dissolved oxygen closer to the mouth at Site 0300024 were not as good, with a range from 4.6 to 13.6 mg/L (Table 2). Only 2 of 25 values were less than 8.0 mg/L. The value of 4.6 mg/L was measured in July, 1976, a time when heavy algal growth may have been present. Percent saturation values ranged from 50.2% to 127.8%. These extreme values in the range can cause stress to aquatic life. This will lead them to be more susceptible to other environmental stresses.

Mature salmonids are apparently not stressed at dissolved oxygen levels of 8.0 mg/L, but are slightly stressed at 6.0 mg/L[26]. These levels are always met at Site 0300025, but not at Site 0300024. As well, when fish eggs or alevins are present, the minimum value should be 8.0 mg/L (mid-October to February), while it should be as high as 11.0 mg/L when embryo larvae are present (March). Although there are insufficient data to confirm our prediction, we expect that these levels are maintained throughout the creek at those times of year.

Therefore, <u>provisional objectives for dissolved oxygen are proposed</u>. The <u>minimum dissolved oxygen value should not be less than 8.0 mg/L for most life stages nor less than 11.0 mg/L when embryo or larvae are present</u>. For the purpose of checking the objective, this latter objective will apply between November and March, yearly. These objectives apply to discrete samples or in-situ measurements made outside the initial dilution zones of effluents, described in Section 2.4.1.

2.4.5 SOLIDS AND TURBIDITY

Suspended solids can at times be high in Kanaka Creek, with values as high as 111 mg/L at Site 0300025 and 85 mg/L at Site 0300024 (Table 2).

Dissolved solids in the creek were low, with a maximum value of 64 mg/L at Site 0300024 (Table 2). This is well below the most restrictive working criterion of 500 mg/L for the protection of drinking water supplies[4].

Turbidity levels ranged to as high as 55 NTU at Site 0300025 and 69 NTU at Site 0300024. Levels in excess of about 5 NTU require physical treatment of the water to remove turbidity if it is to be used as a water supply[4].

Approved Ministry criteria for suspended solids and turbidity relate to induced levels, mainly associated with point discharges. Since suspended solids and turbidity in Kanaka Creek likely originate from diffuse sources, although historically they were also introduced from gravel pits, the criteria would be difficult to apply as site-specific objectives. However, where point or localized diffuse sources are identified, objectives for turbidity and suspended solids should apply. The proposed objectives are that induced suspended solids should not exceed 10 mg/L if background levels are ≦100 mg/L and should not be more than 10% of background if background levels are >100 mg/L. A plot of analytical precision for the suspended solids test and the proposed water quality objective (Figure 11) indicates that in the range of values form 30 to 240 mg/L, the proposed water quality objective could be more restrictive than what can be reproduced in the laboratory. In other words, the increase allowed by the proposed water quality objective could really be no increase at all over background. Sampling precision is also not considered.

In addition, to protect salmonid spawning areas, there should be no significant (95% confidence level) induced benthic sedimentation on the basis of accumulation by weight for particles <3 mm. For the purpose of determining achievement of the objective, the average downstream weight of at least three replicate samples should not exceed 110% of the upstream average of three replicate samples. Thirdly, induced turbidity should not exceed 1 NTU if background levels are <5 NTU, 5 NTU if background levels are ≦50 NTU, and should not be more than 10% of background if background levels are >50 NTU. These objectives apply outside the initial dilution zones of effluents, described in Section 2.4.1.

2.4.6 BACTERIOLOGICAL QUALITY AND COLOUR

Fecal coliform levels have ranged from 18 to 5400 MPN/100 mL at Site 0300024. Similar values were recorded at Site 0300025. It is suspected that the high measured values originated from agricultural operations in the watershed or to failed septic tank systems. When 90th percentile values exceed 100 MPN/100 mL, disinfection plus complete treatment would be required for drinking water supplies(4). To protect livestock, approved B.C. criteria(9) are: 200/100 mL each of Escherichia coli and fecal coliforms and 50/100 mL enterococci, as a maximum; while approved criteria for primary contact recreation are geometric means of ≦200/100 mL fecal coliforms, ≦77/100 mL of Escherichia coli, and ≦20/100 mL enterococci, and a 75th percentile of <2/100 mL Pseudomonas aeruginosa; and for irrigation are geometric means of ≦1000/100 mL for fecal coliforms and Escherichia coli and <250/100 mL enterococci for general irrigation; and geometric mean of ≦200/100 mL fecal coliforms, ≦77/100 mL for Escherichia coli, and ≦20/100 mL for Enterococci for crops eaten raw.

A long-term objective to protect drinking water use is proposed for Kanaka Creek. The objective is that the 90th percentile level should not exceed 100 MPN/100 mL fecal coliforms or escherichia coli, or 25/100 mL enterococci. To protect livestock in the short term, it is proposed that the maximum value not exceed 200/100 mL of fecal coliforms or Escherichia coli or 50/100 mL of Enterococci. The 90th percentile value is to be estimated from at least five weekly samples taken in a period of 30 days.

It should be noted that the sparse data in Table 2 suggest that water is highly coloured, exceeding 15 TCU aesthetic limit(4) and thus is undesirable for drinking, unless the colour is removed.

2.4.7 CHLOROPHENOLS

Swain and Walton[30] reported that chlorophenols could not be detected (<0.005 μg/g, dry-weight) as penta- or tetra-, or as tri- (<0.01 μg/g, dry-weight) in sediments from Site 0300024.

2.4.8 POLYCHLORINATED BIPHENYLS (PCBs)

No PCB isomers (1016, 1221, 1232, 1242, 1248, 1254, and 1260) could be detected (<0.03 μg/g, dry-weight) in sediments from Kanaka Creek[30].

2.4.9 OTHER ORGANIC COMPOUNDS

The following compounds could not be detected (detection limits on dry-weight basis in brackets) in sediments from Kanaka Creek: Aldrin (0.001 μg/g), alpha BHC (0.001 μg/g), gamma BHC (0.001 μg/g), beta BHC (0.001 μg/g), delta BHC (0.001 μg/g), chlordane (0.005 μg/g), 4,4'-DDD (0.003 ug/g), 4,4'-DDE (0.003 ug/g), 4,4'-DDT (0.003 μg/g), dieldrin (0.003 μg/g), endosulfan I (0.01 μg/g), endosulfan II (0.01 μg/g), endosulfan sulfate (0.01 μg/g), endrin (0.01 μg/g), endrin aldehyde (0.01 μg/g), heptachlor (0.001 μg/g), heptachlor epoxide (0.001 μg/g), and toxaphene (0.3 μg/g).

2.5 RECOMMENDED MONITORING

The objectives, as a minimum, should be checked at both Sites 0300024 and 0300025 with 5 samples collected in a 30-day period at least once from June through August, and once from December through March, yearly. Measurements should include pH, chloride, hardness, total and dissolved forms of chromium, copper, lead, manganese, and iron, nitrite, nitrate, ammonia, periphyton chlorophyll-*a*, total phosphorus, dissolved orthophosphorus, dissolved oxygen, temperature, suspended solids, substrate sedimentation, and fecal coliforms.

The exact program could be modified depending on available resources and regional priorities.

2.6 CONCLUSIONS

Flows in Kanaka Creek reflect wet winters and dry summers typical of the Lower Mainland. Only two operations are under permit near the creek, a landfill which has a leachate collection system but which was a significant source of contaminants to the creek in the past, and a dog kennel which discharges treated wastewater to a tile field. The most significant contaminant sources are likely agricultural in nature. These sources are located along the upper reaches of the creek, and could contribute phosphorus, nitrogen, suspended solids, turbidity, and fecal coliforms.

Kanaka Creek is acidic, with levels reflecting the acidic nature of rainfall in the Lower Mainland area. Values for pH are low enough in Kanaka Creek to possibly result in damage to fish eggs and possibly leach dissolved aluminum from surrounding soils. Buffering capacity to acidic inputs can be minimal at times, with the water being very soft, especially in the upper reaches. Some high total chromium, copper, iron, and lead values have exceeded working water quality criteria.

Nitrite, nitrate, and ammonia nitrogen are low enough to pose little concern. However, phosphorus values have been high enough to possibly cause nuisance algal growths. It is possible that these growths could occur in the lower reaches of the creek; the wide range of percent saturation values for dissolved oxygen support this supposition. Dissolved oxygen levels were high in the upper reaches, but some low values have been evident downstream. Generally, dissolved oxygen levels were high enough so that there will be no impairment to any life stages of salmonids.

Dissolved solids were well below all working criteria. Fecal coliforms were such that complete water treatment plus disinfection would be required prior to use, and the water is not satisfactory for livestock use.

3. PITT RIVER

The Pitt River between Pitt Lake and the Fraser River is about 20 km long (Figure 3). Pitt Lake is about 25 km long, while upstream from the lake, the Pitt River is about 50 km long (Figure 1). There is limited road access to the lake and to the river above it. A small number of cottages are on the shores of the lake.

The Pitt River has a drainage area of 515 km^2. The area surrounding the lower Pitt River and its tributaries is low lying. Major tributaries to the Pitt River below Pitt Lake include the North Alouette River and the Alouette River draining Alouette Lake. Dykes are located along the lengths of the Pitt, Alouette, and North Alouette Rivers. Mixed farming occurs (Figure 3) within the basin, with such types of operations as nurseries, mushroom farms, hobby farms, and livestock raising.

A major tributary to the Pitt River is the Alouette River, which divides about four km upstream from the Pitt River into the North Alouette River and the Alouette River. The Alouette River is about 21 km in length downstream from Alouette Lake and 10 km in length above the lake. The North Alouette River is also about 10 km long. The Alouette River has a drainage area of over 235 km^2, while that of the North Alouette River is over 40 km^2. There is a dam at the outlet from Alouette Lake.

3.1 HYDROLOGY

Flows in the Pitt River reflect the influence of wet winter weather in the Lower Mainland and a late spring-early summer freshet due to snowmelt. This combination of runoff results in low flows generally occurring during February or March. The mean flow for the period 1952 to 1965 at station 08MH017 at the mouth of the Pitt River is 54 m^3/s. Seven-day low flows were 8.47 m^3/s for a 2-year return period and 5.48 m^3/s for a 10-year return period.

Flows in the Alouette River are regulated while those in the North Alouette River are not. Flows in both are influenced by wet weather of the Lower Mainland during winter months. The mean flow from 1960 to 1982 (and 1911 to 1913) at station 08MH006 on the North Alouette River near Haney was 2.92 m^3/s. At station 08MH005 on the Alouette River near Haney, the mean flow was 7.34 m^3/s. Seven-day low flows were 0.199 m^3/s on the N. Alouette and 0.558 m^3/s on the Alouette for a 2-year return period. For a 10-year return period, these decreased to 0.105 m^3/s and 0.269 m^3/s, respectively.

Pitt Lake has a surface area of 53.8 km^2, a volume of 2 442 910 dam^3, a maximum depth of 143 m, a mean depth of 46 m, and is at an altitude of 1 m. Alouette Lake has a surface area of 16.1 km^2, a volume of 906 480 dam^3, a shoreline of 36 613 m, a maximum depth of 159 m and a mean depth of 71 m. It has a drainage area of 208 km^2. The discharge from the lake has been regulated by B.C. Hydro since 1925. This has caused a yearly fluctuation in water levels of 6.7 m.

3.2 WATER USES

The Pitt River in its lower reaches and Pitt Lake are used for boating, canoeing, rafting, and some swimming. There are no licensed withdrawals from Pitt Lake or the Pitt River, although 1235 dam^3 per year is used for preservation of wildlife habitat. There is a bird sanctuary at the outlet from Pitt Lake.

The Pitt River downstream from the lake contains large populations of coho salmon, steelhead and cutthroat trout, and some chum salmon. The Lower Pitt River also provides fishery stock for other drainage systems. The former International Pacific Salmon Fisheries Commission (IPSFC) started operation of a hatchery and incubation channels in 1963 at Carbold Creek, a tributary to the east of the Upper Pitt River just north from Pitt Lake (Figure 1). "The purpose of these facilities is to increase the sockeye salmon run from the Pitt River. Eggs are taken from the salmon at the natural Pitt River spawning grounds in late August until they reach the eyed stage and then placed in the incubation channels. The young sockeye rear in Pitt Lake for one or more years in the deep section of the lake between the Upper Pitt and Lower Pitt River estuaries. IPSFC has estimated that Pitt Lake has the capacity to rear ten million sockeye fry."[28].

Sockeye and chinook salmon arrive at Upper Pitt River in August and spawn in September and late August/September, respectively. Coho salmon arrive at Upper Pitt River in mid-September and spawn between early November and early February, peaking in December. Chum escapements between 1981 and 1985 averaged 50 fish per year, with spawning occurring from October to early November. Pink salmon have not been noted in escapement records since 1955, and steelhead since 1957[28]. The average escapement for sockeye, chinook and coho salmon has been as follows:

Average Yearly Escapement

	Sockeye	Chinook	Coho
1950-1959	27 000	1 325	2 150
1960-1969	17 400	980	2 730
1970-1979	22 400	1 300	10 450
1980-1983	16 900	250	4 250

Coho stocks generally seem to be increasing while those of chinook and sockeye seem to be decreasing. Erosion and silting in the 1960's (tributaries subject to quick runoff caused by logging) led to an estimated 50% loss of the sockeye spawn in 1966[28]. As well, extreme flooding in December, 1980 caused large amounts of scouring and gravel shifting throughout the river.

The Upper Pitt River also contains wild stocks of steelhead and cutthroat trout and Dolly Varden char.

The Alouette River is the most important tributary system in terms of the recreational fishery and hatchery production. The hatchery is operated by the Alouette Correction Centre (Section 3.3.3) under the Salmonid Enhancement Program (SEP). In 1985, the hatchery released the following numbers of juveniles: 249 000 chum salmon; 86 581 coho salmon; 44 000 steelhead trout; and 38 000 cutthroat trout[29].

Significant numbers of pink salmon and steelhead trout were last enumerated in 1955 and 1959, respectively. Coho salmon arrive in October and spawn between November and December. Chum salmon arrive in early October and spawn between mid October and late November. Pink salmon have been reported in the Alouette River in recent years, with 3500 being enumerated in 1985 and 500 in 1987. The average yearly escapement for coho and chum salmon has been as follows:

Average Yearly Escapement

	Coho	Chum
1950-1959	560	2 380
1960-1969	90	1 070
1970-1979	580	4 955
1980-1987	560	20 300

These data indicate significant improvements in escapement for chum salmon in recent years. There was a high degree of scouring and silting in the 1950's, in 1961 to 1963, 1966 and 1979, and the data above indicate that, likely as a result of this, stocks were depleted in the 1960's.

The North Alouette River continues to produce coho and chum salmon; however, significant numbers of pink salmon were last enumerated in 1955 and steelhead trout in 1957. Chum and coho arrive at the same time in the Alouette as in the North Alouette River. The average escapement for coho and chum salmon has been as follows:

Average Yearly Escapement

	Coho	Chum
1950-1959	350	1 815
1960-1969	155	330
1970-1979	440	1 310
1980-1983	275	2 250

These data indicate that stocks were depleted in the 1960's, but would seem to have returned to earlier levels. The 1960's saw a lot of erosion, siltation, and scouring.

Consumptive licensed water uses are as follows: 27 m^3/d for drinking water and livestock watering and 19.1 dam^3 per year for irrigation on the North Alouette River; 457 m^3/d for drinking water and 124 dam^3 per year for irrigation on the Alouette River; and 125 dam^3 per year for conservation (maintain wetlands area) on the Pitt River. On Alouette Lake, B.C. Hydro has licenses for power production using 186 255 dam^3 per year.

Alouette Lake, as well as both the Alouette and North Alouette rivers, are used for primary-contact recreation.

3.3 WASTE DISCHARGES

Seven sites with permits are located near the Alouette River or Alouette Lake, while only two are near the Pitt River. Those discharging to the Alouette River system will be discussed first. Sites with waste management permits are referenced on Figure 4 by the permit number.

3.3.1 BOULDER BAY CORRECTIONS CAMP (PR 2989)

This remote correctional facility is located on the east shore of Alouette Lake. A landfill is located at the camp, approximately 300 m from the lake. Municipal-type refuse is placed in the landfill, with paper, boxes, etc. being burned due to limited space. Leachate from the landfill has not been observed. Sanitary sewage is treated in a septic tank which is covered under a permit issued by the Ministry of Health.

Permit PR 2989 allows the placing of 3 m^3/week. Refuse is covered approximately every 20 days.

Due to the nature (non-industrial) and small size of the landfill, and the long distance to Alouette Lake, no impact is expected on water quality. No data have been collected on leachate from the site.

3.3.2 GOLDEN EARS PROVINCIAL PARK (PE 2988)

Wastewater is generated at this day-use site, located on the west shore of Alouette Lake, from May 15 to September 15, yearly. The wastewater originates from a change house and toilet facilities.

The wastewater is treated in a 114 m^3 septic tank, filtered in a 38 m x 23 m x 2 m sand filter, and discharged to Alouette Lake through a 366 m outfall into 10.7 m of water (at low water level).

Permit PE 2988 restricts the maximum discharge to 40.8 m^3/d. An effluent data summary is in Table 5. The few data for flow indicate that flows were less than authorized. Some high fecal coliform levels have also been measured. The close proximity of this operation to the outlet to the Alouette River likely assures good water movement. The following contaminant values were measured in 1984 and 1985: BOD_5, <10 mg/L; suspended solids, 20 mg/L; and fecal coliforms, 200 to 160 000 MPN/100 mL.

If the 2-year, 7-day low flow of 0.558 m^3/s for the Alouette River is assumed, the effluent is diluted by a factor of about 1180:1. Thus, even the high fecal coliform values would be diluted to levels suitable for all water uses except untreated or partially treated drinking water, with complete mixing at low flows. This discharge is therefore not believed to be a significant concern.

3.3.3 BCBC ALOUETTE CORRECTION CENTRE (PE 183)

This facility is located to the east from the Alouette River. It houses 225 inmates. Wastewater generated is typical domestic wastewater. It is treated in an extended aeration plant with disposal to tile fields.

The extended aeration plant consists of two aeration tanks and two clarifiers, however only one set is in use. The second set is used for sludge stabilization. There are two 183 m tile fields which are used during alternate months. They are about 10 m above the river and 100 m from it. A seepage pit exists to receive excess treated wastewater, but it is seldom required for this purpose.

Permit PE 183 allows the discharge of the following maximum quantities: flow, 230 m^3/d; BOD_5, 45 mg/L; and suspended solids, 60 mg/L.

An effluent data summary is in Table 6. The data indicate that the permit levels were usually met. Fecal coliforms in the effluent were high. However, this effluent should be of little concern due to the fact that it is discharged to a soil absorption system.

Samples have been collected near this operation upstream at Site 0301102 and downstream at Site 0301103. Coincident samples showed no increase for suspended solids, nitrate/nitrite, or nitrite. Dissolved oxygen was unaffected. Fecal coliform levels increased on two of six occasions, from <20 MPN/100 mL to 20 MPN/100 mL in January 1979, and from 5 MPN/100 to 17 MPN/100 mL in January 1980. The upstream and downstream levels are not significantly different at the 95% confidence level, and thus there is no firm evidence that these apparent increases in fecal coliforms were due to discharges from this operation.

3.3.4 PACIFIC VOCATIONAL INSTITUTE (PE 2672)

This community college and vocational institute is located in Maple Ridge, east from the Alouette River. Domestic sewage is provided secondary treatment and chlorinated. It is subsequently discharged to a 1348 m tile field, with a percolation rate of about 0.9 min/cm. This treatment method commenced after 1983. The tile field is over 700 m from the river.

Permit PE 2672 allows the discharge of the following maximum quantities: flow, 91 m^3/d; BOD_5, 45 mg/L; and suspended solids, 60 mg/L. An effluent data summary is in Table 7. It indicates that the permit levels were always met.

Due to the high quality of the effluent, and the fact that it is discharged to a soil absorption system far from the river, no impact on river water quality is anticipated.

3.3.5 CORPORATION OF THE DISTRICT OF MAPLE RIDGE (PE 5496)

The District operates a land disposal area for the disposal of domestic wastewater from septic and holding tanks. It is located about 700 m southeast from the Alouette River. The wastes are collected from systems located within the Maple Ridge District, and are discharged to exfiltration pits. The Greater Vancouver Sewage and Drainage District will not allow the wastes to be discharged to the municipal collection system for treatment at the Annacis Island STP.

Permit PE 5496 allows the discharge of a maximum of 70 m^3/d to seepage pits. It is not expected that this operation will impact the river due to the small volume of the discharge and the distance to the river.

3.3.6 PACIFIC MARINE TRAINING INSTITUTE (PE 6837)

This is a firefighter-training facility located about 600 m southeast from the Alouette River. Wastewater originates as rainwater and/or recycled firefighting liquid. The wastewater is passed through an oil separator, and recycled until dissolved solids levels become unacceptably high. The wastewater is treated using activated carbon prior to discharge to a 360 m^3 infiltration basin.

Permit PE 6837 allows the discharge of a maximum 140 m^3/d and an average 23 m^3/d at the following concentrations: pH, 6.5-8.5; COD, maximum of 130 mg/L; oil and grease, maximum of 10 mg/L; MBAS, maximum of 5 mg/L; total dissolved solids, maximum of 3 500 mg/L; and 96 h $LC_{50} \geq 100\%$.

Due to the distance to the river and the small quantity of wastewater discharged to the soil system, no significant impacts on the Alouette River are expected.

3.3.7 KENRAE ENTERPRISES (PE 441)

This company has assumed assets for a site where development has yet to proceed, on the southeast corner of the confluence of the Alouette and Pitt Rivers. The original application originated in 1971, under different ownership. A marina presently exists on the property.

The permit (PE 441) indicates that a pub and restaurant are planned, and that the marina would also be connected to the planned secondary treatment facility. The permit allows the following maximum quantities in the discharge: flow, 273 m^3/d; BOD_5, 45 mg/L; and suspended solids, 60 mg/L. The chlorine residual is to be maintained from 0.1 to 1.0 mg/L.

Impacts on the Pitt River cannot be predicted until firm decisions are made on the type of secondary treatment, discharge location, type of outfall, and the initial dilution provided. Construction had not commenced at the end of January, 1987.

3.3.8 B.C. FOREST PRODUCTS LIMITED (PR 5031)

This company operates a logging camp about 10 km north from Pitt Lake (Figure 1). The camp generally operates from March through December, yearly. It has a population of about 70 people, who are ferried to the site on a daily basis.

Solid wastes from the camp are disposed of in a 75 m x 100 m landfill. The landfill is located about 200 m to the east from the upper Pitt River. Permit PR 5031 allows the disposal of 2.3 m^3/d of domestic refuse, which is covered every 20 days.

Due to the non-toxic nature and small volume of wastes, and the long distance to the river, any leachate generated is not expected to impact the river.

3.3.9 RCB HOLDINGS LTD. (PE 372)

This company owns the Wild Duck Inn, a hotel and restaurant operation located on the west bank of the Pitt River. The wastewater is treated in an extended aeration secondary sewage treatment plant, chlorinated, and discharged to the Pitt River through a submerged outfall about 30 m into the river.

Permit PE 372 allows the discharge of a maximum 30 m^3/d with maximum concentrations of 60 mg/L suspended solids and 45 mg/L BOD_5. Table 8 is an effluent data summary. The limits were generally met, although between 1972 and 1984, 6 of 27 samples exceeded the limit for suspended solids.

Fecal coliforms have been as high as 54 000 MPN/100 mL. The effluent would receive dilution of over 24 000:1 with the 2-year low flow and nearly 16 000:1 with the 10-year low flow. Thus with complete mixing of the effluent and the river water, fecal coliforms in the river would increase to between about 2 and 4 MPN/100 mL, depending upon the flow return period and assuming the maximum effluent flow and maximum fecal coliform concentration coincided. Given the width and the slow velocity of the river, it is more likely that the effluent will mix with only about one quarter of the flow in the river. This would reduce dilution ratios to 6000:1 and 4000:1, and increased resulting coliform concentrations to 8 and 16 MPN/100 mL.

Thus this discharge will not have a significant impact on the water quality in the river.

3.3.10 KENNAMETAL INC. (PE 2350, PR 2351)

This carbide manufacturing plant is located in Port Coquitlam to the west of the Pitt River. It has a refining process consisting of acid leaching of ground metal carbide, washing of settled metal carbide, and centrifuging of flotation skimmings.

Individual effluents from various processes are held in three tanks prior to entering an exfiltration basin. The exfiltration basin is about 4 km from the Pitt River. Permit PE 2350 allows the discharge of 45 m^3/d (labelled "01" in Table 9) to the pond from the refractory carbide refinery with a pH from 8.5 to 10.5 and the following maximum values for the dissolved fractions of: iron, 5.0 mg/L; nickel, 1.0 mg/L; cobalt, 1.0 mg/L; manganese, 1.5 mg/L; and fluoride, 10 mg/L. From the vacuum drying section of the powder milling building, the discharge to the exfiltration basin of a maximum 114 m^3/d (labelled "02" in Table 9) of cooling water at a maximum temperature of 24°C is allowed under Permit PE 2350.

Data in Table 9 indicate that the permit limits are seldom achieved. Data for 1986 do not indicate any improvement in effluent quality.

The company also has a permit (PR 2351) for a refuse site. Metal concentrates are melted and cooled in graphite crucibles which are broken to free the metal. These broken crucibles comprise 90% of the refuse. Broken refractory brick and linings from the furnaces account for the remainder of the refuse. In addition, sludge from the effluent holding tanks and the exfiltration pond are also disposed of at the refuse site. Permit PR 2351 allows the disposal of a total of 1.1 m^3/d to the refuse site.

If lime were added so that the pH of both the refuse and wastewater effluent were at least 10.5, this operation would have only a minimal impact on groundwater. However, this remedy has yet to be implemented.

Due to the quality of the effluent, groundwater monitoring should be undertaken to determine the degree and extent of possible contamination from this operation.

3.3.11 NON-POINT SOURCES

There are several non-point sources in this watershed. These include agricultural inputs into the Alouette, N. Alouette, and Pitt River watersheds, marinas along the Pitt River and log storage along the Pitt River.

The impact of log storage is difficult to quantify. Boomed logs can shed bark which settles to the river bottom. Decomposition of the bark can cause localized areas of oxygen depression.

Swain[20] reported on the quality of precipitation in discrete samples collected during a one-year period in 1980 and 1981 in Vancouver. Mean values for between 150 and 300 measurements were: pH, 4.85; cadmium, 0.0012 mg/L; copper, 0.011 mg/L; lead, 0.033 mg/L; zinc, 0.056 mg/L; ammonium nitrogen, 0.20 mg/L; nitrate-nitrogen, 0.96 mg/L; and nitrite-nitrogen, 0.033 mg/L. These data reflect the potentially acidic nature of rainfall in the lower mainland, and the potential input of certain metals and nutrients to surface waters.

Under a Federal/Provincial monitoring agreement, the MOE is monitoring Marion (Jacobs) Lake in the UBC Research Forest to determine if precipitation is causing acidification. This program of approximately monthly sample collection was begun by MOE in 1984. These data will be used for trend detection sometime after the first five years of data are collected, after April 1989. Some of these data are reviewed in this report to estimate headwater conditions in the North Alouette River (Section 3.4).

There are three marinas located on the Pitt River (Figure 4), one on the west shore and near its confluence with the Fraser River, one near the mouth of the Alouette River, and the third about two kilometres further upstream on the west shore. The marina furthest upstream houses 100 recreational craft. Washrooms are located on-shore. The marina at the mouth of the Alouette River has 100 berths, mostly used for recreational craft. However, an inspection in January 1987, found at least three floating homes and three live-aboards. In addition, there were about three other floating homes in the mouth of the Alouette River, separate from the marina. The third marina, located near the confluence with the Fraser River, has berths for about 50 recreational boats and four live-aboards.

In total, the major concern relates to the potential discharge of untreated wastewater from the 13 live-aboards and floating homes. It is expected that the volume would be small and dilution significant. However, this does not mean that this practice can be condoned. It is expected that each of the 13 live-aboard boats could contribute 1.1 m^3/d with 250 mg/L suspended solids and BOD_5, 25 mg/L ammonia, and 24 000 000 MPN/100 mL fecal coliforms.

Pitt Timber Ltd. is located near the confluence of the Pitt River, on the west bank. It has lumber dipping and uses chlorophenols. These can enter the river in stormwater runoff during rainfall events.

The amount of land in the agricultural land reserve in this watershed is depicted in Figure 3. It is estimated that the total area draining to the Pitt River directly or through tributaries is 94 km^2 or 18% of the drainage area of the Pitt River basin. Based on a rainfall of 1780 mm per year, and concentrations[14] cited in Section 2.3.3, the following potential loadings were calculated:

Potential Loadings (per year) to
Pitt River From Agricultural Sources

BOD_5 (and suspended solids)		502 500 kg
Total Nitrogen		335 000 kg
Total Phosphorus		16 750 kg
Total Copper (and Lead and Zinc)	each	500 kg
Fecal Coliforms		5×10^9 organisms

Depending upon the release period, transmission coefficients, and river flows, the impact of agriculture on Pitt River water quality will vary. For example, if a six-month build-up of contaminants from agricultural sources is assumed during the dry summer period, and if 100% of the build-up is released during a two-week period in November, the following are the potential increases in concentrations:

Potential Increase in Concentrations (mg/L) With Pitt River Flow of 40.1 m^3/s (Mean Flow for November)

BOD_5 (and suspended solids)	5.2
Total Nitrogen	3.5
Total Phosphorus	0.17
Total Copper (and Lead and Zinc)	0.005
Fecal Coliforms (per 100 mL)	<1

These calculations indicate that due to the high flows available in the Pitt River, significant contaminant increases from agriculture will not occur even if what might be called a "worst-case" situation were to occur. Although lower river flows occur in December to February, it is unlikely that these contaminants would continue to accumulate until that time of the year. Regardless, the calculated potential "worst-case" increases would occur at a time of year when conditions in the river would be such that impacts would be minimized (i.e., high dissolved oxygen levels, and a time of year with few hours of daylight and hence minimal algal production).

3.4 AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

Ambient water quality has been measured in the Alouette and North Alouette Rivers, Alouette Lake, Pitt Lake and the Pitt River. Data are summarized in Tables 10, 11, and 12. Data collected monthly on Jacobs (Marion) Lake are summarized in Table 26 for the period April 1984 to October 1987. These data will be examined at a later date for trends. The locations of the monitoring stations are shown on Figure 4.

Site 0300012, near the mouth of the Pitt River, is at the Lougheed Highway crossing, and Site 0300013 in Pitt Lake is near the outlet. On the Alouette and North Alouette Rivers, Sites 0300014 and 0300017, respectively, are west of Haney while Sites 0300015 and 0300018, respectively, are to the east of Haney. Additionally, on the Alouette River, Site 0301102 is located about three kilometres downstream from Alouette Lake, while Site E206673 on

Marion Lake is located in the north portion of the lake at the deepest point. Marion Lake was part of a 10 year International Biological Program from about 1965 to 1975.

Designated water uses proposed are for protection of aquatic life and wildlife, irrigation and livestock watering, and drinking water supplies. As well, primary-contact recreation should be protected in Alouette, Pitt and Marion (Jacobs) lakes, and in the Alouette and North Alouette Rivers.

