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MINISTRY OF ENVIRONMENT, LANDS AND PARKS

THOMPSON RIVER
WATER QUALITY ASSESSMENT AND OBJECTIVES

TECHNICAL APPENDIX

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SUMMARY

This report was written to summarize the water quality of the mainstem Thompson River and to propose water quality objectives which would protect existing and future water uses. The geographic limits of the study include the South Thompson River and its tributaries between Little Shuswap Lake and the confluence with the North Thompson at Kamloops, the North Thompson downstream from McLure, and the lower Thompson River to its confluence with the Fraser River including Kamloops Lake. The study area does not include three watersheds tributary to the lower Thompson which are the subject of past or future water quality studies (the Bonaparte, Deadman and Nicola Rivers).

The South Thompson has numerous water licenses authorizing withdrawals for a variety of purposes: drinking water, irrigation, waterworks and industrial use. The river is important for drinking water, aquatic life and for recreational activities.

The South Thompson River receives a number of waste discharges (wastewater from small industrial as well as municipal and other sources) which appear to have only minor effects on water quality based on existing data. Another concern appears to be non-point sources affecting water quality. These include agriculture, on-site sewage disposal systems, land erosion and storm drains. As specific sources of pollution are identified, they will be targeted for attention by the appropriate government agency.

The water quality of the South Thompson, on the basis of the data collected over the past 20 years, is relatively good and no strong evidence could be found for trends of water quality deterioration over the period for most characteristics. The characteristic for which some concern is noted is the microbiological quality of the water, probably originating from non-point discharges. Water quality objectives for this characteristic are proposed.

The North Thompson River below McLure has numerous licenses authorizing withdrawal for domestic use and irrigation. Protection of aquatic life is also a designated use for water in this reach of the river. There are no direct discharges to the river, but there are a variety of indirect discharges to ground water. The water quality of the North Thompson is relatively similar to the South except that it has higher colour and suspended sediments but it is generally of good quality. Provisional water quality objectives are proposed for fecal coliforms and E. coli as an indicator of microbiological pathogens to protect drinking water uses and body contact recreation.

The section of the Thompson River between the confluence of the North and South Thompson Rivers and Kamloops Lake is an important one as it is the location of the two largest point source discharges to the river system. The municipal discharge for the City of Kamloops has been upgraded and modified in several ways to reduce phosphorus input to the river. This course of action has been followed in response to the problems with excessive algal biomass in the lower Thompson experienced in the early and mid 1970's. At present, the city discharges phosphorus-reduced effluent directly to the river only in the spring and summer period when dilution is high and no downstream algal problems occur. The city also discharges part of its effluent by way of spray irrigation and rapid infiltration. As a result of these changes, the phosphorus contribution from the City of Kamloops has been reduced substantially over the past 12 to 15 years.

The other major discharge to the system is the Weyerhaeuser pulp mill. The components of the discharge which are of concern are nutrients, colour and chlorinated organic compounds. Over the period of record, improvements have been made in all of these areas but concerns still remain as to the effects of these and other discharge components. Increasing production, in some cases, has reduced the net effectiveness of the improvements made in effluent quality by increasing loading of these discharge components. There are few ambient water quality data available for this section of the river because of the difficulties in obtaining representative samples.

Kamloops Lake is a distinctive component of the Thompson system. Because of the large volume of the river flow compared to the volume of the lake, the lake is strongly influenced by the river. The water chemistry and biology data for the lake were reviewed to determine if any changes had occurred. The only possible change noted was in the zooplankton community. Concerns about oxygen depletion and increase in phytoplankton productivity appear to have few supporting data.

The lower Thompson River is subject to a number of influences. There are no major discharges which have significant effects on water quality. The pulp mill, the Kamloops sewage treatment discharge upstream from the lake and non-point sources influence water quality in the lower Thompson. A long-term sampling station near Spences Bridge provides the best record of changes in water quality in the lower Thompson. At present, with limited data, there are no obvious trends.

Considerable public and government concern has been directed to potential contaminants from the Kamloops pulp mill, particularly dioxins and furans. Recent studies have examined the amounts of these contaminants in fish tissues, river sediments and water. As a result of these and previous studies, some Ministry of Health consumption advisories have been issued. Recent improvements at the pulpmill have resulted in reduced amounts of discharges of these compounds of concern.

The problem of heavy attached algal biomass in the lower Thompson, sampled at Savona and Walhachin, is discussed in relationship to trends in nutrient supply and other potential causal factors. On the basis of recommendations of a Federal-Provincial study in 1975, inputs of phosphorus were reduced from the City of Kamloops. Although the data base is poor, it appears that the amount of attached algae has also been reduced from the obvious problem levels of the early 1970's. However, over the time period examined, phosphorus inputs have decreased, and then gradually increased, without any corresponding increase in algal biomass. This data, along with research data published by Environment Canada, indicate that nutrient input and/or concentration may not be the only factors controlling algal biomass in the Thompson and that invertebrate grazers and other factors may play a role in determining algal biomass.

In general, the water quality of the mainstem Thompson is relatively good although there have been, in some cases, significant impacts from municipal or industrial discharges as well as non-point inputs from agriculture. Water uses have been identified and water quality objectives set for characteristics such as microbial indicators, colour, chlorinated organics and resin acids in various reaches of the Thompson to provide a basis for future water quality protection and management.

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1. INTRODUCTION AND BACKGROUND

The Thompson River basin is an important area of the province and the water resource is a very important issue in the area. This report covers the lower portion of the basin: the South Thompson between Chase and Kamloops, the North Thompson below McLure, the Lower Thompson between the confluence of the North and South Thompson, and the mouth of the river at the confluence with the Fraser River at Lytton (Figure 1). There are three major tributaries which are not included. The Bonaparte River is the subject of a separate assessment (Swain, 1985) and the Deadman River will be the subject of a future water quality assessment. The Nicola River sub-basin is the subject of separate, previous and continuing studies.

The drainage area of the Thompson River is about 55,000 km^2 with a mean annual flow of about 783 m^3/s. The upper portions of the basin above the South Thompson River at Chase (16,700 km^2 and 288 m^3/s) and the North Thompson River at McLure (19,600 km^2 and 432 m^3/s) account for 36,300 km^2 (65%) of the drainage area and 92% of the mean annual flow. On a mean annual basis, the South Thompson contributes about 40% and the North Thompson about 60% of the flow in the Thompson River at their confluence. This report covers the lower 35% of the basin, which is arid and contributes only about 8% of the mean annual flow.

Over the period of record for which water quality data have been collected (about the last 25 years) there has been much information collected. The primary purpose of this report is to provide a review of this information primarily those data collected by the Ministry of Environment, Lands and Parks. There are a considerable number of water quality stations which have been established but for which only minimal data (one or two visits) have been collected. These stations are listed in an appendix to provide a more or less complete list of water quality monitoring sites.

2. SOUTH THOMPSON RIVER

2.1 HYDROLOGY

The South Thompson River begins at the outlet of Little Shuswap Lake and flows south-west and west to converge with the North Thompson at the city of Kamloops approximately 60 km distant (Figures 1 and 4). The major hydrologic gauge on the South Thompson is located near Chase (08LE031) monitoring a drainage area of 16,200 km^2. Data have been collected since 1911 at this site. The mean flow of the South Thompson is 288 m^3/s (1911-1986) with the total discharge averaging $9.1x10^6$ dam^3/yr. The flow is modulated because of the upstream lake storage, but a distinct freshet period occurs from May to July with the peak in June. (Figure 2). A gauge was operated at Monte Creek from 1958-1970 (08LE069) and can be used to compare to the upstream gauge at Chase (Figure 3). Flow data for the period 1970-1986 are given as Table 1.

2.2 WATER USES

2.2.1 Water Licenses

There are approximately 200 licenses authorizing water withdrawal from the South Thompson. The majority are for domestic use, but the majority of water volume is for irrigation. There are several major waterworks licenses, for the cities of Chase and Kamloops. Withdrawal of water to the limit of the licenses would remove approximately 10% of the average river flow during late summer. It is known that numerous small unlicensed withdrawals for domestic use also exist.

2.2.2 AQUATIC LIFE

The South Thompson River is an important habitat for fish. The well-known Adams River salmon run uses the river each summer and fall and native species use the river year-round. Important native species include steelhead, rainbow trout and Rocky Mountain Whitefish. For details of this resource and the considerable information already assembled see Brown et al. (1979), Fraser and Fedorenko (1982), Knapp et al. (1982) and a summary of the regional fisheries management plan in Ministry of Environment and Parks (1986).

2.2.3 RECREATION

Because of proximity to the Trans-Canada Highway, the South Thompson provides excellent recreation (body contact, fishing and boating) for non-residents and residents.

2.2.4 DRINKING WATER

Licenses for domestic and waterworks withdrawals are located all along the South Thompson.

2.2.5 INDUSTRIAL WATER USE

A major user of water for industrial purposes is Canada Cement LaFarge (see Figure 5).

The designated water uses for the South Thompson River are domestic water supply, agricultural irrigation, livestock and wildlife watering, water contact recreation, aquatic life habitat and industrial use.

2.3 WASTE DISCHARGES

The waste discharges in the South Thompson River basin occur in several localized areas. These locations are treated more or less in sequence moving from upstream to downstream.

2.3.1 CHASE AREA

At Chase there are three existing waste management permits, all for small discharges to ground. The permits are PE 3470 (a service station and car wash), PE 4424 (laundromat) and PE 6293 (Village of Chase). The locations are shown in Figure 4. The carwash and laundromat waste permits have specifications for volume of flow only, 2.7 m^3/d and 34.0 m^3/d respectively, and discharge to the ground through septic tank/tile field systems. These are very small discharges and unlikely to be of consequence to the Thompson River.

The permit to the Village of Chase is for sewage disposal to ground. The permit specifies a maximum allowable flow (1370 m^3/d or 0.016 m^3/s) as well as maxima for suspended solids (Res NF 105; 60 mg/L) and BOD (45 mg/L). The characteristics of the Chase sewage effluent are shown in Table 2. The limited effluent sampling which was done indicates that there is nothing unusual about the effluent constituents.

Several wells in the vicinity are used to monitor the discharge. Stations 0600430, 431 and 433 are located between the discharge and the South Thompson River, in the general direction of expected flow. Monitoring well 0600432 is closest to the discharge point (Figure 4). The area is quite flat so no obvious topographic gradient exists and the 432 well appears to show the greatest effect of the sewage discharge. This site shows higher concentrations than the other wells of many characteristics including dissolved solids, specific conductance, chloride, ammonia, organic and total nitrogen, total phosphorus, sulfate and sodium (Table 3).

It is uncertain what effect the discharge is having on the South Thompson River. Some of the measured characteristics such as coliform bacteria and BOD decrease relatively rapidly in the soil; however, other characteristics are present in the monitoring wells in concentrations which indicate that they are transported some distance through the soil. The valley bottom is primarily coarse alluvial material so some sewage effluent constituents (nitrogen for instance) may be reaching the river. No downstream river monitoring site exists but with the high flow of the South Thompson relative to this small discharge, it would be difficult to measure an effect in any case. The minimum recorded low flow for the South Thompson at Chase is 45 m^3/s and the discharge flow is 0.016 m^3/s.

2.3.2 BARNHART VALE/CAMPBELL CREEK

East of Kamloops near the South Thompson River are three licensed waste discharges. Permit PE 4579 is to Conagra Research Management Corporation for truck washing effluent (livestock trucks). The discharge is to ground and is limited to 164 m^3/day and 2300 m^3/yr. Effluent data are summarized in Table 4. One sampling well (0600357) is associated with the permit and the data from the well are summarized in Table 5). Conagra also has a waste permit for operation of a landfill for disposal of cattle slaughterhouse waste. (PR 6697). The monitoring well shows some effect of the discharges; however, the effect on the river is probably minimal. The sampling and permit locations are shown in Figure 5.

The second permit (PE 00365) is to LaFarge Canada to discharge primarily cooling water from a cement plant to the South Thompson River. The discharge is through an outfall and the waste management permit specifies a maximum temperature of 32°C and a maximum flow of 6550 m^3/day. LaFarge is also required to monitor oil and grease and suspended solids although no permit limits are specified. A summary of the effluent quality is given as Table 6. There are no ambient water quality monitoring sites immediately downstream from LaFarge to monitor the effect of the effluent on the South Thompson; however, because of the relatively innocuous nature of the effluent, no major environmental effects would be expected. The flow from the plant (0.034 m^3/s) in comparison to the minimum recorded flow at in the South Thompson (about 45 m^3/s) would indicate that the difference in flow volumes is about three orders of magnitude.

Moly-cop Canada has acquired a waste discharge permit PE 7424 for an industrial operation east of Kamloops (see Figure 8). The permit is issued for a plant manufacturing steel grinding balls for the mining industry. The permit was issued in 1986 to authorize discharge of a maximum of 1650 m^3/d (0.019m^3/s) of cooling water which might contain iron, suspended sediments and hydrocarbons. The effluent has an upper temperature limit of 32°C. The discharge is occasional (in summer when cooler river water is required) and is to the South Thompson River. Generally, however, the cooling water is recycled. The effects of discharges to the South Thompson are expected to be negligible given the nature of the effluent and the large dilution (> 2000:1) in the river during extreme summer low flow.

Ten kilometers east of the confluence of the North and South Thompson Rivers between Valleyview and Campbell Creek junction, is a mobile home park/campground which discharges sewage to ground (PE 6294) (Figure 8). The discharge is relatively small and is not expected to have an effect on the water quality of the South Thompson.

2.3.3 KAMLOOPS/VALLEYVIEW

At the most westerly portion of the South Thompson valley, just upstream from the confluence with the North Thompson, there are five discharges (Figure 6). On the south bank, Finning Equipment is licensed to discharge a "general" effluent to ground from a heavy equipment maintenance and fabrication operation. The permit (PE 1502) specifies a maximum average daily flow (3.4 m^3/day) and non-filterable residue NF105 (suspended sediments) monitored by the permittee. The Ministry of Environment has monitored the effluent and the data are shown in Table 7a. The effluent has relatively high values for oil and grease and suspended sediments, but these are not expected to pass through the soil after discharge and affect the South Thompson River. The results of monitoring well 0600089 showing the effects of the effluent are given in Table 7b. It shows a significant reduction in most characteristics but residues were much higher in the monitoring well than the effluent on average. Without a sampling control well, the reasons for this are hard to determine.

On the north shore of the river, three industrial effluents are discharged, all by septic tank-tile field systems to the ground. Ocean Construction was granted waste discharge permit PE 2402 for disposal of truck washing effluent (9.1 m^3/d). Another permit for truck washing effluent disposal (PE 3047) is held by OK Ready Mix and allows

6.8 m^3/d. The third permit (PE 2362) was to Kamloops Meat (now out of operation) for disposal of slaughterhouse effluent to the ground. The maximum daily effluent discharge was 4.1 m^3/d. A monitoring well 0600093 was established to monitor the discharge. The summary of the results for the monitoring well are given in Table 8. The results indicate that relatively little effect would be expected on the Thompson by this discharge although there has been relatively high ammonia measured. A summary of the effluent quality of a storm sewer draining to the South Thompson (XE 0600501 see Figure 6) from Kamloops Meat is shown as Table 9.

There are several storm water discharges (designated by XE designations) to the South Thompson. Their locations are shown in Figure 6. A summary of storm water quality is given in Table 10. The difficulty in assessing the effects of these discharges is the relatively small amount of effluent quality and flow data. The discharges have very poor quality with elevated levels of non-filterable residue and turbidity, chloride, copper, lead, and fecal coliform bacteria. This is an area which requires considerably more investigation.

2.3.4 Non-point Sources

There are a variety of non-point sources in the South Thompson basin which may be more important than point discharges (permitted ground water discharges) in having an effect on river water quality including the storm sewers noted above.

Because of the generally sandy nature of the soils (fine sand/silty/silty clay), it might be expected that some nutrient increase from septic tanks might occur from some of the numerous developments along the river shore.

The South Thompson River receives an unknown quantity of material as a result of agricultural activities, particularly cattle operations. There are small operations on all the tributary creeks to the South Thompson (Chase Creek, Monte Creek, Campbell Creek, Peterson Creek), as well as various locations along the South Thompson itself. As well, there are locations where much more intensive operations are located, particularly Monte Creek and Campbell Creek, where significant effects on water quality have been noted (see Ministry of Environment and Parks (1986), and Ministry of Environment (1980), Part 3 (Wiens)). Few data are available to document these problems (nutrient input, erosion, suspended sediment) and more effort should be expended in investigating this potentially serious problem. These activities can contribute significantly to water quality deterioration. For instance, 100 cattle would be expected to contribute a similar amount of nutrients to the environment as a community of 1,000 people. The areas for the entire Thompson River Basin identified as having either significant or heavy concentrations of cattle (by wintering areas) are shown on page 96 of the report by Ministry of Environment and Parks (1986). An overview map of the land status in the basin is also shown in the same report on page 11.