3.4.1 pH AND ALKALINITY

The pH in the North Alouette River ranged from 5.9 to 7.2 at Site 0300017 (Table 10), reflecting values measured in Marion Lake (5.8 to 7.7) (Table 26). In Marion Lake, pH values are at a minimum (as low as 5.8) in winter (Figure 5), reflecting precipitation events, as was the case for Kanaka Creek. Marion Lake and the North Alouette River are slightly more acidic than the Alouette River where values ranged from 6.1 to 7.5 at Site 0300015 (Table 11). In Alouette Lake, values ranged from 6.0 to 6.9 (Table 11). In the Pitt River, values ranged from 6.4 to 8.0 at Site 0300012, and from 6.5 to 7.5 in Pitt Lake (Table 12).

These data indicate that the drainage basin is acidic. Values can be outside the range of the working water quality criteria of 6.5 to 8.5 to protect drinking water supplies(4) and 6.5 to 9.0 to protect aquatic life(2). The low pH values which are outside the range for the criteria are levels which likely reflect the acidic nature of the precipitation in the Lower Mainland area.

Acidic deposition is occurring in the basin. As well, agricultural operations are sources of nitrogen to the watershed, and pH is an important factor in limiting the toxicity of ammonia. Therefore, a provisional objective is proposed for pH in the Alouette, North Alouette, and Pitt Rivers and in Alouette and Pitt Lakes. The objective is that pH should be in the range 6.5 to 8.5. In proposing this objective, it is recognized that the pH in several of these waterbodies can, at times, fall below the minimum of the range. Therefore, if values upstream are below the minimum of the range, the change in pH going from upstream to downstream from a discharge or series of discharges should not exceed 0.2. The objective applies except in initial dilution zones of effluents, described in Section 2.4.1 for the Alouette and North Alouette Rivers. For the Pitt River, the initial dilution zones of effluents are to extend up to 100 m downstream (or upstream at times of tide reversal) from a discharge, and to occupy no more than 25% of the stream width around the discharge point, from the bed of the stream to the surface. In lakes, initial dilution zones are defined as extending up to 100 m horizontally in all directions, but not exceeding 25% of the width of the waterbody.

Alkalinity values have ranged from 2.4 mg/L at Site 0300018 to 12.5 mg/L at Site 0300017 in the North Alouette (Table 10), from 1.7 to 10.9 mg/L in Marion Lake (Table 26), from 5.5 mg/L at Site 0300015 to 24 mg/L at Site 0300014 in the Alouette River (Table 11), and from 5 to 51.1 mg/L in the Pitt River (Table 12). In Pitt Lake, alkalinity values ranged from 4.7 to 7.2 mg/L (Table 12). Alkalinity could not be detected (<0.5 mg/L) in two samples from Alouette Lake. These data are generally <10 mg/L and indicate that the rivers and lakes are highly sensitive to acidic inputs during much of the year.

The fluctuation in alkalinity throughout the year at Marion Lake is plotted in Figure 6. The highest alkalinity values occur in the summer when precipitation volumes are minimal and in-lake alkalinity generation would be maximized. The lowest values occur in winter, coinciding with the lowest pH.

3.4.2 HARDNESS AND METALS

The waters of the Alouette, North Alouette, and Pitt Rivers would be classified as being soft, i.e., less than 75 mg/L hardness ($CaCO_3$). The water of Alouette, Marion and Pitt Lakes was even softer, with all values being less than 10 mg/L.

Most metal levels were below detection or working water quality criteria. Exceptions to this were the maximum recorded values for chromium, copper, iron, and lead and aluminum and molybdenum in Marion (Jacobs) Lake.

Total aluminum values in Marion Lake ranged from 0.03 to 0.61 mg/L (Table 26), although the value of 0.61 mg/L was recorded in March 1986 (Figure 7) at a time of other high metal values (e.g. copper, 0.3 mg/L; iron, 0.58 mg/L; lead, 0.5 mg/L; and zinc, 0.48 mg/L) which suggests a contaminated sample. The next highest total aluminum concentration was 0.21 mg/L, which, if it were primarily in the dissolved state, would exceed the criterion of 0.1 mg/L maximum to protect freshwater aquatic life (pH >6.5)[32].

Maximum recorded total chromium values were 0.005 mg/L for 2 of 12 measurements in the North Alouette River (Table 10), 0.006 mg/L for 1 of 12 measurements in the Alouette River (Table 11), and 0.027 mg/L for 1 of 10 measurements in the Pitt River. All other river values were below the detection limit of 0.005 mg/L. Chromium could not be detected in Alouette Lake (Table 11), but was as high as 0.011 mg/L (1 of 16 measurements) in Pitt Lake (Table 12). The most restrictive working criterion is 0.002 mg/L to protect phytoplankton and zooplankton[2]. Since most values are below detection and some high values were also found in Kanaka Creek (Section 2.4.2), such values are likely typical of background fluctuations or values which may be introduced in the precipitation.

Maximum total copper values were 0.004 in the North Alouette River (Table 10), 0.011 mg/L in the Alouette River (Table 11), 0.005 mg/L in Alouette Lake (Table 11), 0.013 mg/L in the Pitt River (Table 12), and 0.010 mg/L in Pitt Lake. These exceed the B.C. criterion of 0.002 mg/L (hardness less than 50 mg/L) as an average value and most exceed maximum criteria ranging from 0.0023 mg/L (hardness of 3 mg/L) to 0.007 mg/L (hardness of 54 mg/L). The following numbers of values were >0.002 mg/L in each of the waterbodies: 2 of 12 in the North Alouette River; 5 of 12 in the Alouette River; 2 of 17 in Alouette Lake; 19 of 31 in the Pitt River;

and 2 of 18 in Pitt Lake. Copper was also found to be high at times in Kanaka Creek (Section 2.4.2), therefore these higher values are either background fluctuations or values which may be introduced in the precipitation.

Maximum total iron values in the North Alouette and Alouette Rivers, Pitt River, and Pitt Lake exceeded the criteria of 0.3 to protect aquatic life[2] and drinking water[4] (aesthetics) as follows: 3 of 6 measurements in the North Alouette River, 2 of 6 measurements in the Alouette River, 26 of 30 measurements in the Pitt River, and 1 of 14 measurements in Pitt Lake. Dissolved iron did not exceed criteria, where measured. Total iron may be due to the iron content of suspended sediments and thus may not be noteworthy.

Maximum total lead values exceeded the B.C. aquatic life criteria (related to hardness[25]) of 0.003 mg/L in the North Alouette as a maximum, and 0.009 mg/L as a maximum and 0.007 mg/L as an average in the Pitt and Alouette Rivers. These were exceeded for 2 of 12 measurements in the North Alouette, 2 of 11 measurements in the Alouette River, and 1 of 97 measurements in the Pitt River. There are no known local anthropogenic sources of lead to these waterbodies except runoff from local roads or atmospheric emissions.

The limit of 0.05 mg/L of manganese to protect drinking water aesthetics was exceeded by 12 of 32 measurements in the Pitt River, and by 1 of 12 measurements in each of the Alouette and North Alouette Rivers.

The CCREM guideline of 0.03 mg/L maximum total zinc concentration to protect aquatic life was exceeded by 1 of 52 measurements in Pitt River and Lake (0.08 mg/L), 1 of 13 measurements in the Alouette River (0.05 mg/L) and in 1 of 17 measurements in Alouette Lake (0.04 mg/L). These levels probably reflect natural variations in the basin, although the mean concentration in precipitation in Vancouver was 0.056 mg/L (Section 3.3.11).

Swain and Walton reported[30] on metals in sediments collected at four sites on the Pitt River, one at the mouth of the Alouette River, and at sites on Kanaka Creek, Coquitlam River and the Brunette River system. Based on particle size distribution of the sediments, it was expected that the highest concentrations would be found in sediments from near the mouth of the Pitt River since these finer sized particles could sorb more metals. However, sediments from Still Creek were higher than those from the Pitt River, as follows:

Metal	μg/g dry-weight	
	Pitt River	Still Creek
Cadmium	0.16	1.18
Copper	34.7	122.0
Lead	6.40	238.0
Mercury	0.063	0.12
Molybdenum	<5.0	26.0
Tin	<3.0	5.31
Zinc	78.6	256.0

Thus, anthropogenic activity has not affected sediments in the Pitt River nearly to the same degree (if at all) as those from Still Creek.

3.4.3 NUTRIENTS

Nutrients can enter the rivers, especially the Alouette and North Alouette Rivers, from agricultural operations or from precipitation (Section 3.3.11). Ammonia nitrogen in all the water bodies met the B.C. criteria listed in Tables 3 and 4[6]. Nitrite values met the B.C. criteria of 0.02 mg/L as an average and 0.06 mg/L as a maximum value[6] except for one value (0.061 mg/L) in Alouette Lake. All other 19 values were <0.005 mg/L. All nitrate values were less than 1 mg/L. The most restrictive criterion for nitrate is 10 mg/L to protect drinking water supplies[6].

Since different nitrogen forms can enter the watershed from agricultural sources, precipitation, and from marinas, a provisional objective is proposed for ammonia and nitrite. The ammonia objective is that the maximum and average values should not exceed the values listed in Tables 3 and 4. For nitrite, the 30-day average value should not exceed 0.02 mg/L and the maximum should not exceed 0.06 mg/L. The objectives apply outside the initial dilution zones of effluents, described in Sections 2.4.1 for the Alouette and North Alouette Rivers and in Section 3.4.1 for the Pitt River, Pitt Lake, and Alouette Lake.

Total phosphorus levels have been as high as 0.070 mg/L in the North Alouette River (Table 10), 0.061 mg/L in the Alouette River (Table 11), and 0.286 mg/L in the Pitt River (Table 12). These levels are high enough to cause excessive algal growths assuming that phosphorus is the limiting nutrient, the phosphorus is bio-available, and that suitable substrate and light are available. However, dissolved phosphorus and dissolved orthophosphorus, the noteworthy phosphorus fraction in streams, are much lower. The variability of total phosphorus in Marion Lake is plotted as Figure 8. The highest values for total phosphorus have been 0.009 mg/L, although values through most of the year have been between 0.004 and 0.006 mg/L. Chlorophyll-*a* levels ranged from 0.5 to 2.7 µg/L (Table 26). Therefore, Marion (Jacobs) Lake could be considered oligotrophic.

The highest phosphorus levels in sediments (2 450 µg/g, dry-weight) reported by Swain and Walton[30] were from a site near the mouth of the Pitt River. This high value is to be expected based on the particle size distribution of the sediments from this site.

Measurements of periphyton chlorophyll-*a* have not been made in the North Alouette, Alouette, or Pitt Rivers. Since primary contact recreation is not a designated use for these rivers, the next highest use is the protection of aquatic life. The B.C. criterion to protect aquatic life in rivers is a maximum not to exceed 100 mg/m²[12]. Aquatic life requires protection, therefore a provisional objective is proposed in the three water bodies for periphyton chlorophyll-*a*. The objective is that the average of at least five periphyton chlorophyll-*a* values collected randomly from natural substrate on one day should not exceed 100 mg/m^2. The objectives apply in all areas of the rivers except in initial dilution zones of effluents, described in Section 2.4.1 and 3.4.1.

3.4.4 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

Dissolved oxygen levels have ranged from 5.3 to 14.5 mg/L at Site 0300017 and 9.2 to 13.4 mg/L at Site 0300018 in the North Alouette River (Table 10), from 6.3 to 13.9 mg/L at Site 0300014 and 8.2 to 13.2 mg/L at Site 0300015 in the Alouette River (Table 11), and from 9 to 14.5 mg/L in the Pitt River (Site 0300012) and Pitt Lake (0300013) (Table 12). The lowest values in the ranges were at sites towards the mouths of the waterbodies where water would be slower moving and where oxygen demanding materials introduced in the watershed would accumulate.

The working water quality criteria for dissolved oxygen are 6.0 mg/L for slight impairment to all salmonid life stages except embryo and larvae, and 8.0 mg/L for no impairment (Section 2.4.4). Thus the no impairment levels have always been provided to salmonid life stages (non embryo or larvae) in the Pitt River, Pitt Lake, Site 0300015 on the Alouette River, Site 0300018 on the North Alouette River, and in Alouette Lake. The no impairment level has only been exceeded for 2 of 21 measurements at Site 0300014 in the Alouette River and for 3 of 20 measurements at Site 0300017 in the North Alouette River. At both sites, oxygen concentrations have never been measured at less than 6.0 mg/L.

The apparent differences in dissolved oxygen levels between upstream and downstream sites in both the Alouette and North Alouette Rivers are also reflected in percent saturation values. At the upstream sites, percent saturation values are at about 100% ±20%. Wider ranges in percent saturation values are apparent at the downstream sites. At Site 0300017 in the North Alouette River (Table 10), percent saturation values have ranged from 56.4 to 106.7%, while at Site 0300014 in the Alouette River (Table 11), values have ranged from 70.3 to 246.2%. Such wide variations in percent saturation values are typically associated with algal photosynthesis, respiration, and decomposition.

In the Pitt River (Table 12), percent saturation values ranged from 87.3 to 115.4%, and were of minimal concern.

A provisional water quality objective is proposed for dissolved oxygen in the Pitt River, Alouette River, and North Alouette River. The objective may not always be achieved in the lower reaches of the Alouette or North Alouette Rivers, and measures may have to be taken to improve levels. However, the high values in the upstream reaches should be maintained. The proposed objective is a minimum dissolved oxygen level of 8.0 mg/L for all salmonid life stages except embryo and larvae, when the objective is a minimimum dissolved oxygen of 11.0 mg/L. For the purpose of checking the objective, this latter objective will apply between November and March, yearly. These values apply to the North Alouette, Alouette, and Pitt Rivers, except in initial dilution zones of effluents, described in Section 2.4.1 and 3.4.1.

Extremely good dissolved oxygen levels are found in Alouette and Pitt Lakes. Dissolved oxygen levels have ranged from 10 to 12.6 mg/L in Alouette Lake (Table 11) and from 10.5 to 12.9 mg/L in Pitt Lake (Table 12). In both lakes, on eight (Alouette Lake) or nine (Pitt Lake) occasions, dissolved oxygen levels were measured to as deep as 18.3 m. Percent saturation levels corresponding to these were from 92.1 to 113.1% and 95.5 to 121.8%, respectively.

3.4.5 SOLIDS AND TURBIDITY

Dissolved solids have been as high as 60 mg/L at Site 0300017 in the North Alouette River (Table 10), 78 mg/L at Site 0300014 in the Alouette River (Table 11), 90 mg/L in the Pitt River (Table 12), 20 mg/L in Alouette Lake (Table 11), and 28 mg/L in Pitt Lake (Table 12) and Marion (Jacobs) Lake (Table 26). These levels are well below the most restrictive working criterion of 500 mg/L for the protection of drinking water supplies[4].

Suspended solids levels have been as high as 17 mg/L at Site 0300017 in the North Alouette River (Table 10), 60 mg/L at Site 0300014 in the Alouette River (Table 11), and 305 mg/L in the Pitt River (Table 12). Maximum levels were 20 mg/L in Pitt Lake (Table 13) and 2 mg/L in Alouette Lake (Table 11). It is suspected that the higher suspended and dissolved solids levels in the Pitt River may reflect backup of Fraser River water into the Pitt River at tide reversal and high river flows, since the higher levels occurred in April of two different years.

The B.C. criteria for suspended solids are that induced levels should not exceed 10 mg/L if background is less than 100 mg/L nor be more than 10% of background if background exceeds 100 mg/L[10]. Since some existing operations discharge suspended solids, a provisional water quality objective is proposed. The objective is that induced suspended solids concentrations should not increase by more than 10 mg/L if background is less than 100 mg/L nor be more than 10% of background if background levels exceed 100 mg/L. The objective applies throughout the watershed, except in initial dilution zones of effluents, described in Sections 2.4.1 and 3.4.1. A discussion of this proposed objective in comparison to analytical precision for the test is included in Section 2.4.5.

To protect salmonid spawning areas, there should be no significant (95% confidence level) induced benthic sedimentation on the basis of accumulation by weight for particles <3 mm. For the purpose of determining achievement of the proposed objective, the average downstream weight of at least three replicate samples should not exceed 110% of the upstream average of three replicate samples.

The proposed objective for suspended solids addresses the aspect of physical damage to aquatic life. Turbidity addresses the aspect of aethetics and light attentuation.

Values for turbidity have been as high as 25 NTU at Site 0300017 on the North Alouette River (Table 10), 140 NTU at Site 0300015 on the Alouette River (Table 10), and 100 NTU in the Pitt River (Table 12). The maximum value was 2.4 NTU in Alouette Lake (Table 11) and 3.6 NTU in Pitt Lake (Table 12). Waters used for drinking require less than 5 NTU of turbidity(2). Thus the waters from the river would need treatment while those from the lakes would not. The B.C. criteria for turbidity relate to induced levels(10). These shall be used as proposed objectives.

The proposed objective for turbidity is that induced levels should not exceed 1 NTU for background levels less than 5 NTU (Alouette and Pitt Lakes), 5 NTU for background levels less than 50 NTU nor be more than 10% of background for background levels in excess of 50 NTU. The objectives apply throughout the watershed, except in initial dilution zones of effluents, described in Section 2.4.1 and 3.4.1.

3.4.6 BACTERIOLOGICAL QUALITY AND COLOUR

Fecal coliform levels have exceeded 2 400 MPN/100 mL at Site 0300017 in the North Alouette River (Table 10), equalled 9 200 MPN/100 mL at Site 0300014 in the Alouette River (Table 11), and 5 400 MPN/100 mL in the Pitt River (Table 12). The corresponding median values were 20 MPN/100 mL, 240 MPN/100 mL, and 235 MPN/100 mL, respectively. Maximum values in the lakes were <20 MPN/ 100 mL in Alouette Lake (Table 11) and in Pitt Lake (Table 12). The relatively sparse data suggest that for drinking water supplies, filtration or equivalent plus disinfection would be required for the North Alouette River, complete treatment plus disinfection for the Alouette and Pitt Rivers, and disinfection only for the lakes. Approved B.C. criteria(9) for fecal coliforms are geometric means of ≤200 MPN/100 mL to protect general irrigation, a maximum of 200 MPN/100 mL to protect livestock, and 90th percentile values for drinking water of ≤100 MPN/100 mL for partial treatment or ≤10 MPN/100 mL for disinfection only. Therefore, the following provisional objectives for fecal coliforms are proposed for the watershed: ≤10 MPN/100 mL as the 90th percentile value in Alouette and Pitt Lakes; ≦100 MPN/100 mL (90th percentile) in the North Alouette River; ≦200/100 mL (geometric mean) and a long-term objective of ≦100/100 mL (90th percentile) in the Alouette and Pitt Rivers.

Approved B.C. criteria for other microbiological indicators are ≦1000/100 mL (geometric mean) *Escherichia coli* and ≦250/100 mL (geometric mean) Enterococci for general irrigation; maxima of 200/100 mL and 50/100 mL, respectively to protect general livestock use; ≦77/100 and ≦20/100 mL, respectively (geometric means) and ≦2/100 mL (75th percentile) *Pseudomonas aeruginosa* to protect primary-contact recreation; and ≦10/100 mL and ≦3/100 mL (90th percentiles) to protect drinking water supplies with disinfection only or ≦100/100 mL or ≦25/100 mL to protect drinking water supplies with partial treatment. Therefore the following provisional objectives are proposed for the watershed: ≦10/100 mL (90th percentile) *Escherichia coli* and ≦3/100 mL (90th percentile) enterococci in Alouette and Pitt Lakes; ≦100/100mL *Escherichia coli* (90th percentile) and ≦25/100 mL enterococci (90th percentile) in the North Alouette River; ≦77/100 mL (geometric mean) *Escherichia coli* and ≦200/100 mL (geometric mean) Enterococci; and long-term objectives of ≦100/100 mL (90th percentile) for *Escherichia coli* and ≦25/100 mL (90th percentile) Enterococci in the Alouette and Pitt Rivers.

These objectives apply except in initial dilution zones of effluents, described in Sections 2.4.1 and 3.4.1. The 90th percentile and geometric mean values are to be calculated from at least five weekly samples collected in a period not exceeding 30 days.

The data for colour indicate that the waters of Pitt, Marion (Jacobs) and Alouette Lakes meet the criteria for aesthetics of drinking water of 15 TCU[(4)]. Maximum and mean values in the Alouette, North Alouette, and Pitt Rivers generally exceed this criterion, as follows: for 1 of 5 measurements in the Pitt River, for 2 of 7 measurements in the Alouette River, and for 5 of 8 measurements in the North Alouette River. Therefore, these waters are not desirable as drinking water supplies unless the colour is removed.

3.4.7 CHLOROPHENOLS

One operation located on the west bank of the Pitt River near the mouth (Pitt Timber Ltd., Section 3.3.11) does use chlorophenols to treat lumber. Some chlorophenols could reach the river in stormwater runoff. The concentration would be highly variable depending upon the application and storage method.

Swain and Walton(38) have reported on chlorophenol measurements made in sediment samples collected at four sites on the Pitt River between Pitt Lake and the mouth and at one site in the mouth of the Alouette River. Chlorophenols could not be detected (<0.005 μg/g, dry-weight) as penta- or tetra- or as tri- (<0.01 μg/g, dry-weight).

Water quality objectives for chlorophenols have been approved for the Fraser River(11). These values are proposed as objectives for the Pitt River, to ensure that objectives are not threatened in the Fraser River by discharges into the Pitt River. Thus the proposed water quality objectives for the Pitt River are that the sum of tri-, tetra-, and pentachlorophenol should not exceed 0.2 μg/L in the water, 0.1 μg/g (wet weight) in fish muscle, or 0.01 ug/g (dry-weight) in bottom surface sediments. The level in surface sediments should be considered to be the average of three replicate samples from the same site. The objectives apply in the Pitt River, except in the initial dilution zones of effluents, described in Section 3.4.1. The objective for fish muscle applies to fish of any species caught in any part of the Pitt River, including the initial dilution zones of effluents.

3.4.8 POLYCHLORINATED BIPHENYLS

Swain and Walton(30) reported that no PCB isomers (1016, 1221, 1232, 1242, 1248, 1254, or 1260) could be detected (<0.03 μg/g, dry-weight detection limit) in sediments from four sites on the Pitt River or one site on the Alouette River.

3.4.9 OTHER ORGANIC COMPOUNDS

The organic coumpounds referred to in Section 2.4.9 were also not detected in sediments from the Pitt or Alouette Rivers.

3.5 RECOMMENDED MONITORING

The proposed objectives should be checked at both sites on each of the North Alouette and Alouette Rivers, and at Site 0300012 on the Pitt River, with 5 samples collected in a 30-day period at least once from June through August and once from December through February, yearly. Measurements should be made for pH, hardness, chloride, total and dissolved forms of chromium, copper, iron, lead, manganese, zinc, nitrite, nitrate, ammonia, total phosphorus, periphyton chlorophyll-a, dissolved orthophosphorus, dissolved oxygen, temperature, suspended solids, turbidity, and fecal coliforms. As well, chlorophenols should be measured in water of the Pitt River at Site 0300012 or further upstream and one site near the mouth near the sawmill, while sediments and fish should be collected only near the mouth of the Pitt River. Alouette and Pitt Lakes should be sampled 5 times in a 30-day period in summer for dissolved oxygen, fecal coliforms, pH, and temperature.

The exact program could be modified depending on available resources and regional priorities. In addition, the advent of "replacement chemicals" for chlorophenols is a likelihood, as is a regulating initiative to control contamination at source.

3.6 CONCLUSIONS

Flows in the Pitt, Alouette, and North Alouette Rivers reflect higher flows during wet winters than during the dry summer periods. The Pitt River is also influenced by snowmelt. The area surrounding the rivers, which is dyked, is low-lying. Outflows from Alouette Lake into the Alouette River have been controlled since 1925 by B.C. Hydro.

Five operations with permits issued pursuant to the Waste Management Act are located near the Alouette River or Alouette Lake, while three are near the Pitt River. A refuse site and small treated domestic sewage discharge likely have a minimal impact on Alouette Lake. Two treated domestic sewage discharges have effluent discharged to ground, which likely result in minimal impacts on the Alouette River. A third operation has yet to be built. A refuse site located north from Pitt Lake near the Upper Pitt River, and a treated wastewater discharge from a hotel and restaurant operation near the mouth of the Alouette River, should have no significant impact on water quality. Of more concern could be diffuse sources such as agricultural operations, marinas with floating homes, and sawmill operations.

The pH of the North Alouette, Alouette, and Pitt Rivers can be slightly acidic, likely reflecting the acidic nature of precipitation in the area and minimal buffering by adjacent soils. Thus the buffering capacity to acidic inputs is minimal at times. The water in the three rivers and Pitt and Alouette Lakes is soft. Some chromium, copper, iron, and lead values in the rivers exceeded working water quality criteria, but these high levels were either background fluctuations or present in precipitation itself. Ammonia and nitrite were at or below the criteria for aquatic life. Phosphorus levels may be high enough to cause algal blooms in the Alouette and North Alouette Rivers, which may cause the noted wide ranges of dissolved oxygen and percent saturation in the two rivers. Dissolved oxygen levels were higher in upstream reaches of the two rivers, throughout the Pitt River, and in Pitt and Alouette Lakes. However, only a slight impairment to all life stages of salmonids except larvae and embryos would occasionally be expected. Suspended solids levels in the Alouette and North Alouette were generally low and would not impair designated water uses. Some higher dissolved and suspended solids values in the Pitt River were possibly related to Fraser River flow reversal. Fecal coliforms were low in Alouette and Pitt Lakes and in the North Alouette River, but higher in the Alouette and Pitt Rivers. Levels of chlorophenols in the water column of the Pitt River are not known, but should be determined. Chlorophenols, PCBs, and other organic contaminants could not be detected in sediments from the Pitt or Alouette Rivers.

4. COQUITLAM RIVER

The upper reaches of the Coquitlam River drain into Coquitlam Lake, one of three lakes in the Greater Vancouver Regional District used as the water supply for Greater Vancouver. Water from Coquitlam Lake is also diverted through a tunnel to Buntzen Lake for use at a power station on Indian Arm (Figure 1).

The lake outlet is controlled by a dam. Downstream from the lake, the river has a relatively steep gradient and is bordered by forest, and then by gravel pit operations. Towards its mouth, the topography near the river is relatively flat with dykes along its length to prevent flooding. Agriculture occurs along this downstream reach (Figure 3).

The Coquitlam River has a drainage area of about 240 km^2.

Tributaries to the Coquitlam discussed in this chapter include Or Creek which enters from the east just downstream from the lake, and Scott and Hoy Creeks which enter from the west near the mouth.

Or Creek is the major tributary inflow (19.2 km^2) below the dam at the outlet of Coquitlam Lake.

4.1 HYDROLOGY

The flow in the Coquitlam River is regulated by a dam at the outlet of Coquitlam Lake. Flows are relatively consistent during the year. Flows from the dam would be augmented by unregulated downstream tributary inflows.

Peak flows in the Coquitlam River typically occur between November and May, presumably associated with high volumes of precipitation during this period. Low flows occur during late summer and fall. The mean flow at Site 08MH002 was 4.88 m^3/s from 1968 to 1982. In the Coquitlam River at station 08MH002 near the mouth, the two-year seven-day low flow was 0.67 m^3/s, while the 10-year seven-day low flow was 0.363 m^3/s. Limited data (four years) for Or Creek at station 08MH004 indicated a two-year seven-day low flow of 0.186 m^3/s.

4.2 WATER USES

The Coquitlam River contains populations of steelhead trout, cutthroat trout, chum salmon, and coho salmon. Populations of the latter three species are presently being augmented with out-of-watershed hatchery production. The best spawning habitat occurs between the GVRD dam at the outlet from Coquitlam Lake and the gravel operations which are generally located upstream from the Hoy Creek confluence. There is also some fish spawning in the tributaries to the lower Coquitlam River.

The Coquitlam River Study[(23)] indicated that the peak abundance of fish occurred before the early 1950's and that by the early to mid 1960's, only population remnants remained. "Pink salmon (an odd year stock) disappeared entirely in 1957". Declines occurred for species using "areas susceptible to flooding, gravel removal, sedimentation and urban development". "However, the main source of environmental damage was undoubtedly the widespread, year-round gravel removal activities in and along the river, commencing in the 1950's". The presence of steelhead trout was last reported in 1967[(28)].

Coho and chum salmon continue to return to the Coquitlam River, arriving in October. Coho start to spawn in tributaries in late October, ending in late December. Chum salmon start to spawn mainly in the centre portion of the Coquitlam River in mid October and finish spawning by mid November. Coho and chum spawn in Scott and Hoy Creeks upstream from their junction, while coho spawn in the upper reaches of Or Creek. Escapements have been as follows:

Average Yearly Escapement

	Coho	Chum
1950-1959	490	3050
1960-1969	115	60
1970-1979	470	1250
1980-1983	200	960

These data indicate a sharp decline in escapement since the 1950's. For the period 1980-1983, average yearly escapements to Hoy Creek have not been included (these were included for 1950-1979); however, the average yearly coho and chum escapements to Hoy Creek were 20 coho and 260 chum.

Rearing of coho salmon occurs throughout the system below the dam while some rearing of chinook salmon occurs in the lower reaches of the Coquitlam River.

Fishing, hiking, rafting, canoeing, and some swimming occur in the lower reaches of the river. Water is removed from the northern portion of the drainage basin and passed through a diversion tunnel from Coquitlam Lake to Buntzen Lake for power generation by B.C. Hydro (82 m^3/s). The GVRD is licensed to withdraw 159 100 m^3/d for a water supply. One gravel operator is permitted to withdraw 612 m^3/d from the Coquitlam River for industrial use.

Licensed withdrawals on tributaries occur only on Hoy Creek, where 9.1 m^3/d is withdrawn for limnological purposes, 32.7 m^3/d is used by B.C. Hydro, and 616.7 m^3 is used for irrigation on a yearly basis.

Designated water uses are for aquatic life, wildlife, irrigation, livestock watering, and primary-contact recreation, as well as for a drinking water supply in Coquitlam Lake.

4.3 WASTE DISCHARGES

Waste discharges are indicated on Figure 9 by reference to the waste management permit number. Most domestic sewage from Coquitlam and Port Coquitlam is treated at the Annacis Island STP.

4.3.1 ADOLPH VRAN (EVERGREEN TRAILER PARK) (PE 1508)

This 87-unit trailer park discharged secondary treated domestic wastewater to Hoy Creek. It served an average population of 300. Treatment was provided by two septic tanks, an aeration tank, an oxidation ditch, two-stage settling, and chlorination. In November 1986, sewer was made available to this area, and the site was re-developed to a commercial site. The permit was cancelled in April 1988.

Permit PE 1508 allowed the discharge of a maximum 63.6 m^3/d with maximum concentrations of 45 mg/L BOD_5 and 50 mg/L suspended solids. Effluent monitoring data are in Table 13. The maximum recorded flow (n=13) was less than permitted. Permit levels were not met on 9 of 47 measurements for suspended solids and 16 of 49 measurements for BOD_5. Fecal coliform levels in the effluent greater than 1 000 MPN/100 mL were recorded for 18 of 49 measurements.

Of most concern with this discharge are ammonia levels which were as high as 25.7 mg/L and chlorine residual values which were as high as 3 mg/L. If these maximum levels corresponded to low creek flows, some concern may have existed for coho and chum salmon.

4.3.2 COQUITLAM REDI-MIX LTD. (PE 6013)

This ready-mix cement plant was located on the west side of the Coquitlam River, towards the lake. The truck washing water and surface runoff were treated in three concrete-lined settling/recycle ponds operated in series. The total capacity of the ponds is nearly 90 m^3. The permit was cancelled in December 1988.

The maximum effluent discharged to the pond allowed under permit PE 6013 was 25 m^3/d, with no overflow allowed to the river. This operation should not have had any impact on the river if most surface runoff was collected and recycled, and if overflows did not occur.

4.3.3 JACK CEWE LTD. (PE 4869)

This company operates a gravel washing plant on the west bank of the Coquitlam River, about midway between the Fraser River and Coquitlam Lake.

It is one of several such operations adjacent to the river in this general area.

Gravel washwater is discharged to two settling/recycle ponds operated in series. Each is circular (30 m diameter). Solids are removed by a backhoe. Permit PE 4869 allows the discharge of 1360 m^3/d to the recycle system. Although there is not to be a direct discharge to surface waters, stormwater runoff from this and other nearby operations is of concern. This is discussed more fully in Section 4.3.5.

4.3.4 REMPEL BROTHERS CONCRETE LTD. (PE 5500)

This company operates a ready-mix concrete plant about 200 m from the Coquitlam River. Wastewater originates as concrete truck washdown water. The washdown water is treated in two settling/recycle ponds (25 m x 5 m x 4 m deep), operated in series.

Permit PE 5500 allows the discharge of a maximum 55 m^3/d to the ponds with no overflow to the river. The area adjacent to the plant has been covered with crushed aggregate to minimize siltation due to stormwater runoff.

There are no data related to this discharge.

4.3.5 NON-POINT SOURCES

Contaminants from non-point sources come from septic tanks, agriculture, a closed refuse site, a woodwaste site, runoff from the gravel operations, and contaminated precipitation (see Section 3.3.11).

Swain and Holms[13] have estimated that in the Serpentine River drainage, as many as 1300 residences could be using septic tanks. If land areas for the Coquitlam and Serpentine Rivers are assumed to have similar use, it is possible that 300 homes may be using septic tanks. If a factor of 10 percent of the total loading generated is used to estimate the loading reaching the river due to septic tank failures or other factors, it is possible that 6300 kg/ year each of BOD_5 and suspended solids, 65 kg/year of ammonia-nitrogen, and $6x10^{12}$ fecal coliform organisms could enter the Coquitlam River. These loadings were based on a sewage flow of 2.3 m^3/d/residence, concentrations of 250 mg/L each for BOD_5 and suspended solids, 2.6 mg/L of ammonia nitrogen, and a fecal coliform concentration of $24x10^6$ MPN/100 mL.

Due to the diverse nature of agriculture in the watershed, loadings from the land area (4.7 km^2) in the Agricultural Land Reserve (Figure 3) were estimated. These were based upon rainfall estimated from Figure 2 in Reference 14 to be 1 780 mm per year and on assumed concentrations[14] of 3000 MPN/ 100 mL fecal coliforms, 3 mg/L BOD_5, 2 mg/L total nitrogen and 0.1 mg/L total phosphorus. Thus agriculture could contribute 25 100 kg/year of BOD_5, 16 730 kg/year of total nitrogen, 835 kg/year of total phosphorus, and 2.5 x 10^8 fecal coliform organisms.

A small closed municipal refuse site is on the east side of the Coquitlam River, and is shown on Figure 9. Atwater[15] indicated that groundwater would be expected to move through the fill into the Coquitlam River; however, he found no visual evidence of leachate in 1979.

Atwater indicated that a small woodwaste site was located on the west side of the Coquitlam River (Figure 9), but it had the smallest estimated volume (330 m^3) of any in the study area[15]. No impact would be expected.

Runoff from the gravel operations has been the most significant source of loadings from non-point sources. Discharges of large volumes of sediments with stormwater have been documented as causing siltation of the river bed[23]. "A large volume of sediment comes off these gravel pits each year and finds its way into the Coquitlam River. At times during a heavy storm the loading is so heavy that deltas are built out into the Coquitlam River from tributary streams flowing through the gravel operations"[23].

A concern still exists with the impact from these operations since J. Cewe Ltd. was prosecuted under the Fisheries Act by the Department of Fisheries and Oceans for deposition of a deleterious substance and harmful alteration and destruction of habitat (resulted in creation of a delta in the Coquitlam River). The company was acquitted of the charges in 1987.

4.4 AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

Data for the Coquitlam River are summarized in Table 14, while those for Or Creek are in Table 15 and for Scott Creek, in Table 16.

Some sites on the Coquitlam River coincide. These include Sites 1189003 and 0300019 near the headwaters, and Sites 0300010 and 1189008, near the mouth (Figure 9).

4.4.1 pH AND ALKALINITY

The pH of the Coquitlam River just downstream from Coquitlam Lake ranged from 5.8 to 6.3 in 1975-1976 at Site 1189001 (Table 14). Whitfield[31] analyzed pH data collected at the water intake near the Coquitlam Lake dam for 25 years by the Greater Vancouver Water District beginning in 1959. Weekly average pH values appear to have declined by 0.275 units during this time period. This may be a result of acidic precipitation, such as had been measured at Kanaka Creek[3].

Values in Or Creek were slightly more buffered, with values from 6.0 to 6.6. in 1975-1976 (Table 15). The pH increased going downstream so that at Site 0300010 near the mouth, values ranged from 6.0 to 7.5 during 1972-1982. The influence of slightly more acidic water from Scott Creek (pH from 6.3 to 6.9 at Site 1189007, near the mouth in 1975-1976, Table 16) tempered this trend, slightly.

In Section 3.3.11, the acidic nature of precipitation in the lower mainland was cited. Due to this, it is desirable that the pH regime in the watershed not become two acidic. Therefore, a provisional objective is proposed for pH in the watershed. The objective is that the pH be between 6.5 and 8.5. If the lower objectives of pH 6.5 can not be attained, the pH should not decline by more than 0.2 units going from upstream to downstream of a discharge or series of discharges.

Alkalinity values were measured only at Sites 0300010, 0300011, and 0300019. The same trend for increasing values going downstream was apparent for alkalinity. The mean value of 13.6 mg/L at Site 0300010, near the mouth, reflects the fact that the Coquitlam River has from a moderate (10-20 mg/L) to high sensitivity (<10 mg/L) to acidic inputs during much of the year.

Alkalinity data were not available for Or or Scott Creeks; however, on the basis of pH values, it is likely that these creeks have a high sensitivity to acidic inputs.

4.4.2 HARDNESS AND METALS

Values of total hardness also followed the trend of increasing values from the headwaters (3.0 to 3.8 mg/L at Site 1189001) to the mouth (4.5 to 39.4 mg/L at Site 0300010). The Coquitlam River would be classed as having extremely soft water. This is an important fact with respect to toxicity of metals which is greater in soft water than in hard water.

The measured hardness in Or Creek was similar to that in the headwaters of the Coquitlam, with values from 3.1 to 6.2 mg/L at Site 1189002. In Scott Creek, values ranged from 6.4 mg/L at Site 1189006 to 19.5 mg/L at Site 1189007. Thus, the tributary waters in the watershed also are extremely soft.

Only iron and manganese were measured at most sites on the river and tributaries, with most other metals having been measured only at Sites 0300010, 0300011, and 0300019 on the Coquitlam River. The maximum iron value was 23.7 mg/L at Site 0300011. This value was recorded on January 30, 1973 and had a corresponding suspended solids value of 682 mg/L. This indicates that the iron was in the suspended form, and not generally available to aquatic life. The most restrictive working water quality criterion for total iron is 0.3 mg/L maximum for drinking water, aesthetics[4], and to protect freshwater aquatic life[2]. Of 96 total iron measurements along the length of the Coquitlam River, 61 exceeded the criterion compared to only 3 of 31 dissolved iron measurements. The dissolved iron values above the criterion were at Site 1189008, near the mouth. Since many total iron values in the Coquitlam River do not meet this criterion, it is likely that the iron originates from bank erosion and stormwater runoff from the gravel operations. Dissolved iron levels in Scott (n=9) and Or Creeks (n=5) met the criterion; however, total iron values (n=1) did not.

The most restrictive water quality criteria for manganese are 0.05 mg/L maximum to protect drinking water supplies (aesthetics)[4] and 0.1 to 1.0 mg/L to protect freshwater aquatic life[16]. Total manganese values often exceeded the working drinking water criterion (22 of 74 measurements), but rarely exceeded the more restrictive criterion (0.1 mg/L) to protect freshwater aquatic life (2 of 74 measurements). All 20 dissolved manganese levels met both criteria. Dissolved manganese levels in Or and Scott Creeks (n=3 or 4) met the criteria, although 1 of 2 total manganese values in Or Creek (0.18 mg/L) exceeded both criteria.

Total aluminum values exceeded the B.C. water quality criteria[32] of 0.2 mg/L maximum dissolved to protect drinking water supplies and 0.05 (pH>6.5) as an average and 0.1 mg/L as a maximum to protect freshwater aquatic life at the three locations that single measurements were made (total of 5 measurements). However, these comparisons are not very meaningful since dissolved values are usually lower than total values and therefore may have met the criterion. The highest values did not always correspond to high suspended solids concentrations (e.g., 1.31 mg/L Al on December 1, 1982, at Site 0300011, which had a suspended solids level of 18 mg/L). Future measurements should include dissolved aluminum to allow interpretation of results.

B.C. water quality criteria for total copper are 0.5 mg/L to protect drinking water supplies (aesthetics), 0.3 mg/L to protect wildlife and livestock, 0.2 mg/L to protect irrigation supplies, and a 30-day average of 0.002 mg/L and a maximum of about 0.003 mg/L to protect freshwater aquatic life if hardness is less than 50 mg/L(5). Values at all three sites in the Coquitlam River achieved all the criteria for all measurements, except for the aquatic life maximum criterion which was often exceeded (24 of 82 measurements) at all sites, including Site 0300019 near the lake outlet. It is possible that total copper levels higher than the freshwater criteria are naturally occurring or that copper is being introduced directly from the precipitation (Section 3.3.11).

All other metals were below varying detection limits or working water quality criteria.

4.4.3 NUTRIENTS

Nitrogen and phosphorus values were measured only in the Coquitlam River, at Sites 0300010, 0300011, and 0300019 (Table 14).

Nitrogen values were low along the length of the river. The maximum ammonia value of 0.45 mg/L was well below the criteria listed in Tables 3 and 4 given the relatively low pH of the water. The maximum nitrite value of 0.008 mg/L at Site 0300010 was well below the most restrictive B.C. criteria (to protect aquatic life) of 0.02 mg/L as a 30-day average value or 0.06 mg/L as a maximum value(6). The maximum nitrate value of 1.15 mg/L at Site 0300010 was well below the most restrictive B.C. criterion (to protect drinking water supplies) of 10 mg/L(6).

Stormwater runoff from agricultural areas can transport nitrogen compounds to the river. In order to maintain the water quality for all water users, the following provisional objectives are proposed: <u>the 30-day average and maximum total ammonia-nitrogen values are not to exceed those values listed in Tables 3 and 4, respectively</u>; and <u>the 30-day average</u>

nitrite-nitrog· ·alue is not to exceed 0.02 mg/L while the maximum value is not to exceed ·.06 mg/L. The 30-day average values are to be calculated from at least five weekly samples collected in a 30-day period. The proposed objectives apply to the Coquitlam River, Or, and Scott Creeks, except in the initial diluton zones of effluents, described in Section 2.4.1.

Maximum dissolved orthophosphorus values increased from 0.006 mg/L at Site 0300019 to 0.046 mg/L at Site 0300010, near the mouth (Table 14). Dissolved phosphorus (maximum) values followed the same trend, increasing from 0.011 mg/L to 0.058 mg/L. Maximum total phosphorus values increased from 0.13 mg/L at Site 0300019, to 0.199 mg/L at Site 0300011. These increasing maximum values show the presence of increased phosphorus in the lower reaches of the river.

The B.C. Ministry of Environment has approved water quality criteria to address algal growth in flowing waters. These criteria take into account several of the factors, including nutrients, that can limit algal growth. Since recreational use of the Coquitlam is the use which has the lowest associated criterion, that criterion shall be proposed as the provisional objective for periphyton chlorophyll-a. The objective is that the maximum average value calculated from at least five periphyton chlorophyll-a samples collected on one day from natural substrate should be less than 50 mg/m². The objective applies to the Coquitlam River, Or, and Scott Creeks, except in the initial dilution zones of effluents, described in Section 2.4.1. Sufficient data are not available to determine if this objective is achieved.

4.4.4 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

The lowest dissolved oxygen levels in the Coquitlam River, Or, and Scott Creeks were measured at Site 0300010 at the mouth of the Coquitlam River. Values at this site have ranged from 8.2 to 13.2 mg/L (Table 14). These oxygen levels are greater than the working criterion of 8.0 mg/L to protect all salmonids except larvae and embryo (Section 2.4.4), and there would be consistently little or no impairment (9 and 11 mg/L, respectively) when salmonid embryo and larvae are present.

Since some oxygen-consuming materials can be introduced into the river from agricultural sources, a provisional objective is proposed for dissolved oxygen. The objective is that at all times, the minimum dissolved oxygen level should be greater than 8.0 mg/L. As well, when embryo or larvae are present, the minimum concentration should not be less than 11.0 mg/L. For the purpose of checking the objective, this latter objective will apply between November and March, yearly. The objectives apply in all reaches of the Coquitlam River, and Or and Scott Creeks except in the initial dilution zones of effluents, described in Section 2.4.1.

Percent saturation values were generally at 100% ±20% at all sites on the three streams, except on the Coquitlam River just downstream from the lake at Site 1189003, where values as high as 132.2% were found. These high values are likely a result of air being entrained as water is released from the spillway. Since values otherwise are within about 20% of 100% saturation, aquatic life would be afforded good oxygen levels with minimal associated stress.

Total gas pressure (TGP) is the sum of partial pressures created by all dissolved gases in solution, predominantly oxygen and nitrogen. TGP can cause gas bubble disease in fish, which can result in chronic or acute toxicity. TGP can be increased by intrusion of air into water, heating of water, excessive biological productivity, and biochemical transformations in groundwater. Of particular relevance to the Coquitlam River system is intrusion of air at the Spillway from Coquitlam Lake.

The effect of total gas pressure on fish depends upon several factors:

1. Duration of exposure: Meekin and Turner[35] found that juvenile chinook salmon and steelhead could repeatedly tolerate 122% TGP for 16 hours provided they were returned to 100% TGP for eight-hour periods.

This does not mean that short-term elevated TGP, as would be associated with excess biological productivity, is of minor concern. Exposure to excess total gas pressure levels (104-109+%) associated with Gas Bubble Trauma can result in mortalities of 1.5 to 5% over exposure periods of about 3 months[36].

2. Temperature: Jensen[37] reported significant mortalities (13% in 53 days) of alevins at temperatures of 12°C, but not at 8°C or 10°C, all at 110% TGP.

3. Water Hardness: Jensen[37] also reported that the significant mortalities at 12°C and TGP of 110% were at a hardness of 10 mg/L. At a hardness of 100 mg/L, but 12°C and TGP of 110%, no significant mortalities occurred.

4. Life Stage: Several researchers have found that tolerance to TGP is very high for eggs and adults, but very low in larval and juvenile stages[37,38,39,40]. Alderdice and Jensen accounted for the resistance in eggs being due to internal pressures in salmonid eggs[41].

5. Hydrostatic pressure: Greater water depths can reduce the risk of gas bubble disease[8]. A TGP of 110% is reduced to about 103% at 70 cm depth, and 100% at 1 m depth.

6. Oxygen-Nitrogen Ratios: If these ratios are varied, mortality does not necessarily correlate linearly with TGP. Rucker[2] found mortality at TGP of 119% was reduced significantly when the oxygen-nitrogen ratio increased from 159%/109% to 173%/105%.

Alderdice and Jensen[43], in reviewing gas supersaturation in the Nechako River, recommended that TGP should be less than 110% to guard against acute conditions, although as much as 5% mortality (cited as chronic) would occur between 105% and 110% TGP. Chronic conditions would occur in the range of 108% to 110%. It is likely that TGP near the outlet from the lake exceeds this range. Monitoring should be undertaken to confirm this.

4.4.5 SOLIDS AND TURBIDITY

Suspended solids entering the Coquitlam River, especially from gravel operations, have been a concern for a number of years. Data in Table 14 seem to indicate that on occasion a large amount of suspended solids may be natural. For example, the maximum suspended solids from upstream to downstream on June 10, 1981 were 439 mg/L at Site 0300019, 293 mg/L at Site 0300011, and 53 mg/L at Site 0300010. These data indicate that suspended solids are settling out along the length of the river, or that the high initial values are being diluted significantly by water with appreciably less solids. Since the terrain of the tributaries adjacent to the Coquitlam River is similar, the latter reason can likely be dismissed. This argument is credible if the maximum value of 433 mg/L for Or Creek (Table 15) and 69 mg/L for Scott Creek (Table 16) are taken into account. The Coquitlam River study found that the "ratio of natural and man-generated sediment in the Coquitlam River varies with the distribution of sediment inflow to the river. Data taken during this study showed that Coquitlam River sediment concentration increases resulting from man-generated sediment ranged from negligible to six fold"[23].

To protect aquatic life in the Coquitlam River and its tributaries, <u>a water quality objective is proposed for suspended solids</u>. The objective is that <u>induced levels should not increase by more than 10 mg/L if upstream levels are ≦100 mg/L, nor by more than 10% if upstream levels exceed 100 mg/L</u>. The objective applies outside the initial dilution zone or series of dilution zones, described in Section 2.4.1. In addition, to protect salmonid spawning areas, <u>there should be no significant (95% confidence level) induced benthic sedimentation on the basis of accumulation by weight for particles <3 mm</u>. In order to check the attainment of this latter objective, the average of these replicate samples should not increase by more than 10% going from upstream to downstream of a discharge or series of discharges.

The maximum recorded dissolved solids value was 64 mg/L at Site 0300010, near the mouth. Such low levels are well below the most restrictive working water quality criterion of 500 mg/L to protect drinking water supplies[4] and irrigation supplies[2].

Turbidity relates to aesthetics and the visible content of suspended sediment in a stream as opposed to suspended solids which reflect the aspect of physical damage to aquatic life and their habitat. Turbidity values as high as 160 NTU have been present at Site 1189004 (Table 14). In Or Creek, values have been as high as 104 NTU (Table 15) but were only 34 NTU in Scott Creek (Table 16). In analyzing GVRD data for the water intake in Coquitlam Lake, Whitfield[31] found turbidity levels to be quite low (<5 JTU) most of the time. However, the data did reflect the highly episodic nature of turbidity with values on two occasions (1972 and 1981) exceeding the 5 JTU level. Waters used for drinking require less than 5 NTU of turbidity[2]. Thus the waters from the streams would need treatment if used for drinking.

The B.C. criteria for induced turbidity[10] shall be used as <u>the proposed provisional objective</u>. The proposed objective is that <u>induced turbidity should increase by no more than 1 NTU if upstream values are ≤5 NTU, 5 NTU if upstream values are ≤50 NTU, and by not more than 10% if upstream values are >50 NTU</u>. These objectives will protect drinking water supplies and aquatic life, and are to apply to the Coquitlam River, Or and Scott Creeks, except in initial dilution zones of effluents, described in Section 2.4.1.

4.4.6 BACTERIOLOGICAL QUALITY AND COLOUR

Approved B.C. criteria[9] are as follows: a maximum value of 200/100 mL fecal coliforms or <u>Escherichia coli</u> or 50/100 mL Enterococci to protect livestock; geometric means of ≦200/100 mL fecal coliforms, ≦77/100 mL *Escherichia coli*, and ≦20/100 mL Enterococci, or ≦2/100 mL (75th percentile) *Pseudomonas aeruginosa* for primary-contact recreation; and geometric means of ≦1 000/100 mL fecal coliforms or *Escherichia coli* or ≦250/100 mL Enterococci for general irrigation.

In the upper reaches of the Coquitlam River, fecal coliform levels are fairly low, with a maximum value of 49 MPN/100 mL at Site 0300019 (Table 14). Values began to increase at Site 1189005 (maximum 130 MPN/100 mL) and continue to increase until a maximum level of 1300 MPN/100 mL was reached at Site 0300010. This may reflect the influence of agricultural activities or septic tanks in the lower reaches of the watershed. In the upper reaches of the watershed downstream from Coquitlam Lake, to be used for a drinking water supply, filtration or equivalent plus disinfection would be required(4). In the lower reaches, complete treatment plus disinfection would be necessary(4). The geometric mean fecal coliform concentration at all sites was less than 200 MPN/100 mL; however, values in excess of 200 MPN/100 mL were noted on 15 of 28 occasions at Site 0300010 and 2 of 34 occasions at Site 0300011, which is above the area of urbanization. Values have been as high as 630 MPN/100 mL in Scott Creek (Table 16) with all ten values exceeding 200 MPN/100 mL at Site 1189007, near the mouth. At the headwaters, all values were less than 200 MPN/100 mL. This difference could be related to urbanization in the lower reaches of Scott Creek.

The lower reaches of the Coquitlam River do not have to be maintained for drinking water since this urbanized area is provided water by the Greater Vancouver Water District. However, a high quality of water should be maintained for future and present users such as for higher livestock or industrial use. Therefore the following objectives are proposed for the Coquitlam River from the dam at Coquitlam Lake to the southern boundary of the Coquitlam River Park: ≦100/100 mL 90th percentile for fecal coliforms and for *Escherichia coli*, and ≦25/100 mL 90th percentile for enterococci. In the Coquitlam River below the Coquitlam River Park, including Scott and

Hoy creeks, the objectives are: ≤ 200/100 mL geometric mean for fecal coliforms, ≤77/100 mL geometric mean for *Escherichia coli*, ≤20/100 mL geometric mean for enterococci, and ≤2/100 mL 75th percentile for *Pseudomonas aeruginosa*. These objectives apply in all areas except the initial dilution zones of effluents, described in Section 2.4.1 and are to be calculated on the basis of a minimum of 5 weekly samples collected in a period no longer than 30 days.

In Or Creek, the maximum fecal coliform value was 2 MPN/100 mL in 1975-76. Such high quality water would require only disinfection prior to use. Therefore to maintain this high quality, an objective is proposed for fecal coliforms in Or Creek. The objective is that the 30-day 90th percentile should be less than 10/100 mL for fecal coliforms and *Escherichia coli* and ≤25/100 mL for enterococci based on a minimum of 5 weekly samples collected in a 30-day period. The objective applies in all of Or Creek, except in initial dilution zones of effluents, described in Section 2.4.1.

The few data on colour (n=5 at each of Sites 0300010 and 0300011) indicate that 3 of 5 measurements at each site exceeded 15 NTU, the criterion for aesthetics of drinking water[4].

4.4.7 CHLOROPHENOLS

Chlorophenols could not be detected as penta- or tetra- (<0.005 µg/g, dry-weight) or as tri- (<0.01 µg/g, dry-weight) in sediments from two sites near the mouth of the Coquitlam River[30].

4.4.8 POLYCHLORINATED BIPHENYLS

No PCB isomers (1016, 1221, 1232, 1242, 1248, 1254 or 1260) could be detected (<0.03 µg/g, dry-weight) in sediments from two sites near the mouth of the Coquitlam River.

4.4.9 OTHER ORGANIC COMPOUNDS

The organic compounds referred to in Section 2.4.9 were also not detected in sediments from the Coquitlam River.

4.5 RECOMMENDED MONITORING

Notwithstanding these recommendations, any monitoring undertaken will depend upon available resources and regional priorities.

The proposed objectives should be checked five times in a 30-day period from June through September and from December through February, yearly. Sampling should occur at a site near the mouth of Or and Scott Creeks, downstream from Or Creek on the Coquitlam River (Site 0300019), but above the gravel operations, at a site downstream from the gravel operations on the Coquitlam River, and at Site 0300010 on the Coquitlam River.

Analyses should include pH, temperature, total hardness, total and dissolved forms of iron, manganese, aluminum, and copper, total phosphorus, orthophosphorus, chloride, ammonia, nitrite, nitrate, periphyton chlorophyll-a, dissolved oxygen, suspended solids, turbidity, and fecal coliforms. Benthic sedimentation should be checked yearly, during the December through February period. As well, total gas pressure should be monitored below the spillway on the Coquitlam River at varying flow regimes and temperatures.

4.6 CONCLUSIONS

Peak flows in the Coquitlam River occur during winter, in response to high volumes of precipitation during this period. A major tributary to the Coquitlam River just downstream from Coquitlam Lake is Or Creek, which increases low flows by about 25%.

The Coquitlam River provides important habitat to several salmonid species and is used for recreation. Coquitlam Lake is also used as a water supply to Greater Vancouver and is diverted for power production at Buntzen Lake.

There is one licensed discharge to Hoy Creek, a tributary to Scott Creek. The discharge is secondary-treated domestic wastewater from a trailer park. The licensed discharges along the Coquitlam River are from ready-mix concrete and gravel operations.

Non-point sources to the Coquitlam include contamination in precipitation, septic tanks, agriculture, a small closed municipal refuse site, and a small woodwaste site. Runoff from the gravel operations has been the most significant source of sediment loadings from non-point sources.

The pH of the river is acidic just downstream from the lake, but reaches neutral values towards the mouth. Alkalinity follows a similar trend, with the sensitivity of the river to acidic inputs being from moderate to high. The water is very soft. Several values for iron, manganese, aluminum, and copper exceeded working water quality criteria to protect aquatic life. All other metals were below varying detection limits or working water quality criteria.

Nitrogen values were low along the length of the river, but phosphorus levels increased from Coquitlam Lake to the river mouth. Dissolved oxygen and percent saturation values were good, so that algal problems are not suspected to be present.

Suspended solids and turbidity can be high; however, these high levels can be natural or be a result of anthropogenic activities. A concern exists that these solids can settle in the river and cause degradation of the spawning beds, and cause impacts on rearing fish related to gill damage, food availability, and visibility. Dissolved solids were low, and did not affect water uses.

Bacteriological quality was good in the upper reaches of the river, but was degraded towards the mouth. If the water was to be used as a drinking water supply, disinfection only would be required in Coquitlam Lake, partialtreatment plus disinfection in the upper reaches, and complete treatment plus disinfection in the lower reaches. Throughout the system, bacteriological quality would be considered as satisfactory for other designated water users.

5. BRUNETTE RIVER

This river basin includes the Brunette River which flows into the Fraser River, Burnaby Lake which empties into the Brunette River, Still Creek which flows into Burnaby Lake, and Deer Lake which also drains into Burnaby Lake (Figure 10). The Brunette River near its mouth has industrial activity associated with it. Further upstream are located residential areas. The central portion has forested banks. Burnaby Lake has a good buffer area of trees and parkland around it, and serves as a wildlife refuge. Still Creek receives a large number of stormwater outfalls; however, it does have grassed banks and trees.

The Brunette River has a drainage area of about 70 km^2.

5.1 HYDROLOGY

Flows in the Brunette River are regulated by a dam at the outlet from Burnaby Lake. Minimal flows occur in the summer period when inflows to Burnaby Lake are a minimum. The 7-day low flow for a two-year return period for station 08MH026 on the Brunette River at Sapperton for those years with complete flow data was 0.122 m^3/s.

Flows in Still Creek followed a similar pattern to those in the Brunette River, with the lowest flows occurring in the summer period and the highest flows in the winter, in response to precipitation events. At Station 08MH061 on Still Creek at Burnaby, the 7-day low flows were 0.040 m^3/s (2-year return flow period) and 0.028 m^3/s (10-year return period).

Burnaby Lake has a surface area of 1.34 km^2 and a maximum depth of 3 m. A consultant for the District of Burnaby estimated that the lake had an average 31-day retention period[22].

5.2 WATER USES

The Brunette River contains hatchery-augmented populations (from hatcheries outside this watershed) of cutthroat trout, and coho and chum salmon. This river is the subject of a major effort through the Salmonid Enhancement Program to re-establish self-sustaining salmon and trout populations. Fish are beginning to re-utilize Burnaby Lake tributaries for spawning and rearing.

Steelhead trout were last reported to be present in 1955. Sharp declines in the escapement of coho salmon have occurred. The average yearly escapement of 930 in the 1950's declined to 40 in the 1960 to 1967 period. Thereafter, records were discontinued until 1982 when six spawners were recorded, increasing to 46 in 1983. Chum escapements were 30 and 13, respectively.

There are no licensed water withdrawals for the Brunette River system. This river system has the least potential for primary-contact recreational use of any of the water bodies discussed in this report. Burnaby Lake is used for secondary-contact recreation.

5.3 WASTE DISCHARGES

The locations of waste discharges with waste management permits are shown in Figure 10 by their permit numbers.

5.3.1 LAMFORD CEDAR PRODUCTS (PE 414)

This operation consists of a sawmill and an area which remanufactures rough-cut lumber into specialty cedar products. It discharges boiler blowdown water (after passing the effluent through a holding tank) to the Brunette River, approximately 100 metres above the Fraser River confluence.

Permit PE 414 allows the discharge of a maximum 80 m^3/d at a maximum temperature of 35°C. The maximum oil and grease concentration is to be 10 mg/L, and the pH should be in the range 6.5 to 8.5. At the maximum permitted discharge rate and two-year low flow, a dilution of about 130:1 is available in the Brunette River assuming complete mixing.

Data for this operation are summarized in Table 17. Recent (1986) data (n=3) for oil and grease indicate that the permit level was generally met but that the pH was above the permitted range. In the past, effluent quality has been poor, with high colour, BOD_5, and suspended solids. This may have caused localized impacts in the Brunette River above its confluence with the Fraser River.

5.3.2 SCHOOL DISTRICT NO. 41 (BURNABY) (PR 6897)

School District 41 has a waste management permit for landfilling hog fuel in a bog area prior to pre-loading the site with mineral fill. The site is 600 m south from Still Creek and is connected to Still Creek via a ditch. To minimize the generation and discharge of hog fuel leachate, the hog fuel is entirely below the watertable and areas not covered by a building will be used as an asphalt parking area. Surface runoff is discharged to the municipal storm sewer.

Permit PR 6897 allows the deposit of 6500 m^3 of hog fuel for this construction activity. Leachate from the site should be minimal, if any, and have no impact on Still Creek since the site will be covered with either the building or the asphalt parking lot.

5.3.3 CONTINENTAL CAN CANADA INC. (PE 2642)

This company operates a metal can manufacturing plant in Burnaby, north from the Brunette River. Wastewater originates as cooling water (which is city water) and roof stormwater. The cooling water is used to cool the cans on one process line, while it is totally recycled on three other lines. Cooling water also originates from three compressors and two vacuum pumps.

Permit PE 2642 allows the discharge to the Brunette River of the following maximum quantities: flow, 200 m^3/d; temperature, 22°C; and oil and grease, 2.0 mg/L. Data for 1983 (15°-22° C) and 1984 (10°-21° C) indicate that the temperature requirement was met. Oil and grease values were generally less than 2 mg/L. These data agree with those on the computer file, summarized in Table 18. The impact on the Brunette River should be negligible since the effluent has been of relatively good quality, and the dilution in the Brunette River is about 50:1 assuming complete mixing of the maximum permitted flow and the two-year low stream flow.