Monitoring the effects of non-point discharges is very difficult since high runoff concentrations are associated with short periods during snow melt or thawing, spring freshet or rainstorms, and are invariably missed by routine water quality sampling.

2.3.5 Other concerns

Another concern which does not fit into any of the above categories is Eurasian water milfoil. From its first identification in Okanagan Lake in the early 1970's, this plant has spread into the Shuswap system where considerable amounts of money are presently being spent on trying to control its spread. It is presently in the western part of Shuswap Lake but has not been found in Little Shuswap Lake as of 1991. The concern is that the plant may become established in the South Thompson River, Kamloops Lake and the lower Thompson. In these locations it would probably cause major changes in aquatic biological communities and be of concern to recreationalists. The threat of a variety of biological introductions (e.g.. zebra mussel or exotic fish species) is a danger which is of concern to managers of a number of resources.

2.4 WATER QUALITY

In the Chase area, there are only two ambient surface water quality monitoring sites. Chase Creek is sampled near the village of Chase (0600065) (Figure 4) and the South Thompson River is monitored at the outlet of Little Shuswap Lake (0600136). The latter provides a background site for the South Thompson. A summary for Chase Creek water quality is shown as Table 11. There appear to be no unusual features of the water chemistry results for the characteristics tested other than relatively high phosphorus and silica concentrations. The water has considerably higher total dissolved constituents (filterable and non-filterable residues, specific conductance) than the South Thompson into which it flows. The recorded sampling was done during 1972-77 and no more recent data exist.

The water quality data for the South Thompson at Chase begin in 1973 and run to 1984 with a very wide range of water quality characteristics being sampled (Table 12). The water is essentially Little Shuswap Lake water and reflects that origin. It is relatively low in dissolved materials, nutrients, colour and suspended sediments and would generally be considered to be of very high quality; however, there are a few anomalously high values reported for resin acids, copper, zinc, and fecal coliforms. The resin acid data are older analysis and appear to be very inaccurate to the point that they should be dismissed. The data reported in other tables for ambient resin acids should similarly be disregarded. There may be effects on water quality from the Adams River salmon run since benthic invertebrate data collected in 1973-74 (1974 was a dominant year in comparison to a small run in 1973) do show a strong correlation with the size of the run (Derksen pers. comm.). Data have been collected by both the federal government and the Ministry of Environment to quantify attached periphyton algae at this site and will be discussed with periphyton data collected at other sites. The complete data set for this station provides a good background against which to examine information for the lower portions of the river.

Proceeding down the South Thompson, an ambient water quality site existed at Pritchard (0600001) but was discontinued in 1975 (Table 13). At this site, as well, there are high results occasionally reported for copper and lead.

There are three inflow tributaries of measurable or significant size along the South Thompson downstream of Chase (Monte, Campbell and Peterson Creeks; see Figure 1). Monte Creek drains a watershed of 184 km^2 at flow gauge 08LE013 and has some water quality data from a site from near its mouth (0600062). The data are summarized in Table 14 and show a marked contrast to the water chemistry of the South Thompson. There are relatively high concentrations of a number of characteristics - colour, dissolved residues and specific conductance and other characteristics related to dissolved ion content, nitrate, total nitrogen, silica, calcium and magnesium. The average flow is extremely low - 0.2 m^3/s - so its addition to the South Thompson is negligible.

Campbell Creek drains an area of 521 km^2 at flow gauge 08LE058. From the existing data, there is only measurable flow for six months from April through September. The average flow for nine years between 1949 and 1967 was 0.52 m^3/s compared to the average flow of the South Thompson which averages 288 m^3/s, so Campbell Creek contributes a little more than one-tenth of one percent to the flow of the South Thompson. Campbell Creek drains an agricultural area which contributes significant pollutants. Near the cement plant east of Kamloops, a monitoring site (0600061) exists on Campbell Creek (Figure 6). The samples were taken in part to determine the effect of upstream residential development (Barnhart Vale) and agriculture and the effects of Campbell Creek on the South Thompson. The data for this site are summarized in Table 15. The results show very high dissolved minerals (mean Res 105 is 425 mg/L, mean specific conductance is 550 μS/cm). There are also high levels of several other characteristics some of which may be influenced by residential development and agriculture, but some of which may naturally be high and no upstream data are available for comparison. The creek has high colour and average turbidity and very high concentrations of nutrients (0.400 mg/L nitrate, 0.108 mg/L total dissolved phosphorus) as well as silica (mean 18.6 mg/L). Some metals appear to be high (e.g. copper, molybdenum and aluminum) although too few samples are available to make an evaluation. Only two fecal coliform samples were taken, and these show some contamination which is of human or animal origin. A report on these pollutants by the Ministry Kamloops office, is presently in draft form.

Peterson Creek drains a watershed south of Kamloops and flows through the city entering the South Thompson just upstream from the confluence with the North Thompson. There are flow data from two sites (08LE035 and 08LE061). The most downstream site cites a drainage area of 103 km^2 with an average 6 month flow of 0.016 m^3/s based on very few data . Because of the location of the sampling site (0600055) downstream from a heavily urbanized area, the water chemistry results show the effects of urban drainage with high concentrations of oil and grease, turbidity, chemical oxygen demanding materials, metals, nutrients and coliforms. The overall water quality is very poor (Table 16) and the nutrient levels are of particular concern. The mean nitrate concentration was 0.142 mg/L and the mean total dissolved phosphorus was 0.560 mg/L. In a system sensitive to nutrient inputs, control of this loading might be considered; however, the volume of flow may be insufficient to be of concern. This stream functions almost as a storm drain as it passes through the city of Kamloops.

A long-term data set exists for the South Thompson at Pioneer Park (0600135) (Table 17). The federal government collected data on a regular basis from 1967-74 on the South Thompson near Kamloops but fewer data are available (site 0920104, Table 18) than for the provincial sites. Two other federal government sites in the same area (in the South Thompson upstream of the confluence) are 0900244 and 0900245.

It is of some interest to determine if trends in water quality are occurring in the South Thompson. One question is whether there are changes with distance along the length of the river between Chase and Kamloops. The other question is whether there have been changes with time over the period of record (1973-1984). Both these questions are, unfortunately, not easy to answer since the existing data are collected on an irregular basis and not easily usable for this kind of analysis.

An assessment of the effects of land use can be made in comparing the water quality data for the stations at Chase and Pioneer Park (Table 19). Evaluating changes over the length of the river by simply comparing mean values for the Chase and Kamloops stations over the period 1973-1984 (Table 20), shows that most characteristics decrease in concentration or are similar at the two sites. The only characteristics which increase are turbidity and nutrients (ammonia, organic nitrogen and total phosphorus). Turbidity is of concern with regard to drinking water filtration. It is difficult to determine what can be interpreted from this unexpected decrease in concentrations. It is unusual to see decreases in conservative parameters such as total residue, conductance, alkalinity, sulfate or calcium when comparing upstream to downstream sites, particularly since several of the inflow streams seem to contribute high amounts of dissolved ions. The improvements may be due to stabilization of stream banks in the watershed and improved watershed practices. The increases in nutrients might be expected because of the population and agricultural activities along the river. The data used in this comparison, it should be emphasized, are not really suitable for this kind of analysis and a proper evaluation can only be done when proper data are collected.

Trends over time are also difficult to discern. Table 20 shows a comparison of four 4 year time periods. The major confounding factor is the intra-annual variation in flow. The means of flow for the four year periods vary by more than 30% and individual years vary in flow by as much as 44% above normal to 25% below normal (Table 21). In the context of this variation, it is difficult to discern trends. There is need for a specialized analysis of trend assessment for this station and others along the Thompson system both for downstream trends and trends over time.

With regard to two of the major foci of this review, nutrients and colour, it would appear that nutrient concentrations in this portion of the river are relatively low. Total phosphorus is estimated to average about 12 µg/L. Total dissolved phosphorus is in the 4-5 µg/L range. Ortho phosphorous from low-level analyses done in 1987-88 is about 1 µg/L. Bothwell (1988) reports soluble reactive phosphorus in 1984-85 of 1.2 to 5.4 µg/L (mean 2.3) and contrasts this to mean values in 1980-81 of 0.7 µg/L (Bothwell 1985, from a station on the South Thompson near Kamloops). The differences may be due to differences in analytical methods and sampling locations, as well as the differences due to the conditions in different years.

Total nitrogen concentrations range from 140-200 µg/L, Kjeldahl nitrogen is in the 90-135 range and nitrate 50-75 with more typical concentrations about 50 µg/L. Ammonia is generally low (5-15 µg/L).

Colour in the South Thompson is low, generally less than 5 and probably averaging 4 units (TAC) over the long term.

2.5 PROVISIONAL WATER QUALITY OBJECTIVES

The only water quality characteristic which appears to be of some concern for the South Thompson River is the microbiological quality of the water. With more than 200 water licenses, many of them for drinking water, it would seem prudent to insure that the water meets criteria defined to prevent risk of human illness. The Ministry of Health advises disinfection for all domestic water supplies but with increased pathogen concentration, additional treatment becomes necessary.

There are some data (Table 17) suggesting that fecal coliform bacterial density is above the desirable levels. The arithmetic mean of 7 samples analyzed for fecal coliforms at Pioneer Park 1973 to 1984 was 25, with a range of less than 2 to 130 / 100 mL. For Chase, the mean was 17, with a range from less than 2 to 170. The inflow creeks probably have higher counts, for example, Peterson Creek had one sample with a count of 1600. The values in the South Thompson would certainly be of concern for drinking water and the provisional objectives are to protect the most sensitive water uses.

For the full length of the South Thompson River it is proposed that the fecal coliform bacteria density not exceed 10 per 100 mL, (calculated as 90th percentile) for areas near water intakes to permit the use of the water for drinking after disinfection only (standards set by B.C. Ministry of Health). For areas where body contact recreation occurs, concentration of E. coli should not exceed 2000/L (geometric mean)(Guidelines for Canadian Recreational Water Quality). A minimum of 5 weekly samples should be collected in a 30 day period for comparison with these objectives.

3. NORTH THOMPSON RIVER (MCLURE TO CONFLUENCE)

3.1 HYDROLOGY

The best hydrologic metering station for this section of the river is at McLure (08LB064) with a drainage area of 19,600 km^2. Data are available since 1958 and show a mean annual flow of 432 m^3/s. The flow envelope is relatively narrow (Figure 7) and freshet generally peaks in June. Data for mean annual discharge are shown in Table 22. The North Thompson, in contrast to the South Thompson, is a free flowing river (no intervening lakes) and is greatly affected by heavy rains and sudden snow melt.

3.2 WATER USES

3.2.1 Water Licences

On this section of the river there are more than 75 licenses authorizing withdrawal. The majority of licenses and by far the largest volume (approximately 20 000 dam^3) is for irrigation (50+ licenses). There are 11 licenses for domestic use, but since most are small (2.3 - 4.6 m^3/d), the volume withdrawn is small. There are also 7 waterworks licenses (30 000 m^3/d) and three small licenses for industrial uses. As with the South Thompson, it is expected that there would be numerous small unlicensed domestic withdrawals.

Aquatic life is important in this reach of the river and this water use should be protected. This section of the river is also a source of water for livestock watering and wildlife. The areas close to Kamloops are also important for summer recreation activities.

For the portion of the North Thompson River between McClure and the confluence with the South Thompson, the designated water uses are: domestic water supply, agricultural irrigation, livestock and wildlife water supply, aquatic life habitat, recreation, and industrial use.

3.3 WASTE DISCHARGES

In the watershed below McClure, there are no direct effluent discharges. There are stormwater drains and indirect discharges to tributary streams and the ground water (Figure 8).

There have been three non-point problems identified in the lower North Thompson watershed. These are the storm sewer outfalls mentioned above, housing development effects (primarily nutrients from cottage development and ground water contamination from sewage) and logging effects (potential problems with suspended solids). There are, however, insufficient data to quantify these impacts on the North Thompson River.

Discharges which have been permitted by the Ministry are shown on Figure 8. Near the outlet of Paul Lake, there is a sewage discharge to ground from Paul Lake Holdings from an apartment/condominium building. The permit (PE 4357) specifies maximum quantities of suspended solids (NF105 - 60 mg/L), B.O.D. (45 mg/L) and flow (80 m^3/d) (Table 23). Since the discharge is to ground, some effect may occur on Paul Creek, but the effect on the North Thompson should be negligible. Site 0600355 on Paul Creek (Table 24) provides some monitoring results. The data show relatively high total dissolved solids / specific conductance and coliform bacterial concentrations. The area has numerous private dwellings on septic tank/tile field disposal systems and these may have some effect on ground and surface water.

Similarly, a discharge to ground of sewage effluent occurs at the Todd Mountain ski facility (PE 1535). Some effect may occur on Louis Creek but by the time Louis Creek enters the North Thompson (north of McClure) the effect on the river is likely to be unmeasurable (this permit is not shown on the maps).

A third ground discharge of sewage occurs in Westsyde in Kamloops. Permit PE 357 allows 52.5 m^3/d to be discharged to ground. A summary of the limited monitoring data is shown in Table 25. There are many private septic tank and tile field systems in Westsyde about which some concern has been expressed. The discharges may affect ground water since the area has primarily porous gravel sub-soils. Whether or not any changes in the water quality of the North Thompson occur as a result of this discharge is unknown. There are plans to sewer the Westsyde area within the next few years.

Sampling done in 1988, in areas of the riverbank adjacent to Westsyde, found that there was considerable seepage emanating from the banks along the North Thompson River and directly entering the river. Based on analytical results, the seepage appeared to be ground water contaminated with sewage. Fecal coliform bacterial concentrations were low; however, high nutrients and other water chemistry constituents were noted in a memorandum report in the Ministry files associated with PE 357.

A discharge of sewage to ground also occurs at Rayleigh (PE 6611), but no monitoring data are available. Balco Industries discharges waste to ground water (PE 4856) from a veneer and plywood plant; however, the effects on surface water quality would be expected to be negligible (Table 26).

There are three storm water drains along the lower North Thompson (XE 06016, 017, 018, see Figure 6) and data from these are summarized in Table 27. The data show that the quality is poor with very high values of a large variety of characteristics: oil and grease, suspended sediments, chloride, nutrients and metals (XE 6016) and coliform bacteria. There are limited data with at most four samples being taken and no flow data so loadings can be estimated. More investigation of this aspect of water quality is needed to determine the magnitude of the problem.

3.4 WATER QUALITY

A summary of the North Thompson water quality data is given in Tables 28 (McLure) and 29 (North Kamloops) and the station locations are shown in Figure 8. The summary tables show some unexpectedly high values for some metals (copper, lead, zinc molybdenum and aluminum), although these are primarily in the total fraction.

The water chemistry of the North Thompson at McClure (0600002, Table 28) is markedly similar in many ways to that of the South Thompson at Chase (Table 12), despite draining two entirely different watersheds. The North Thompson has a mean total residue of 74 mg/L (South Thompson 67 mg/L), specific conductance 91 uS/cm (101), alkalinity of 36 mg/L (38), chloride of 0.3 mg/L (0.5), hardness (both 91 mg/L), silica of 5.4 mg/L (5.3), sodium of 1.5 mg/L (2.0), and pH 7.6 (7.7).

There are, however, a number of characteristics which differ noticeably between the two sites. The North Thompson appears to have a higher colour although comparing the different colour measurements is not directly possible (9.6 apparent and 6.5 true) in comparison to the South (3.7 TAC), higher turbidity (3.9 NTU, South Thompson 1.7), organic carbon of 3.8 mg/L (2.3), suspended sediments (30 mg/L in comparison to 15 for the South). Nutrients are an important aspect of this report and it is significant that a number of nitrogen and phosphorus components differ between the North and South Thompson Rivers. Nitrate in the North Thompson averaged 93 μg/L in contrast to only 47 μg/L for the south, although the more downstream site at North Kamloops (0600164) on the North Thompson shows concentrations more similar to the South Thompson. Kjeldahl nitrogen was slightly higher in the North (127 μg/L) than the South (105 μg/L), The data for both total and total dissolved phosphorus from Ministry sampling indicate a similar overall mean concentration (6 ug/L TDP and 11 ug/L TP at both Chase and McLure). However, the Federal government data (Bothwell 1985, Bothwell and Daley 1981) measuring soluble reactive phosphorus and algal growth potential would seem to indicate that the South Thompson has less biologically available phosphorus, although the data are not without some analytical and interpretation problems.