5.3.4 CRANE CANADA LIMITED (PR 3141)

This company manufactures vitreous chinaware. It is located on the north shore of the Brunette River. Waste from the operation consists of clay, flint, and syenite (raw materials). Waste Management Branch personnel, in conducting a site inspection, have not noted solid waste being disposed of since about 1982.

Permit PR 3141 allows the discharge of 11.5 m^3 of the inert industrial material every three weeks to a landfill located about 150 m from the Brunette River (and 10 m above).

It is doubtful if there would be any impact on surface water quality from this operation due to the inert nature of the waste.

5.3.5 IMPERIAL OIL LIMITED, LOUGHEED TERMINAL (PE 3840)

Imperial Oil Limited operates a bulk marketing terminal in Burnaby. Stormwater from the pump area, the tank farm area, and the truck loading area is treated in an oil separator and discharged to a ditch which enters Silver Creek, a Brunette River tributary.

Permit PE 3840 allows a maximum of 5 mg/L of oil and grease in stormwater from each of the three areas. It also allows the following average and maximum flows:

Source		Flow (m^3/d) Average	Maximum
Tank Farm Area	("01")	91	1 963
Loading Area	("02")	45	909
Pump Area	("03")	7.3	209

Effluent data are summarized in Table 19. The data indicate that high oil and grease concentrations have been measured in stormwater from each source. The highest values have been measured in the stormwater from the pump area. Oil and grease concentrations have been measured as high as 200 mg/L. It is likely that these high oil and grease levels could cause at least some localized impacts on Silver Creek.

This stormwater could be a source of polycyclic aromatic hydrocarbons (PAHs) to the Brunette River system.

5.3.6 SHELL CANADA (BURMOUNT TANK FARM) (PE 3138, PR 5476)

This petroleum tank farm is located at the headwater of Eagle Creek, a tributary to Burnaby Lake. The tank farm has three - 19 870 m^3 tanks for crude oil, one - 15 100 m^3 tank for regular gasoline, one - 12 080 m^3 tank for jet fuel, and two - 23 050 m^3 tanks for distillate. The three tanks used for crude oil receive and store product from the Trans Mountain pipeline system (Section 5.3.7). The crude oil in these tanks is continuously agitated, and the tanks are never drained.

Water collects in the treated distillate tanks when dissolved water separates as the desulphurized products cool. These tanks are usually drained of about 39 m^3 of water once per year. Rainfall can enter the gasoline and jet fuel tanks. As much as about 15 m^3/month in the rainy season can be drained.

Water drained from any of the tanks enters the dyked area in which the tanks are located. Each dyked area is drained independently to the refinery or to a stormwater retention pond, which is emptied as required to Eagle Creek, a tributary to Burnaby Lake.

Permit PE 3138 allows a discharge of 300 m^3/d. Water drained from the petroleum products storage area is to contain a maximum 5 mg/L oil and grease and 20 mg/L suspended solids. Data on effluent quality are in Table 20. Although some high values have been recorded (e.g., copper at 0.07 mg/L, oil and grease at 39 mg/L), mean values were generally low. Due to the intermittent nature of the discharge, its relatively low volume, and generally low concentrations, this discharge is not expected to impact Eagle Creek.

The company also has a dyked soil degradation bed (≈0.2 ha) for the disposal of oily sludge from the cleaning of hydrocarbon storage tanks. The sludge is applied to a maximum 0.08 m depth and treated with lime and a nitrogen-phosphorus fertilizer. Excess oil in the dyked area is skimmed from the stormwater and is returned to the refinery for treatment while excess stormwater is discharged to the stormwater retention ponds.

Permit PR 5476 allows for the discharge of 80 m^3/year of oil sludge. Data on stormwater from the dyked soil degradation bed area are in Table 21. These indicate that oil and grease concentrations being discharged to the retention pond can be high.

Stormwater from this operation could be a source of PAHs to the Brunette River system.

5.3.7 TRANS MOUNTAIN PIPE LINE (PE 6945)

Trans Mountain Pipeline has a tank farm (10 tanks) located near the headwaters of Eagle Creek, a tributary to Burnaby Lake. Stormwater from the dyked tank area is treated in an oil separator prior to entering a containment lagoon (13.7 m x 3.7 m x 1.8 m deep).

Permit PE 6945 allows the discharge of a maximum of 10 500 m^3/d to Eagle Creek with a maximum oil and grease concentration of 5 mg/L. The 96 h LC50 is to be ≧100%. Data for this discharge are in Table 22. The one bioassay performed (January 1985) had a 96 h LC50 >100%. All other values for other characteristics generally were low, and therefore of little concern for these characteristics with respect to Eagle Creek. However, the stormwater could be a source of PAHs to the Brunette River system.

5.3.8 STORMWATER DISCHARGES

The locations of stormwater and combined sewer discharges into the Still Creek/Burnaby Lake/Brunette River system are shown on Figure 1 of Reference 14 and reproduced in Figure 10. A summary found in Ferguson and Hall[(14)] of work conducted by Westwater Research is reproduced below.

"A series of stream sediment and street surface material were collected and analyzed for 11 trace metals and 17 chlorinated hydrocarbons. Considerable variation in street surface trace metals concentrations was found for any one land use area. Industrial and commercial areas generally had the greatest trace metal accumulations. However, Pb was the only contaminant which showed significant accumulation in all land use areas except green space. Street surface materials were found to contain from 1.8 to 5.7 times the average levels of Cd, Co, Cr, Cu, Hg, Ni, Pb, and Zn found in the stream sediments.

Chlorinated hydrocarbons found in both stream and street surface samples include p,p'-DDT, p,p'-DDE, p,p'-DDD, alpha chlordane, gamma chlordane, and PCBs. Levels of up to 0.78 ppm dry weight of PCB were found in Still Creek and substantial levels were detected in every sample. Significant concentrations of PCBs were also found in street surface materials with the mean levels of 0.091, 0.05, 0.096 and 0.14 ppm recorded for residential, green space, industrial and commercial land uses, respectively.

Grab samples were also obtained under high and low flow conditions at six stations to assess the importance of rainfall events in the transport of trace metals from street surfaces. At most stations, Cu, Pb, and Zn levels increased during high flows. Manganese concentrations increased during low flows and were thought to originate from groundwater"[14].

The effect of stormwater on the water quality of Still Creek was examined in 1973 by the Greater Vancouver Sewerage and Drainage District and was summarized by Ferguson and Hall[14]. Their summary indicated that fecal coliforms increased in Still Creek during wet weather, probably as a result of stormwater runoff. As well, after extended dry periods, levels of BOD_5, colour, nitrogen, phosphorus, suspended and total solids, and heavy metals increased substantially.

The B.C. Ministry of Environment carried out a stormwater monitoring program in 1982-1983 in a light-industrial catchment area draining to Still Creek[19]. The following arithmetic mean concentrations of all samples collected over all storms studies were determined: fecal coliforms, 2860 MPN/100 mL; 8.72 mg/L total aluminum; 0.02 mg/L total chromium; 0.04 mg/L total copper; 0.22 mg/L total lead; 0.00007 mg/L total mercury; 0.24 mg/L total zinc; 0.092 mg/L total ammonia; 0.025 mg/L nitrite; 0.063 mg/L orthophosphorus; 0.418 mg/L total phosphorus; and 242 mg/L suspended solids. Most of these are significantly higher than found by Swain[20] for a residential area draining to the Fraser River. Swain[20] had found that many of the contaminants in the stormwater were actually introduced in the precipitation itself (see Section 3.3.11).

Ferguson and Hall estimated stormwater flows and loadings by municipality[14]. They indicated that Burnaby had a catchment area of 7 340 ha draining to the Fraser River. The Brunette River catchment is about 7 000 ha, or about 95% of this area. Using this drainage area, and estimates in Appendix 3 of Ferguson and Hall[14], the following loadings and concentrations were calculated as entering the Brunette River drainage from stormwater:

	Estimated Stormwater Loadings kg/d	Estimated Average Stormwater Concentrations mg/L+
BOD_5	2679	22.9
Total nitrogen	200	1.7
Total phosphorus	57	0.5
Fecal Coliforms*	$1.0x10^{13}$	$8500x10^6$MPN/100mL
Copper	1.7	0.015
Iron	30.4	0.26
Manganese	2.7	0.025
Nickel	0.26	0.023
Lead	5.6	0.050
Zinc	2.0	0.017

+ Based on a stormwater flow of 42 700 X 10^3 m^3/year (Appendix 3: Reference 14)

* MPN/d

Based on the 2-year low flow of 0.04 m^3/s, if all the stormwater from the basin was discharged at the mouth of the Brunette River, it would be nearly 34 times the volume of the river. That is, during storms, stormwater would comprise much of the stream flow and thus determine quality. Since the stormwater would not enter the Brunette River during low flow, the degree of impact would not be as great as calculated.

Based on ambient water quality criteria for each characteristic predicted in stormwater which would in essence define the ambient water quality in the Brunette River, copper and lead would be at levels which exceed criteria ([5],[25]) for freshwater aquatic life while fecal coliform levels would be too high to permit any water use other than by aquatic life([9]). Levels of iron, manganese, nickel and zinc met the most restrictive CCREM criteria([2]).

In 1985, a fish kill in the Brunette River was attributed to the dumping of chlorophenols into a storm drain which entered a tributary to the Brunette River.

5.3.9 OTHER POLLUTANT SOURCES

Atwater[15] indicated that one small closed municipal landfill (Sperling Avenue) could affect this drainage basin, as well as one closed woodwaste site. However, the effects were not quantified.

5.4 AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

Water quality data are summarized in Table 23 for Still Creek, Table 24 for Burnaby Lake, and Table 25 for the Brunette River. Proposed designated water uses are for the protection of aquatic life and wildlife, and for secondary-contact recreation, with eventual upgrading of Deer and Burnaby Lakes to permit primary-contact recreation during the summer months.

5.4.1 pH AND ALKALINITY

The working water quality criteria for pH are 6.5 to 9.0 for the protection of freshwater aquatic life[2] and 6.5 to 8.3 (desirable)[18] or 5.0 to 9.0 (acceptable)[2] for recreation. Going in a downstream direction, the pH varied from 6.6 to 7.4 in Still Creek, 6.0 to 7.8 in Burnaby Lake, and 6.6 to 7.9 in the Brunette River. In Burnaby Lake, all but two values (n=31) were above 6.5.

The stormwater discharges (Section 5.3.8) can contain ammonia from fertilizer application or cross connections with domestic sewage lines. The amount of ammonia which is toxic decreases with lower pH values (and lower temperatures). As well, the acidic nature of precipitation in the Lower Mainland has been cited (Section 3.3.11). In order to maintain pH levels so that freshwater aquatic life are protected, a provisional objective is proposed for pH. The objective is that the pH in the Brunette River system should be in the range from 6.5 to 8.5. The upper value in the range is slightly higher than the most restrictive criterion due to a concern that the data base may not be sufficient to define an upper value with such precision, i.e., citing a value of 8.3 implies extreme confidence in the value used for an upper limit. The objective applies in all areas except initial dilution zones of effluents, described in Section 2.4.1 for rivers and streams, and in Section 3.4.1 for lakes.

Minimum alkalinity values were 20 mg/L in Still Creek (Table 23), 17.3 mg/L in Burnaby Lake (Table 24), and 18.5 mg/L in the Brunette River (Table 25). These alkalinity values indicate a moderate to low sensitivity of these water bodies to acidic inputs.

5.4.2 HARDNESS AND METALS

The minimum hardness value was 25.1 mg/L in Still Creek (Table 23), while the maximum value was 290 mg/L at the same site. Average values throughout the system were from about 40 to 60 mg/L. This range of values indicates that hardness in the system can be from low to moderately high.

Several metals were at or below detection limits or the criteria to protect aquatic life. Those which exceeded criteria on occasion are discussed below.

At pH values ≧6.5, the B.C. criterion for maximum dissolved aluminum values to protect aquatic life is 0.1 mg/L[32]. This value was exceeded by almost every total aluminum value throughout the system (23 of 24 values), therefore it is likely that these high aluminum values are background to the system. What percentage of the total aluminum was in the dissolved form is not known. Dissolved aluminum values met the criterion on all six occasions that dissolved aluminum was measured.

Total chromium was detected at Site 0300008 on Still Creek and Site 0300112 on the Brunette River, at levels as high as 0.04 mg/L and 0.01 mg/L, respectively. The working criteria to protect aquatic life are 0.002 mg/L for phytoplankton and zooplankton and 0.020 mg/L for fish[2]. The former criterion was exceeded all 24 times when detection limits allowed interpretation of the data relative to the criterion. The latter criterion was exceeded on 3 of 79 measurements. Two metal finishing operations discharged wastes to Still Creek in the past[14]. However, high values have occurred since these operations stopped discharging. Therefore, more sampling should be undertaken to determine chromium levels and effects of existing discharges. It is possible that there is a relationship to stormwater discharges. In the meantime, a long-term objective is proposed for total chromium in the Brunette River system. The objective is that the maximum concentration should not exceed 0.020 mg/L. The long-term objective will apply in all parts of the Brunette River basin, except initial dilution zones of effluents.

Approved B.C. criteria for copper to protect aquatic life[5] are 0.002 mg/L average (hardness ≦50 mg/L) and a maximum of 0.004 mg/L for a hardness of 20 mg/L and 0.005 mg/L for a hardness of 30 mg/L. Total copper values at sites throughout the watershed usually exceeded these criteria for all 37 measurements in Still Creek, 10 of 16 measurements in Burnaby Lake, and 25 of 37 measurements in the Brunette River. In Section 5.3.8, it was noted that stormwater could cause ambient levels to be about 0.015 mg/L. The fact that values exceeded the criteria throughout the watershed implies that high copper values originate from stormwater. Similarly, total iron values exceeded the working criterion of 0.3 mg/L[2] throughout the watershed (all 95 measurements at four sites). A long-term objective proposed for total copper in the Brunette River system is that the average value should be ≦0.002 mg/L. Other objectives are that the long-term maximum should be 0.004 mg/L for hardness ≧20 mg/L and 0.005 mg/L for hardness >30 mg/L. The proposed objectives apply to all areas except initial dilution zones of effluents.

The B.C. criterion for total lead to protect aquatic life is an average of 0.004 mg/L for a hardness of 20 mg/L to 30 mg/L[25]. These hardness levels were the minimum for Burnaby Lake, and Still Creek and Brunette River sites, respectively. The criterion was exceeded for all 17 measurements in Burnaby Lake, all 38 measurements in Still Creek, and 8 of 47 measurements in the Brunette River. In Section 5.3.8, it was noted that lead from stormwater discharges could be as high as 0.05 mg/L, and that stormwater often comprised the ambient flow in the watershed. The largest number of stormwater overflows[23] (and the two combined sewer overflows) is into Still Creek. There are seven into Burnaby Lake, two to Deer Lake, and six to the Brunette River.

Long-term objectives are therefore proposed for lead in Still Creek, Burnaby and Deer Lakes, and the Brunette River to protect aquatic life in these water bodies. The objectives are that the 30-day average value calculated from at least five weekly samples should be ≤0.004 mg/L and that the maximum total lead concentration should not exceed 0.012 mg/L in Burnaby Lake or 0.018 mg/L in Still Creek or the Brunette River. The objectives apply in all areas, except initial dilution zones of effluents, described in Section 2.4.1 for rivers and streams, and in Section 3.4.1 for lakes.

The B.C. criteria[25] note that the total lead concentrations in the edible portions of fish should not exceed 0.8 µg/g (wet-weight). When levels exceed this alert level, site specific studies should be carried out to determine the lead intake and body burden of consumers [25]. This level is proposed as a water quality objective for lead in muscle tissue.

Values for total mercury at Site 0300009 on Burnaby Lake (Table 24) and Site 0300111 on the Brunette River (Table 25) exceeded the criterion of 0.0001 mg/L as a maximum value to protect consumers of fish[21], for two of ten and one of twelve samples, respectively. Most other values were <0.00005 mg/L, the detection limit. Draft B.C. criteria for mercury also call for a 30-day average concentration of 0.02 µg/L[44]. As well, the draft B.C. criteria outline concentrations of total mercury in edible portions of fish depending upon quantity consumed, ranging from 0.5 µg/g (wet-weight) for 210 g consumption to 0.1 µg/g for 1 050 g consumption[44]. More sampling is recommended to determine if there are anthropogenic sources of this mercury.

Long-term objectives are proposed for mercury in the Brunette River basin. The proposed objectives are that the maximum total mercury concentration should not exceed 0.1 μg/L and the 30-day average 0.02 μg/L. At the same time, in edible fish tissues, the maximum concentration of total mercury should not exceed 0.5 μg/g (wet-weight). The objectives for fish apply in all areas of the Brunette River basin, while those for the water column do not apply in the initial dilution zones of effluents.

Total zinc values at all sites sometimes exceeded the criterion of 0.03 mg/L to protect aquatic life[2]. This took place for 34 of 39 values in Still Creek, 2 of 17 measurements in Burnaby Lake, and 7 of 36 measurements in the Brunette River. A mean zinc concentration of 0.24 mg/L was measured in stormwater from a light industrial catchment (Section 5.3.8). Therefore, stormwater may be the cause of these high zinc values.

To protect aquatic life, a long-term provisional water quality objective is proposed for total zinc in the Brunette River system. The objective is that total zinc should not exceed a maximum of 0.03 mg/L. The objective applies in the entire basin except in initial dilution zones of effluents, described in Section 2.4.1 for rivers, and Section 3.4.1 for lakes.

Swain and Walton ([30]) collected data on sediments from two sites near the mouth of the Brunette River and one site on Still Creek just upstream from Burnaby Lake (T-10, T-11, and T-12 on Figure 10) in a survey of sediments in tributaries to the Fraser River. The highest cadmium level was in Still Creek at 1.18 μg/g, dry-weight, which was about twice the concentration (0.6 μg/g) allowed under the old Ocean Dumping Control Act (the Act was repealed in June 1988 and control measures incorporated into the Canadian Environment Protection Act). These high levels were not evident at Site T-11 on the Brunette River.

The highest values were also noted in Still Creek for copper (122 μg/g, dry-weight), lead (238 μg/g, dry-weight), mercury (0.12 μg/g, dry-weight), molybdenum (26 μg/g, dry-weight), tin (5.31 μg/g, dry-weight), and zinc (256 μg/g, dry-weight). The concentration of zinc was between four and five times the level found in Kanaka Creek, a site with similar particle size distribution as in Still Creek, and was as high as found in contaminated sediments adjacent to the outfall from the Iona STP. Hall et al. (1976) [33] had found that copper, lead, and zinc were the most significant trace metal contaminants in the Brunette Basin (including Still Creek).

The sediment gradation for the data collected by Swain and Walton[30] was such that very similar particle sizes existed between the Kanaka Creek sample and the Still Creek sample and between a sample collected in the Pitt River above the Alouette River confluence. Both the Pitt River and Kanaka Creek samples could be considered as relatively uncontaminated. Taking the higher value from these two sites for each of copper, lead, mercury and zinc and increasing these by 20% to account for potential laboratory precision problems, the following values were calculated which are meant to be used as long-term provisional water quality objectives for sediments in the Brunette River and Still Creek: maximum copper, 30 μg/g (dry-weight); maximum lead, 5.0 μg/g (dry-weight); maximum mercury, 0.070 μg/g (dry-weight); and maximum zinc, 70 μg/g (dry-weight). These objectives apply outside the initial dilution zones of effluents. In proposing these objectives, it is recognized that especially for lead and zinc, current concentrations are far in excess of these proposals; however, these are proposed as long-term goals. It is recognized that the proposed objectives are not based upon bioaccumulation, bioconcentration, or toxicity data; however, these data can be obtained in the interval required to modify existing discharge practices. Great care should be paid to not using these proposed objectives in other waterbodies unless the sediment gradation is similar to those on which these objectives are based (i.e., approximately 60% to 70% sands, 20% to 30% silt, and 10% clay).

5.4.3 NUTRIENTS

The maximum recorded ammonia-nitrogen value of 1.26 mg/L at Site 0300111 on the Brunette River was below the B.C. criteria for a maximum and average value at pH 7.9 in Tables 3 and 4. Section 5.3.8 indicated that the average ammonia concentration in stormwater from an industrial area could be 0.092 mg/L. Due to the large number of stormwater outfalls to this catchment as well as two combined sewer overflows, a provisional objective is proposed for ammonia-nitrogen. The objective is that the maximum and average values should not exceed values listed in Tables 3 and 4, respectively. These objectives apply except in the initial dilution zones of effluents, described in Section 2.4.1 for streams and rivers and in Section 3.4.1 for lakes.

Nitrite values in the basin were elevated, but met the approved B.C. criteria for aquatic life (6) (see Table below) because of the high corresponding chloride concentrations.

The high nitrite and chloride levels are unusual for a freshwater stream. High nitrite values in Still Creek have been associated with high COD or BOD_5 levels and low dissolved oxygen. These results tend to indicate that ammonia is only partially oxidized to nitrate due to low dissolved oxygen, and/or that nitrite is being discharged to the receiving water.

In Section 5.3.8, average nitrite levels in stormwater were cited as 0.025 mg/L. Since there are anthropogenic sources of nitrite to the watershed, and fish are beginning to use tributaries to Burnaby Lake for spawning, nitrite levels can be a concern. A provisional objective is therefore proposed for nitrite. The objective is that the average and maximum values should not exceed the values in the following table:

Chloride (mg/L)	Nitrite 30-d Average* (mg/L)	Nitrite Maximum (mg/L)
<2	0.02	0.06
2-4	0.04	0.12
4-6	0.06	0.18
6-8	0.08	0.24
8-10	0.10	0.30
>10	0.20	0.60

* The 30-d average chloride concentration should be used to determine the appropriate 30-d average nitrite criterion.

The objectives apply in all areas, except initial dilution zones of effluents, described in Section 2.4.1 for streams and rivers and in Section 3.4.1 for lakes.

The maximum total phosphorus value was at Site 0300008 on Still Creek (Table 23), at 0.59 mg/L with a maximum dissolved phosphorus level of 0.126 mg/L. Values in Still Creek and the Brunette River were high enough to cause algal growths, if phosphorus was the limiting factor.

The minimum total phosphorus value in Burnaby Lake (0.03 mg/L) is two to six times the B.C. criteria of 0.005 to 0.015 mg/L to protect habitat and food supplies for salmonids[6]. In order to produce an environment suitable for aquatic life, it is proposed that the average total phosphorus measured over the growing season (April to October) at any point in Burnaby Lake at a depth of 1 metre below the surface should not exceed 0.015 mg/L. This is the proposed long-term objective for Burnaby Lake outside the initial dilution zone of effluents, described in Section 3.4.1. The objective should be checked by collecting five weekly samples in a thirty-day period during the July/August period.

In Section 5.3.8, it was noted that phosphorus as high as 0.5 mg/L could be in stormwater discharges. In order to protect the Brunette River habitat for salmonid populations, the B.C. criterion for periphyton chlorophyll-a of 100 mg/m^2 maximum will be the proposed provisional objective. This is to be based upon the average of five periphyton chlorophyll-a samples collected on natural substrate on the same day, outside the initial dilution zones of effluents, described in Section 2.4.1 for streams and rivers and in Section 3.4.1 for lakes. Since measurements have not been made, it is not known if this proposed provisional objective can be achieved.

5.4.4 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

Dissolved oxygen values have been as low as 1.95 mg/L in Still Creek (Table 23), well below 6.0 mg/L where a slight impairment would occur and 8.0 mg/L where no impairment would occur to all salmonid life stages except embryo and larvae (Section 2.4.4). Values less than 6.0 mg/L have been recorded for 7 of 38 measurements in Still Creek (usually October or July of different years), one of 35 measurements in Burnaby Lake (September 1972), but zero of 43 measurements in the Brunette River. For a criterion level of 8.0 mg/L, the number of values not meeting this minimum were 12 of 38 in Still Creek, 9 of 35 in Burnaby Lake, and 6 of 43 in the Brunette River. For early life stages of salmonids, a criterion of 11.0 mg/L has been used earlier in this document, for the periods November through March. An examination of dissolved oxygen data for this period indicated that only 3 of 15 samples in Still Creek, 4 of 14 samples in Burnaby Lake, and 10 of 14 samples in the Brunette River met this criterion.

In order to protect aquatic life, a provisional objective is proposed for dissolved oxygen of 8.0 mg/L in the Brunette River, 6.0 mg/L in Still Creek and Burnaby Lake, and a long-term objective of 8.0 mg/L in Still Creek and Burnaby Lake. During the period November through March, the long-term objective for all these water bodies is that the minimum dissolved oxygen concentration not be less than 11.0 mg/L. These minimum values are to be achieved in all parts of these water bodies, except in initial dilution zones of effluents, described for streams in Section 2.4.1 and in Section 3.4.1 for lakes.

Percent saturation values in Still Creek have been as low as 21.4%. These fluctuating levels could cause stress to fish populations. The fact that BOD_5 and COD are measurable is indicative of the presence of large quantities of organic material which exert an oxygen demand. Percent saturation values in Burnaby Lake ranged from 42.5 to 115.1%. This range of values can cause stress to aquatic life, making the organisms more susceptible to other stresses. Percent saturation values in the Brunette River ranged from 73.6% at Site 0300111 to 136.9% at Site 0300112 (Table 25). Such ranges of percent saturation can cause a slight stress to aquatic life.

5.4.5 SOLIDS AND TURBIDITY

Dissolved solids levels were very high in Still Creek on one sampling, at 1226 mg/L (Table 23). The corresponding field-measured conductivity, not reported in Table 23, was >1 000 µS/cm. Significantly lower dissolved solids values were found in Burnaby Lake and the Brunette River, where maximum values were 160 mg/L and 166 mg/L, respectively. In Still Creek, if the value of 1 226 mg/L were excluded, the maximum value was 174 mg/L. There are no water quality criteria for dissolved solids to protect aquatic life. However, the source and nature of unusally high levels should be investigated.

The maximum suspended solids value was recorded at Site 0300111 on the Brunette River, at 456 mg/L (Table 25). The maximum values in Still Creek and Burnaby Lake were about 130 mg/L. Due to the large number of stormwater outfalls located in this watershed, a concern exists that suspended solids could increase. In Section 5.3.8, the mean level in stormwater discharges was 242 mg/L.

B.C. water quality criteria[10] to protect aquatic life are that induced suspended solids should not be increased by more than 10 mg/L or by more than 10% of upstream values, whichever is greater. Therefore, this is the proposed provisional water quality objective for suspended solids. Figure 11 indicates that in the range from 30 mg/L to 240 mg/L, this allowable percentage increase is really no increase if laboratory precision is considered.

Suspended solids levels indicate the possible physical damage to aquatic life, while turbidity addresses the aspect of aesthetics and light attenuation. There is no constant relationship between these two characteristics[10].

Turbidity values decreased going downstream in the watershed. Maximum values were 105 NTU in Still Creek, 28 NTU in Burnaby Lake, and 13 NTU in the Brunette River. The discrepancy which appears to occur between turbidity and suspended solids is likely due to different numbers of samples and periods of record. B.C. criteria for induced turbidity to protect aquatic life are that levels should not increase by more than 5 NTU or by more than 10% of upstream values, whichever is greater. This is the proposed water quality objective for turbidity. For turbidity levels <5 NTU, the objective is that induced turbidity should not increase by more than 1 NTU.

Both the turbidity and suspended solids objectives apply in all areas of the watershed, except in initial dilution zones of effluents, described in Section 2.4.1 for streams and rivers and in Section 3.4.1 for lakes. They apply to one discharge or a series of discharges.

The B.C. criterion to protect habitat for salmonid spawning is that there should be no induced benthic sedimentation for particles <3 mm in size. This is the proposed water quality objective for spawning areas in the Brunette River downstream from Burnaby Lake. The level of significance for this objective is defined as the 95% confidence level when comparing average sediment compositions at background and potentially affected sites. Sediment compositions can be determined using sediment traps, freeze-core samplers, or other types of bottom sediment samplers which do not lose fine sediment particles during sampling. In reality, the number of samples required to determine this level of significance is inordinate. Therefore, for purposes of checking attainment of the objective, there should be less than a 10% increase.

5.4.6 BACTERIOLOGICAL QUALITY

Fecal coliforms have been high throughout the watershed. Median values were 3390 MPN/100 mL in Still Creek (Table 23), 490 MPN/100 mL in Burnaby Lake (Table 24), and 200 MPN/100 mL at Site 0300112 and 920 MPN/100 mL at Site 0300111 on the Brunette River (Table 25). Significant increases in fecal coliforms can occur due to stormwater runoff (Section 5.3.8).

There are no B.C. water quality criteria[9] for aquatic life or secondary-contact recreation. For primary contact recreation, the B.C. criteria[9] are that geometric means of fecal coliforms be ≦200/100 mL, of Escherichia coli ≦77/100 mL, and of enterococci ≦20/100 mL. As well, the 75th percentile of Pseudomonas aeruginosa should be ≦2/100 mL. The proposed long-term water quality objective to allow primary-contact recreation are that the geometric mean value should be ≦200/100 mL for fecal coliforms, ≦77/100 mL for Escherichia coli, ≦20/100 mL for Enterococci, and that the 75th percentile Pseudomonas aeruginosa be ≦2/100 mL. Also, the 90th percentile for fecal coliforms should be less than 400/100 mL. The long-term objectives apply in Deer and Burnaby Lakes, except in initial dilution zones of effluents, described in Section 2.4.1 for streams and rivers and in Section 3.4.1 for lakes. The geometric mean value is to be based upon a minimum of five samples collected weekly in a 30-day period.

5.3.7 TRACE ORGANIC CONTAMINANTS

Hall et al.[24] conducted an investigation in 1983 of selected trace organic contaminants in sediments and fish tissue at ten sites in the Fraser River Estuary area, one of which was on Still Creek. In composite surface sediment samples, the following[24] levels were found:

	Concentration ng/g dry weight
Diethylphthalate	Trace
Di-n-butylphthalate	64
Bis (2-ethylhexyl)phthalate	57
Phenanthrene	35
Fluoranthene	53
Pyrene	108
Phenol	25

These levels generally were lower than found at several other sites in the Fraser River Estuary area during the same survey, indicating that the Still Creek sites were not highly contaminated.

Swain and Walton (30) measured chlorophenols, PCBs, and other organic compounds at two sites on the Brunette River (Sites T-11,and T-12: Figure 10) and at one site on Still Creek (Site T-10: Figure 10). No PCB isomers (1016, 1221, 1232, 1242, 1248, 1254, or 1260) were detected above the detection limit of 0.03 µg/g dry-weight. Chlorophenols could not be detected (<0.005 µg/g, dry-weight) as penta-or tetra- or as tri- (<0.01 µg/g, dry-weight), an interesting result in light of the spill of chlorophenols in 1985. Other organic compounds referred to in Section 2.4.9 were also not detected in sediments from Still Creek or the Brunette River.

5.5 RECOMMENDED MONITORING

Sampling actually undertaken will depend upon available resources and regional priorities. It is recommended that four sites be used for sampling, as follows: Site 0300008 on Still Creek; Site 0300009 on Burnaby Lake; and Sites 0300111 and 0300112 on the Brunette River. Monitoring should occur for one period from mid-June through mid-September and once in the period from October through February, with five samples being collected in 30 days in each period.

Samples should be analyzed for the following characteristics: pH; dissolved oxygen; specific conductivity; temperature; total hardness; total and dissolved forms of chromium, copper, iron, lead, and zinc; total mercury; ammonia; nitrite; nitrate; chloride; total phosphorus and orthophosphorus (summer only in Burnaby Lake); chlorophyll-a (Burnaby Lake only); periphyton chlorophyll-a (all sites except Burnaby Lake in summer period); suspended solids; turbidity; benthic sedimentation (Brunette River only from beginning of spawning to emergence); lead and mercury in edible resident fish tissue; copper, lead, mercury, and zinc in sediments and fecal coliforms.

5.6 CONCLUSIONS

Flows in the Brunette River are regulated by a dam at the outlet from Burnaby Lake. Low outflows occur in the summer period when inflows to the lake from tributaries such as Still Creek, are a minimum. The highest flows occur during the winter in response to precipitation. The retention time in Burnaby Lake is short, approximately one month in duration on average.

The importance of this river system to aquatic life is growing. The Brunette contains hatchery-augmented populations of cutthroat trout, coho salmon, and chum salmon. Fish are beginning to use Burnaby Lake tributaries for spawning and rearing.

Operations of most importance in this watershed with waste management permits are the Imperial Oil and Shell Oil operations. Both discharge treated stormwaters to tributaries of either Burnaby Lake or the Brunette River. Of most importance in this area, but not under a waste management permit, are stormwater outfalls and two combined sewer overflows. These can cause increases in metals, coliforms, solids, nitrogen, and phosphorus.

The pH of the system was slightly acidic, reflecting the importance of rainfall in determining the water quality of the system. The system had a moderate buffering capacity to acidic inputs, "soft" water, and some high metals values exceeding water quality criteria for aquatic life, including aluminum, chromium, copper, iron, lead, mercury, and zinc.

Ammonia and nitrite values were high but below B.C. criteria for aquatic life. Phosphorus levels in Burnaby Lake exceeded criteria for the protection of habitat and food supplies for salmonids. Dissolved oxygen values can be low and below some criteria for the protection of salmonids in Still Creek and Burnaby Lake, but are better in the Brunette River.

One dissolved solids value in Still Creek was extremely high but all others were significantly lower, and of the same magnitude as found in Burnaby Lake and the Brunette River. Suspended solids have been high throughout the watershed, likely as a result of the impact of stormwater discharges. Turbidity decreased going downstream from Still Creek to the

Brunette River, but these results may be related to turbidity and suspended solids samples being collected over different periods of record.

Fecal coliforms have been high throughout the watershed, likely due to the impact of stormwater discharges. If recreational (primary-contact) use is to be made of the these waters, modifications to current practices will be required to improve water quality.

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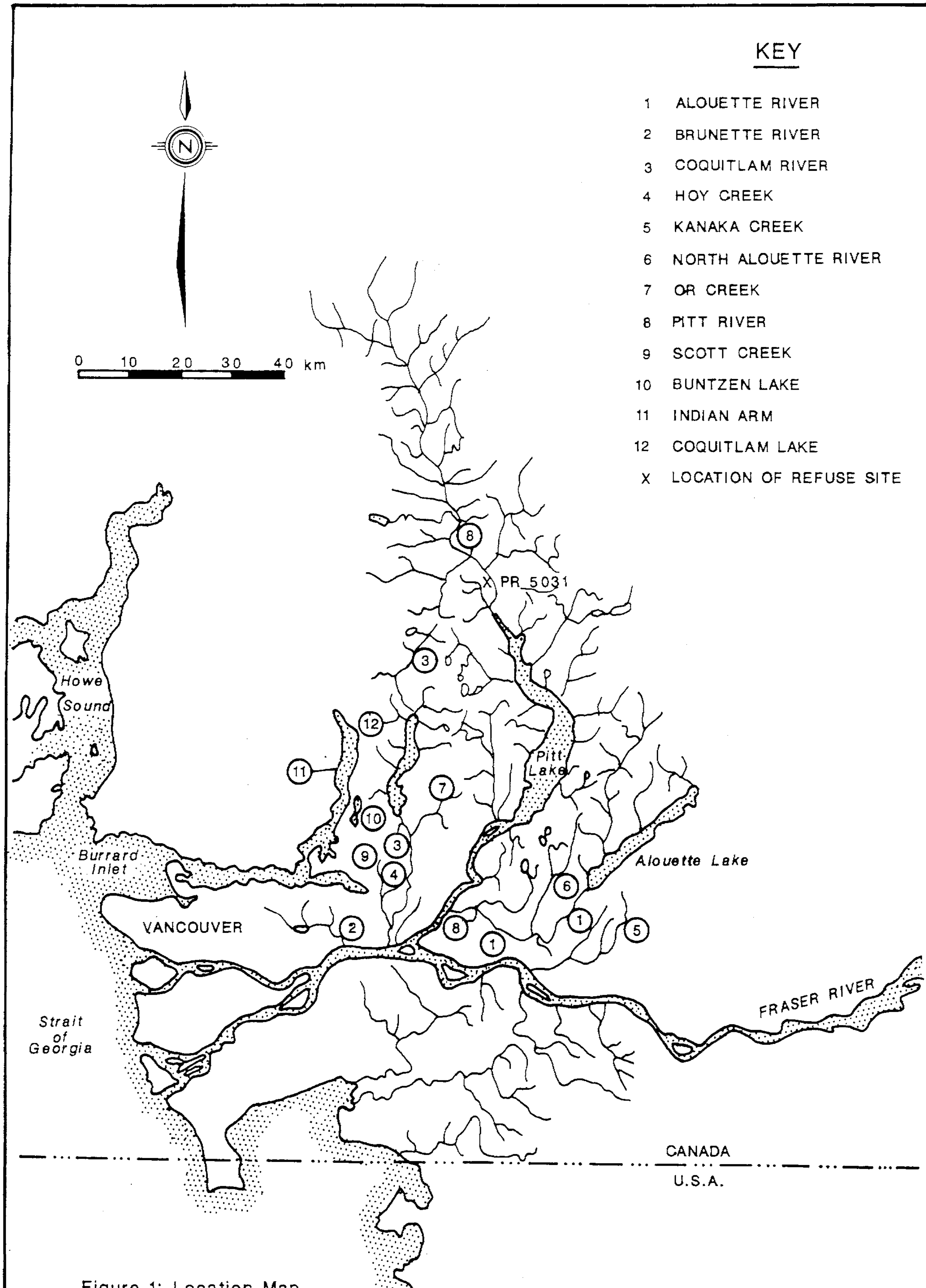

Figure 1: Location Map.

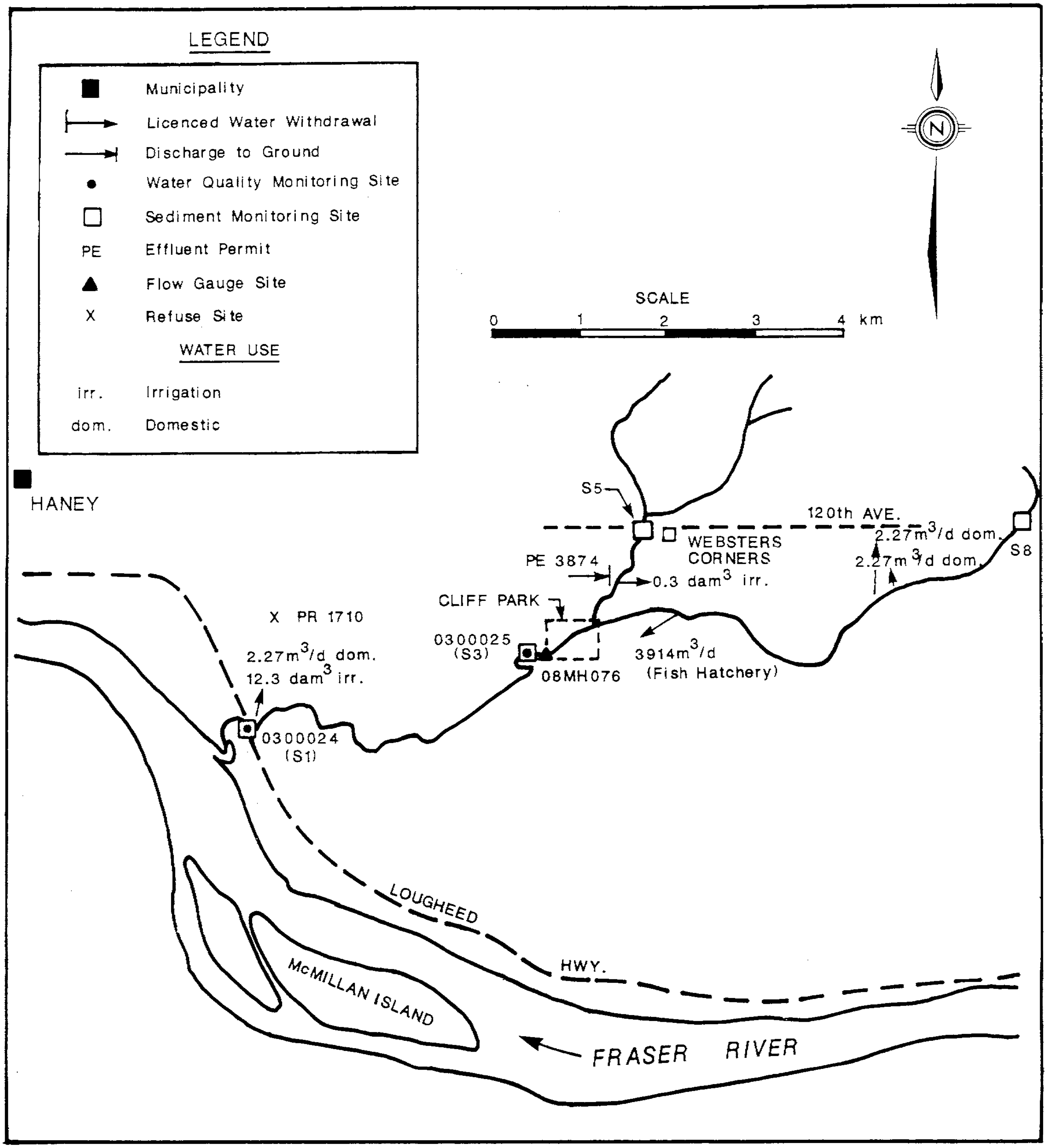

Figure 2: Locations of Sites Discharging Effluents, Ambient Water Quality Monitoring Sites, and Locations of Water Withdrawals: Kanaka Creek.

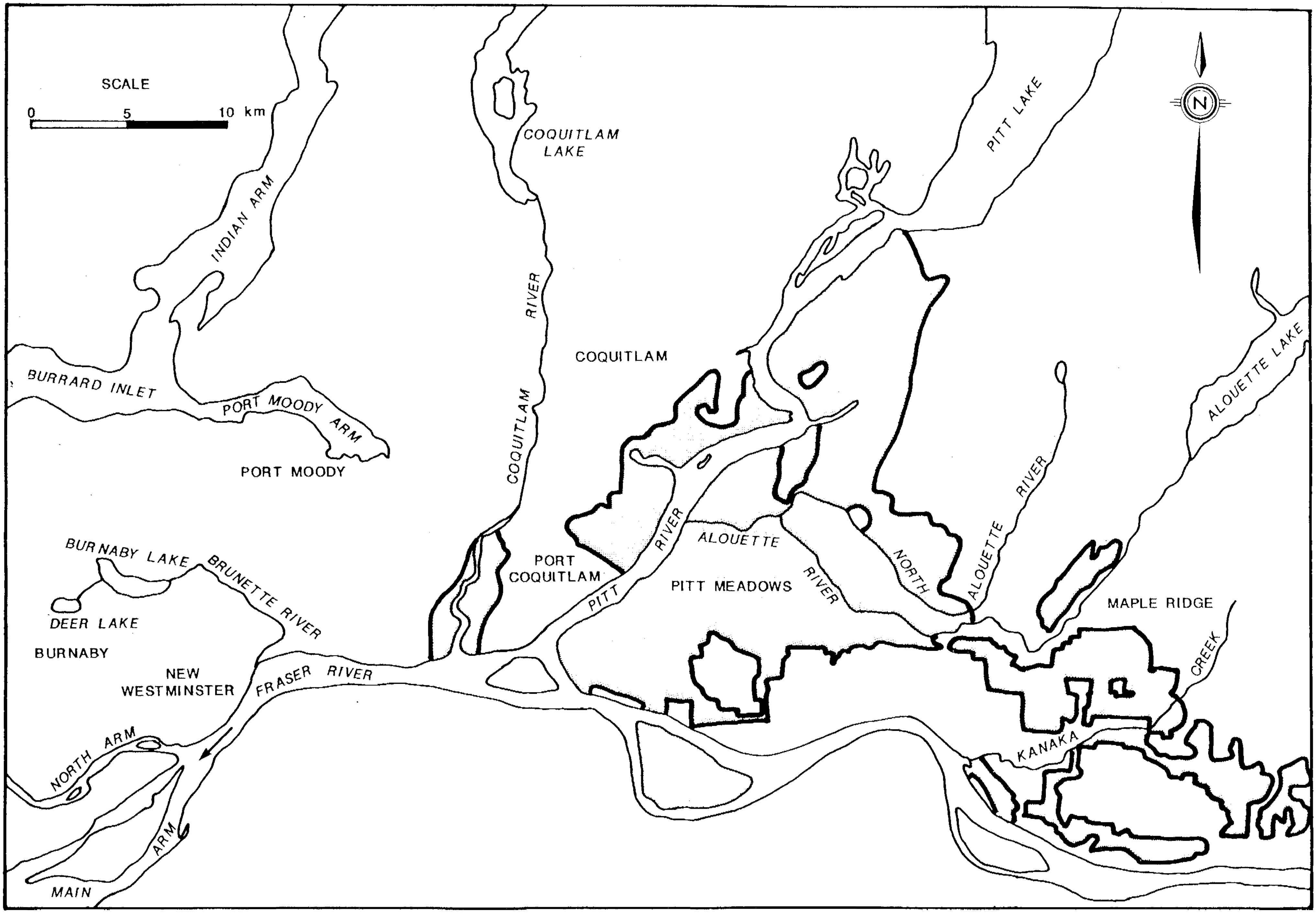

Figure 3: Land Areas in the Agriculture Land Reserve.

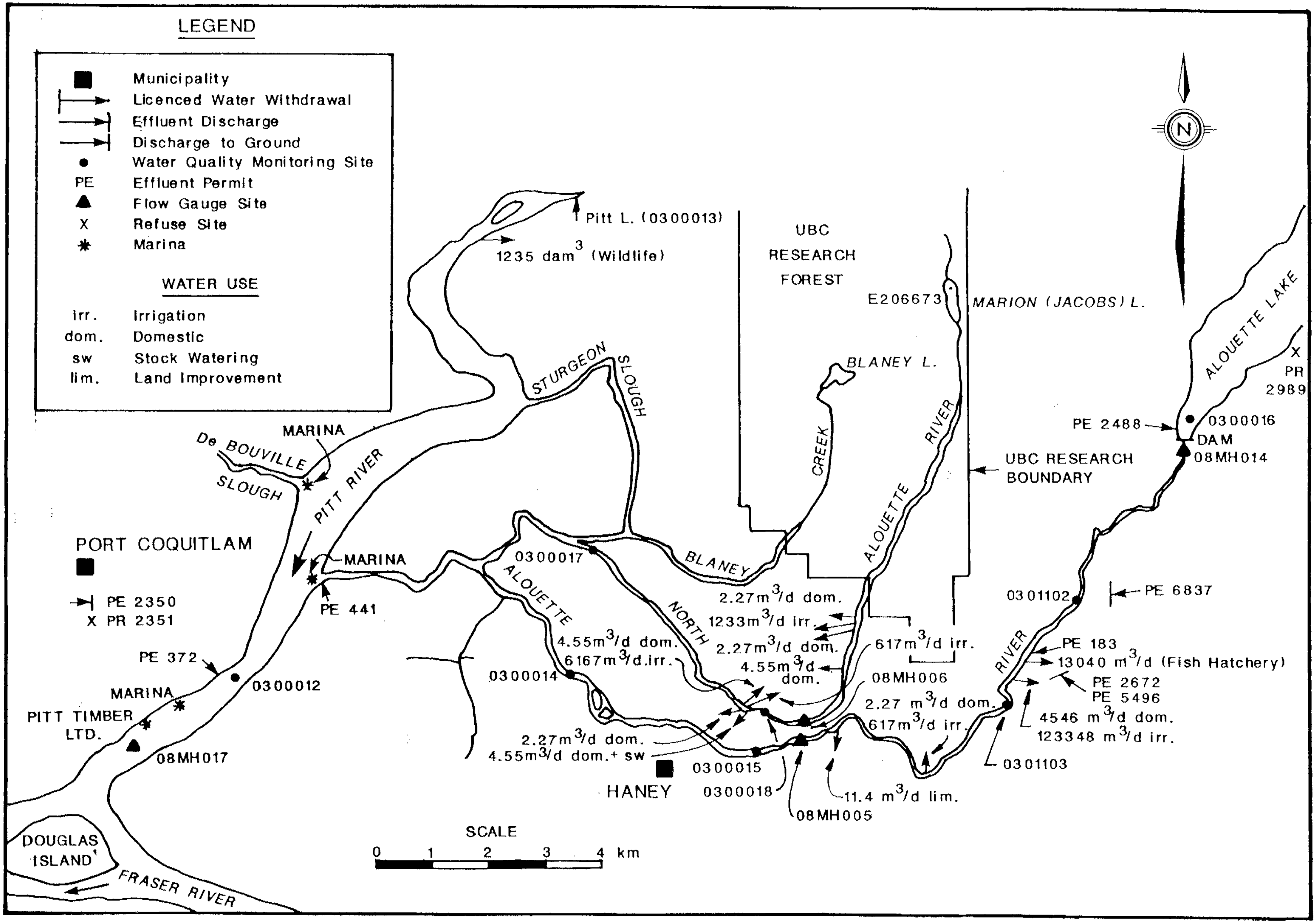

Figure 4: Locations of Sites Discharging Effluents, Ambient Water Quality Monitoring Sites, and Locations of Water Withdrawals: Pitt River and its Tributaries.

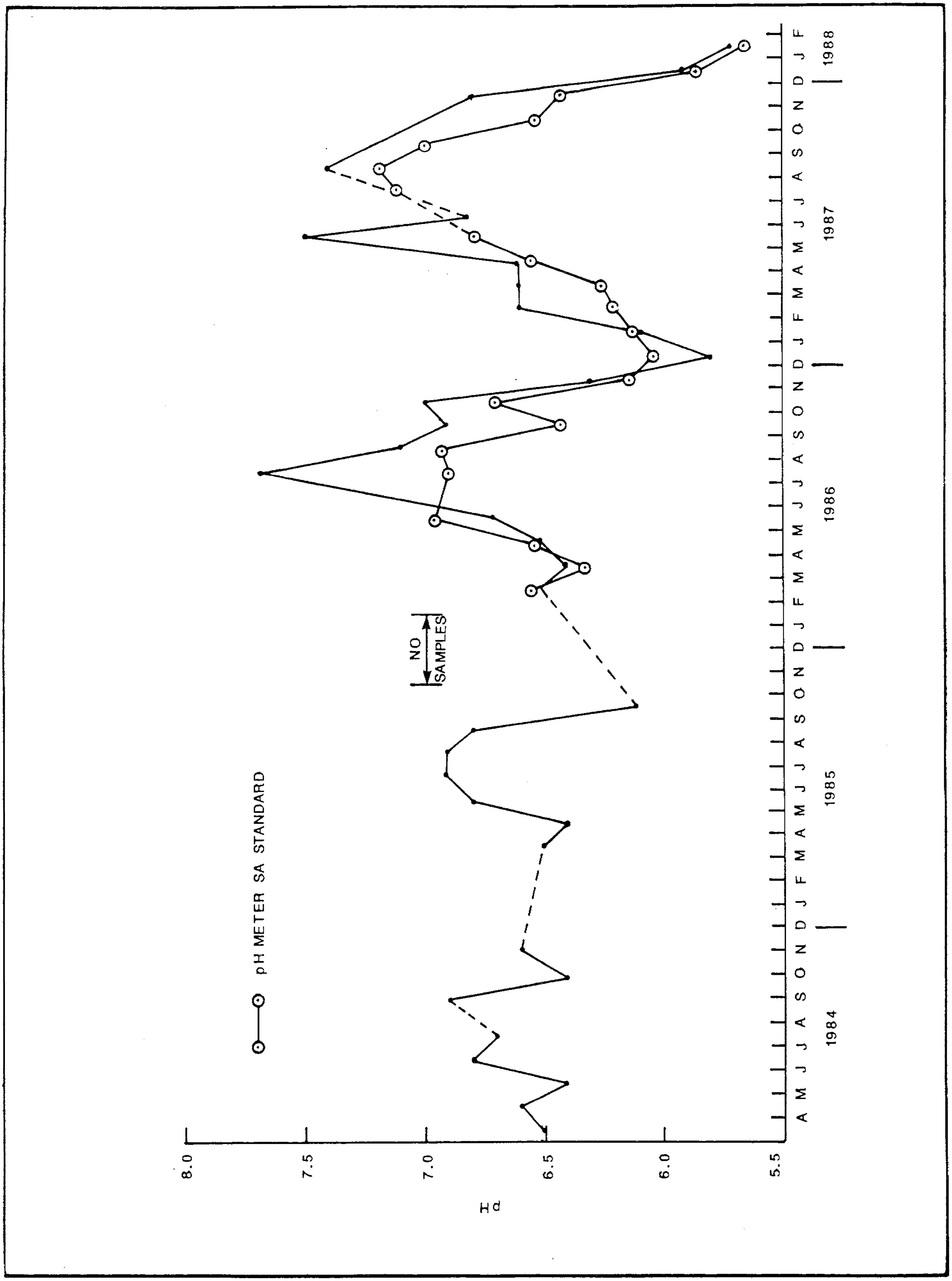

Figure 5: Yearly Variability in pH in Marion (Jacobs) Lake

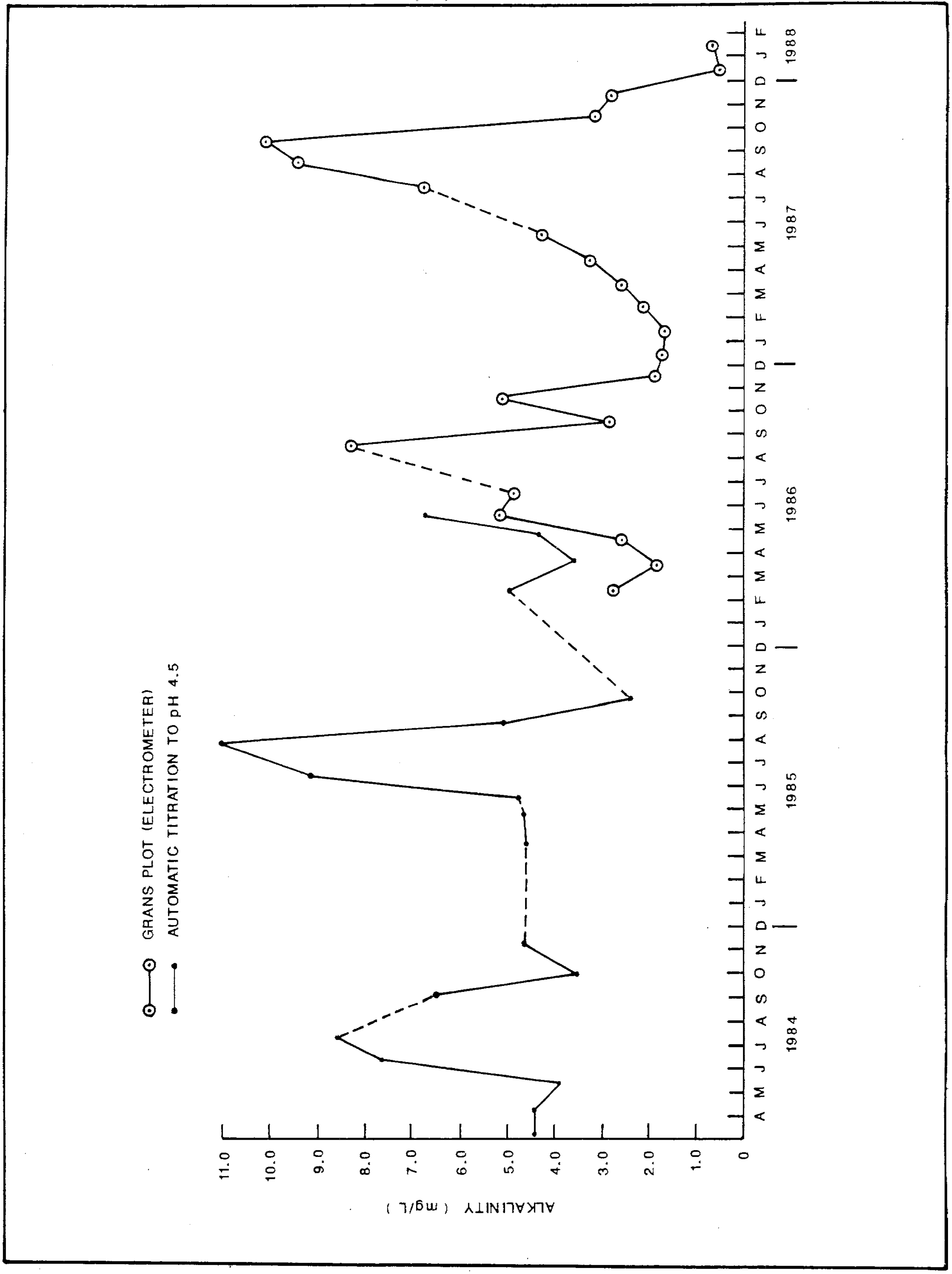

Figure 6: Yearly Variability in Alkalinity in Marion (Jacobs) Lake

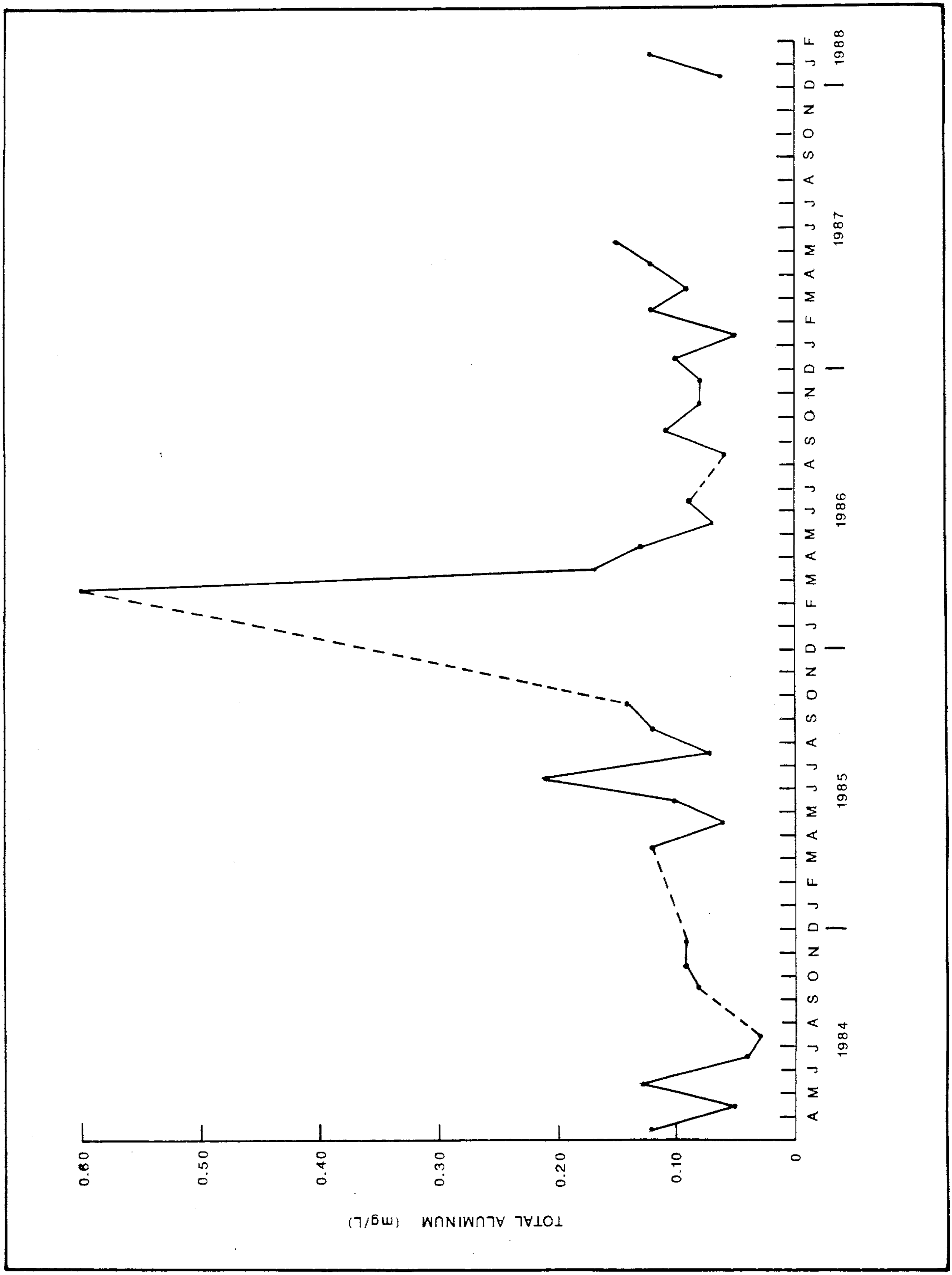

Figure 7: Yearly Variability in Aluminum in Marion (Jacobs) Lake.