Below the confluence, the higher dissolved inorganic (biologically available) nitrogen of the North Thompson system, mixing with the input of available phosphorus from the city discharge and the pulp mill, may be a factor in the nutrient and algal problems discussed at length later in the report.

A comparison of upstream/downstream changes as might be interpreted from a comparison of the data from McLure and North Kamloops is difficult because the samples are not paired, have different numbers of values and cover different periods of time. A number of characteristics are higher at North Kamloops than McLure: total residue 105, specific conductance, TAC colour, chloride, Kjeldahl nitrogen, all three forms of phosphorus, and silica. Many other characteristics are higher at McLure: apparent colour, turbidity, alkalinity, hardness, ammonia and nitrate. The metals are not easily interpretable because of the many values less than detection limits and the changing detection limits. Overall, there is no obvious indication that there are upstream/downstream differences.

Data for several of the tributaries to the North Thompson are available. Jamieson Creek (0600119, Table 30) drains a 230 km^2 watershed on the west side of the North Thompson and empties into the river about 25 km north of Kamloops. This watershed drains an area characterized by both extensive wilderness and logging. There is measured flow for the creek (gauge 08LB008) only from April to October and the mean flow for the period of record from earlier this century is about 2.5 m^3/s in comparison to the average flow of the North Thompson of 432 m^3/s or an addition of about 1/2 of 1 %. The creek has a higher dissolved ions content than the Thompson (filterable residue (total dissolved solids) 144 mg/L, conductance 225 µS/cm, alkalinity 98mg/L, hardness 106mg/L). It contributes relatively little nutrient mass (total P 6 µg/L, Kjeldahl N 90 µg/L); however, silica is relatively high (11.8 mg/L).

Heffley Creek (0600182, Table 31) drains a 168 km^2 watershed on the east side of the North Thompson including Heffley Lake. The flow gauge data (08LB004) shows summer flows only (measurements in the irrigation season) with a mean flow of 0.2 m^3/s. The sampling station at the mouth indicates that the water is more alkaline (pH 8.4) than the river and has relatively high dissolved solids (385 µS/cm), quite high nitrate (147 µg/L), phosphorus (22 µg/L TP) and silica (15 mg/L).

Noble Creek (0600118, Table 32) is a west side tributary and drains into the North Thompson about 15 km north of Kamloops. This watershed has both agriculture and logging activities. The water quality is distinctive due to its high concentration of dissolved material. Total residue is 863 mg/L and the specific conductance exceeds 1 000 µS/cm. The dissolved material appears to be predominantly calcium sulfates. Nutrients are similar to Jamieson and Heffley Creeks with nitrate quite high (100 µg/L) and total P about 13 µg/L. Dissolved metals also seem to be high with dissolved copper and molybdenum being present in relatively high quantities but well below any water quality criteria considering the high hardness (598 mg/L as $CaCO_3$).

The tributary for which the largest set of data is available is Paul Creek which drains a 254 km^2 watershed east of Kamloops. The three stations discussed are above the lake (0600305), just below the lake outlet (0600134) and at Highway 5 (0600070). A comparison of the three sites is given in Table 33. There appears to be little deterioration in water quality when looking at the upstream (control) and the lake outlet site. The lake outlet has increased concentrations in a few characteristics (chloride, ammonia, Kjeldahl N), but most are similar or decrease, probably due to the influence of the lake. There seems to be no strong evidence in the available data for deterioration of water quality caused by the fairly intensive lakeside development. The probable mode of effect, via the ground water, may mean that the stream may be affected beyond the sampling site (contaminated water flowing underground past the site); however, without hydrogeological data, this is difficult to evaluate.

A comparison of the lake outlet data with data collected for the Creek at Highway 5 shows significant increases in most parameters, particularly dissolved solids, suspended solids and turbidity, chloride, all phosphorus fractions and coliforms. The origins of these increases are not known but irrigation return flows or agriculture and livestock may be possibilities. Complete summaries of the data for the three stations are given in Tables 34 to 36.

Data for four Paul Lake sites 0603023, 24, 25, and 26 (see Figure 8) are given in Tables 37 to 40. The data were collected to document offshore ambient water quality rather than the effects of the lakeshore development; however, few if any differences between sites can be discerned which might be attributed to the development. Another unpublished study done by the Kamloops regional office did find evidence of the effects of development on nearshore water quality. Four other sites (0603000, 3065, 3066 and 3085) have also been established but few or no data collected.

Too few data are available to assess time or seasonal trends in the tributary streams; however, the North Thompson itself has better data (Tables 28 and 29). The changes in the North Thompson River water quality were examined in the same way as were changes in the South Thompson River, by dividing the data set from the North Kamloops station (Table 27) into four time periods of four years each (Table 41). Because the data were not collected on a regular basis and the subsets are not matched in numbers of samples, time of year when samples were taken, etc., this analysis does not provide a definitive evaluation of trends over time. It does serve as a rough gauge of changes in the data collected over the past 16 years.

There are a number of characteristics for which increases may be occurring. Many characteristics show increases in the first three periods, but a decrease in the last period. This may be a reflection of the very low flows of the river during that period. Analyses which show increases include those related to dissolved ions (total residue, conductance, alkalinity) as well as some of the component ions (sulfate, sodium).

Of particular interest in this review are changes in nutrient concentration. Phosphorus is generally accepted as the limiting nutrient for algal growth in the Thompson system. Neither dissolved phosphorus nor total phosphorus show any evident trend over time. Ortho phosphorus has been generally found to be less than the detection limit of 3 µg/L when sampled. In 1987 and 1988, sampling using low-level detection limits was done (not included in Table 39) with the results showing a mean ortho phosphorus concentration of 1.5 µg/L for the 11 samples obtained (3 of the 11 samples were below the minimum detection limit of 1 ug/L). In comparison, total dissolved phosphorus, although it varies appreciably from year to year, probably averages 4 to 5 µg/L. Total phosphorus is more variable because of suspended sediments in the river, but probably averages about 15 µg/L on an average year. The ratio of TP:TDP:OP is likely 15:5:1.

Nitrogen, or at least some of the fractions, do seem to show increases over time. Trends are not evident for ammonia, but appear to be present for Kjeldahl nitrogen and total nitrogen, although a decrease in concentration in the last two years is evident for Kjeldahl. Nitrate/nitrate nitrogen shows the clearest evidence of trends with increases from the 66 ug/L (as nitrate-nitrite) to 88 µg/L (as nitrate) in the 1973-1976 data to concentrations averaging 103 in 1977-78. The 1981-84 data show an average of 104 ug/L and the 1985-87 mean is 109 mg/L for both nitrate-nitrite and nitrate. The cause of this apparent increase is not known, but watershed development (logging, settlement and sewage disposal) are possibilities. Increases in nitrate may not cause any change in algal growth potential if phosphorus remains the limiting nutrient. Ratios of dissolved inorganic nitrogen (DIN):total dissolved phosphorus would appear to be greater than 20:1 by weight and ratios of DIN:otho-phosphorus greater than 60:1, so phosphorus limitation would be expected. A more detailed analysis of these data are needed.

Another trend which should be further investigated and checked is the apparent increase in colour over the period of record. The 1973-76 data show TAC colour values averaging 5 units. The 1977-80 mean value was 7 units and the 1981-84 mean value was 12.7 units.

3.5 PROVISIONAL WATER QUALITY OBJECTIVES

Because of the numerous water intakes, many of which provide drinking water, there must be efforts made to maintain a high level of quality. The most likely source of problems is biological contaminants from sewage disposal. The few data collected show concentrations of indicator organisms (fecal coliforms, see Tables 25, 26, 27) to be high enough to be of concern.

For the reach of the North Thompson between McClure and the confluence with the South Thompson, it is proposed that the fecal coliform bacteria density not exceed 10 per 100 mL, (calculated as 90th percentile) for areas near water intakes to permit the use of the water for drinking after disinfection only. For areas where body contact recreation occurs, concentration of E. coli should not exceed 2000/L (geometric mean). A minimum of 5 weekly samples should be collected in a 30 day period for comparison with these objectives.

4. THOMPSON RIVER BETWEEN THE CONFLUENCE AND KAMLOOPS LAKE

4.1 HYDROLOGY

There are no flow gauges between the confluence of the North and South Thompson Rivers and Kamloops Lake. The combined North and South Thompson drainage area at this point is 37,800 km^2. A gauging station was established there between 1911 and 1914 (08LF023) but insufficient data are available to be useful. Because the flow in this particular reach of river is important with regard to dilution and the effects of two large waste discharges, estimated flows were generated by adding the flows of the North Thompson at McLure and the South Thompson at Chase. These stations represent 95% of the drainage area at their confluence (35,800 vs. 37,800 km^2). Data are contained in Table 42 (taken from Derksen, 1988 MS) and shown as Figure 9.

4.2 WATER USES

4.2.1 Water Licenses

There are presently 14 licenses to withdraw water on this section of river. The types of use for this water includes irrigation, waterworks, domestic water supply and industrial use. In the latter category, by far the largest license is for the Weyerhaeuser Pulp Mill - 2.3 m^3/s or 200,000 m^3/d. Another industrial license is to Transmountain Pipe Line for fire protection. The City of Kamloops has a license to withdraw 670 m^3/d from this section of the river, as well as those noted previously on the North and South Thompson, for domestic water supply as well as separate licenses for irrigation.

4.2.2 Aquatic Life

The entire Thompson River system is an extremely important spawning and rearing area for fish and an environment for those organisms which are a part of this productive ecosystem. For details of this resource and the considerable information already assembled see Brown et al. (1979), Fraser and Fedorenko (1982), Knapp et al. (1982) and a summary of the regional fisheries management plan in Ministry of Environment and Parks (1986).

4.2.3 Recreation

There are several public access points along this reach of the river and the fine sand beaches provide excellent and well used sites for body contact recreation.

4.2.4 Designated Water Uses

The designated uses in this portion of the Thompson River are agricultural irrigation, waterworks, drinking water supply, industrial use, and aquatic life use.

4.3 WASTE DISCHARGES

There are two major discharges to this section of the river: the City of Kamloops sewage and effluent discharge from the Weyerhaeuser pulp mill (Figure 10). These two discharges have been subject to numerous past studies and are still major considerations in management of the water quality of the river. These two discharges are examined in detail below.

4.3.1 Weyerhaeuser (PE 1199)

The Weyerhaeuser pulp mill is a bleached kraft mill originally constructed in 1965. The initial mill produced 225 air-dry tons per day (ADT/d). A major expansion was undertaken in 1970-71 and completed in 1972 (startup about February). The original mill was converted to process sawdust or chips and expanded to 295 ADT/d. A second mill (referred to as "B" mill) was constructed to process 839 ADT pulp/d from wood chips (Derksen 1988 MS). By 1980-81, the production (measured as 90th percentile of production) for the mill was 1 250 ADT/d with 1 000 T/d of standard kraft pulp from chips and 250 T/d from sawdust on the smaller production line (Eckstein 1982). By 1984, production was 1 330 T/d: 380 T/d from the sawdust pulp line and 960 T/d from the chip line (Whiticar 1984). Present (1989-91) production is estimated to be a total of 1250 metric T/d (average production) (330+920).

Waste Discharges

In the mill, two waste mill effluent streams are created. These are neutralized, combined, settled and treated in an aeration basin. The description below is taken from Whiticar (1984).

a. Alkaline Sewer

The alkaline sewer is often referred to as the general sewer because the alkaline stages of the bleach plant, the screen and machine room white waters, and the high stack gas cooler/scrubber effluent are the major sources of this stream. It contains reject fiber, some flyash, some pulping debris, sand and grit. The readily settleable portion is removed by a 76 m diameter clarifier . The overflow from the clarifier is directed to an effluent mix tank for mixing with the acid sewer.

b. Acid Sewer

The acid sewer originates from the chlorine and chlorine dioxide filtrates and excess white water from the bleach plant. It includes some floor drains from the steam plant area, water treatment effluent from the recaust sump system and chemical preparation. It is combined with the recausticizing sewer and lime mud to raise the pH. The total acid sewer is directed to the final mix tank for mixing with the alkaline sewer. The neutralization raises the acid sewer pH from about 2.2 - 2.5 to about 4.5. This results in a combined effluent pH of about 6.0 - 7.0.

Treatment Works

From the mix tank, the effluent enters 4-hour settling basins for further solids removal and then enters the aeration pond or aerated stabilization basin (ASB) for biological treatment. The ASB covers 72 acres and was designed for 5-day retention but now, as a result of the water reduction program, gives 7 days retention. Following this treatment, the final effluent is discharged to the Thompson River via a two-pronged submerged diffuser.

Effluent Characteristics

There are a number of characteristics of the pulp mill effluent which are of concern since they have the potential to cause a variety of environmental problems. In the permit which authorizes the pulp mill discharge to the Thompson River (PE 1199), limits of a number of characteristics are stated. The existing permit was first issued in 1972 and amended in 1977, 1981, 1982 and 1985.

The maximum discharge rates specified in the 1985 permit are a monthly mean of 182,000 m^3/d (2.11 m^3/s) and a maximum of 273,000 m^3/d (3.16 m^3/s).

The effluent characteristics specified in the 1985 permit are:

pH	-	between 6.5 and 8.0
B.O.D. (5d)	-	10,050 kg/d maximum
dissolved oxygen	-	monthly average, 2.0 mg/L
	-	minimum, 1.0 mg/L
temperature	-	1^{o} C maximum rise in initial dilution zone
total suspended solids	-	monthly average 13,400 kg/d maximum
toxicity	-	96 hr TLm of 50% survival in undiluted effluent (i.e., a 96 h LC 50 of 100%)

The permit specifies details of sampling and requires measurement of a number of characteristics not specified in the permit. Colour is a characteristic of particular importance and is measured on a daily basis. Phosphorus is also of importance and is measured regularly. Neither have effluent limits. A receiving environment program including total dissolved phosphorus, pH, conductivity, temperature, colour, turbidity, flow velocity, is done from October to April at two sites upstream and two sites downstream from the mill. Biological sampling has been done for periphyton in the 1970's and benthic invertebrate sampling has been done at the downstream sites for more than 15 years. These data for the benthic invertebrates are being reviewed and interpreted in detail by George Derksen of Environment Canada at the present time and are not considered in this report. It was felt that to attempt to evaluate the area of benthic stream invertebrates in this report would be a duplication of effort. The results of the other ambient monitoring are discussed below.

The Ministry office in Kamloops has collected only a small amount of effluent data (Table 48), relying on the permittee to gather most of the effluent and ambient water quality information. In examining the characteristics of the effluent, it is useful to examine each individually.

1. <u>pH</u>.

The pH of the discharge is initially controlled by controlled mixing of the alkaline and acid sewers. It can be affected by fluctuations in the sewer inputs. The balance between alkaline and acid sewers is maintained by an automatic pH measuring device which controls the lime mud addition. The pH of the effluent entering the pond does fluctuate, but the biological action of the ASB tends to stabilize the pH which is generally within the 6.5 to 8.0 range upon discharge (Whiticar 1985).

There appear to be few problems with pH discharges outside the range specified by the permit. Continuous monitoring is specified; however, averages over much longer periods are often reported (Table 51 lists daily and monthly pH data). There are some extreme pH values (3.7 - 9.6) and it is likely they are caused by significant plant accidents of relatively short duration. The standard deviation around the mean is low (7.3+/- 0.25) suggesting that the occurrence of high or low pH is rare. With an initial dilution as low as 20:1 at low river flows, the alkalinity of the river would probably neutralize acidic discharges. Alkaline discharges are more of a problem because natural waters are essentially unbuffered for alkalinities between pH 7.5 and 9.0.

2. Suspended Solids.

In the wood pulping process, the wood is broken apart and suspended in solution. Most of the wood fiber is recovered as are most of the chemicals. Some chemicals such as suspended lime particles and the reject fiber are removed in the clarifier and settling basins prior to the effluent flowing to the aeration ponds.