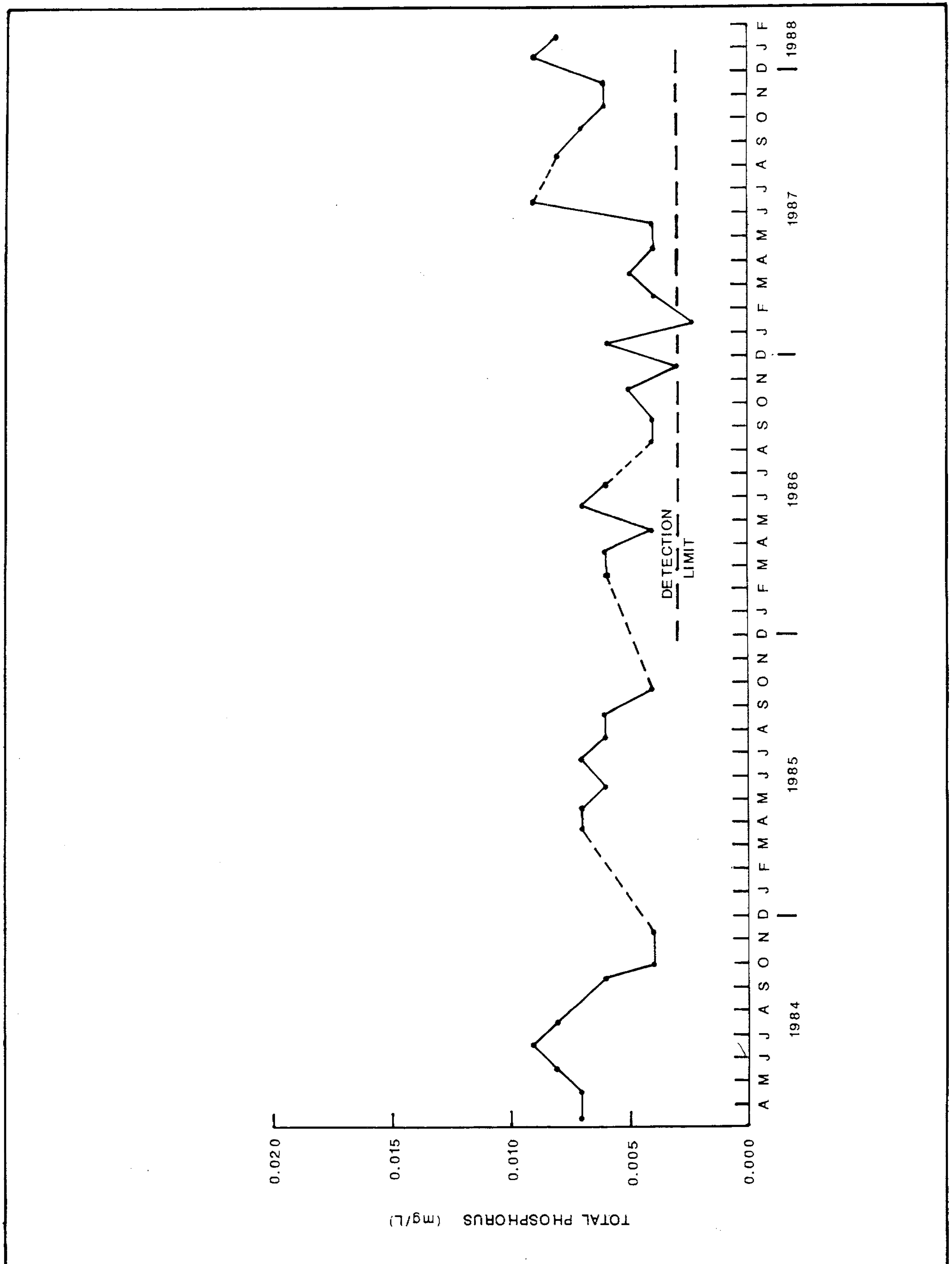

Figure 8: Yearly Variability in Total Phosphorus in Marion (Jacobs) Lake.

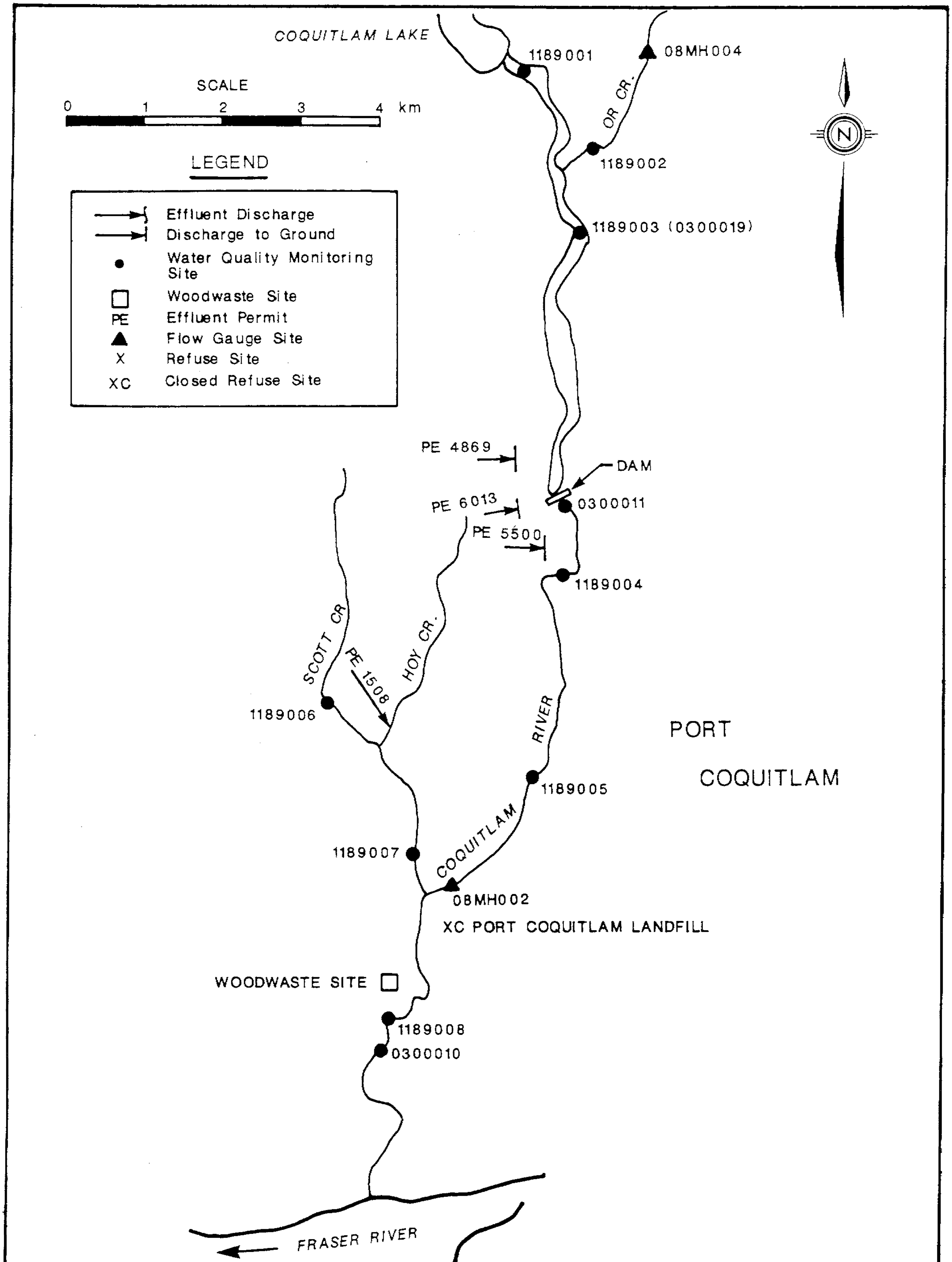

Figure 9: Locations of Sites Discharging Effluents and Ambient Water Quality Monitoring Sites: Coquitlam River Basin

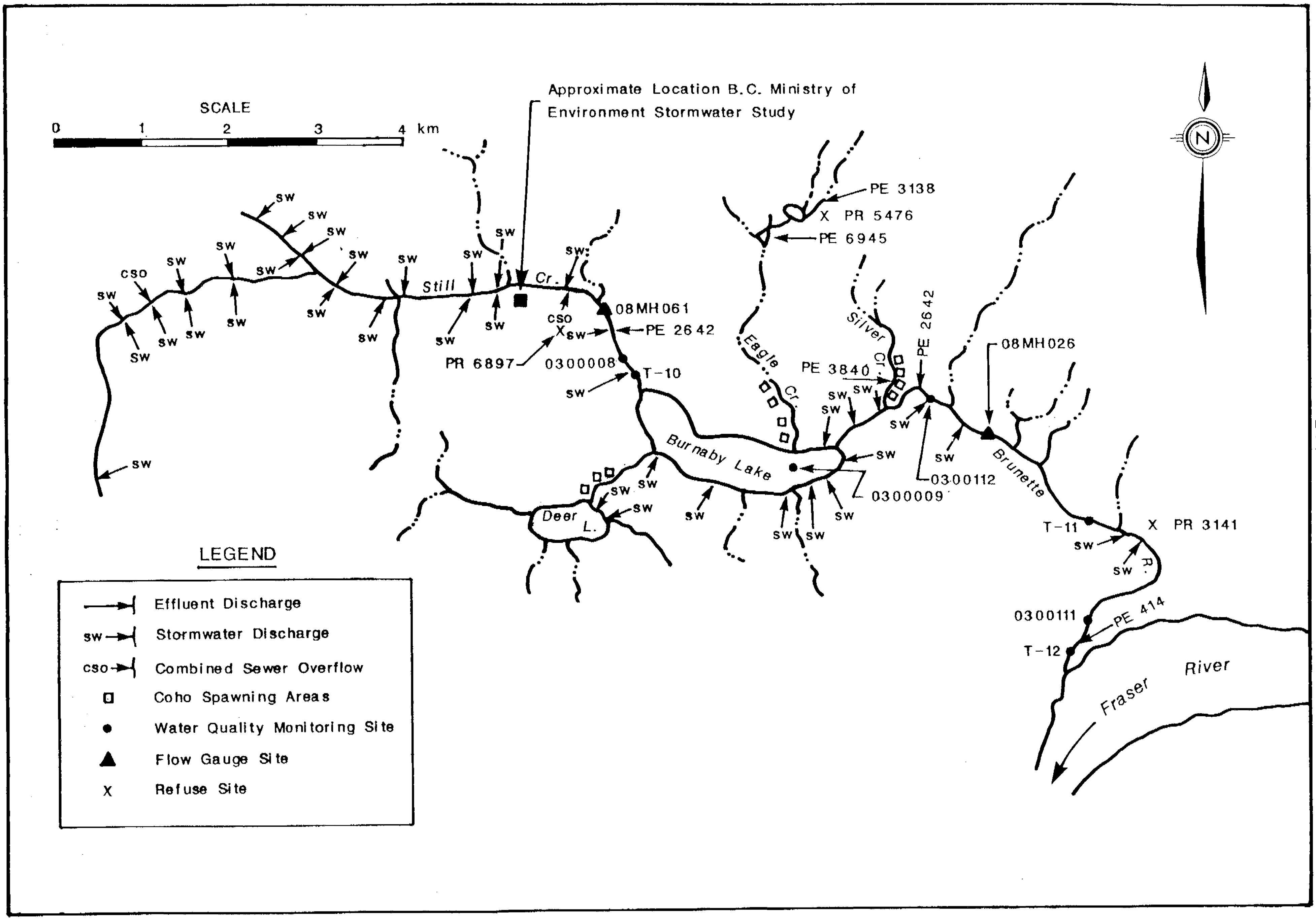

Figure 10: Locations of Sites Discharging Effluents and Ambient Water Quality Monitoring Sites: Brunette River Basin

Figure 11: A Comparison of Laboratory Analytical Precision and the Proposed Objective for Suspended Solids.

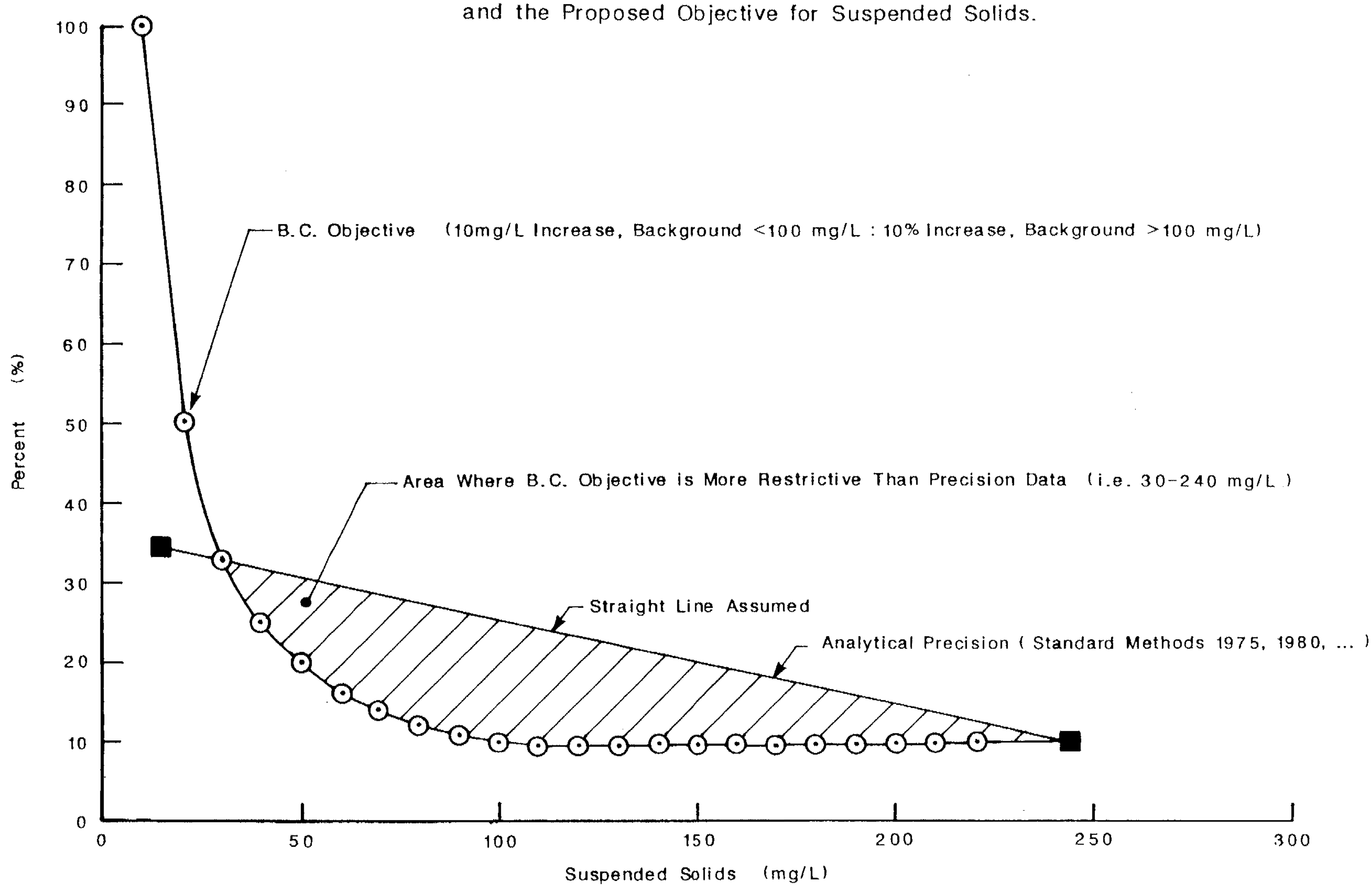

TABLE 1
WATER QUALITY SUMMARY
COTTONWOOD DRIVE REFUSE SITE
(DITCHWATER: SITE 0301270)

Characteristic	No. of Values	Values* Maximum	Minimum	Mean
Coliforms - fecal	6	>24 000	800	>24 000+
Colour (true)	11	300	20	134
Metals (total):				
Boron (diss)	10	1	0.2	0.67
Chromium	12	0.49	<0.005	0.065
Copper	13	0.75	<0.001	0.076
Iron	12	1 020	2.4	109
Lead	12	0.043	<0.001	0.009
Manganese	12	13.1	0.67	4.6
Mercury	3	<0.00005	<0.00005	<0.00005
Zinc	11	36.3	0.03	3.83
Nitrogen: Ammonia	8	66	4.75	27.1
Nitrite	13	0.089	<0.005	0.017
Nitrate	11	1.23	<0.02	0.131
Oxygen - dissolved	6	4.3	0.4	3
- BOD_5	12	651	<10	276
pH	13	8.1	6.4	7.6+
Phosphorus - total	9	8.26	0.03	1.48
Potassium	12	144	10.3	85.1
Sodium	12	196	16.4	122
Specific Conductivity	13	3 220	475	2 016
Sulphate	8	189	<5	69
Sulphide	2	16	16	16
Tannin and Lignin	12	150	1.1	31.4
Turbidity	11	1 000	16	223

Period of Record: 1976-1979
+ Median Value

* All values are as mg/L except:
(1) Coliforms - fecal as MPN/100 mL
(2) Colour
(3) pH
(4) Specific Conductivity as μS/cm
(5) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 2
DATA SUMMARY
AMBIENT WATER QUALITY - KANAKA CREEK

Characteristic	Kanaka Creek at Lougheed Hwy (Site 0300024)					Kanaka Creek at 112 Avenue (0300025)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1972-1984	28	30.5	5.3	12	1972-1984	20	14.1	3.1	7.2
Arsenic	1975	2	0.007	<0.005	-	1975	2	0.006	0.006	0.006
Carbon: - Organic	1983-1984	3	4	2	3	1983-1984	2	4	1	2.5
Coliforms - Fecal	1973-1984	23	5 400	18	330+	1973-1984	15	>2 400	20	375+
- Total	1972-1976	15	>24 000	80	1100+	1972-1976	14	<2 400	40	600+
Colour	1972-1974	4	80	10	35	1972-1974	4	70	10	28.8
Cyanide	1975	1	<0.01	-	-	-	-	-	-	-
Hardness	1972-1979	25	38.2	5.7	13.5	1972-1977	19	13.3	4.9	7.7
- Calcium	1972-1979	25	11.5	1.6	3.8	1972-1977	19	4.2	1.5	2.3
- Magnesium	1973-1978	3	1.3	0.4	0.94	1973-1977	16	0.69	0.29	0.45
Metals: (total)										
- Boron(diss)	1972	3	<0.2	<0.1	<0.2	1972	3	<0.2	<0.1	<0.2
- Cadmium	1974	1	<0.0005	-	-	1974	1	<0.0005	-	-
- Chromium	1972-1978	14	0.005	<0.005	<0.005	1974	1	<0.005	-	-
- Copper	1972-1978	16	0.005	<0.001	0.002	1974	1	<0.001	-	-
- Iron	1973-1979	20	4.9	0.3	1.2	1973-1977	14	2	0.1	0.5
- Lead	1972-1978	17	0.028	<0.001	0.003	1972-1977	16	0.012	<0.001	0.002
- Manganese	1972-1979	20	0.13	0.01	0.05	1972-1977	14	0.14	<0.01	0.03
- Nickel	1972-1978	17	<0.01	<0.01	<0.01	1972-1977	16	<0.01	<0.01	<0.01
- Zinc	1972-1978	17	0.02	<0.005	0.007	1972-1977	15	0.02	<0.005	0.008
Nitrogen: - Ammonia	1974-1984	19	0.149	0.007	0.047	1974-1984	12	0.058	<0.005	0.017
- Kjeldahl	1972-1984	22	1	0.07	0.34	1972-1984	15	1.43	0.02	0.25
- Nitrate	1977-1984	12	1.28	<0.02	0.46	1977-1984	5	0.58	0.13	0.28
- Nitrite	1972-1984	26	0.009	<0.005	0.005	1972-1984	19	<0.005	<0.005	<0.005
-Nitrate/Nitrite	1977-1984	12	1.29	<0.02	0.46	1977-1984	5	0.58	0.13	0.28
- Organic	1973-1984	17	0.56	0.06	0.27	1973-1984	11	0.19	0.08	0.12
Oxygen - COD	1983-1984	4	19	10	13	1983-1984	2	10	<10	-
- dissolved	1972-1984	26	13.6	4.6	10.2	1972-1984	21	13.2	8.3	10.9
% saturation	1972-1984	25	127.8	50.2	94.3	1972-1984	21	114.6	81.4	98.5
pH	1972-1984	23	7.4	6.2	6.8+	1972-1984	18	7.3	5.9	6.7+
Phosphorus										
- Dissolved Ortho	1973-1984	21	0.03	<0.003	0.008	1973-1984	14	0.008	<0.003	0.003
- Total Dissolved	1979-1984	11	0.041	0.008	0.019	1977-1984	4	0.01	0.008	0.009
- Total	1972-1977	17	0.054	0.015	0.033	1972-1977	17	0.087	0.006	0.017
Solids: - Dissolved	1972-1978	20	64	24	40	1972-1977	18	58	18	37
- Suspended	1974-1983	29	85	2	18	1974-1977	11	111	1	19
- Total	1972-1984	14	174	30	72	1972-1984	7	262	20	72
Specific Conductivity	1972-1984	27	95	20	42	1972-1984	21	47	15	26.2
Sulphate	1972-1983	24	5.5	3.1	5	1972-1977	16	<5	<5	<5
Temperature	1972-1984	27	26	1	11.4	1972-1984	22	21	1	9.6
Turbidity	1972-1983	8	69	2.7	16.5	1972-1983	8	55	0.6	8.8

* All values are as mg/L except: (1) Coliform as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

+ Median Value

Data Source: B.C. Ministry of Environment

TABLE 3

MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF FRESH WATER AQUATIC LIFE
(mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	27.7	28.3	27.9	27.5	27.2	26.8	26.5	26.2	26.0	25.7	25.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8	25.5	25.2	25.0	24.7
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9	24.6	24.4	24.1	23.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9	23.6	23.4	23.1	22.9
6.9	24.6	24.2	23.9	23.6	23.3	23.0	22.7	22.5	22.2	22.0	21.8
7.0	23.2	22.8	22.5	22.2	21.9	21.6	21.4	21.1	20.9	20.7	20.5
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9	19.7	19.5	19.3	19.1
7.2	19.9	19.6	19.3	19.0	18.8	18.6	18.3	18.1	17.9	17.8	17.6
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.2	16.0
7.4	16.2	16.0	15.7	15.5	15.3	15.2	15.0	14.8	14.7	14.5	14.4
7.5	14.4	14.1	14.0	13.8	13.6	13.4	13.3	13.1	13.0	12.9	12.7
7.6	12.6	12.4	12.2	12.0	11.9	11.7	11.6	11.5	11.4	11.3	11.2
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10.0	9.92	9.83	9.73	9.65
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57	8.48	8.40	8.32	8.25
7.9	7.82	7.71	7.60	7.51	7.42	7.33	7.25	7.17	7.10	7.04	6.98
8.0	6.55	6.46	6.37	6.29	6.22	6.14	6.08	6.02	5.96	5.91	5.86
8.1	5.21	5.14	5.07	5.01	4.95	4.90	4.84	4.80	4.75	4.71	4.67
8.2	4.15	4.09	4.04	3.99	3.95	3.90	3.86	3.83	3.80	3.76	3.74
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09	3.06	3.03	3.01	2.99
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47	2.45	2.43	2.41	2.40
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98	1.96	1.95	1.94	1.93
8.6	1.69	1.67	1.65	1.63	1.61	1.60	1.59	1.58	1.57	1.56	1.55
8.7	1.35	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.26	1.26	1.25
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.831
9.0	0.703	0.697	0.692	0.688	0.685	0.682	0.681	0.681	0.680	0.681	0.682

pH	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	25.2	25.0	24.8	24.6	24.5	24.3	24.2	24.0	23.9	23.8
6.6	24.5	24.3	24.1	23.9	23.8	24.6	23.5	23.3	23.3	23.2
6.7	23.7	23.5	23.3	23.1	23.0	22.8	22.7	22.6	22.5	22.4
6.8	22.7	22.5	22.3	22.2	22.0	21.9	21.8	21.7	21.6	21.5
6.9	21.6	21.4	21.3	21.1	21.0	20.8	20.7	20.6	20.5	20.4
7.0	20.3	20.2	20.0	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.9	18.8	18.7	18.5	18.4	18.3	18.2	18.1	18.0	17.9
7.2	17.4	17.3	17.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.9	15.7	15.6	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	14.2	14.1	14.0	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.6	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12.0
7.6	11.1	11.0	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.57	9.50	9.43	9.37	9.31	9.26	9.22	9.81	9.15	9.12
7.8	8.18	8.12	8.07	8.02	7.97	7.93	7.90	7.87	7.84	7.82
7.9	6.92	6.88	6.83	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8.0	5.81	5.78	5.74	5.71	5.68	5.66	5.64	5.62	5.61	5.60
8.1	4.64	4.61	4.59	4.56	4.54	4.53	4.51	4.50	4.49	4.49
8.2	3.71	3.69	3.67	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.97	2.96	2.94	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.38	2.37	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.92	1.91	1.91	1.90	1.90	1.90	1.90	1.90	1.91	1.92
8.6	1.55	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.56	1.57
8.7	1.25	1.25	1.25	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.02	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.870	0.880	0.891
9.0	0.684	0.688	0.692	0.698	0.704	0.711	0.720	0.729	0.740	0.752

TABLE 4
AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF FRESH WATER AQUATIC LIFE
(mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.6	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.7	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.8	2.08	2.05	2.02	1.99	1.96	1.94	1.92	1.90	1.88	1.86	1.84
6.9	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.0	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.1	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.2	2.08	2.05	2.02	1.99	1.96	1.95	1.92	1.90	1.88	1.86	1.85
7.3	2.08	2.05	2.02	1.99	1.97	1.95	1.92	1.90	1.88	1.86	1.85
7.4	2.08	2.05	2.02	2.00	.97	1.95	1.92	1.90	1.88	1.87	1.85
7.5	2.08	2.05	2.02	2.00	.97	1.95	1.93	1.91	1.88	1.87	1.85
7.6	2.09	2.05	2.03	2.00	.97	1.95	1.93	1.91	1.89	1.87	1.85
7.7	2.09	2.05	2.03	2.00	1.98	1.95	1.93	1.91	1.89	1.87	1.86
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.60	1.59
7.9	1.50	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34
8.0	1.26	1.24	1.23	1.21	1.20	1.18	1.17	1.16	1.15	1.14	1.13
8.1	1.00	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.730	0.724	0.718
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380	0.377	0.375	0.372	0.370
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305	0.303	0.301	0.300	0.298
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.161	0.160	0.160	0.160	0.160
9.0	0.135	0.134	0.133	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131

pH	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.6	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.7	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.8	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.42	1.32	1.22
6.9	1.82	1.81	1.80	1.78	1.77	1.64	1.53	1.42	1.32	1.22
7.0	1.83	1.81	1.80	1.79	1.77	1.64	1.53	1.42	1.32	1.22
7.1	1.83	1.81	1.80	1.79	1.77	1.65	1.53	1.42	1.32	1.23
7.2	1.83	1.81	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.3	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.4	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.5	1.83	1.82	1.81	1.80	1.78	1.66	1.54	1.43	1.33	1.23
7.6	1.84	1.82	1.81	1.80	1.79	1.66	1.54	1.43	1.33	1.24
7.7	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.33	1.32	1.31	1.31	1.30	1.21	1.12	1.04	0.970	0.904
8.0	1.12	1.11	1.10	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.240	0.240	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.160	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 4.
- each measured value is compared to the corresponding individual values in Table 4. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding criteria values in Table 4.

TABLE 5
EFFLUENT DATA SUMMARY
BCG LANDS, GOLDEN EARS PROVINCIAL PARK
(PE 2988)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Coliforms - Fecal	1976-1986	15	54 000	<20	600+
- Total	1984	1	<200	-	-
Flow	1975	5	20	1.32	7.7
Nitrogen					
-Ammonia	1980-1984	3	27.2	0.023	9.43
-Kjeldahl	1982-1984	2	28	1.58	14.8
-Nitrate	1980-1984	3	9.01	2.06	6.14
-Nitrite	1980-1984	3	1.09	<0.005	0.373
-Nitrate/Nitrite	1980-1984	3	10.1	2.06	6.5
-Organic	1984	1	0.5	-	-
Oxygen - BOD_5	1976-1986	22	59	<10	12.2
pH	1976-1986	23	6.6	4.9	5.9+
Phosphorus					
- Ortho Dissolved	1984	1	0.085	-	-
- Total Dissolved	1976-1984	2	0.104	0.05	0.08
- Total	1976	1	0.42	-	-
Solids - Dissolved	1984	2	102	58	80
- Suspended	1976-1986	22	59	1	13.5
Specific Conductivity	1976-1986	23	550	51	143.2
Temperature	1979	1	13	-	-

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Flow as m^3/d
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 6
EFFLUENT DATA SUMMARY
BCBC ALOUETTE CORRECTION CENTRE
ALOUETTE RIVER (PE 183)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Carbon - Organic	1973	2	56	29	42.5
Coliforms - Fecal	1975-1980	5	>24 000	2 400	13 000+
- Total	1975	1	24 000	-	-
Flow	1976-1977	15	68.19	68.19	68.19
Nitrogen - Ammonia	1972-1973	4	10	2	5.5
- Kjeldahl	1976-1977	2	39	3	21
- Nitrate	1972-1973	4	3.7	0.02	2.58
- Nitrite	1972-1984	8	3.8	0.01	1.06
- Organic	1972-1976	5	14	4	8.02
- Nitrate/Nitrite	1977-1984	3	15.6	9.1	12.2
Oxygen - BOD_5	1972-1984	49	126	10	25.9
- Dissolved	1976-1980	2	11	6.1	8.6
pH	1972-1984	26	7.6	4.8	7+
Phosphorus					
- Ortho Dissolved	1972-1973	4	7.2	5	6
- Total Dissolved	1984	1	3.2	-	-
- Total	1972-1977	5	8.7	5.6	7
Solids					
- Suspended	1972-1984	50	191	3	38
- Total	1972-1984	17	376	202	287
Specific Conductivity	1973-1984	20	605	250	398
Temperature	1974-1980	3	15	2	6.3

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Flow as m^3/d
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 7
EFFLUENT DATA SUMMARY
PACIFIC VOCATIONAL INSTITUTE,
MAPLE RIDGE (PE 2672)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Coliforms - Fecal	1980	1	<20	-	-
Flow	1980	2	163.7	124.5	144.1
Hardness					
- Magnesium	1977	1	1.1	-	-
Metals					
- Copper - dissolved	1977-1979	3	0.05	0.03	0.04
- Iron - dissolved	1977-1979	3	0.2	<0.1	0.1+
- Lead - dissolved	1977-1979	3	0.01	<0.001	0.005
- Zinc - dissolved	1977-1979	3	0.03	0.02	0.02
Nitrogen					
- Ammonia	1979-1984	5	1.54	0.029	0.640
- Kjeldahl	1977-1979	3	3	1	2.3
- Nitrate	1977-1984	5	5.11	0.04	1.83
- Nitrite	1977-1984	5	0.089	<0.005	0.057
- Organic	1979	2	1	1	1
Oxygen - BOD_5	1977-1986	48	44	<10	11.4
pH	1977-1986	48	10	6.6	7.2+
Phosphorus					
- total dissolved	1979-1984	3	0.682	0.135	0.423
- total	1979	1	0.308	-	-
Solids - dissolved	1984	1	130	-	-
- suspended	1977-1986	48	51	1	10.2
- total	1977-1984	33	252	52	105.7
Specific Conductivity	1977-1986	43	318	25.5	60
Temperature	1979	2	16	13	14.5

+ Median Value

* All values are as mg/L except:
  (1) Coliforms as MPN/100 mL
  (2) Flow as m^3/d
  (3) pH
  (4) Specific Conductivity as µS/cm
  (5) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 8
EFFLUENT DATA SUMMARY
RCB HOLDINGS PORT COQUITLAM (PE 372)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Chlorine Residual	1974-1980	17	0.2	0.0	0.13
Coliforms - Fecal	1975-1984	15	54 000	200	21 000+
- Total	1975	2	24 000	200	12 100+
Nitrogen					
- Ammonia	1980-1986	5	12.3	1.21	3.9
- Kjeldahl	1977-1983	5	10	0.05	4.8
- Nitrate	1977-1984	8	23	0.13	7.75
- Nitrite	1977-1984	8	0.097	0.005	0.03
- Nitrate/Nitrite	1977-1978	8	23	0.13	8
Oxygen - BOD_5	1972-1986	31	72	10	27.3
pH	1972-1986	31	7.3	3.6	5.7+
Phosphorus					
- Total Dissolved	1982	1	1.27	-	-
- Total	1977	3	8.1	0.004	4.73
Solids - Suspended	1972-1986	32	381	3	59
- Total	1972-1984	13	558	84	179
Specific Conductivity	1974-1986	26	489	12	228.8
Temperature	1979	1	7	-	-

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) pH
(3) Specific Conductivity as μS/cm
(4) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 9
EFFLUENT DATA SUMMARY
KENNAMETAL (PE 2350)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Arsenic	1978-1986	3	<0.39	<0.25	-
Flow ("01")	1979-1980	119	57.3	0.45	19.7
("02")	1979-1980	119	134	18.6	71.9
Hardness					
- Calcium	1984-1986	3	1 060	657	809
- Magnesium	1978-1986	3	205	8.6	76.3
Metals (Dissolved)					
- Aluminum	1975-1986	12	48.8	1.5	14.8
- Barium	1984-1986	3	0.06	0.04	0.05
- Boron	1984-1986	3	8.93	0.13	3.2
- Cadmium	1984-1986	3	0.43	<0.01	-
- Chromium	1984-1986	3	4.1	0.06	1.42
- Cobalt	1974-1986	23	805	<0.03	88.7
- Copper	1984-1986	3	2.95	0.01	1.0
- Iron	1974-1986	23	4 440	<15.5	917.2
- Lead	1984-1986	3	0.3	0.1	0.17
- Manganese	1975-1986	22	15.5	0.61	4.8
- Molybdenum	1984-1986	3	0.15	<0.01	0.09
- Nickel	1974-1986	24	1 290	<0.1	14.3
- Titanium	1978	1	<0.01	-	-
- Tungsten	1978	1	40.6	-	-
- Vanadium	1984-1986	3	0.23	0.01	0.09
- Zinc	1984-1986	3	0.05	<0.01	0.04
Nitrogen					
- Kjeldahl	1975	1	7	-	-
- Nitrate	1974-1976	4	40	0.51	14.3
- Nitrite	1976-1977	2	0.172	0.047	0.11
- Nitrate/Nitrite	1976-1977	2	10.2	5.4	7.8
pH	1974-1986	31	10.8	1.5	3.1+
Solids - Dissolved	1974-1975	3	4 300	2 068	2 845
- Suspended	1975-1984	11	11 000	3	1 064
- Total	1975	3	6 954	3 004	4 458
Specific Conductivity	1974-1986	18	10 300	1 380	5 307
Sulphate	1974-1978	13	4 103	268	2 222
Temperature	1974-1975	4	24	5	18
Turbidity	1975	2	220	16	118

+ Median Value
* All values are as mg/L except:
  (1) Flow as m^3/d
  (2) pH
  (3) Specific Conductivity as µS/cm
  (4) Temperature as °C
  (5) Turbidity in NTU

"01" = discharge from refractory carbide refinery

"02" = discharge from vacuum drying section of the powder milling building

Data Source: B.C. Ministry of Environment

TABLE 10
AMBIENT WATER QUALITY DATA SUMMARY
NORTH ALOUETTE RIVER

Characteristic	North Alouette River at 208 St. (Site 0300017)					North Alouette River at 232 St. Site (0300018)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1972-1979	22	12.5	2.5	6.6	1972-1977	18	8.2	2.4	4.4
Coliforms - Fecal	1973-1979	16	>2400	2	20+	1973-1977	11	50	2	20+
- Total	1972-1976	14	>2400	20	150+	1972-1976	13	140	5	20+
Colour	1972-1977	4	40	5	23.8	1972-1977	4	40	5	17.5
Hardness	1972-1979	23	22.1	3.7	8.4	1972-1977	19	8	2.8	5
- Calcium	1972-1979	23	6.8	1.2	2.5	1972-1977	19	2.5	0.9	1.6
- Magnesium	1973-1979	20	1.3	0.2	0.5	1973-1977	16	0.35	0.14	0.24
Metals: (total)										
- Boron (diss)	1972	3	<0.2	<0.1	<0.2+	1972	3	<0.2	<0.1	<0.2+
- Cadmium	1978	1	<0.0005	-	-	-	-	-	-	-
- Chromium	1972-1977	6	0.005	<0.005	<0.005	1972-1977	6	0.005	<0.005	<0.005
- Copper	1972-1977	6	0.004	0.001	0.002	1972-1977	6	0.003	<0.001	0.001
- Iron	1975-1977	3	0.9	0.3	0.6	1972-1977	3	0.4	0.1	0.2
- Lead	1972-1977	6	0.017	<0.001	0.005	1972-1977	6	0.005	<0.001	0.002
- Manganese	1972-1977	6	0.03	<0.01	0.02	1972-1977	6	0.12	<0.01	0.03
- Nickel	1972-1977	6	<0.01	<0.01	<0.01	1972-1977	6	<0.01	<0.01	<0.01
- Zinc	1972-1978	7	0.011	<0.005	0.006	1972-1977	6	0.005	0.005	0.005
Nitrogen:										
- Ammonia	1974-1979	13	0.172	<0.005	0.033	1974-1977	9	0.015	<0.005	0.009
- Kjeldahl	1972-1979	16	0.54	0.07	0.23	1972-1977	12	0.48	<0.01	0.11
- Nitrate	1977-1979	6	0.38	<0.02	0.18	1977	2	0.16	0.12	0.14
- Nitrite	1972-1979	19	<0.005	<0.005	<0.005	1972-1977	15	<0.005	<0.005	<0.005
- Organic	1973-1979	12	0.37	0.05	0.17	1973-1977	8	0.14	0.01	0.05
Oxygen - Dissolved	1972-1979	20	14.5	5.3	10.1	1972-1977	17	13.4	9.2	11.2
% saturation	1972-1979	20	106.7	56.4	93.4	1972-1979	17	112.7	84.2	99.6
pH	1972-1979	18	7.2	5.9	6.5+	1972-1977	14	7.1	6	6.5+
Phosphorus										
- Ortho Dissolved	1973-1978	12	0.006	<0.003	0.004	1973-1977	11	<0.003	<0.003	<0.003
- Total Dissolved	1977-1979	5	0.057	0.006	0.019	1977	1	<0.003	-	-
- Total	1972-1977	16	0.07	0.003	0.02	1972-1977	16	0.022	<0.003	0.006
Potassium	1972	3	0.5	0.2	0.4	1972	3	0.3	0.2	0.3
Sodium	1972	2	5.7	0.8	3.3	1972	2	1.4	0.7	1.1
Solids: - Dissolved	1972-1978	19	60	12	29.5	1972-1977	18	26	10	18
- Suspended	1974-1979	14	17	<1	5.7	1974-1977	11	5	<1	2.3
- Total	1972-1979	10	84	14	37.2	1972-1974	6	164	18	46.7
Specific Conductivity	1972-1979	20	75	12	31.8	1972-1977	15	23	10	15.7
Sulphate dissolved	1972-1974	5	<5	<5	<5	1972-1974	4	<5	<5	<5
Temperature	1972-1979	21	25.5	0	11.5	1972-1977	18	19.8	0.5	8.7
Turbidity	1972-1973	6	25	0.8	6.4	1972-1973	6	22	0.3	4.2

* All values are as mg/L except:
(1) Coliform as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

\+ Median Value

Data Source: B.C. Ministry of Environment

TABLE 11
AMBIENT WATER QUALTIY DATA SUMMARY
ALOUETTE RIVER

Characteristic	Alouette River at 208 St. (Site 0300014)					Alouette R. at 232 St. (Site 0300015)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1972-1984	25	24	7.5	16	1972-1977	18	20.6	5.5	14.4
Carbon: - Organic	1983-1984	2	2	1	1.5	-	-	-	-	-
Coliforms - Fecal	1973-1983	19	9 200	13	240+	1973-1977	12	2400	50	175+
- Total	1972-1976	15	>24 000	70	790+	1972-1976	14	5400	50	350+
Colour	1972	3	45	5	20	1972-1977	4	30	5	12.5
Hardness	1972-1979	23	29.5	10.8	21.1	1972-1977	19	27.9	9	17.4
- Calcium	1972-1979	23	9.2	3.3	6.4	1972-1977	19	9.2	2.2	5.7
- Magnesium	1973-1979	20	1.6	0.61	1.2	1973-1977	16	1.2	0.42	0.86
Metals: (total)										
- Boron (dissolved)	1972	3	<0.2	<0.1	<0.2+	1972	3	<0.2	<0.1	<0.2+
- Chromium	1972-1977	6	0.006	<0.005	0.005	1972-1976	5	<0.005	<0.005	<0.005
- Copper	1972-1977	6	0.01	<0.001	0.004	1972-1977	6	0.011	<0.001	0.003
- Iron (dissolved)	1972	3	0.29	0.12	0.20	1972	3	0.08	<0.02	0.05
- Lead (dissolved)	1972	1	<0.003	-	-	1972-1977	6	0.027	<0.001	0.006
- Manganese	1972-1977	6	0.05	0.01	0.03	1972-1977	6	0.26	<0.01	0.06
- Nickel	1972-1977	6	<0.01	<0.01	<0.01	1972-1977	6	<0.01	<0.01	<0.01
- Zinc	1972-1978	7	0.03	<0.005	0.01	1972-1977	6	0.05	<0.005	0.013
Nitrogen:										
- Ammonia	1974-1984	16	0.09	0.02	0.05	1974-1977	9	0.016	0.007	0.010
- Kjeldahl	1972-1984	19	0.5	0.09	0.26	1972-1977	12	0.37	<0.01	0.13
- Nitrate	1977-1984	6	0.79	0.35	0.5	1972-1977	13	0.32	0.08	0.17
- Nitrite	1972-1984	18	0.007	<0.005	0.005	1972-1977	15	<0.005	<0.005	<0.005
- Nitrate/Nitrite	1977-1984	6	0.79	0.35	0.5	1972-1977	2	0.2	0.13	0.17
- Organic	1973-1984	15	0.48	0.06	0.21	1973-1977	8	0.17	0.04	0.11
Oxygen - COD	1983-1984	2	14	<10	-	-	-	-	-	-
- Dissolved	1972-1984	22	13.9	6.3	9.9	1972-1977	17	13.2	8.2	10.7
% saturation	1972-1984	22	246.2	70.3	93.3	1972-1977	17	123.3	84	101.
pH	1972-1984	22	7.4	6.3	6.9+	1972-1977	14	7.5	6.1	7.1+
Phosphorus										
- Ortho Dissolved	1973-1984	18	0.024	<0.003	0.007	1972-1977	10	0.004	<0.003	0.003
- Total Dissolved	1977-1984	8	0.054	0.011	0.019	1977	1	0.008	-	-
- Total	1972-1977	16	0.061	<0.003	0.030	1972-1977	16	0.023	0.003	0.010
Potassium	1972	3	1.1	0.5	0.77	1972	3	0.6	0.5	0.57
Sodium	1972	2	7	2.9	5.0	1972	2	5.7	2	3.9
Solids: - Dissolved	1972-1978	19	78	34	58.2	1972-1977	18	76	26	49
- Suspended	1974-1984	17	60	3	16.8	1974-1977	11	13	<1	3.8
- Total	1972-1984	13	158	36	80.8	1972-1974	6	1 114	30	232.3
Specific Conductivity	1972-1984	23	112	35	70	1972-1977	16	91	23	56.2
Sulphate	1972-1974	4	<5	<5	<5	1972-1974	4	<5	<5	<5
Temperature	1972-1984	10	8.8	6.7	7.3	1972-1977	18	22.5	1	11.4
Turbidity	1972-1973	6	34	3.8	12.8	1972-1973	6	140	0.3	26.2

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

+ Median Value

Data Source: B.C. Ministry of Environment

TABLE 11 (Continued)

Characteristic	Period of Record	No. of Values	ALOUETTE LAKE (Site 0300016) Values*		
			Maximum	Minimum	Mean
Alkalinity	1977	2	<0.	<0.5	<0.5
Arsenic	1975	2	0.[illegible]09	<0.005	0.007
Carbon - Organic	1982	3	1	1	1
- Inorganic	1982	3	1	1	1
Coliforms - Fecal	1974-1977	8	<20	<2	<16.5+
- Total	1972-1976	9	49	<2	20+
Colour	1972-1982	9	5	<5	-
Hardness - Total	1972	22	6	3	3.9
- Calcium	1972-1977	22	1.8	1	1.2
- Magnesium	1972-1977	20	0.21	0.13	0.16
Metals: (Total)					
- Boron (Dissolved)	1972	4	<0.2	<0.1	-
- Cadmium	1982	1	<0.0005	-	-
- Chromium	1972-1977	14	<0.005	<0.005	<0.005
- Copper	1972-1982	17	0.005	<0.001	0.001
- Iron (Dissolved)	1972	4	0.07	0.03	0.05
- Lead	1972-1982	17	<0.003	<0.001	0.002
- Manganese	1972-1977	14	<0.02	<0.01	<0.02
- Nickel	1972-1982	17	<0.01	<0.01	<0.01
- Zinc	1972-1982	17	0.04	<0.005	0.009
Nitrogen					
- Ammonia	1975-1982	15	0.035	<0.005	0.011
- Kjeldahl	1972-1982	19	0.25	<0.01	0.09
- Nitrate	1972-1976	16	0.11	0.08	0.10
- Nitrite	1972-1977	20	0.061	<0.005	0.008
- Nitrate/Nitrite	1977-1982	7	0.15	0.13	0.14
- Organic	1973-1982	14	0.21	<0.01	0.08
Oxygen - COD	1982	3	<10	<10	<10
- Dissolved	1972-1977	22	12.6	10	11.3
% Saturation	1972-1977	22	113.1	92.1	100.5
pH	1972-1982	23	6.9	6	6.4+
Phosphorus					
- Ortho Dissolved	1974-1982	17	0.027	<0.003	0.004
- Total Dissolved	1977-1982	7	0.004	<0.003	0.003
- Total	1972-1982	23	0.053	<0.003	0.006
Postassium	1972-1984	11	0.2	<0.1	0.1
Sodium	1972-1982	9	1.1	0.6	0.7
Solids - Dissolved	1972-1977	18	20	0.8	12.8
- Suspended	1974-1982	19	2	<1	1.3
- Total	1972-1982	11	16	9	12
Specific Conductivity	1972-1982	23	16	10	13
Sulphate	1972-1977	10	<5	<5	<5
Temperature	1972-1977	22	20	3	9
Turbidity	1972-1982	9	2.4	0.3	0.9

+ Median Value

* All values are as mg/L except:

(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

Data Source: B.C. Ministry of Environment

TABLE 12
AMBIENT WATER QUALITY DATA SUMMARY
PITT RIVER

Characteristic	Pitt River at Lougheed (Site 0300012)					Pitt Lake (Site 0300013)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1972-1979	39	51.1	5	30.8	1972-1977	24	7.2	4.7	6.0
Arsenic	1975	1	<0.005	-	-	1975	2	0.006	0.005	0.006
Carbon: - Inorganic	1974	17	11.6	0.2	7.7	-	-	-	-	-
Coliforms - Fecal	1973-1984	24	5 400	13	235+	1974-1977	8	<20	<2	<11+
- Total	1972-1976	22	>24000	23	2 400+	1972-1976	8	22	2	20+
Colour	1972-1974	5	40	<5	15	1972	4	5	5	5
Hardness - Total	1972-1979	40	53.9	6.2	34.4	1972-1977	24	8.8	5.7	6.6
- Calcium	1972-1979	40	17.8	2.1	10.8	1972-1977	24	2.6	1.9	2.2
- Magnesium	1972-1979	38	4	0.23	1.8	1972-1977	22	0.75	0.17	0.25
Metals: (Total)										
- Boron (Dissolved)	1972	3	<0.2	<0.1	-	1972	4	<0.2	<0.1	-
- Cadmium	1974-1979	20	<0.001	<0.0005	<0.001+	-	-	-	-	-
- Chromium	1972-1977	10	0.027	<0.005	0.007	1972-1977	16	0.011	<0.005	0.005
- Copper	1972-1979	31	0.013	<0.001	0.004	1972-1977	18	0.01	<0.001	0.002
- Iron	1974-1979	30	9.9	0.2	1.4	1974-1977	14	0.5	<0.1	0.2
- Lead	1972-1977	29	0.009	<0.001	0.002	1972-1977	18	0.027	<0.001	0.003
- Manganese	1972-1979	32	0.22	0.01	0.06	1972-1977	16	<0.02	<0.01	<0.02+
- Mercury	1974	16	<0.00005	<0.00005	<0.00005	-	-	-	-	-
- Nickel	1972-1977	12	0.02	<0.01	0.01	1972-1977	18	<0.01	<0.01	<0.01
- Zinc	1972-1979	34	0.024	<0.001	0.008	1972-1977	18	0.08	<0.005	0.015
Nitrogen:										
- Ammonia	1974-1979	13	0.043	0.007	0.022	1974-1977	14	0.018	<0.005	0.007
- Kjeldahl	1972-1979	33	0.36	0.06	0.19	1972-1977	16	0.16	<0.01	0.07
- Nitrate	1972-1976	14	0.19	0.04	0.10	1972-1976	16	0.09	0.02	0.07
- Nitrite	1972-1979	20	<0.005	<0.005	<0.005	1972-1977	20	<0.005	<0.005	<0.005
-Nitrate/Nitrite	1972-1979	24	0.22	<0.01	0.1	1977	4	0.1	0.09	0.1
- Organic	1973-1979	13	0.32	0.04	0.13	1973-1977	14	0.15	0.02	0.08
Oxygen - BOD_5	1974	6	<3	<1	-	-	-	-	-	-
- Dissolved	1972-1979	37	14.5	9	11.4	1972-1977	24	12.9	10.5	11.6
% saturation	1972-1979	37	115.4	87.3	99.6	1972-1977	24	121.8	95.5	106.5
pH	1972-1979	35	8	6.4	7.6+	1972-1977	20	7.5	6.5	6.9+
Phosphorus										
- Ortho Dissolved	1973-1979	16	0.014	<0.003	0.005	1974-1977	16	<0.003	<0.003	<0.003
- Total Dissolved	1977-1979	5	0.019	0.004	0.010	1977	4	0.003	0.003	0.003
- Total	1972-1977	33	0.286	0.012	0.055	1972-1977	20	0.036	<0.003	0.008
Potassium	1972-1979	17	0.8	0.3	0.6	1972-1977	10	0.4	0.1	0.3
Sodium	1972-1979	16	4.4	0.9	2.1	1972-1977	8	4.7	0.7	1.3
Solids: - Dissolved	1972-1978	19	90	18	46	1972-1977	22	28	10	17
- Suspended	1974-1979	14	305	4	46.3	1974-1977	16	20	<1	3
- Total	1972-1979	11	192	20	79	1972-1974	6	24	14	18.7
Specific Conductivity	1972-1979	38	129	19	78.7	1972-1977	20	47	14	20.7
Sulphate	1972-1979	34	9.8	<5	6.7	1972-1977	10	<5	<5	<5
Temperature	1972-1979	38	21	0	8.8	1972-1977	24	22	3	9.9
Turbidity	1974	17	100	3	31.7	1972-1977	9	3.6	1.1	1.8

* All values are as mg/L except:

(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

+ Median Value

Data Source: B.C. Ministry of Environment

TABLE 13
EFFLUENT DATA SUMMARY
EVERGREEN TRAILER PARK (PE 1508)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Chlorine Residual	1974-1983	48	3	0	0.36
Coliforms - Fecal	1974-1983	49	2 200 000	2	20+
- Total	1974-1976	26	17 000 000	2	35+
Flow	1974-1975	11	54.6	19.1	31.3
Nitrogen					
- Ammonia	1973-1977	5	25.7	2	17.6
- Kjeldahl	1974-1978	7	36	3	17
- Nitrate	1974-1976	4	0.14	0.02	0.068
- Nitrate	1977	2	0.07	0.02	0.045
- Nitrate/Nitrite	1977	2	0.07	0.06	0.065
- Organic	1976-1977	3	10.3	2.4	5.27
Oxygen - BOD_5	1973-1983	48	438	7.2	48.9
- Dissolved	1977	4	6.5	0.4	3.95
pH	1977-1986	6	7.2	5.6	6.8+
Phosphorus					
- Total	1974-1978	4	5.8	3.7	4.4
Solids - Dissolved	1974-1975	9	133	58	100
- Suspended	1973-1986	49	138	2	39
- Total	1976-1979	30	316	28	154
Specific Conductivity	1974-1986	23	462	138	257
Temperature	1974-1977	2	11	9	10

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Flow as m^3/d
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 14
AMBIENT WATER QUALITY DATA SUMMARY
COQUITLAM RIVER

Characteristic	Coquitlam River at Mouth (Site 0300010)					Coquitlam River at Galette Ave. (Site 0300011)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Alkalinity	1972-1982	36	39.7	3.1	13.6	1972-1984	40	16.2	2.5	7.4
Arsenic	1975-1982	3	<0.25	<0.005	-	1975-1984	4	<0.25	<0.005	-
Coliforms - Fecal	1973-1984	29	1 300	<2	215^{+}	1973-1983	34	920	<2	20^{+}
- Total	1972-1984	17	16 000	8	1250^{+}	1972-1976	17	2 200	8	70^{+}
Colour	1972-1973	5	25	10	18	1972-1973	5	40	5	21
Hardness	1972-1981	33	39.4	4.5	15.3	1972-1981	33	13.6	3.6	7.7
- Calcium	1972-1981	33	12.5	1.4	4.6	1972-1981	33	3.8	1.1	2.2
- Magnesium	1972-1981	31	2.7	0.24	0.9	1972-1981	31	1	0.2	0.5
Metals: (Total)										
- Aluminum	1982	1	1.52	-	-	1982-1984	2	1.31	0.71	1.01
- Boron (Dissolved)	1972	3	<0.2	<0.1	-	1972	3	<0.2	<0.1	-
- Cadmium	1978-1982	8	<0.01	<0.0005	<0.0005+	1978-1982	9	<0.01	<0.0005	<0.0005+
- Chromium	1972-1982	15	<0.01	<0.005	<0.005+	1972-1984	16	<0.01	<0.005	<0.005+
- Cobalt	1982	1	<0.1	-	-	1982-1984	2	<0.1	<0.1	<0.1
- Copper	1972-1982	29	0.02	<0.001	0.004	1972-1984	30	0.02	<0.001	0.005
- Iron	1972-1974	4	0.55	0.07	0.285	1973-1984	29	23.7	0.15	2.4
- Lead	1972-1982	20	<0.1	<0.001	0.001+	1972-1984	22	<0.1	<0.001	0.001+
- Manganese	1972-1982	25	0.1	0.02	0.05	1972-1984	26	0.14	<0.02	0.05
- Molybdenum	1982	1	<0.01	-	-	1982-1984	2	<0.01	<0.01	<0.01
- Nickel	1972-1982	20	<0.05	<0.01	0.01	1972-1984	21	<0.05	<0.01	0.01
- Vanadium	1982	1	<0.01	-	-	1982-1984	2	<0.01	<0.01	<0.01
- Zinc	1972-1982	21	0.02	<0.005	0.007	1972-1984	23	<0.015	<0.005	0.006
Nitrogen: - Ammonia	1974-1982	27	0.45	0.008	0.060	1974-1984	32	0.022	<0.005	0.010
- Kjeldahl	1972-1982	29	0.83	<0.01	0.24	1972-1984	36	0.38	<0.01	0.11
- Nitrate	1976-1982	17	1.15	0.09	0.37	1976-1984	22	0.69	0.08	0.26
- Nitrite	1972-1982	29	0.008	<0.005	0.005	1972-1984	33	<0.005	<0.005	<0.005
-Nitrate/Nitrite	1972-1982	18	1.15	0.09	0.36	1972-1984	25	0.69	0.07	0.24
- Organic	1973-1982	23	0.46	0.02	0.20	1973-1984	27	0.38	0.01	0.11
Oxygen - COD	-	-	-	-	-	1983	5	12	<10	10.6
- Dissolved	1972-1982	34	13.2	8.2	10.7	1972-1984	39	15.4	8.8	11.7
% saturation	1972-1982	33	113.6	75	95.6	1972-1984	36	116.9	86.1	102
pH	1972-1982	31	7.5	6	6.7^{+}	1972-1984	41	7.6	6	6.8^{+}
Phosphorus										
- Dissolved Ortho	1974-1982	27	0.046	<0.003	0.007	1974-1984	24	0.014	<0.003	0.004
- Total Dissolved	1976-1982	18	0.058	0.003	0.013	1976-1984	22	0.02	<0.003	0.007
- Total	1972-1978	20	0.145	0.007	0.034	1972-1984	23	0.199	0.006	0.039
Potassium	1972-1974	4	1	0.4	0.6	1972-1974	5	1	0.2	0.52
Sodium	1972-1974	3	3.9	1.8	3.1	1972-1974	4	2.9	0.5	1.5
Solids: - Dissolved	1972-1978	25	64	18	40	1972-1978	25	38	14	24
- Suspended	1974-1982	27	84	3	23	1974-1984	37	293	1	46.3
- Total	1972-1982	19	272	23	93	1978-1984	29	716	17	138

TABLE 14 (Continued)

Characteristic	Coquitlam River at Mouth (Site 0300010)					Coquitlam River Galette Ave (0300011)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Specific Conductivity	1972-1978	32	123	14	48.4	1972-1984	42	50	11	23.4
Sulphate	1972-1974	4	<5	<5	<5	1972-1974	4	<5	<5	<5
Temperature	1972-1982	33	19	1	9.7	1972-1984	38	19.5	1	8.5
Turbidity	1972-1975	7	59	0.7	19	1972-1984	10	16.4	1.1	6.7

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as μS/cm
(6) Temperature as °C
(7) Turbidity in NTU

Data Source: B.C Ministry of Environment

TABLE 14 (continued)

Characteristic	Coquitlam River downstream Or Creek (Site 0300019)				
	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1976-1977	2	<0.5	<0.5	<0.5
Arsenic	1975-1984	3	<0.25	<0.005	-
Carbon - Organic	1984	1	2	-	-
Coliforms - Fecal	1974-1984	26	49	<2	11+
- Total	1973-1984	13	49	2	18+
Colour	1974	1	7	-	-
Hardness - Total	1973-1982	29	24.3	3.07	5.2
- Calcium	1973-1984	29	2.4	1.0	1.6
- Magnesium	1973-1984	29	0.45	0.14	0.27
Metals (Total):					
- Aluminum	1982-1984	2	0.15	0.09	0.12
- Cadmium	1978-1984	9	<0.01	<0.0005	<0.0005+
- Chromium	1974-1984	14	<0.01	<0.005	<0.005+
- Cobalt	1982-1984	2	<0.1	<0.1	-
- Copper	1973-1984	25	0.01	<0.001	0.003
- Iron	1973-1984	26	7.5	0.05	0.7
- Lead	1973-1984	18	<0.1	<0.001	<0.001+
- Manganese	1974-1984	15	0.1	<0.01	0.027
- Molybdenum	1982-1984	2	0.01	<0.01	-
- Nickel	1973-1984	18	<0.05	<0.01	0.01
- Vanadium	1982-1984	2	<0.01	<0.01	<0.01
- Zinc	1973-1984	19	0.014	<0.005	0.006
Nitrogen					
- Ammonia	1974-1984	27	0.016	<0.005	0.007
- Kjeldahl	1974-1984	28	0.3	0.02	0.1
- Nitrate	1976-1984	18	0.52	0.07	0.22
- Nitrite	1973-1984	29	<0.005	<0.005	<0.005
- Nitrate/Nitrite	1976-1984	20	0.52	0.07	0.22
- Organic	1973-1982	20	0.3	<0.01	0.09
Oxygen - COD	1984	1	<10	-	-
- Dissolved	1973-1982	30	15.4	9.2	11.8
% Saturation	1973-1982	28	134	84.9	103
pH	1974-1984	33	7.3	6.1	6.7+
Phosphorus					
- Ortho Dissolved	1974-1984	20	0.006	<0.003	0.003
- Total Dissolved	1976-1982	16	0.011	0.003	0.006
- Total	1973-1984	20	0.13	0.005	0.018
Postassium	1974	1	0.1	-	-
Sodium	1974	1	0.3	-	-
Solids - Dissolved	1973-1981	20	24	10	15.8
- Suspended	1974-1984	33	439	<1	28.3
- Total	1973-1984	17	216	10	33.1
Specific Conductivity	1973-1984	14	97	9	27.4
Sulphate	1974	1	<5	-	-
Temperature	1973-1982	30	18	2.5	8.1
Turbidity	1973-1979	5	16	0.2	3.7

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as percent
(4) pH
(5) Specific Conductivity as µS/cm
(6) Temperature as °C
(7) Turbidity in NTU

Data Source: B.C. Ministry of Environment

Table 14 (continued)

Characteristic	Coquitlam R. at Dam (Site 1189001)					Coquitlam R. at GVWD Gate (Site 1189003) (Downstream Or Creek)				
	Period of Record	No. of Values	Values*			Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Arsenic	1975-1976	7	<0.005	<0.005	<0.005	1975-1976	7	<0.005	<0.005	<0.005
Coliforms - Fecal	1975-1976	10	33	<2	2+	1975-1976	10	11	<2	2+
- Total	1975-1976	10	49	<2	2+	1975-1976	10	31	<2	3+
Hardness	1975-1976	11	3.8	3.0	3.4	1975-1976	11	6.1	3.3	4.7
- Calcium	1975-1976	11	1.2	0.1	1.1	1975-1976	11	1.7	1	1.4
- Magnesium	1975-1976	11	0.2	0.2	0.2	1975-1976	11	0.45	0.19	0.29
Metals										
- Iron (Dissolved)	1975-1976	5	<0.1	<0.1	<0.1	1975-1976	5	<0.1	<0.1	<0.1
- Manganese (Dissolved)	1975-1976	4	<0.02	<0.02	-	1975-1976	4	<0.02	<0.02	<0.02
Oxygen - Dissolved	1976	4	13.8	12.7	13.1	1976	4	13.9	12.9	13.2
% Saturation	1976	4	127.3	107	113.8	1976	4	132.2	106.5	115
pH	1975-1976	11	6.3	5.8	6.1+	1975-1976	11	6.7	6	6.4+
Solids: - Dissolved	1975-1976	11	18	8	12.9	1975-1976	11	20	14	17
- Suspended	1975-1976	10	63	1	15	1975-1976	10	376	2	49
- Total	1975-1976	11	82	10	27.8	1975-1976	11	406	20	91.5
Specific Conductivity	1975-1976	11	12	10	11.4	1975-1976	11	17	11	15.2
Temperature	1975-1976	5	14	3	7	1975-1976	5	15	3	7
Turbidity	1975-1976	11	27	0.6	5.4	1975-1976	11	144	0.6	19.4