There are a variety of small particles which pass out the diffuser to the river. These include algal, bacterial and fungal cells and biological detritus which develop largely in the ASB, after the clarifier. There is an increase in total suspended solids (TSS) from the inlet to the outlet of the ASB. The second non-settleable component are large organic molecules from the pulping process (calcium - lignin macromolecules). The amount of TSS discharge is reported as kg/d. The 1982 permit specified maximum discharge as 8510 kg/d. The mill was out of compliance for this parameter for the majority of samples. The permit value was raised to 13,400 kg/d in the 1985 amendment. Tabulated results for 1977 - 85 are shown in Table 43. The data from 1977 - 85 show that the old permit level was frequently exceeded but the new permit level would have been met. The measured discharge over time is partially a reflection of increased production, but the mill has over the years reduced the volume of water usage so that better settlement of solids now occurs. The concentration of suspended solids in the effluent would typically be 75 mg/L based on present loadings and flows.

The potential consequences of this input of fine suspended organic material are primarily increases in phosphorus in water leached from the small organic particles, some minor change in water clarity, and potential oxygen demand (see next section). This fraction is also associated with TCDD/DF.

3. Biochemical Oxygen Demand (BOD).

Some organic material that originates from the pulping process (like dissolved organics) has a high oxygen demand. The aeration basin reduces the BOD by 85% (Whiticar 1985) but significant amounts are still released to the river because of the large effluent flow. Average annual BOD's are shown in Table 44.

The permit allows a maximum of 8510 kg/d and this was occasionally exceeded. Theoretically, high BOD values could lead to transient sags in river dissolved oxygen but the data collected to date show little evidence of this problem. In terms of concentration, the average BOD is probably about 20 mg/L with many values <10 mg/L. It is not known if any modeling of BOD effects has been done but this would probably be a useful analysis since there is so few ambient monitoring data.

4. Dissolved Oxygen.

The dissolved oxygen in the effluent is determined by the aeration in the aeration pond and the oxygen demand of the effluent as it enters the pond. Any failure of the aerators or large increases in organic loading can obviously affect oxygen in the pond outflow.

The Waste Management permit specifies a monthly average of at least 2.0 mg/L and a minimum at any time of 1.0 mg/L. Whiticar (1985) states that under normal operating conditions, the discharge DO ranges from 3.1 to 5.2 mg/L (mean 4.4 mg/L). Considering available dilution and near saturation in the Thompson River, no problems should be expected with low DO discharges to the river. Low DO in the river, if it occurred, would likely be due more to BOD loading than to DO in the effluent

5. Temperature.

The effluent discharged from the mill is significantly warmer than the Thompson River water. A large amount of water is used in the mill for cooling purposes. Normal effluent temperatures are 20^{o} (winter) and 32^{o} (summer) (Whiticar 1985). Much of the effluent cooling takes place in the aeration pond and care must be taken because too high a temperature affects treatment in the pond since microbial action is inhibited by temperatures which are too high.

Environmental consequences of a heated effluent are primarily concerns for modification of fish habitat and effects on fish behaviour and physiology. An analysis done in 1982 and 1983 showed that the maximum temperature increases were $0.5^{o}C$ with a worse case projected temperature increase of about 1^{o} C (Whiticar 1985). The permit specifies a maximum allowable rise of 1^{o} C in the initial dilution zone. There is no data to suggest that this is approached and temperature does not appear to be an issue.

6. Toxicity. The following is modified from Whiticar (1985).

There are several sources of toxicity in the mill. Some of the more important constituents of the effluent that contribute to toxicity include chlorinated organics (such as chlorinated acetic acids or chlorophenols), resin acids, and fatty acid soaps. The toxicity of these compounds to fish has been well proven in the past as has the fact that their acute toxicity is reduced during treatment in the ASB.

The level of toxicity is controlled in two ways. Firstly, the amount of toxicants entering the ASB is limited. This is done through in-plant control and recycling. Black liquor spills are isolated and sent to the spill pond from which the black liquor can be fed slowly into the ASB. Condensates are stripped of foul odors and reused. Although these and other steps are taken, some toxicity does leave the mill. The ASB is the second step in toxicity control. Under optimum operating conditions, an ASB can eliminate acute toxicity. The most important factor affecting the degree of toxicity removal is adequate detention time relative to BOD and aeration. The two most important categories of toxic compounds are the resin and fatty acids and chlorinated phenolics. The resin acids are readily removed by secondary treatment. Chlorinated phenolics are somewhat more refractory.

Toxicity testing in the 1985 permit specifies that a 96-h test with undiluted effluent must result in 50% survival of rainbow trout (i. e., the 96-h LC_{50} is 100%). A number of changes in the procedure have taken place over the years for which data exist. Prior to 1977, a static 96-h LC_{50} was done on a quarterly basis. Derksen (1988 MS) reviewed the bioassay results for 1974 - 88 and examined the details of the program. He indicated that the Weyerhaeuser bioassays done at 90% or 100% effluent in 1976 and 1977 showed satisfactory results.

In 1978, one failure was reported at the 90% and at the 100% concentration (96-h LC_{50} for the sample was 78%). In 1979, two failures were reported at the 90% effluent limit. The June 21, 1979 failure had a 96-h LC_{50} of 44%. The failures reported in June 1979, were attributed to a black liquor spill.

In 1980, only two bioassay results were located and there were several for 1981 and 1982. In 1983, some comparative work was done and most results for 1985 and 1986 are available. The 1980 to 1986 results are summarized in Table 45. Overall, the data indicate that, on the basis of the fish bioassay results, the effluent was generally not acutely toxic, with 100% survival at 100% effluent.

In the 1985 permit amendment, it was proposed that instead of using the undiluted effluent for testing, the effluent should be diluted. This change was requested by the mill since the mill was undertaking a program to reduce the volume of water used and discharged and the mill wanted to be consistent with the Ministry regulations which stated that the objectives were determined for a mill with an effluent volume of $150 m^3$/ADMT. There was concern (unfounded as subsequent results showed) that the water reduction would result in a more concentrated (more toxic) effluent. After evaluation of the bioassay tests, the Waste Management Branch decided to continue with the standard bioassay test (Henderson 1987).

7. Effluent Volume.

The volume of effluent varies considerably on a day-to-day basis. Whiticar (1985) states that these fluctuations are due to constantly changing quantities of mill process water which result in changes in the ASB level.

There are four discharge pumps used for ASB level control. However, one pump is not sufficient to maintain the pond level. When the level of the pond rises to the maximum height, another pump is used to lower the level. The fluctuation in the pond level can be as much as 15 cm.

The ASB level is lowered prior to a shutdown or start-up so that, when the mill starts discharging again, there will be increased detention time for the initial effluent. This drawdown causes an increase in the discharge volume for one or two days. Usually the initial influent quality is substandard until the mill is operational. This strategy has proven to be an effective method of producing an acceptable discharge and should be encouraged.

The fluctuation in the ASB level does not appear to effect effluent quality since most of the characteristics of discharge have a reasonably constant concentration. A larger volume discharged will result in a corresponding increase in the quantity of the characteristics discharged on a mass basis. This illustrates why these characteristics are specified on a daily mass basis.

Although the mill is on a water reduction program, the fluctuations in mill process water usage will continue. However, the range of these fluctuations should be reduced to a point where the maximum discharge volumes will be less than the authorized average of 182 000 cubic meters per day. The target for the daily discharge is around 110 cubic metres per ADT of pulp produced versus 150 in the 1971 Pollution Control Objectives. The effluent discharge should range from 110 000 to 160 000 cubic metres per day.

Data for mean monthly flow for 1974 to 1988 are included in Appendix 1. Derksen (1988 MS) calculated dilution ratios for the period 1972 to 1976. He reported dilutions of 74:1 for mean monthly flows and 50:1 for minimum flows and maximum discharge. Derksen

(1988) calculated that the percentage of effluent in the Thompson River in the low flow period (December to April) was 0.72 % and in April to November 0.25 %. Worst case winter flows situations resulted in pulp mill effluent comprising more than 1% of the river flow (1.08-1.17 %).

8. Colour.

Two of the effluent characteristics which are the focus of most of the controversy and complaints about the pulp mill discharge have no permit restrictions placed on them (colour and phosphorus).

Colour has been a source of controversy since the mill started production. The brownish colour of the effluent originates from the lignin of the pulped wood. The bulk of the lignin is dissolved in the pulping process and is burned in the recovery boiler. The remainder is removed by the bleach plant. This leaves white fiber and coloured effluent which is sewered. About 75 to 80% of the colour is produced at the caustic extraction stage of the bleach plant. Little is known about the identity of the molecules causing colour. Colour has been attributed to macro-organic ringed molecules which are partially chlorined; however, this has not been confirmed. These molecules are of small size since there is little change in true colour between a sample which has been passed through a 1.2um filter and an unfiltered sample.

Colour is difficult to remove. The mill has, during periods of low river flow, used hydrogen peroxide at the caustic extraction stage effluent which reduces the effluent colour. This was expensive and therefore is done only in the winter when the colour is most noticeable. The aim of the program was to limit the colour increase in the river to about 10 colour units above background. This procedure is no longer followed.

The South Thompson River is generally low in sediment load and colour, while the North Thompson River is higher in sediment load and colour. The two rivers meet about 4 km upstream from the mill, but complete mixing does not occur by the time the mainstem Thompson passes the mill. Although the diffuser discharges into the deepest part of the channel, the effluent is visible to the eye and on colour aerial photographs .

Colour is primarily an aesthetic problem, but in a river of high aesthetic value, this is an important problem to address. The effluent discharged to the river typically has a colour intensity of 1500 to 2000 colour units. The present permit specifies measurement of a single wavelength colour method (SWC) based on light absorbance at 465 nm. A correlation which has been cited in the Waste Management Permit between the TAC method (Total Absorbance Colour) and the SWC method is TAC = 108 + 0.66 SWC.

Results are typically reported on the basis of kg/d by equating a colour unit to 1 mg/L. Annual data for 1977 to 1981 are shown in Table 46a and monthly data for 1984 and 1985 are given in Table 46b. A detailed tabulation is given in Table 47.

In 1973, an Order was issued by the Waste Management Branch (20 June) for colour limits to effluent. In the period December to April inclusive, maximum effluent colour was to be 1200 SWC colour units and May through November, 1500 units. This was based on the receiving water not increasing more than 25 units (SWC) although the colour increase is generally less than 10 units. Whether this has been achieved is not determined since no detailed ambient monitoring in the section of the river downstream of the mill has been undertaken.

9. Phosphorus.

Phosphorus is discharged to the river as a result of phosphorus released by the pulping process and contained in or adsorbed to particulate matter which passes through the settling basin and the ASB.

Phosphorus in the effluent averages 1.3 mg/L total P (1986 B.C. Ministry of Environment data) and, with the large volume of water discharged, this amounts to about 156 kg/d total P (1986 data Table 50). Weyerhaeuser data indicate that the concentration is more typically in the 0.9-1.1 mg/L range in recent data. Dissolved P made up about 30% of the total in 1986. A summary table showing annual loads and an apparent change in the proportion of dissolved to total phosphorus over the period of record is given in Table 48. These data, collected by the mill, show that the proportion of dissolved phosphorus in the 1976-80 period was higher than the 1974-75 and 1982-86 periods. Other data, for example, B.C. Research (undated), show that for the 1976 (July-Nov. period) raw influent the ratio of TP:TDP is relatively high (0.41-0.65) but the treated effluent has a lower (0.20-0.56) ratio. The reason for the differences between the two data sets may be a change in methods. CPAR methods after 1981 (pretreatment with XAD-2 resin) would likely effect the total phosphorus results. The drop in proportion of TDP in 1982 may be related to the mills water use reduction program initiated in June 1982 and completed in January 1983. In comparison to the other major phosphorus discharge to the river (the Kamloops sewage treatment plant (STP)), which discharges about 27 kg/d over the spring and summer period or about 11 kg/d on an annual basis, the contribution of the mill is very substantial. In comparison to the load of the river, it is, depending on the time of the year and other considerations, either insignificant or with the potential for downstream consequences (discussed below).

Because of the amount of prior study with regard to phosphorus input into the system, and the importance of phosphorus discharges in the management of the river, the subject of phosphorus loading has been explored in some detail. Data are available from 1973.

The first question considered is whether there have been changes in phosphorus loading over the period of record. Figure 11 shows some data for 1974-1980. Monthly loadings 1973-1986 are tabulated in Table 50. It would appear that total loading may have decreased in the 1981 to 1983 period although strikes at the mill in mid-1981 and early 1984 have influenced this. What appears clearer is a decrease in total dissolved P loading in 1982 and later. Although total P is typically used to quantify loadings from the mill, total dissolved P may be a better indicator of immediately biologically available P. Particulate P may be broken down to more available forms after discharge, but in winter water temperatures the mineralization is likely quite low. Whiticar (1985) cites P solubilization of 5 to 12% although the time period is not specified.

Simplifying the data and reducing the loading estimates to an annual input (Table 48), it appears that dissolved P from 1982 to 1986 (18,000 kg) showed a reduction of more than half in comparison to the five year period 1976 to 1980 (40,000 kg). The total P decreased from approximately 60,000 kg per year (1976 to 1980) to about 50,000 kg (1982 to 1986). The data for the ambient water quality monitoring conducted by Weyerhaeuser (Table 49), which provides total phosphorus data, do not show any obvious pattern.

The change in total loading indicates that some effort has been undertaken by the mill to reduce phosphorus loading; however, the reduction in the amount of potentially bio-available P measured as total dissolved P is more important and is a key factor in evaluation of algal trends in the Thompson River.

These reductions have been offset in the most recent years by production increases. Derksen (1988) data indicate that Weyerhaeuser's P loads in 1988 were significantly increased from previous years. These data, and the City of Kamloops P loading, are discussed below.

The effluent from Weyerhaeuser contains a variety of other materials. Those measured on a regular basis are summarized in Table 51. Some of the notable results are the total dissolved ions measured as total residue (mean 1643 mg/L), specific conductance (2153 uS/cm), and others. Sulfate (167 mg/L), sodium (328 mg/L), calcium (162 mg/L) and chloride (456 mg/L) are high. Oil and grease is surprisingly high (a mean of 10 mg/L based on 26 samples). Turbidity is surprisingly low (18 NTU). The nitrogen and phosphorus have a relatively low ratio: the ratio of Kjeldahl N:TP was about 5.3:0.64 or about 8:1 by weight. Not surprisingly the relative proportion of total coliforms to fecals is very wide - probably much greater than 100:1 since the fecal mean value is a statistical artifact and probably should be an order of magnitude lower than indicated.

There are only minimal data for chlorinated organics reported in the table, reflecting the general time period when the samples were collected and the unawareness at that time of the significance of this group of compounds. There has been considerable recent data collection by Weyerhaeuser and government agencies, the latter reported in Mah et al. 1989, and Waste Management Branch (1989) and subsequent reports by Hatfield Consultants Ltd. (1991) and B.C.Environment (1991). These reports indicated that dioxins in drinking water downstream of the pulpmill are low in concentration and generally not an item of concern. There were, however, significant concentrations of 2,3,7,8-tetrachlorodibenzofuran (T4 CDF) and total T4 CDF in bottom sediments downstream of the mill and of 2,3,7,8-TCDD dioxin and 2,3,7,8-TCDF in some fish tissues downstream of the mill. The earlier data included only a limited number of fish and showed generally higher concentrations. The recent Ministry of Environment sampling data and the Hatfield data show lower concentrations. This issue (and the associated fish consumption advisories) remains one which is of considerable public interest, and sampling for furans and dioxins is being continued by Weyerhaeuser and government agencies. Further discussions of, and objectives for, dioxins and furans in the lower Thompson River are found below in the section on water quality objectives.

4.3.2 City of Kamloops Sewage Treatment Plant Discharge (PE 399)

Facilities and Treatment. The following short summary of the discharge history is taken partially from Wetter (1983). In March 1970, the City first applied for a discharge permit.

Prior to 1970, sewage was treated in two sets of lagoons, one on the south shore of the river and another on the north shore. In the initial application, a proposal was made to consolidate the lagoon system to the south side of the river. A provisional permit was issued in April, 1971, authorizing a discharge of an average of 17,050 m^3/d with maximum 50 mg/L BOD and 65 mg/L suspended solids. The sewage lagoons were built on the coarse riverside gravels and not sealed. Discharge to the river occurred by exfiltration with no surface flow occurring until the fall of 1974 (Olan, 1975). As a consequence of the preliminary findings of the Federal-Provincial Task Force in October 1973 (established to investigate the complaints of excessive algal growth, foam, fish tainting, and colour in the Thompson River - see "Task Force Report 1976" in the references), the Director of the Pollution Control Branch required the City of Kamloops to investigate the feasibility of nutrient removal from the effluent or alternative disposal. In December 1975, the Federal-Provincial Task Force presented its final report and findings. It reported that the large amounts of attached algae occurring downstream of Kamloops Lake were likely due to inputs of nutrients from the Weyerhaeuser pulp mill and the Kamloops sewage discharge and that reductions from these two sources were the only practical means of reducing the problem.

In 1976, the Waste Management Branch assisted the City of Kamloops with assessing phosphorus removal using alum in the treatment lagoons (Wetter 1977). In 1977, alum treatment began and the fourth cell was treated with alum on a year-round basis. In September 1977, the city applied for permission to increase the volume discharged to 34,100 m^3/d, double that specified in the existing permit. In May 1978, this application was refused on the basis of concerns expressed by a number of agencies regarding the volume of proposed effluent. The city was required to reduce discharge phosphorus concentrations to less than 1.5 mg/L in the December to March period.

In 1978, the city was again ordered to investigate alternative methods of treatment and disposal. Associated Engineering was retained to evaluate the lagoons and Stanley and Associates were engaged to study alternatives for treatment and disposal. Stanley provided five volumes of reports between 1978 and 1980 examining a number of options. In 1980, the city applied for a permit to discharge 41,000 m^3/d of effluent to the river. After evaluation and referral, a permit for 25,000 m^3/d was issued in March, 1981. The permit specified that the volume of discharge was to be as close to zero as possible, December to March inclusive. Other times of the year, discharge was not to exceed inflow except during drawdown in late summer to provide storage for winter inflows. A restriction of a maximum concentration of 1.5 mg/L phosphorus was specified for the December to March period. One change was the removal of a clause not permitting any toxic chemical discharges.

Another task force to consider the city discharge was organized in April 1981, chaired by Dr. R. Smillie. The report (Kamloops Waste Management Task Force 1981) issued in November 1981 reinforced previous studies that the phosphorus concentrations in winter (December through March) were critical, but that in the summer no problems with attached algae existed and no restriction of phosphorus discharge was needed. In May 1983, the permit was amended to allow a discharge of 37,300 m^3/d with a maximum of 3,700 m^3/d during the period December 1 to March 31, and a maximum total phosphorus concentration during this period of 1.0 mg/L (2.0 mg/L during the rest of the year - April to November, inclusive). A rapid infiltration system was also approved, allowing a maximum daily discharge of 15,700 m^3/d in the Cinnamon Ridge area primarily in winter. Approval was also given for spray irrigation of 6,000 m^3/d effluent on private land adjacent to the infiltration site. This permit remains in effect.

Amendments in 1985, 1988 and 1989 allowed for additional land to be spray irrigated with sewage. The land, owned by the City of Kamloops, is 150 ha and additional privately-owned land, for which the owners requested sewage effluent, for spray irrigation comprises 77 ha. Prior to 1983, the Gulf Oil Refinery had discharged its waste into the city sewer system. With the refinery closed, the requirements in the permit to monitor sulfide, phenols and hydrocarbons were removed.

<u>Effluent volumes, and phosphorus concentrations and loadings</u> The discharges from the city can be divided into a number of periods to obtain an understanding of changes since 1970. Prior to the first discharge permit (1971), there appear to be few records of the effluent quantity or quality discharged by the city. The first four-cell lagoon system constructed on the south shore site in the early 1970's had a surface area of 90 hectares and was designed to serve a population of approximately 36,000. The discharge in 1970 was probably about 15,000 m^3/d. Without phosphorus removal facilities, assuming total phosphorus and total dissolved phosphorus concentrations of 7.0 and 5.5 mg/L, respectively, the river likely received a loading of about 105 and 80 kg/d total P and total dissolved P, respectively (see Table 52). When the initial complaints of heavy algal mats occurred in late summer and autumn of 1972, the loadings from the Kamloops sewage

discharge were probably in this range. The discharge to the river occurred through the river gravels by exfiltration.

With rapid growth of the city, the volume of effluent increased. Olan (1975) estimates that, in 1973 or 1974, the sewage volume was 18,000 m^3/d and represented a discharge of 135 kg/d total phosphorus.

By 1977, the sewered population was about 45,000 (Table 53) and experimental removal of phosphorus was initiated (using batch treatment by alum) in the lagoons. Routine treatment of the lagoons during the winter was begun in December, 1977 and continues to the present with various modifications. A summary of phosphorus discharge data for the period 1974-84 is given as Table 54. Table 54a summarizes influent sewage quality to the plant. Table 55 summarizes lagoon water quality before alum treatment and Table 56 effluent quality for the fourth cell after alum addition. The data indicate a substantial reduction in phosphorus - from about 6 mg/L to about 0.7 mg/L (90 percent). Data for the outfall are summarized in Table 57.

By 1978, the average daily inflow was about 20,000 m^3/d. The provincial government ordered a reduction in phosphorus discharge concentration from December to April to less than 1.5 mg/L. Summer discharge was 140 kg/d and winter (December to March) was 30 kg/d (Table 52).

By 1979, year-round P removal was being undertaken. In 1981, the city's discharge permit was amended to allow a daily discharge of 25,000 m^3/d in the April to November period, but no discharge in December to March. Sewered population was 51,000. Monitoring of ground water in wells adjacent to the lagoons has been done. Tables 58 and 59 summarize the data, which are unfortunately insufficient to use as the basis for determining the quality of (or quantity of) sewage effluent being contributed to the river by ground water.

In 1983, the permit was amended to discharge a maximum of 37,300 m^3/d and 2 mg/L total P with winter discharge limited to 5,700 m^3/d and 1 mg/L (December to March). The serviced population at this time was about 51,000 and the input/outflow volumes were 21,000 m^3/d. Some summer disposal was done through spray irrigation (6,000 m^3/d possible) and some winter disposal was done using rapid infiltration basins (15,700 m^3/d maximum). The discharge of phosphous to the river at this time was about 4 kg/d in winter and 15 kg/d in summer.

The 1989 annual loadings to the river were about 4,000 kg (July - November 1989) with no winter discharge. Typical inflow volumes were about 22,000 m^3/d to 24,000 m^3/d (July to September).

The 1989 data provide some information on the current disposal of effluent. Table 60 shows the inflow volumes and the timing and volume of discharge from the lagoons to the river (July - November, approximately 3,000 dam^3). Table 61 shows the timing of the two other possibilities for disposal: rapid infiltration used January to April, spray irrigation from May to October and rapid infiltration in November and December. The rapid infiltration system was used for disposal of about 1,000 dam^3 in 1989 and the spray irrigation about 2,000 dam^3. The water disposed of by rapid infiltration probably enters the river flow soon after disposal.

Alum has been used as the phosphorus binding agent since 1977 and appears to be quite efficient. The volumetric dosage rate is 150 ppm for the lagoon treated; however, the use of liquid alum (50% water) has reduced the efficiency somewhat in recent years. The difference between influent (Table 54) and lagoon effluent (Table 56 and 57) after alum treatment is significant. The influent averaged 7.5 mg/L total phosphorus during 1972-82 but appears to have changed in recent years, while the effluent averaged 1.9 mg/L during 1971-83 and 1.3 mg/L in 1989.

Discharge Quality The present waste management permit contains a number of effluent requirements for river discharge. These include:

5-d BOD	- 45 mg/L
Total Suspended Solids	- 60 mg/L
total P (Apr to Nov)	- 2.0 mg/L
total P (Dec to Mar)	- 1.0 mg/L
total coliforms	- 1,000 MPN/100 mL
bioassay TL_m (96-h LC_{50})	- 100% effluent concentration
sulfide	- 0.5 mg/L
phenols	- 0.2 mg/L
hydrocarbons	- 15 mg/L

The three latter constituents were included in earlier permits because of the oil refinery effluent discharged into the city sewer system. The oil refinery has since been closed and these characteristics dropped from requirements (April 1985 amendment). The effluents which are discharged by rapid infiltration or spray irrigation have different requirements for quality in comparison to the river discharges.

Some water quality monitoring requirements are keyed to particular activities. For instance, fish bioassays are only required when direct river discharges occur. A summary of bioassay results is given in Table 62.

Discharges to the river have to be monitored for total phosphorus. The 1989 data are tabulated in Table 60. The limits were below the concentration specified in the permit for April to November discharge (2 mg/L).

Effluent from the rapid infiltration basins have a requirement for biological oxygen demand (BOD) and suspended sediments. The data for 1989 are tabulated in Table 63 and show that both BOD and suspended solids were low. Effluent disposed of by rapid infiltration has requirements for total phosphorus as well as total and fecal coliforms. The data for 1989 are shown in Table 61.

In general, the Kamloops city discharge has had a much reduced effect on the river since the first monitoring data were collected 20 years ago. The increasing use of spray irrigation to dispose of the effluent is desirable and appears to be technically advantageous and has public support as well.

4.3.3 Gulf Oil Refinery (PE 419)

Between 1954 and 1983, when it was shut down, Gulf Oil operated a refinery north of the airport (Figure 10). The facility is still used for bulk storage and distribution. Discharges from the operation were to ground and via the city sewer system. Sampling wells with data for 1973-1982 (Tables 64 and 65) show high suspended and dissolved materials as well as phenols and sulfide and perhaps some elevated metals. Monitoring data for the Skim Pond discharge and the treatment lagoons (Tables 66 - 69) show some similar characteristics, as well as elevated cyanide, ammonia and Kjeldahl nitrogen and distinctly high levels for several metals.

In evaluating the operation, Miller (1981) noted problems with phenols, sulfides, oil and grease, total suspended solids and pH. In addition, in 1981, a review of data to that time

(Eckstein memo of April 7, 1981 in Regional office files) presented some concern regarding ground water contamination based on the monitoring well data. A summary of operations and permit conditions are contained in the permit files (resume 1970 Weldon, 1979 Sedivy).

Few data exist which allow evaluation of the environmental effects of the refinery discharges; however, the potential for damage of ground water is significant and seepage to the river through soils and the discharge through the sewage treatment plant may have had some effect. This area is now considered a contaminated site because of hydrocarbons in the ground water. Remediation efforts have been underway since 1987.

4.4 WATER QUALITY

There are few ambient water quality data collected in the reach of river between the confluence of the North and South Thompson and Kamloops Lake. Some data have been collected at station 0920167 (see Figure 10, Table 70). Samples were collected by the federal government during the Federal-Provincial study of 1973-74 and at a station which was part of a monitoring network discontinued in 1974. Minimal data are also available for site 0900243. The data are insufficient to address the effects of discharges or trends in water quality over time.

One creek which enters the Thompson River downstream from the confluence of the North and South for which there are data is Guerin Creek (0600056, Figure 10, Table 71). This creek flows under the old Kamloops landfill and most of the watershed drainage channels have been filled by development. The drainage now appears to originate largely from ground water. Guerin Creek water quality is poor, probably as a result of the developed area it drains and the typically alkaline conditions of the area. The dissolved ions in Guerin Creek are very high (total residue averages almost 4000 mg/L and specific conductance 2500 uS/cm). The suspended sediments are very high (2628 mg/L) as is turbidity (average 378 NTU). Sulfate is noticeably high (1081 mg/L) and there are a number of total metals which show elevated concentrations (copper, lead, zinc) but, with high levels of particulate material, this may not be unexpected.

2.5 PROVISIONAL WATER QUALITY OBJECTIVES

With two major discharges, the city sewage treatment plant and pulp mill, this section of the river should receive special attention. However, there appears to have been very little ambient monitoring in this section of the river due to the difficulty of obtaining most kinds of quantitative or consistent samples. In this reach between the confluence and Kamloops Lake, the water from the North and South Thompson remain separate and relatively unmixed on their respective sides of the river. Below the discharges from the City of Kamloops STP and the Weyerhaeuser pulpmill, separate streams of diluted effluent are added to the already non-homogeneous river flow. The temporal and spatial variability are complex so that consistent and representative samples may be difficult to obtain. The objectives in this case, and with any other direct discharges, do not apply in an initial dilution zone. In the case of both the city sewage treatment plant discharge and the pulp mill discharge, the dilution zone extends 100 metres downstream.

There are several water quality characteristics which appear to be of some concern for the section of the Thompson River below the confluence and upstream of Kamloops Lake but of particular concern in this reach of the river is the microbiological quality of the water. Water withdrawn for drinking water is obviously a very sensitive use and should be protected. Likewise body contact recreational usage should be protected.

For the Thompson River from the confluence of the North and South Thompson Rivers to Kamloops Lake, it is proposed that the fecal coliform bacteria density not exceed 10 per 100 mL (calculated as 90th percentile) for areas near water intakes to permit the use of the water for drinking after disinfection only. For areas where body contact recreation occurs, concentration of E. coli should not exceed 2000/L (geometric mean). A minimum of 5 weekly samples should be collected in a 30 day period for comparison with these objectives. These objectives are designed to protect the designated uses of drinking water and body contact recreation.

Protection of aquatic life using water quality objectives in this reach of river is difficult because of some of the characteristics discussed above. Water chemistry is very non-homogeneous both across the river channel and with depth. Samples taken in the effluent plume are obviously not representative of the entire river. It is proposed that objectives should apply anywhere outside the initial dilution zone to protect this sensitive use.

Because of the pulp mill, resin acid toxicty is a concern. Ontario Environment has reviewed the toxicity of resin acids and produced a criteria document (Taylor et al. 1988) and the objectives are based on that document. Provisional objective concentrations for the Thompson River are specified for dehydroabietic acid (DHA - a common resin acid and the most persistent of the group) and for total resin acids. Both criteria values are keyed to environmental pH. The provisional objectives for resin acids are listed below.

receiving water pH	concentrations (ug/L) DHA	total resin acids
6.0	2	4
6.5	4	9
7.0	8	25
7.5	12	45
8.0	13	52
8.5	14	60

It must be noted that there are some data in previous tables for resin acids at ambient sites which, because they were collected many years ago and analyzed with unknown methods, are of extremely dubious accuracy. In the context of these objectives, they are considered irrelevant.

Chlorinated organics from pulpmill discharges comprise a very large group of chemicals which is only partially identified as to specific chemical compounds. Derksen (1988) reports some unpublished data by Rogers in which four chlorinated phenolics were reported: 2,4,6-trichlorophenol, pentachlorophenol, 3,4,5-trichloroguaiacol and tetrachloroguaiacol. The concentration of these compounds ranged from 30-60 ng/L.

These compounds appear to be formed primarily in the bleaching process. Organochlorine chemicals are of special environmental concern because of their persistence, toxicity to aquatic organisms and genotoxicity (Suntio et al. 1988). More than 250 chemicals have been identified in pulpmill effluents and few of these have been characterized in any detail with regard to environmental effects. Compounds of particular concern have been identified as the chlorophenols, chloroguaiacols, chlorocatecols, dioxins and furans.

Dioxins from pulpmills were identified in 1987 by the U.S. Environmental Protection Agency, National Dioxin Study (USEPA 1987) and by researchers (Amendola 1987). In 1988, dioxin-contaminated shellfish resulted in the closure of areas adjacent to two pulpmills discharging to the marine waters of Howe Sound. In January, 1989, Weyerhaeuser issued an information bulletin discussing the problem and describing some of the steps being taken by the mill to reduce the amount of dioxins being discharged to the river (Weyerhaeuser 1989).

In 1989, a report was released with data on concentrations of dioxins and furans in fish flesh and sediments downstream from B.C. pulpmills (Mah et al. 1989). They reported relatively high concentrations in sediments of a furan identified with a high toxicity risk (2,3,7,8 tetrachlorodibenzofuran) and total tetrachlorodibenzofuran below the pulpmill. The downstream sites (0.2-0.3 km below the mill) had concentrations of 2445-3168 parts per trillion (pg/g) of dry sediment of 2,3,7,8-T4CDF and 3459-4521 ppt of total T4CDF. Upstream sites were below detection limits for these compounds (10 ppt). Dioxins were below detection limits (15 ppt) in sediments both upstream and downstream from the mill.

In fish flesh, concentrations of dioxins and furans were significantly higher downstream than upstream from the mill (Mah et al.1989). For the resident fish sampled downstream from the mill (largescale sucker, mountain whitefish, northern squawfish), concentrations were as high as 60 pg/g (wet weight) for dioxin isomer 2,3,7,8T4CDD and 704 pg/g for the furan isomer 2,3,7,8T4CDF. The data from Hatfield Consultants (1991) showed concentrations of dioxins and furans in mountain whitefish ranged from 9.2-49.8 ppb 2,3,7,8 TCDD-TEQs. Other species of fish had much lower concentrations of dioxins and furans (large scale sucker 1.6-1.9 ppb, rainbow trout reported in B.C. Environment (1991) 3.1-7.4 ppt)

Concentrations of dioxins and furans in fish tissues have been the cause of two advisories by Health and Welfare Canada regarding consumption of fish from the Thompson River. In May 1989, advisories were issued to limit the consumption of mountain whitefish, northern squawfish and peamouth chub. In April 1990, an advisory was issued to limit the amount of dolly varden char which could be eaten.