Characteristic	Coquitlam R. at Hockaday (Site 1189004)					Coquitlam R. at Railway Bridge (Site 1189005)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Arsenic	1975-1976	7	<0.005	<0.005	<0.005	1975-1976	7	<0.005	<0.005	<0.005
Coliforms - Fecal	1975-1976	10	49	2	15+	1975-1976	10	130	5	39.5+
- Total	1975-1976	10	70	8	23+	1975-1976	10	170	22	64+
Hardness	1975-1976	11	9.4	3.4	6.6	1975-1976	11	12.9	5.2	8.8
- Calcium	1975-1976	11	2.6	1	1.9	1975-1976	11	3.9	1.6	2.6
- Magnesium	1975-1976	11	0.7	0.2	0.5	1975-1976	11	0.8	0.3	0.5
Metals:										
- Iron (Dissolved)	1975-1976	5	0.1	<0.1	0.1	1975-1976	6	0.1	<0.1	-
- Manganese (Dissolved)	1975-1976	4	0.02	<0.02	-	1975-1976	4	0.02	<0.02	-
Oxygen - Dissolved	1976	4	14	12.1	12.8	1976	4	13.6	11.9	12.6
% saturation	1976	4	121.2	107.3	112.7	1976	4	119.2	106.4	111.3
pH	1975-1976	11	6.9	6	6.5+	1975-1976	11	7.1	6.2	6.5+
Solids: - Dissolved	1975-1976	11	34	16	23	1975-1976	11	34	18	26
- Suspended	1975-1976	10	420	2	74.2	1975-1976	10	81	3	26
- Total	1975-1976	11	503	26	137	1975-1976	11	375	28	83
Specific Conductivity	1975-1976	11	28	12	21	1975-1976	2	65	<50	-
Temperature	1975-1976	5	14	3	8	1975-1976	5	14	4	8
Turbidity	1975-1976	11	160	1.8	33.3	1975-1976	11	72	1.3	17.5

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) % saturation as percent
(3) pH
(4) Specific Conductivity as μS/cm
(5) Temperature as °C
(6) Turbidity in NTU

+ Median Value

Data Source: B.C. Ministry of Environment

TABLE 14 (Continued)
Coquitlam R. at Red Bridge (Site 1189008)
(at mouth)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Arsenic	1975-1976	7	<0.005	<0.005	<0.005
Coliforms - Fecal	1975-1976	10	140	<20	75+
- Total	1975-1976	10	1100	50	350+
Hardness - Total	1975-1976	11	17.9	5	12.5
- Calcium	1975-1976	11	5.6	1.5	3.9
- Magnesium	1975-1976	11	1	0.3	0.7
Metals:					
- Iron (Dissolved)	1975-1976	6	0.6	0.2	0.4
- Manganese (Dissolved)	1975-1976	4	0.05	0.04	0.05
Oxygen Dissolved	1975-1976	4	12.8	12	12.3
% Saturation	1975-1976	4	123	100.8	110.3
pH	1975-1976	11	6.6	6.2	6.4+
Solids - Dissolved	1975-1976	11	60	18	39
- Suspended	1975-1976	10	58	5	20.5
- Total	1975-1976	11	385	40	90.3
Specific Conductivity	1975-1976	11	77	16	46.8
Temperature	1975-1976	5	15	4	8.4
Turbidity	1975-1976	11	66	2.8	14.2

Site and Description	Iron (Total) mg/L
Coquitlam R. u/s of Slough (Site 1189009)	0.9
Coquitlam R. at Kelly St. (Site 1189010)	0.4
Coquitlam R. at Wilson Ave. (Site 1189011)	0.3
Coquitlam R. at Bury St. (Site 1189012)	0.3

Date of Collection: 1976

+ Median Value

* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) % saturation as percent
(3) pH
(4) Specific Conductivity as µS/cm
(5) Temperature as °C
(6) Turbidity in NTU

Data Source: B.C. Ministry of Environment

TABLE 15
AMBIENT WATER QUALITY DATA SUMMARY
OR CREEK AT COQUITLAM R. (1189002)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Arsenic	1975-1976	6	<0.005	<0.005	<0.005
Coliforms - Fecal	1975-1976	10	2	<2	2+
- Total	1975-1976	10	8	<2	2+
Hardness - Total	1975-1976	10	6.2	3.1	4.3
- Calcium	1975-1976	10	1.9	1	1.3
- Magnesium	1975-1976	10	0.4	0.2	0.2
Metals:					
- Iron (Dissolved)	1975-1976	5	<0.1	<0.1	<0.1
- Manganese	1975-1976	4	<0.02	<0.02	<0.02
Oxygen - Dissolved	1976	4	14.8	12	13.2
% Saturation	1976	4	120.2	106.1	112.5
pH	1975-1976	10	6.6	6	6.4+
Solids - Dissolved	1975-1976	10	20	12	16
- Suspended	1975-1976	10	433	3	77
- Total	1975-1976	10	452	18	94
Temperature	1975-1976	5	14	2	7
Turbidity	1975-1976	10	104	7	21

+ Median Value

* All values are as mg/L except:
  (1) Coliforms as MPN/100 mL
  (2) % saturation as percent
  (3) pH
  (4) Temperature as °C
  (5) Turbidity in NTU

Data Source: B.C. Ministry of Environment

TABLE 16
AMBIENT WATER QUALITY DATA SUMMARY
SCOTT CREEK (Site 1189006)

Characteristic	Scott Creek (Site 1189006)					Scott Creek at Hwy 7 (Site 1189007)				
	Period of Record	No. of Values	Values*			Period of Record	No of Values	Values*		
			Maximum	Minimum	Mean			Maximum	Minimum	Mean
Arsenic	1975-1976	10	<0.005	<0.005	<0.005	1975-1976	7	<0.005	<0.005	<0.005
Coliforms - Fecal	1975-1976	10	33	<2	7+	1975-1976	10	630	230	420+
- Total	1975-1976	10	170	2	14+	1975-1976	10	9200	490	2300+
Hardness - Total	1975-1976	10	11.8	6.4	8.4	1975-1976	11	19.5	11.4	14.3
- Calcium	1975-1976	10	3.2	1.9	2.3	1975-1976	11	6	3.5	4.4
- Magnesium	1975-1976	10	0.92	0.4	0.6	1975-1976	11	1.1	0.6	0.8
Metals:										
- Iron (Dissolved)	1975-1976	4	0.2	<0.1	0.1	1975-1976	5	0.3	0.1	0.1
- Manganese	1975-1976	3	0.02	0.02	0.02	1975-1976	4	0.05	0.03	0.04
Oxygen - Dissolved	1976	3	14.4	11.4	12.7	1976	4	13.8	11	12.2
% saturation	1976	3	114.2	110.8	112.8	1976	4	110.8	102	107.9
pH	1975-1976	10	6.8	6.3	6.5+	1975-1976	11	6.9	6.3	6.6+
Solids: - Dissolved	1975-1976	10	36	24	28	1975-1976	11	104	34	48.7
- Suspended	1975-1976	9	38	1	10	1975-1976	10	69	4	18
- Total	1975-1976	10	42	26	33	1975-1976	11	122	46	72
Specific Conductivity	1975-1976	10	46	21	28	1975-1976	11	167	40	64
Temperature	1975-1976	4	14	4	8	1975-1976	5	14	4	8
Turbidity	1975-1976	10	6.8	0.8	2.7	1975-1976	11	34	1.8	8.9

+ Median Value

* All values are as mg/L except:
  (1) Coliforms as MPN/100 mL
  (2) % saturation as percent
  (3) pH
  (4) Specific Conductivity as µS/cm
  (5) Temperature as °C
  (6) Turbidity in NTU

Data Source: B.C. Ministry of Environment

TABLE 17
EFFLUENT DATA SUMMARY
LANFORD CEDAR PRODUCTS (PE 414)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1977-1978	3	418	0.5	153.3
Carbon - organic	1973-1974	2	359	273	316
Colour	1973-1974	4	1600	1 000	1 400
Nitrogen					
- Kjeldahl	1974	1	8	-	-
- Nitrate	1973-1974	2	60	25.6	42.8
- Nitrite	1973-1974	2	0.166	0.025	0.096
- Organic	1973-1974	5	12	4	7.74
Oil and Grease	1986	3	11	5	7.3
Oxygen - BOD_5	1972-1979	23	269	3	121
- COD	1973-1974	3	809	216	489
pH	1972-1986	23	11.1	3.8	8.6+
Phosphorus					
- Ortho Dissolved	1974	2	0.01	0.01	0.01
- Total	1973-1974	5	1.82	0.03	0.84
Potassium	1974	2	23	6.9	14.95
Sodium	1973-1974	5	514	130	268.8
Solids - Dissolved	1972	1	674	-	-
- Suspended	1972-1986	25	879	0.5	217.4
- Total	1972-1979	18	2 942	336	1 575
Specific Conductivity	1973-1986	19	2 780	160	1 334
Sulphate	1973-1974	5	283	83.5	170
Temperature	1973-1979	6	92	12	37.3

+ Median Value

* All values are as mg/L except:
(1) Colour as true colour units
(2) pH
(3) Specific Conductivity as μS/cm
(4) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 18
EFFLUENT DATA SUMMARY
CONTINENTAL CAN. BURNABY (PE 2642)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1975	1	8.1	-	-
Arsenic	1986	1	<0.25	-	-
Flow	1975	19	163.7	65.5	126.1
Metals (Total)					
- Aluminum	1986	1	0.09		
- Cadmium	1986	1	<0.01	-	-
- Chromium	1986	1	<0.01	-	-
- Cobalt	1986	1	<0.1	-	-
- Copper	1975-1986	2	0.05	0.03	0.04
- Iron	1975-1986	2	1.38	0.7	1.04
- Lead	1975-1986	2	<0.1	0.02	-
- Manganese	1986	1	0.05	-	-
- Molybdenum	1986	1	<0.01	-	-
- Nickel	1986	1	<0.05	-	-
- Vanadium	1986	1	<0.01	-	-
- Zinc	1975-1986	2	0.02	0.007	0.014
Oil and Grease	1975-1986	13	6.8	<1	2
Oxygen - BOD_5	1975	1	<10	-	-
pH	1975-1985	9	6.9	6	6.5$^+$
Solids - Suspended	1975-1985	11	9	<1	3
- Total	1975	1	24	-	-
Specific Conductivity	1975-1985	9	34	20	26
Temperature	1977-1979	5	21	8	14.6

+ Median Value

* All values are as mg/L except:
(1) Flow as m^3/d
(2) pH
(3) Specific Conductivity as µS/cm
(4) Temperature as °C

Data Source: B.C. Ministry of Environment

TABLE 19
EFFLUENT DATA SUMMARY
IMPERIAL OIL
N. BURNABY (PE 3840)

Characteristic	No. of Values	Values*		
		Maximum	Minimum	Mean
Tank Farm Area ("01")				
Flow (m^3/d)	13	341	37	131
Oil and Grease (mg/L)	46	21.9	0	3.6
pH	46	9.1	6.0	6.85^+
Solids - Suspended (mg/L)	3	14	3	8
- Total (mg/L)	45	449	49	123
Loading Area ("02")				
Flow (m^3/d)	1	121.4	-	-
Oil and Grease (mg/L)	50	18.6	0.2	3.2
pH	50	7.8	5.9	6.8^+
Solids - Suspended (mg/L)	2	22	4	13
- Total (mg/L)	49	585	56	140
Pump Area ("03")				
Flow (m^3/d)	13	30.6	3.3	11.9
Oil and Grease (mg/L)	45	204.3	0.7	17.2
pH	45	8.2	5.9	6.7^+
Solids - Suspended (mg/L)	2	42	9	25.5
- Total (mg/L)	45	455	54	153

+ Median Value

Data Source: B.C. Ministry of Environment Computerized
Data Storage and Retrieval System

TABLE 20
EFFLUENT DATA SUMMARY
SHELL OIL, BURNABY (PE 3138)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Cyanide	1974-1976	6	0.01	0	0.003
Flow	1978	8	195.8	-	-
Metals (Total)					
- Chromium	1974-1976	7	0.005	0	0.002
- Copper	1974-1976	20	0.07	0	0.004
- Iron	1974-1976	7	3.2	0	0.58
- Lead	1974-1976	20	0.02	0	0.002
- Nickel	1975-1976	6	<0.01	0	0.003
- Zinc	1974-1976	3	0.04	0.016	0.025
Nitrogen					
- Ammonia	1974-1986	5	0.022	0.008	0.011
- Kjeldahl	1986	2	0.27	0.19	0.23
Nitrite	1986	1	0.005	-	-
Nitrate/Nitrite	1986	2	0.16	0.1	0.13
Oil and Grease	1974-1986	70	39	<0.1	3.9
Oxygen - BOD_5	1974-1976	2	<10	<10	<10
pH	1974-1986	70	8.1	5.9	7.1+
Phosphorus					
- Ortho	1984-1986	2	0.004	0.003	0.004
- Total Dissolved	1986	1	0.006	-	-
- Total	1984-1986	3	0.021	0.015	0.018
Solids - Suspended	1974-1984	45	24	0.5	6.92
- Total	1974-1986	8	88	40	54
Specific Conductivity	1974-1986	13	158	50	80.5
Sulphate	1985	1	8.5	-	-
Sulphide	1974-1976	24	<0.5	0	0.06
Temperature	1974-1984	2	10	8	9
Turbidity	1984-1985	3	11	3.1	6.07

\+ Median Value
* All values are as mg/L except:
(1) Flow as m^3/d
(2) pH
(3) Specific Conductivity as µS/cm
(4) Temperature as °C
(5) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 21
DATA SUMMARY
SHELL OIL, BURNABY (PR 5476)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Nitrogen					
- Ammonia	1984-1986	3	0.014	0.012	0.01
- Kjeldahl	1986	2	1.43	0.32	0.88
- Nitrite	1986	2	0.008	<0.005	0.007
- Nitrate/Nitrite	1986	2	0.02	<0.02	-
Oil and Grease	1980-1986	7	19.5	1.4	6.2
pH	1984-1986	5	7	6.4	6.6+
Phosphorus					
- Ortho	1984-1986	2	0.007	<0.003	-
- Total Dissolved	1986	1	0.016	-	-
- Total	1984-1986	3	0.144	0.027	0.085
Potassium	1986	1	1.6	-	-
Solids - Suspended	1984-1986	5	24	4	11
- Total	1984-1986	3	212	112	165
Specific Conductivity	1984-1986	5	490	104	201
Temperature	1984	1	8	-	-
Turbidity	1984-1985	3	6.6	3.2	5.4

+Median Value
*All values are as mg/L except:
(1) pH
(2) Specific Conductivity as μS/cm
(3) Temperature as °C
(4) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 22
EFFLUENT DATA SUMMARY
TRANS MOUNTAIN PIPELINE, BURNABY (PE 6945)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Arsenic	1984	2	<0.25	<0.25	<0.25
Carbon - Organic	1984-1985	4	5	1	2
- Inorganic	1985-1986	3	13	6	8.3
Hardness					
- Calcium (Dissolved)	1984	2	14.1	8.8	11.5
- Magnesium	1984	2	3.1	2	2.5
Metals (Dissolved)					
- Aluminum	1984	2	0.12	0.03	0.075
- Barium	1984	2	0.02	<0.01	-
- Boron	1984	2	0.01	0.01	0.01
- Cadmium	1984	2	<0.01	<0.01	<0.01
- Chromium	1984	2	<0.01	<0.01	<0.01
- Cobalt	1984	2	0.11	<0.1	-
- Copper	1984	2	<0.01	<0.01	<0.01
- Iron	1984	2	0.35	0.27	0.31
- Lead	1984	2	<0.1	<0.1	<0.1
- Manganese	1984	2	0.33	0.02	0.18
- Molybdenum	1984	2	<0.01	<0.01	<0.01
- Nickel	1984	2	<0.05	<0.05	<0.05
- Vanadium	1984	2	<0.01	<0.01	<0.01
- Zinc	1984	2	0.04	<0.01	-
Nitrogen					
- Ammonia	1984-1986	7	0.083	0.005	0.029
- Kjeldahl	1984-1986	7	0.47	0.09	0.22
- Nitrate	1985	2	0.18	0.09	0.14
- Nitrite	1985-1986	5	0.006	0.005	0.005
- Nitrate/Nitrite	1984-1986	7	0.31	<0.02	0.1
Oil and Grease	1984-1986	7	4.6	<1	3.2
pH	1984-1986	7	9.5	6.9	7.1+
Phosphorus					
- Ortho	1985-1986	3	<0.003	<0.003	<0.003
- Total Dissolved	1985-1986	3	0.01	0.005	0.007
- Total	1984-1986	7	0.027	0.008	0.017
Potassium	1984-1986	7	1	0.5	0.7
Sodium	1984-1985	4	15.9	2.9	7.0
Solids - Suspended	1984-1986	7	15	2	5
- Total	1984-1986	7	144	60	86
Specific Conductivity	1984-1986	7	221	42	104
Temperature	1984-1985	4	22	2	11

+ Median Value

* All values are as mg/L except:
(1) pH
(2) Specific Conductivity as μS/cm
(3) Temperature °C

Data Source: B.C. Ministry of Environment

TABLE 23
AMBIENT WATER QUALITY DATA SUMMARY
STILL CREEK (Site 0300008)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1972-1984	41	101	20	50
Arsenic	1975-1984	7	<0.25	<0.005	0.168
Carbon-Organic	1978-1984	3	13	5	9
Chloride	1972-1982	37	235	2.7	13.5+
Coliforms - Fecal	1973-1984	33	>24000	<2	3390+
- Total	1972-1984	17	<240000	78	19295+
Colour	1972-1980	8	110	20	58.8
Hardness	1972-1982	35	290	25.1	63.1
- Calcium	1972-1984	39	80	8.8	19.5
- Magnesium	1972-1984	37	22	0.77	3.4
Metals (Total):					
- Aluminum	1983-1984	5	0.59	0.18	0.36
- Barium (Dissolved)	1982-1984	4	0.09	0.02	0.04
- Boron (Dissolved)	1972-1983	8	<0.2	0.02	-
- Cadmium	1974-1984	14	<0.01	<0.0005	0.0035
- Chromium	1972-1984	30	0.04	<0.005	0.009
- Cobalt	1982-1984	5	<0.1	<0.1	<0.1
- Copper	1972-1984	38	0.18	0.007	0.028
- Iron	1973-1984	35	25	1	3.3
- Lead	1972-1984	38	0.2	0.005	0.053
- Manganese	1973-1984	32	0.42	0.08	0.21
- Molybdenum	1982-1984	5	<0.01	<0.01	<0.01
- Mercury	1978-1982	10	0.00009	<0.00005	0.00006
- Nickel	1972-1984	26	<0.05	<0.01	-
- Vanadium	1982-1984	5	<0.01	<0.01	<0.01
- Zinc	1972-1984	39	0.19	0.02	0.07
Nitrogen					
- Ammonia	1974-1984	32	0.406	0.005	0.134
- Kjeldahl	1972-1984	34	2	0.32	0.8
- Nitrate	1977-1984	23	1.77	0.15	0.79
- Nitrite	1972-1984	38	0.199	0.007	0.026
- Nitrate/Nitrite	1972-1984	24	1.78	0.22	0.8
- Organic	1973-1984	27	2	0.26	0.71
Oil and Grease	1981	3	1.7	<1	1.2
Oxygen - BOD_5	1974-1978	16	25	<10	12.8
- COD	1974-1983	27	81.6	<10	32.9
-Dissolved	1972-1984	39	12.2	1.95	8.4
- % Saturation	1972-1984	38	98.6	21.4	76.5
pH	1972-1984	36	7.4	6.6	7.1+
Phosphorus:					
- Ortho	1974-1984	33	0.098	0.005	0.027
- Total Dissolved	1976-1984	19	0.126	0.016	0.045
- Total	1972-1980	26	0.59	0.01	0.14
Potassium	1972-1982	33	3.1	0.7	1.9
Sodium	1972-1982	32	26	2.8	11.5
Solids - Dissolved	1972-1978	24	1226	60	169.8
- Suspended	1974-1984	31	132	5	20.9
- Total	1978-1984	23	1276	92	195
Specific Conductivity	1972-1983	37	240	67	175
Sulphate	1972-1982	32	17.3	5.2	12.4
Temperature	1972-1984	38	22	1.5	11.4
Turbidity	1972-1975	12	105	3.2	21.8

+ Median Value

*All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) % saturation as %
(4) pH
(5) Specific Conductivity as µS/cm
(6) Temperature as °C
(7) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 24
Ambient Water Quality Data Summary
Burnaby Lake (Site 0300009)

Characteristic	Period of Record	No. of Values	Values*		
			Maximum	Minimum	Mean
Alkalinity	1972-1982	36	69	17.3	36.8
Arsenic	1975-1982	3	<0.25	<0.005	0.087
Chloride	1972-1982	36	74.2	3	16.6
Coliforms - Fecal	1973-1982	30	>24000	<20	490+
- Total	1972-1976	16	16000	220	2200+
Colour	1977-1982	15	160	20	55.7
Hardness - Total	1982-	2	59.9	52.1	56
- Calcium	1972-1981	33	20.7	6.3	12.9
- Magnesium	1972-1981	31	6.2	1.3	2.6
Metals (Total)					
- Aluminum	1982-	1	0.49	-	-
- Boron - Dissolved	1972-	3	<0.2	<0.1	-
- Cadmium	1980-1982	7	<0.01	<0.0005	-
- Chromium	1972-1982	9	<0.01	<0.005	-
- Cobalt	1982-	1	<0.01	-	-
- Copper	1972-1982	17	0.021	0.002	0.008
- Iron	1973-1982	14	2.6	0.8	1.7
- Lead	1972-1982	17	0.2	0.007	0.033
- Manganese	1972-1982	11	0.38	0.07	0.17
- Mercury	1978-1982	10	0.00015	<0.00005	0.00007
- Molybdenum	1982	1	<0.01	-	-
- Nickel	1972-1982	14	<0.05	<0.01	-
- Vanadium	1982	1	<0.01	-	-
- Zinc	1972-1982	17	0.06	<0.005	0.02
Nitrogen:					
- Ammonia	1974-1982	27	0.68	0.006	0.13
- Kjeldahl	1972-1982	30	4	0.29	0.89
- Nitrate	1972-1976	11	0.87	<0.02	0.29
- Nitrite	1972-1977	14	0.128	<0.005	0.024
- Nitrate/Nitrite	1972-1977	4	1.05	0.02	0.59
- Organic	1973-1982	26	4	0.27	0.82
Oxygen - Dissolved	1972-1982	35	16.1	3.9	9.4
% Saturation	1972-1982	34	115	42.5	88
pH	1972-1982	31	7.8	6	7.2+
Phosphorus:					
- Ortho Dissolved	1974-1982	28	0.048	0.005	0.012
- Total Dissolved	1976-1982	17	0.102	0.011	0.026
- Total	1972-1978	23	0.13	0.03	0.07
Potassium	1972-1978	5	3	1.5	1.9
Sodium	1972-1978	4	12.5	7.4	9.8
Solids - Dissolved	1972-1978	25	160	64	102.6
- Suspended	1974-1982	27	128	5	21.1
- Total	1972-1982	17	213	94	139
Specific Conductivity	1972-1982	33	332	65	148.6
Sulphate	1972-1978	5	11.3	6.8	9.2
Temperature	1972-1982	34	27.5	1.5	12.1
Turbidity	1972-1974	7	28	3.7	10.5

\+ Median Value

* All values are as mg/L except:
(1) Coliforms are as MPN/100 mL
(2) Colour as true colour units
(3) Flow as m^3/s (m^3/d)
(4) % saturation as %
(5) pH
(6) Specific Conductivity as µS/cm
(7) Temperature as °C
(8) Toxicity as % effluent
(9) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 25
AMBIENT WATER QUALTY DATA SUMMARY
-BRUNETTE RIVER

Characteristic	Brunette River Spruce Street (Site 0300111)					Brunette River Upstream (Site 0300112)				
	Period of Record	No. of Values	Values* Maximum	Values* Minimum	Values* Mean	Period of Record	No. of Values	Values* Maximum	Values* Minimum	Values* Mean
Alkalinity	1973-1985	42	54.6	>18.5	37.7	1973-1984	10	85.8	28.9	42.4
Arsenic	1975-1985	13	<0.25	<0.005	-	1983-1984	4	<0.25	<0.25	<0.25
Carbon - Organic	1973-1985	9	14	3	8.2	1973-1984	2	15	4	9
Chloride	1973-1984	34	32.6	5.9	14.6	1973-1984	8	17.2	8.3	12.5
Coliforms - Fecal	1973-1984	31	9200	50	920+	1973-1974	4	1100	<20	200+
- Total	1973-1976	13	>24000	1600	3500+	1973-1974	4	>24000	330	800+
Colour	1977-1985	22	60	15	36.4	1974-1984	7	75	20	43
Hardness - Total	1973-1981	27	59.3	30.3	44.9	1973-1974	4	49.4	29.4	38.2
Calcium	1982-1985	11	16.2	7	12.5	1973-1984	4	14.6	11.8	13.1
Magnesium	1973-1985	13	5.15	1.28	2.54	1973-1984	5	4.1	2.3	2.9
Metals - Total										
- Aluminum	1982-1984	8	13.7	0.07	2.1	1983-1984	4	5.1	0.13	1.5
- Boron Dissolved	1974-1984	3	<0.1	<0.01	-	1974	1	<0.1	-	-
- Cadmium	1973-1985	22	<0.01	<0.0001	-	1973-1984	8	<0.01	<0.0001	-
- Chromium	1973-1985	22	<0.01	<0.001	-	1973-1984	8	0.01	<0.005	0.008
- Cobalt	1983-1985	6	0.16	<0.1	0.11	1983-1984	4	<0.1	<0.1	<0.1
- Copper	1973-1985	39	0.07	<0.001	0.01	1973-1984	9	0.03	0.002	0.01
- Iron	1973-1985	39	19.9	<0.01	2	1973-1984	9	7	<0.1	2.4
- Lead	1974-1985	38	0.31	0.001	0.035	1973-1984	9	0.1	0.002	0.04
- Manganese	1973-1985	37	1.8	0.05	0.17	1973-1984	7	0.58	0.08	0.22
- Mercury	1978-1985	16	0.00015	<0.00005	-	1981-1984	6	0.00007	<0.00005	-
- Molybdenum	1982-1985	11	0.02	<0.01	0.01	1983-1984	4	0.02	<0.01	0.02
- Nickel	1973-1985	37	<0.05	<0.01	0.02	1973-1984	8	<0.05	<0.01	0.03
- Vanadium	1982-1985	11	0.04	<0.01	0.01	1983-1984	4	0.02	<0.01	0.02
- Zinc	1973-1985	39	0.21	0.005	0.028	1973-1984	9	0.09	<0.005	0.03
Nitrogen										
- Ammonia	1974-1985	38	1.26	<0.005	0.132	1981-1984	6	0.119	0.022	0.077
- Kjeldahl	1974-1984	33	2.83	0.2	0.72	1981-1983	3	1.1	0.4	0.8
- Nitrate	1976-1984	24	2	0.17	0.56	1973-1974	4	0.74	0.04	0.31
- Nitrite	1973-1985	37	0.037	<0.005	0.012	1973-1983	7	0.02	0.01	0.01
- Nitrate/Nitrite	1976-1984	24	2	0.17	0.57	1981-1983	3	0.26	0.13	0.18
- Organic	1973-1984	24	1.05	0.16	0.55	1973-1974	4	0.68	0.4	0.55

TABLE 25 (CONTINUED)
AMBIENT WATER QUALITY DATA SUMMARY
BRUNETTE RIVER

	Brunette River Spruce Street (Site 0300111)					Brunette River Upstream (Site 0300112)				
			Values*					Values*		
Characteristic	Period of Record	No. of Values	Maximum	Minimum	Mean	Period of Record	No. of Values	Maximum	Minimum	Mean
Oil and Grease	1973-1982	23	27.1	<1	3.3	1973-1974	4	2.9	<1	1.6
Oxygen - BOD_5	1973-1982	22	<10	<10	<10	1973-1974	3	<10	<10	<10
- COD	1974-1984	7	22	12	18.6	-	-	-	-	-
- Dissolved	1973-1984	36	14.2	6.6	9.9	1973-1984	8	13.9	6.1	9.9
% Saturation	1973-1984	34	107.9	73.6	94.2	1973-1984	8	136.9	79	99.7
pH	1974-1985	40	7.9	6.6	7.2+	1974-1984	8	7.5	6.6	6.9+
Phosphorus										
- Ortho	1973-1984	33	0.018	0.004	0.010	1973-1974	3	0.014	0.01	0.012
- Total Dissolved	1976-1984	22	0.033	0.012	0.02	1981-1983	3	0.04	0.02	0.03
- Total	1973-1978	19	0.14	0.03	0.06	1973-1974	4	0.1	0.1	0.1
Potassium	1974-1985	34	7.4	1	1.8	1974-1984	8	2.6	1.2	1.7
Sodium	1974-1985	34	21.2	5.8	9.9	1974-1984	8	10.1	7	8.3
Solids - Dissolved	1973-1978	20	166	76	105.7	1973-1974	4	118	85	101
- Suspended	1974-1985	38	456	3	28.8	1974-1984	7	173	3	32.9
- Total	1973-1985	23	196	63	118.9	1973-1984	6	154	92	115
Specific Conductivity	1974-1985	40	225	66	144.1	1974-1984	8	224	112	140.9
Sulphate	1973-1985	34	14	6	9.6	1973-1984	8	10.3	<0.5	6.6
Sulphide	1981-1985	7	<0.5	<0.5	<0.5	1983-1984	4	<0.5	<0.5	<0.5
Temperature	1973-1984	35	22.5	2	12.1	1973-1984	8	25	3	13.7
Turbidity	1974-1975	3	13	4.4	8.6	-	-	-	-	-

+ Median Value
* All values are as mg/L except:
(1) Coliforms as MPN/100 mL
(2) Colour as true colour units
(3) Flow as m^3/s (m^3/N)
(4) % saturation as %
(5) pH
(6) Specific conductivity as µS/cm
(7) Temperature as °C
(8) Toxicity as % effluent
(9) Turbidity as NTU

Data Source: B.C. Ministry of Environment

TABLE 26
AMBIENT WATER QUALITY DATA SUMMARY
MARION (JACOBS) LAKE
(1984-1987)

Characteristic	No. of Values	Values*		
		Maximum	Minimum	Mean
Alkalinity	26	10.9	1.72	4.8
Chorophyll-a	21	2.7	<0.5	1.1
Colour	34	15	4	9.3
Hardness: Calcium	34	3.84	1.0	2.02
Magnesium	35	1.68	0.13	0.28
Metals (Total):				
- Aluminum	30	0.61	0.03	0.12
- Cadmium	25	0.04	<0.0005	<0.0005+
- Chromium	34	0.09	<0.01	<0.01+
- Copper	34	0.3	0.001	<0.01+
- Iron	34	0.58	<0.01	0.13
- Molybdenum	34	0.07	<0.01	<0.01+
- Lead	25	0.5	<0.001	0.022
- Zinc	34	0.48	<0.01	<0.01+
Nitrogen:				
- Kjeldahl	34	0.24	0.05	0.12
- Nitrate/Nitrite	18	0.95	<0.02	0.08
Oxygen: Dissolved				
pH	33	7.7	5.8	6.6+
Phosphorus:				
- Total	33	0.009	<0.003	0.006
- Dissolved	26	0.006	<0.003	0.004
Solids: - Dissolved	33	28	8	17.8
Specific Conductivity	33	28	11	16.1

+ Median Value

* All Values are as mg/l except:

(1) Chlorophyll-a as ug/L
(2) Colour as TAC
(3) pH
(4) Specific Conductivity as µS/cm

Data Source: B.C. Ministry of Environment

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