In a separate study of dioxins in drinking water below pulpmills, (Waste Management Branch 1989) the Thompson River was sampled at Savona, Walhachin and Ashcroft. At the first two locations, dioxins were not present above the analytical detection limits. At Ashcroft, a concentration of 0.08 ppq (parts per quadrillion or picograms/L or 1×10^{-15} parts of dioxin per part of water) toxic equivalents of 2,3,7,8, TCDD was found. This can be compared to the national guideline for dioxin in drinking water which is 15 ppq.

These data show that the Weyerhaeuser pulpmill does produce compounds which are generally felt to be toxic and which are present in sediments and biota downstream of the mill. Because they are present in such small quantities, they are difficult to detect in water samples.

Because of the difficulty in detecting these chlorinated organics in water, the more efficient place to monitor these compounds would be in sediments and biota rather than water. The lack of historical data for organics in any media makes it difficult to make any observations on historical trends in concentration. However, the sediments of Kamloops Lake contain a chronology of chemicals which could provide an interesting record of changes over time. The mill has undertaken a number of changes in their processes to minimize the amounts of dioxins and furans discharged and further sampling is expected to show that concentrations in fish and sediment will decrease.

The form of monitoring programs for pulpmills using bleaching processes has been discussed by Bernard and Everett (1987). The monitoring parameters which were recommended were summarized by Kelso (1989) and listed below.

WATER	SEDIMENT	BIOTA
River Velocity	Resin Acids	Tissue Body Burden
Turbidity	EOX	EOX
non- filt/filt resid	Bioassay	Histopathology
AOX	-acute	- gill, liver
Chloroform	-sub-lethal	EROD (Mixed function Oxidase)
Chlorophenols	Chlorophenols	
Chloroguaiacols	Chloroguaiacols	
Chlorocatechols	Chlorocatechols	

With regard to water quality objectives, there has been little, if any, specification of maximum acceptable concentrations because of the lack of toxicity information or environmental effects for most of these measurement parameters.

There has been use of AOX (adsorbable organohalides - i.e., solvent extractable chlorinated organics, from water, sediments and tissues) as a general measurement for all chlorinated compounds, or another measurement of chlorinated organics (TOCl or total organochlorine). In some regulatory jurisdictions, acceptable discharge of contaminants from pulpmills has been generally linked to production so that discharges are specified on the basis of pulp production per day. Typical TOCl targets in Sweden for pulpmills are 1.5 - 3.5 kg/dry tonne. Other jurisdictions specify targets as low as 1.0 kg/tonne. Ontario has recently specified that discharge of TOCl (measured as AOX) be less than 2.5 kg/adt by December 31, 1991. The present B.C. regulations are for mills to produce less than 1.5 kg/ADT by December 1995.

AOX appears to be a more desirable measurement to use than TOCl if other jurisdictions are any guide; however, specifying acceptable concentrations is more difficult. AOX has the disadvantage in that it is not a class of compounds that might be causing problems. It would be more desirable if objectives were to be set for chlorophenols, chloroguaiacols and chlorocatecols in water, sediment or tissues, but research on effect levels must be accomplished first.

This concern, which has only begun to be investigated in more depth, is the issue of the discharge of the variety of individual chlorinated organic chemicals from the pulping and bleaching processes. Existing studies show that although there is no immediate, or obvious problem, there are a variety of concerns with these chemicals that need to be addressed.

For the areas of further investigation, this one (chlorinated organics) should receive higher priority than it now has. Of particular interest is the significance of the bioaccumulation of these compounds in biota (stream invertebrates, flora and fish) and in stream and lake sediments and the potential of using these concentrations of these compounds as environmental indicators.

Derivation of an objective for dioxins and furans in water

An objective to protect aquatic life is specified because of the public concern about these chemicals. No B.C. criteria have been established for any of this group of chemicals, and the objective proposed for 2,3,7,8 TCDD is based on recent data from the literature (see below) and compiled largely by Butcher (1991) for establishing objectives for the Columbia River system. The objective is derived from two lines of evidence: bioconcentration and bioassay.

The long-term continuous flow bioconcentration factor (BCF) of 159,000 for fathead minnows for 2,3,7,8 TCDD is probably the most reliable estimate presently available (Cook et al. 1991). Dividing the no-observable-effect level for body burden (34 pg/g Walker et al. 1991) by the BCF gives a concentration of 0.2 pg/L in water. This concentration should protect fish from excessive bioconcentration of dioxins/furans in their tissues excluding dietary intake. Information on the role of dietary intake is lacking at present and, until data on this aspect of effects on organisms are available, the conclusions about an appropriate safe concentration in water remains provisional.

The chronic (28 d) bioassay work by Mehrle et al.(1988) indicated that the no-observed-effect concentration for rainbow trout survival, growth and behavioral responses was lower than the lowest concentration that they had used (38 pg/L). Using an a safety factor of 0.01, which is commonly used for persistent, bioaccumulative contaminants, yields an objective level of 0.3-0.4 pg/L. Lupp and McCarty (1989) used the Ontario Ministry protocol for guidelines development to derive guidelines for 2,3,7,8 TCDD (0.1 pg/L) and 2,3,7,8 TCDF (0.2 pg/L). They did not use TEQs in deriving their numbers. The TEQ concept has some inherent value and for that reason the objective for the Thompson River is a maximum concentration of 0.2 pg/L of 2,3,7,8 TCDD TEQ in water.

Sampling reported in Waste Management Branch (1989) for Walhachin and Ashcroft, indicated that all results, except for one relatively low toxicity congener, were below the minimum detection limits for the laboratory used. However, the detection limit for 2,3,7,8 TCDD was 10 pg/L which is poor in comparison to the objective concentration.

Dioxins and furans in fish tissue

British Columbia has not established criteria for dioxins and/or furans on which to base a site specific objective. The provisional objective is based on recent literature and levels established for the protection of human and wildlife consumers of fish.

Biochemical indicators is one method of determining no-effect concentration for toxicants. Using Fraser River chinook fry, Servizi (1990) reported a threshold for ethoxyresorufin-O-deethylase (EROD) induction in the range of 1-10 ppt TCDD TEQ body burden. Hodson (personal communication to G.A. Butcher, B.C. Min. Env., Victoria) found an induction threshold of 10 ppt for the enzyme aryl hydrocarbon hydroxylase in white sucker. These levels are lower than the lowest levels for conventional observed biological effects (behavior, reproduction, toxicity) and thus should be protective of fish health.

The tissue objective should also be protective of animals higher in the food chain consuming fish tissues. For the protection of piscivorous mammals and birds feeding primarily on fish, the New York Dept. of Environmental Conservation arrived at a criterion of 3 ppt TCDD (Newall 1987). The B.C. Ministry of Environment Toxicology Unit and Ministry of Health have recommended that human health advisories be issued when the concentration of 2,3,7,8 TCDD TEQs in the edible portions of fish exceeds 11.4 ppt.

For protection against environmental damage by dioxins and furans, a maximum concentration of 2,3,7,8 TCDD TEQs in the edible portions of fish should not exceed 1 pg/g (ppt) wet weight.

Sampling done by Mah et al. (1989) showed a substantial difference between concentrations of dioxins and furans in fish upstream of the pulp mill and downstream of the mill in the area of the river above the lake. The concentration of 2,3,7,8 TCDD in large scale sucker was 12.5 pg/g wet weight, in mountain whitefish 60.9, and in squawfish 59.9. The concentrations of 2,3,7,8 TCDF were, for the same species above 16, 387, and 704 respectively. The TEQ for 2,3,7,8 TCDF is 0.1 that of 2,3,7,8 TCDD. The results for several other congeners were reported. Sampling was done for dioxins in fish in the lower Thompson River in 1989 and 1990 by the regional office of Ministry of Environment.

<u>Dioxins and furans in sediments</u>

There are no B.C. criteria for dioxins and furans in sediments. British Columbia and other jurisdictions are in the process of establishing these. These are persistent compounds with half-life in sediments estimated to be greater than 10-15 years (Rabert 1990). Dioxin persistence and potential availability from the sediments will present a contamination problem for the Thompson River in the future and the objective proposed is designed to protect aquatic life.

One method used to derive sediment quality criteria is based on equilibrium partitioning from the sediment to the water and biota. The resulting criterion (expressed as ng/g organic carbon) is a product of the octanol-water partition coefficient and the water quality criterion (EPA 1989). The partition coefficient for 2,3,7,8 TCDD is 6.31×10^6 (Shio <u>et</u> <u>al</u>.1988) and the provisional water quality objective is 0.2 pg/L, thus the sediment criterion can be calculated as 1 ng TCDD/g organic carbon or 10 pg/g (ppt) for sediment containing 1% organic carbon. Assuming that the water quality objective is appropriate for benthic animals, this value should protect them from effects of TCDD/TCDF associated with the sediments but may not address the possible contamination of upper trophic levels.

Another approach to deriving a sediment TCDD criterion protective of upper trophic level organisms would be to work back from a safe tissue level to a safe sediment level using bioavailability data. Bioavailability indices (BI = pg/g lipid weight divided by pg/g sediment organic carbon) for TCDD and TCDF were derived from the Mah et al. (1989) data as cited in the paper of Muir et al.(1991). Data collections were in the reach of river upstream of the lake and would be expected to have higher concentrations than these present in the lower river. The paper of Muir et al. incorrectly gives the sample location as the Fraser River.

	mean BI	
	TCDD	TCDF
Suckers	0.33	0.01
Whitefish	1.53	0.18

The most conservative approach would be to use the highest bioavailability index, in this case 1.53. Assuming a safe concentration of TCDD TEQs in fish to be the tissue objective (1 pg/g 2,3,7,8 TCDD TEQ), it was calculated that the maximum concentration of TCDD TEQs in the sediment should not exceed 0.7 pg/g (1.0 pg/g divided by 1.53, rounded). This concentration should be protective of upper trophic level organisms such as suckers feeding on detritus at the sediment water interface and whitefish feeding on filter feeding insects.

Thus, for the Thompson River below the confluence and above the lake, the maximum concentration of TCDD TEQs in the sediment should not exceed 0.7 pg/g.

Sampling done by Mah et al.(1989) provides some results for dioxins and furans in sediments. For all of the dioxin congeners tested, the concentrations were below the detection limits used both above and below the mill. However, for furans, some high concentrations (68-3168 pg/g dry weight) were reported, mostly in the 2,3,7,8 TCDF form. No data are available for the lower river (below the lake).

In summary then, in this section of the river, there are provisional objectives for chlorinated organics in water (0.2 pg/L 2,3,7,8-TCDD TEQ), in fish tissue (1.0 pg/g 2,3,7,8-TCDD TEQ (ww)), and in sediments (0.7 pg/g 2,3,7,8-TCDD TEQ (dw)) .

5. KAMLOOPS LAKE

Kamloops Lake was examined in a comprehensive study in 1974-75 by the Pacific and Yukon research group of Canada Centre for Inland Waters/Environment Canada (St. John et al. 1976) as part of a Federal-Provincial Task Force. Much of the limnological knowledge that exists about Kamloops Lake originates with that study. An earlier study (Ward, 1964) was the first examination of the limnology of the lake and contains considerable basic information. Kelso and Derksen (1976) published a report on plankton standing crop also done as part of the Task Force. Since then, no published data exist other than papers which resulted from the work done by Environment Canada / CCIW (Carmack et al, 1979; Carmack and Daley, 1977; Hamblin and Bull, 1976; Hamblin, 1977, 1978; Pharo and Carmack, 1979; Carmack and Farmer, 1982; Carmack, 1979; Killworth and Carmack, 1979; Hamblin and Carmack, 1978). Data have been collected by waste permittees, particularly Weyerhaeuser, since 1978; however, this information has only been partially summarized or interpreted (Kelso, 1984; Derksen, 1988).

5.1 MORPHOLOGY AND HYDROLOGY

For a map of Kamloops Lake bathymetry refer to St. John et al (1976) p. 17, and for the hypsographic curve refer to the same source (p. 16). The basic morphometric data are given in Table 72 and some of the relevant hydrologic data in Table 73.

Kamloops Lake can be basically characterized as a long, narrow, steep-sided lake, physically dominated by the inflow of the Thompson River. The short theoretical water residence time, seasonally high turbidity, and low available nutrient input combine to produce a system of relatively low biological productivity.

5.2 WATER USES

There are 13 water licenses to withdraw water from Kamloops Lake. The majority of the licenses are for irrigation, but there are several domestic licenses as well as 17,820 m^3/d for a mining operation (Afton), some small industrial licenses (railway, sawmill) and a waterworks license - Savona Waterworks District - for 1,800 m^3/d.

Certain areas of the lake are well utilized for recreation (boating, fishing and body contact recreation) and the lake is an aesthetic value to the area. The lake is a rearing area for sockeye salmon and so has considerable value as aquatic life habitat.

On the basis of these considerations, the following designated water uses are identified: irrigation, drinking water, aquatic life, industrial, livestock and wildlife watering and recreation. These water uses apply to the entire lake.

5.3 WASTE DISCHARGES

5.3.1 PE 1643

Tranquille School, prior to 1982, disposed of treated sewage effluent by spray irrigation in summer and discharge to Kamloops Lake during winter (Figure 10). In 1982, winter effluent began to be disposed of by a rapid infiltration system, avoiding the lake discharge. The school was closed in 1985.

Monitoring was carried out for the two spray irrigation sites (Tables 74, 75, and 76) for the effluent effects on the lake, as well as for the rapid infiltration facility. The results are normal and for analyses are typical of sewage effluent under those circumstances. The discharges to ground, either by way of irrigation or rapid infiltration, are expected to have little, if any, effect on surface water quality. Tables 77 and 78 show results of ground water sampling associated with the discharges. The discharge to the lake was of more concern; however, the small volume likely caused only localized effects. With the closure of the school, no further effects on water quality would be expected.

5.3.2 PE 429, 430, and 431

Savona Timber operates a sawmill and plywood plant at the west end of Kamloops Lake (Figure 14). The monitoring data are shown as Tables 79 to 82. The limited data for the sawmill show no results which might raise concerns for deterioration of the lake water quality. The data from the plywood plant are limited to a few data over 3 years in the 1970's and the results for the ground water sampling well show nothing particularly except some detectable phenols and surprisingly high coliforms for a ground water sample.

5.3.3 AFTON MINES (PE 3904)

Afton Operating Corporation was issued Permit PE 3904 in 1976 for discharge of mine mill waste west of Kamloops in the Cherry Creek watershed (Figure 13). The mine processed approximately 3 1/2 million tons of ore per year and process water (maximum 33,650 m^3/d) and tailings were discharged to a pond for settling. The pond seepage rate is about 6.5 L/s. Seepage is intercepted and returned to seepage ponds or to the tailings pond. There are no surface flows to Cherry Creek, the nearest receiving water flow. As conditions of its permit, seepage and piezometer data are obtained, as well as ambient water quality data for Cherry Creek. The water quality characteristics which are monitored are suspended sediments, pH conductivity, sulfate, fluoride, arsenic, mercury, copper and iron.

The early Alkali Creek data (0600210) are summarized as Table 83, and other stream data are summarized in Tables 84 - 89 (Bowers Creek and Cherry Creek). There are also eight piezometer and well sites, some of which were monitored for ground water quality (Tables 90-94). Data for the seepage recovery pond are summarized in Table 95 and show some elevated metals.

The water quality data (sites 0601013, 1600177, 178 and 0600212) indicate that there is an increase in specific conductance, sulfate and fluoride with distance downstream. However, it is unclear if the mining activities play a role in the increase since input from Alkali Creek (which is, as its name indicates, is an alkaline stream,high in dissolved ions) or ground water, naturally high in dissolved minerals, may be responsible. There are occasionally high concentration of some metals (mercury, copper, arsenic and iron) but no obvious causal pattern is apparent.

The low volume of discharge for Cherry Creek (mean annual flow of 0.15 m^3/s) precludes any significant impact on Kamloops Lake at the low concentrations noted.

Afton submits annual data reports summarizing the water quality data collected as a responsibility of their permit as well as other reports (e.g.Pecek, 1988). Afton has applied for an additional permit to work a second copper ore body (Ajax) in the Peterson Creek watershed, south east of the present site. It is planned that the site would also have no discharges to surface water.

5.3.4 Non-point Source Discharges

Three of the tributaries which drain into Kamloops Lake are identified as having actual or potential effects on water quality caused by cattle operations. The headwaters of Cherry

Creek have been identified as having a large concentration of cattle. Durand Creek and the Tranquille River have been noted to have been subject to some water quality degradation due to concentration of cattle for winter feeding operations (Ministry of Environment and Parks, 1986; Ministry of Environment, 1980).

The effects of these activities on the streams may be quite significant; however, their effect on the lake or the mainstem Thompson water quality is probably not easily measurable for each individual source. Of more concern is the additive effect of the multitude of these small non-point discharges throughout the watershed.

5.4 WATER QUALITY - KAMLOOPS LAKE AND TRIBUTARIES

5.4.1 KAMLOOPS LAKE

As noted in the introduction, there have been a number of examinations of the water quality of Kamloops Lake. The purpose of this review is to relate those published data to other information which has not been evaluated to this time and provide an overview of Kamloops Lake water quality.

Figures 12 - 14 give locations of provincial sampling sites as well as discharges to the lake. The discharges to the lake from the direct watershed (Savona Timber, Tranquille School and Afton) seem to have been of relatively minor consequence to the lake water quality. The effects of non-point sources have not been evaluated, but are probably minor in comparison to the effects of the two major upstream inputs - Weyerhaeuser and the Kamloops sewage discharge. There are no current data available to make a judgment on the present (1992) water quality conditions, although the Task Force Report (1975) indicated that the lake should be relatively insensitive to changes in nutrient loading.

The other aspect of Kamloops Lake water quality which is of interest is trends over time in water quality characteristics which can be used as indices of general lake condition. The indices discussed below are hypolimnetic oxygen depletion, nutrient concentrations, colour, phytoplankton and zooplankton.

Ward (1964) reported that the minimum dissolved oxygen he measured was 66-67% saturation in August and September 1963, at 143 m. The comprehensive NWRI study of St. John et al. (1976) indicated lowest dissolved oxygen in October, 1974 at 70%

saturation (bottom deepest depth, their station 6, Ward's station C-2). As a part of the permit requirements, Weyerhaeuser was required to monitor Kamloops Lake and a series of reports give some information on oxygen depletion. Weyerhaeuser (1974) for station C-2, gives a D.O. saturation of 52% for October, 1973 at 153 m. This seems low, but since the oxygen concentration is not given, it cannot be verified. The November sampling result is given as 79%. For 1975 for the same station and depth (Weyerhaeuser, 1976) gives oxygen saturation as 70%. The 1976 data show a minimum of 71% in August (Weyerhaeuser 1977), the 1978 result for September was 67% (Bechtel, 1979), the 1980 result for September is 71% (Anderson, 1981), and for 1982, 81.5% (Weyerhaeuser, 1983). Most years for which there are data show a similar oxygen saturation minimum of about 70%. Two years show quite different results (1973 and 1982), but there appears to be no apparent trend or change in hypolimnetic oxygen content. This conclusion is also reached by Kelso (1984) and Derksen (1988).

Another index of possible change in biological production is nutrient concentrations tabulated in Table 96. The changes in phosphorus over time would, if taken at face value, indicate an increase between Ward's sampling in 1963 and samples taken in the early 1970's, then a major increase in the 1970's and then very low concentrations by 1982. However, some of the data are suspect for a number of reasons. The 1980 values show higher dissolved than total in a number of instances. Earlier data show very high analytical detection limits (20 μg/L), and some years have values far too high to be even reasonable. As a result, it is probably not possible to use these poor data to interpret trends in total phosphorus or dissolved phosphorus, and to tell whether there is any change in lake phosphorus concentrations over the period of record. The limnology of the lake is complex and makes interpretation of data such as these very difficult.

Evaluation of a sediment core taken from the western basin of Kamloops Lake was done to determine if, by looking at the diatom deposition sequence, any change in phosphorus concentration had taken place over the recent past. The conclusion from this analysis was that there appeared to have been little if any change in the phosphorus concentration inferred by the diatom assemblages in the 50 cm core (Hall 1991). The period of primary interest, the last 30 years, would have not have been identified by this analysis since the subsamples were taken at 5 cm. intervals and the past 30 years is probably represented in the top interval. However, there is certainly no evidence that the relatively long term stability of the lake phosphorus concentration has been affected by recent events.

Changes in nitrogen concentration are also difficult to interpret. Ward's "historical" data show very high nitrate and low organic (Kjeldahl) nitrogen. These older data must be viewed with some reservations because of the relatively inaccurate analytical methods of the time. The NWRI data from 1974 and the 1973 Weyerhaeuser data show lower nitrate and increased Kjeldahl. The trend indicated by the remaining data is one of increasing nitrate and increasing Kjeldahl through 1982 when the last lake data were collected. The analytical method changes are a confounding problem particularly with nitrate. Ammonia, although the data are not as complete, also appears to show some increase over time.

The last water chemistry indicator examined was colour. Data for the lake exist only since 1973 and show little, if any, noticeable change over this time period. Data for the period prior to the pulp mill would be useful to have, if they existed.

The zooplankton data for Kamloops Lake, summarized in Table 97, have a number of shortcomings in terms of utility in evaluation of trends or changes in the lake over the 20 years for which data are available. There are problems with continuity of method (net mesh size changes, changes in units and reporting methods and a variety of other changes). No mouth size is given in any of the Wisconsin net (vertical tow) data. With these limitations, it is difficult to comment on the available results and changes in zooplankton. In examining the zooplankton standing crop data, it would appear that the data of the 1970's show higher numbers of organisms than the 1963 data of Ward. However, as noted above, the data inconsistencies make it difficult to give strong support for this apparent change.

One change which seems to be more significant is the apparent change in species composition. Ward (1964) reports that Holopedium was the most abundant cladoceran in the lake during the summer months. The data of Kelso and Derksen (1976) indicate that Holopedium was generally less abundant than Daphnia and often less numerous than Bosmina (however there was considerable variation from place to place and at different sampling times). Data collected in 1978-1982 (Bechtel 1979, Anderson 1981, Weyerhaeuser 1983) indicate Holopedium to be entirely absent during that period. The reasons for the absence of Holopedium are unknown. Ward also reported that despite sampling in 1954, 1955 and 1956 in Shuswap Lake the organism was absent there although Clemens et al. 1937 reported Holopedium in the 1930's.

Other changes in the zooplankton species composition are also apparent. Ward lists four cladocera (Daphnia, Bosmina, Holopedium, and Leptodora) and four copepods (Cylops, Tropocyclops prosinius, Diaptomus, and Epishura). Kelso and Derksen list only three copepods (Tropocyclops not reported). The data collected by Weyerhaeuser (referenced as Bechtel, Anderson, and as Weyerhaeuser) show a new species of Cyclops and at least six species of Cladocera were recorded from the lake. Notable here are the large number of Diaphanosoma which are present by 1982. More detailed analysis of the data might reveal a variety of other changes in terms of zooplankton community composition, but in general the data are so poor and sketchy that this would be difficult. The best reexamination would be of the original samples if they existed. However, based on the existing data, it appears likely that the zooplankton species composition has gone through a number of changes in the 20 years from 1963 to 1982. For future monitoring, the samples should be retained to provide data for future investigators to make unequivocal judgments about changes in community composition and to avoid problems with changing taxonomy.

The input of toxicants (likely during the early 1970's) would not necessarily mean any change in nutrient cycling or dynamics or any change in productivity (Schindler 1988) and might best only be reflected in community structure change.

Phytoplankton data were also examined. It would appear that little change has occurred in this community (Table 98).

There are data collected for six stations on Kamloops Lake from 1973-74 which provide some information for the lake at that time (Tables 99-104). These data, supplemental to the interpreted data in St. John et. al., could be the basis for future comparison if another detailed study were to be undertaken.

5.4.2 TRIBUTARY STREAMS

Several small tributary streams have existing water quality data. Durand Creek (Table 66) has high values for colour, phosphorus and metals. Table 84 summarizes the data for Bowers Creek. Tables 85-88 summarize data for Cherry Creek (0600177, 178, 212). Data for the Tranquille River are given in Table 105 and Durand Creek data are summarized as Table 106. Other monitoring has been done relating to the Afton Mine discussed earlier: Table 84 lists the effluent characteristics for PE 4367. Tables 90-93 are piezometer data. Table 94 is a sampling well (0600222) and Table 95 is the settling pond (0601055). More recent data exist for all these sites and are summarized in Afton's annual reports on environmental monitoring.

2.5 PROVISIONAL WATER QUALITY OBJECTIVES

Kamloops Lake is an important component of the Thompson River system. There are several identified water uses and water withdrawn for drinking water is obviously a very sensitive use and should be protected. Likewise, body contact recreation should be protected.

For Kamloops Lake, it is proposed that the fecal coliform bacteria density not exceed 10 per 100 mL for areas near water intakes to permit the use of the water for drinking after disinfection only. For areas where body contact recreation occurs, fecal coliforms should not exceed 2000/L (geometric mean). A minimum of 5 weekly samples should be collected in a 30 day period for comparison with these objectives.

For protection of aquatic life, the major concerns are compounds from the pulp mill: resin acids and chlorinated organic compounds. For Kamloops Lake the same rational and objectives are applied. There are provisional objectives for chlorinated organics in water (0.2 pg/L 2,3,7,8-TCDD TEQ), in fish tissue (1.0 pg/g 2,3,7,8-TCDD TEQ (ww)), and in sediment (0.7 pg/g 2,3,7,8-TCDD TEQ (dw)).

6. LOWER THOMPSON RIVER

6.1 HYDROLOGY

The Thompson River between Savona and the confluence with the Fraser River at Lytton has one long term hydrology site (08LF051) at Spences Bridge. This site includes the incremental increases in flow to the Thompson added by Deadman, Bonaparte, and Nicola Rivers. The annual hydrograph is shown in Figure 15 and the annual flow data from 1970 through 1986 are given in Table 107.

The Bonaparte, Deadman and Nicola represent 0.7%, 0.2%, and 3.7% of the Thompson flow at Spences Bridge based on annual means for each of these tributaries.

6.2 WATER-USE

There are more than 40 licenses issued for water withdrawal on the Lower Thompson for a variety of uses. The largest volume licensed from the river is for irrigation, 22,000 dam^3 or considerably less than 1% of the average mean discharge at Spences Bridge over the June to September period. The second most important withdrawal in terms of volume is for mining purposes by Lornex. There are four waterworks licenses for the Village of Ashcroft (the largest license) as well as Lytton (back up supply only) and two smaller withdrawals. There are also some small industrial licenses and several domestic licenses.

The entire reach of the lower Thompson is an extremely important area for fish spawning and rearing. The river supports a well-known recreational fishery for steelhead and rainbow trout as well as being the passage way for a variety of salmonid species which spawn in the North and South Thompson. For details of this resource and the considerable information already assembled see Brown et al. (1979), Fraser and Fedorenko (1982), Knapp et al. (1982) and a summary of the regional fisheries management plan in Ministry of Environment and Parks (1986). One important aspect of the aquatic community which has received considerable attention is the benthic invertebrates. A review of all the studies done to date is presently being undertaken by Environment Canada (George Derksen) and so, rather than duplicating efforts in this specialized and complex area , that aspect is not reviewed in any detail in this report.

The lower Thompson is also used for recreation activities from fly fishing to river rafting. The area is an extremely attractive one with a variety of aesthetic attributes.

6.3 WASTE DISCHARGES

Figure 17 shows the locations of point source discharges along the lower Thompson by their permit numbers and the associated water quality monitoring sites. Proceeding downstream from Kamloops Lake, the first discharge is PE 1758, Westcoast Transmission. The discharge is cooling water from a natural gas pipeline pumping station. The permit sampling data are summarized in Tables 108 and 109. There are some extreme values reported (a pH value of 2.5 (suspect?!), a temperature of 80°C, and relatively high dissolved copper) which should be of some concern. In general, the effluent seems unlikely to cause problems, particularly considering the amount of the effluent (0.13 m^3/s) in comparison to the recorded low flow in the river at that point (121 m^3/s).

The next discharge is the Ashcroft sewage treatment plant (PE 420). Prior to 1982, the north Ashcroft area was served by a separate system and permitted separately as PE 273. The Ashcroft area is presently served by a single treatment plant and discharge permitted as PE 420 (originally issued in 1971).

A summary of the data for the inflow effluent is given as Table 110 and the wastewater discharge from PE 273 as Table 111. The effluent data for PE 420 are summarized as Table 112. The Ashcroft sewage treatment plant uses secondary treatment and is permitted to discharge up to 2273 m^3/d. Monitoring is required for suspended solids, B.O.D., total phosphorus, flow and fecal coliforms. No chlorination is required because of fish toxicity concerns in the Thompson. However, because of the lack of chlorination, there is some concern for pathogens from sewage in the river.

There is a plant located in Ashcroft for treating railroad ties but there is no discharge from the facility so no waste discharge permit is required and no monitoring for effects done.

In the headwaters of Pukaist Creek, Highland Valley Copper (formerly Lornex) operates a copper mine which has some potential effect on the Thompson River. Permit PE 376 authorizes discharge of up to 176 m^3/d (yearly average - 341 m3/d maximum) of mine process water. This waste water is discharged to ground water either by septic tank or by spray irrigation in the May to October period. There are limits of 40 mg/L B.O.D. and 60 mg/L total suspended solids for the treated effluent. The disposal of this waste is in the Witches Brook watershed which drains to the Nicola System.

Some concern was expressed for water quality of Pukaist Creek due to the mine operation (file memo, Kamloops office, from Environment Canada (Ito), July 31, 1980) because of higher sulfate, conductance alkalinity and hardness and possible increases of molybdenum and phosphorus. There was also some evidence of elevated copper in fish tissue. At that time there was no evidence of any effects in the lower part of Pukaist Creek. Summaries of data collected by the Ministry for ambient conditions are given in Tables 113 - 121 (113 Pimainus Creek, 114 and 115 Pukaist Creek, 116 Woods Creek, 117 - 119 dam seepage, 120 for Upper Pukaist and 121 for a lower tailings pond). The data were collected irregularly from 1972-81 and show some evidence at most stations of elevated metals but no other notable aspects except for occasional high values of colour or phosphorus. Other associated sites with data are 0600516-519, 0600187, 0600324, 0601006 but the data are too few to interpret. Flow data exist for Pukiast Creek collected over 1967-77 below Woods Creek at 08LF069 (103 km^2, mean flow 0.119 m^3/s) and at 08LF036 in the 1920's and show relatively low seasonal flow. The very low input of water volume would mean that there would not probably be any measurable effect on the Thompson river itself.

DeKalb Mining Corporation operated an underground mine and ore processing plant in the headwaters of Inkikuh Creek in 1980-81 and was authorized to discharge by permit PE 405. The mine had originally operated (as the Alwin Mine) in 1917-18 and again in 1971-74. The mine produced copper concentrate with commercially extractable amounts of gold and silver. The operation was a crushing, grinding and flotation system producing 750 tonnes per day of concentrate and using about 30,000 Igpd of water. A mine description and site inspection are contained in Hallam (1980). The mine was in operation from 1917-18 and 1971-74. The operation was a relatively small one and the observed effects on water quality of Inkikuh Creek were small, and thus the effects on the Thompson River would be expected to be insignificant.

Any evidence of negative effects of these two mining operations (Lornex and the DeKalb mine) on stream water quality entering the Thompson is difficult to find. The DeKalb mine is no longer operating and monitoring data are sparse, but it seems unlikely that any major effect on the Thompson River would occur as a result of this operation. The much larger and continuing operation of Lornex (see Section 6.3) in the headwaters of Pukaist Creek has more data associated with it but no obvious consequences are apparent on water quality.

6.4 WATER QUALITY

The lower Thompson River between Kamloops Lake and the Fraser River is a distance of approximately 100 km. This reach has received the most attention and effort to document water quality. The important stations on the Thompson and the inflow streams are discussed below.

6.4.1 Lower Thompson River at Savona

This station (0600004, Figure 17) is used as a monitoring point for the pulpmill and sewage treatment plant discharge upstream, as well as an index for potential changes downstream. Data were collected by the Ministry from 1971 to 1982 as part of provincial or federal-provincial studies and are summarized in Table 122. Considerable amounts of other data have been collected at this location by Weyerhaeuser as a condition of their permit. These data are contained in their annual monitoring reports and only selected data are discussed here.

The data in Table 118 show a number of high values, some of which appear to be errors; if the data were accurate, there would be some cause for concern. A dissolved oxygen measurement of 4.8 mg/L is very low and would be a cause for concern if more similar data were additionally present to confirm it. It would appear to be an isolated and perhaps erroneous measurement. An analytical result for ammonia of 49.4 is almost certainly an error. There are a number of instances where relatively high concentrations of metals (copper, lead and zinc) have been measured, some which exceed ambient water quality criteria for the protection of aquatic life. Because this is a highly mineralized area, ambient natural background levels of metals (particularly in the particulate form) like copper might naturally be high. A better definition of background concentration is needed.

From the Weyerhaeuser data at Savona, a number of generalizations can be drawn. True colour over this period varied over a relatively narrow range, from less than 5 units to up to 15 units, averaging 7.5 true colour units (and 8 TAC units). This is, by this very rough comparison, higher than either the North Thompson at North Kamloops (6.5 TAC units) or the South Thompson at Pioneer Park (mean of 3.4 TAC units). The additional colour from Weyerhaeuser has been identified for some time and the subject of colour in the Thompson River system is examined in detail (annual periodicity, time trends) in section 6.5.2. Similarly, there are increases in the mean values of several characteristics in comparison to data from the North and South Thompson (see Table 123). These include conductance, total organic carbon, chloride, nitrate, and sodium. Interestingly, there are reductions in some characteristics, probably due to the presence of Kamloops Lake and the loss of particulate fractions of some constituents, particularly total residue (which includes non-filterable), turbidity, and Kjeldahl nitrogen (likely some sedimentation of organics in the lake). Total phosphorus also decreases for the same reason. The apparent trend for total dissolved phosphorus from this data set is for an overall higher value for Savona in comparison to the South Thompson, but a decrease when comparing the North Thompson and Savona. In the latter case, this may be an artifact of the difference in sampling dates and some data of questionable quality and particularly the difference in flow. From the data summarized here it would appear that if a weighted mean is calculated, i.e. taking into account the contributory flow (40% south Thompson, 60% North Thompson) from each source and the mean concentration for each (4 ug/L for the South Thompson and 5.6 for the North Thompson), the calculated result (4.96) is almost identical to the mean recorded for the site (5 ug/L). Other data (e.g., Bothwell 1985) show a different pattern of phosphorus concentration. Phosphorus contributions to the river are discussed in detail in Section 7. The interpretation of the components of total phosphorus and relative bioavailability is difficult since factors like the presence of colloidal apatite in the North Thompson and its reduction in the lower Thompson have to be taken into account.

6.4.2 Deadman River

Proceeding downstream from Savona, the first input which influences the Thompson River is the Deadman River. A summary of water quality in the Deadman River at the mouth (site 0600117 Figure 17) is given as Table 124. Since it drains a relatively dry watershed, the water quality at the mouth of the Deadman reflects this. The total and dissolved residues are high (202 and 173 mg/L) compared to the Thompson (62 and 60 mg/L) and several other related characteristics (conductance, alkalinity, silica, sulfate, calcium and magnesium) show similar higher concentrations. The Deadman also shows high colour (23 true colour units, 15 TAC colour units) and fecal coliforms (78.6/100mL). The available nutrient data show some relatively high phosphorus concentrations but nitrogen is not particularly high. The flow of the Deadman is sufficiently small (mean flow 1.7 m^3/s or approximately 0.2% of Thompson at that point) that only a localized effect at the confluence would be expected.

6.4.3 Walhachin

A water quality monitoring station was sampled on the lower Thompson between 1975 and 1980 at Walhachin (site 0600163,). A summary of the data collected by the Ministry show, not surprisingly, little difference between values collected there (Table 125) and at Savona (Table 122). Walhachin is one of the downstream monitoring sites (the other being Savona) monitored by Weyerhaeuser as part of its permit. There are considerable, largely uncompiled, data available.

6.4.4. Bonaparte River

The next station downstream for which data exists is for a location just above Ashcroft and above the confluence with the Bonaparte River (site 0600325, Figure 17). The data for 1973 to 1978 are summarized in Table 126. The results again are quite similar to Savona, but there are minor increases in a number of characteristics. Because of the small amount of inflow (0.7% of the flow of the Thompson River at this point) it would not be expected that the water quality of the Bonaparte would have a measurable effect on the Thompson.

The inflow of the Bonaparte represents a significant difference to the water quality of the Thompson. Tables 127 and 128 summarize the data for 1978 and 1979 and 1985 to 1988. The Bonaparte is high in dissolved ions, nutrients and fecal coliform bacteria (agriculture, the Clinton STP and the Cache Creek STP). In comparing the two sampling periods (Table 129), there are a few notable differences but the data are really not sufficient to provide the basis for a good comparison. The change in suspended sediments, turbidity, Kjeldahl N and total P may all be related to differences in sample size or time of the year or other circumstances. There was an increase in some other general ions. It is unclear whether these changes relate to changes in upstream activities or whether they are a reflection of different annual hydraulic regimes.

6.4.5. Nicola River

The Nicola River (Table 130, site 0600007, Figure 17) is the largest tributary input into the Lower Thompson. The flow at the mouth averages 28 m^3/s in comparison to 783 m^3/s for the Thompson at Spences Bridge (i.e., 4% on average). The Nicola has somewhat higher colour, twice the dissolved ion concentration, generally lower nitrogen constituents but higher phosphorus and relatively high metal concentrations (copper, lead, zinc). There are some anomalies in that the means for dissolved copper and zinc are higher than the means for total metals. The reason for this may be contamination or simply a statistical quirk due to uneven sample size and lack of paired samples. The river also carries relatively high concentrations of fecal and total coliform bacteria and suspended sediment. The effect of this large input on the overall water quality of the Thompson is expected to be minimal. The effects of the Nicola would be expected to be found in the mixing zone since the dilution would be about 25:1 after complete mixing.

6.4.6. Spences Bridge

The most downstream water quality station on the Thompson River is at Spences Bridge (sites 0600005 and E206586, Figure 17). This site has by far the best set of data of any site in this study area. Regular data were collected here from 1966 to 1976 (0600005) and intensive trend monitoring began in 1985 (E206586 also data stored on NAQUADAT 00BC08LF0001) and has continued on a bi-weekly or monthly basis since that time. The trend data provide the best descriptions of annual patterns of water chemistry for any location in the basin and the most frequent and systematic program. A summary of the 1966-76 data is given in Table 131 and a summary of the 1984-90 data as Table 132. Table 133 gives a comparison of the two time sets in an attempt to evaluate changes over time. There are a number of characteristics which increase (colour, conductivity, chloride, nitrate, calcium, sodium, sulfate and phosphorus). All of these are water quality characteristics which might be affected by discharges from a pulp mill.

In comparing the mean value for the two sets, it would appear that most characteristics have increased. The exceptions are non-filterable residue (suspended sediments) and turbidity. This is likely a reflection of the low flows occurring in these years. Silica and dissolved phosphorus have decreased marginally. An apparent decrease in pH is due to an analytical problem rather than a real trend (Clark 1991). The increase in the other characteristics may be a reflection of anthropogenic activities or lower flows.

Recent Water Quality Conditions in the lower Thompson

In 1985, a cooperative agreement between the Federal and Provincial governments was the basis for the establishment of the trend monitoring station near Spences Bridge mentioned above. At this site, a variety of water quality characteristics are monitored every two weeks. The purpose of the site is to provide a data set to determine water quality trends (on a five or ten year basis). At this time, about five years of data have been collected but the data have yet to be evaluated in detail. This station is one of a network of sites around the province which will be evaluated in the next four or five years.

The data that have been collected at this site provide the best data set which is available for the Thompson River system and some of the data show interesting patterns (Figure 18).

Because of the unusual runoff regimes from 1986 to 1988, the dominant factor in year to year (and seasonal) changes is probably hydrology. Figures 18a-f show the distinct annual cycle of conservative characteristics such as dissolved anions and cations. Both sodium and chloride (often used as bleached kraft mill effluent indicator) show increased concentrations in winter during low flow and decreases in spring and summer when freshet dilutes the concentrations. Alkalinity and specific conductance (Figure 18 c and d) show a similar pattern, as do calcium and hardness (Figure 18e and f).

A variety of other characteristics show different patterns. Colour shows peaks both in freshet and at low flow, reflecting inputs of natural colour and colour from the pulpmill (Figure 18g). This distinctive pattern is quite different from the annual cyclic pattern of anions and cations. Turbidity, as might be expected, shows peaks in freshet, but the very low flows of 1987 and 1988 are reflected in the low turbidity of freshet in those years. Nutrient concentrations (18 j, k and l) show interesting results where dissolved nitrogen shows some cyclic hydraulic related pattern, dissolved phosphorus seems to be almost random, and the high peaks of total phosphorus reflect the particulate fraction. As noted above, the pH data are confounded by disparate results during 1987 and 1988 by Environment Canada and B. C. Ministry of Environment (Figure 18 i). It has been determined that the federal data were inaccurate prior to May 1988 (Clark 1991). There are at least two very questionable data points in 1990.

The last three figures show characteristics with surprising concentrations. Figure 18l shows fluoride with some relatively high results (possibly due to particulates?) but below levels which would be a human health concern (mottling of tooth enamel). Arsenic was detectable in most samples, but values were well below the drinking water criterion of 0.050 mg/L. Copper was analyzed as total copper which includes much in particulate form, and shows a relatively high concentration over the period. (Figure 18n). Derksen (1986) reported higher copper in the muscle tissue of mountain whitefish in the lower Thompson than the North Thompson. Dissolved copper would be a more useful indicator of potential problems in this highly mineralized area. The significance of these results has not yet been established but there are some documented problems with samples analyzed by the federal laboratory. Sample contamination due to bottle washing and failure of preservative vial lids may be responsible for elevated copper and zinc in some samples.

6.5 PROVISIONAL WATER QUALITY OBJECTIVES - LOWER THOMPSON

The discussion of water quality and potential objectives has been limited to the discussion of five major concerns: algal biomass (periphyton), colour, chlorinated organic compounds, resin acids, and biological pathogens (bacteria and viruses). A variety of other issues exist, particularly trends or changes in the interdependent biological communities of the river. Very important aspects such as the fishery populations and fisheries habitat have not been considered here but should be the subject of some future detailed review. The existing data with regard to benthic stream invertebrates has been reviewed by Derksen (1988). Another issue, that of taste, colour and fish tainting in the lower Thompson, has been the subject of many earlier studies, but little information from the past few years is available (see Kovaks 1982, Kovaks and Voss 1985).

6.5.1 PERIPHYTON IN THE THOMPSON RIVER: DISCUSSION AND WATER QUALITY OBJECTIVES

6.5.1.1 Background

Excessive algal biomass in the lower Thompson River in the early 1970's was a source of considerable concern. The most compelling information which conveys the extent of the problem are the photographs of algal biomass shown in Langer and Nassichuk (1975). However, there are considerable amounts of data, which must be the basis of any evaluation of the situation if quantitative guidelines (water quality objectives) are to be proposed to protect the present and future uses of the river.

Considerable work has been carried out since 1973 to answer questions regarding what has been perceived, in the 1970's at least, as excessive algal growth in the Thompson River below Kamloops Lake. Along with the complaints regarding change in water colour and tainting of fish flesh, the problem of dense mats of accumulated algae in the river resulted in numerous objections from fisherman who encountered the hazard of poor footing in the river caused by the thick slippery algae covered rocks. Others were upset with the general aesthetics of the brown slimy algal accumulations and by concern for potential effects on fisheries (egg survival, changes in the number or type of fish food organisms). Minimal data (one pink salmon survey) suggest the increased algal growth increased fish survival.

The existing data for periphyton are in a variety of disparate reports. The initial investigations were reported in Langer and Nassichuk (1975). Some of these data were re-worked and reported in Olan (1976). Weyerhaeuser, as a requirement of its permit, collected periphyton (and benthic invertebrate data) from about 1975. The information is contained in Weyerhaeuser (1978), Weyerhaeuser (1980) and Anderson (1981). At the same time, the Waste Management office in Kamloops was also collecting data with an emphasis on Chase - some of which is contained in Holmes (1979) and some retained on the Ministry data base (EQUIS) in an uncompiled, uninterpreted form. Environment Canada's work from 1981-1986 was research oriented rather than the previous emphasis on documentation and monitoring. That ongoing research brought to light a range of valuable information, but did not elucidate long term-trends in periphyton biomass and response to changing environmental conditions.

The following examination of the causes of the algal accumulation and the pattern of growth (location, annual pattern, changes over the year) is based on a summary of the numerous sources of data and research information available. For details of some of these aspects, reference must be made to the original material since this summary is not meant to be comprehensive but to present an overall perspective.

There are a series of questions which have been considered (and are still being considered) with regard to algae in the river. The basic questions of where the problem occurs (geographically) and the time of the year the heaviest accumulations occur were considered in the earlier reports. Langer and Nassichuk (1975) and Olan (1974) provide the earliest data on Thompson River algal growth and describe the heaviest algal accumulation at the outlet of Kamloops Lake at Savona, but with significant amounts of algae downstream at Walhachin and perhaps as far as Ashcroft. Few detailed data exist in any reports for affected locations other than Savona and Walhachin. The period of concern has been identified as the January to April low flow period. Some noticeable growth may also occur in October due to suitable conditions at that time. The St. John et al. (1976) report provided the critical explanation as to why the algal growth at Savona occurred in spite of the presence of Kamloops Lake which would have been expected to provide an apparent larger dilution between the nutrient sources and problem locations. During the low flow period, the Thompson River flows across the surface of the lake in a coherent stream such that very little mixing occurs. The character of the river at the lake outlet at Savona is very similar to what it is as it flows into the lake downstream from Kamloops. (see also Bothwell et al. 1991).

From the initial evaluation, phosphorus from the Kamloops sewage treatment plant and pulpmill were implicated in the increased algal growth (Kussat and Olan 1975). However, there was little direct evidence of this until the research by Bothwell was undertaken to evaluate, on a detailed basis, the physiology of the Thompson River periphyton (Bothwell 1983, Bothwell and Jasper 1983, Bothwell 1985, Bothwell 1988).

In the first detailed report on the work undertaken on periphyton in the Thompson, Bothwell and Daley (1981) concluded that phosphorus levels in the lower Thompson (below Kamloops Lake) were significantly higher and that the algal growth rates were also higher than for periphyton growing in similar experimental troughs at sites on the North Thompson or South Thompson. In retrospect, the growth rate conclusion is supported by data collected earlier by Langer and Nassichuk (1975) but was never evaluated with that perspective. Bothwell and Daley (1981) concluded that the nuisance growths of benthic algae in the lower Thompson River were caused by elevated levels of phosphorus and that this phosphorus originated from Weyerhaeuser pulpmill and the Kamloops sewage discharge. The joint research program of Weyerhaeuser and the National Water Research Institute (Bothwell and Jasper 1983, Bothwell 1983, Jasper et al. 1984) provided the basis for a series of investigations which have been on-going since 1980.

Bothwell (1985) reported that the periphyton growing in the experimental troughs on the North, South and lower Thompson Rivers required very low concentrations of soluble reactive phosphorus (3-4 ug/L) to maintain high growth rates. Further research using a facility at Chase to further investigate this phenomenon, found that growth rate saturation occurred at concentrations of 0.3 to 0.6 μg P/L (Bothwell 1988, Bothwell, Jasper and Daley 1989).

The implications of these findings were discussed by Bothwell et al.(1989) in relation to environmental protection and management. Since very low levels of phosphorus satisfy the nutritional needs of periphyton, it may be that nutrient input increases were not as important as originally concluded by the federal-provincial task force. With regard to the cause of algal growth in the lower Thompson River, the present policy of removing phosphorus from sources such as the City of Kamloops sewage treatment plant or considering same for the Weyerhaeuser pulpmill would cause only minor reductions in the algal biomass unless overall reductions are greater than 90% (Bothwell et al. 1989).

This fundamental change in interpretation which arises from Bothwell's ongoing research program has some support in the existing data. By best estimates available (Derksen 1988 see Table 134) between 1976 (and prior) and 1986, total phosphorus loadings have been reduced about 33% during the critical winter period. According to Bothwell's interpretation, this should not have any measurable effect on the standing crop of periphyton in the lower Thompson. In looking at reductions in total dissolved phosphorus and "available" phosphorus data given by Derksen, the reductions are higher - approximately 50% for each fraction. According to the relationship described in Bothwell et al. 1989 (his Figure 12) a 50% reduction in phosphorus concentration translates to an 18% reduction in periphyton biomass. This amount of change should be measurable in the river if detailed sampling results were available.

One difficulty with this trend evaluation of phosphorus loading is the change which occurred in 1988 as a result of substantial increases in loadings from the pulpmill. Derksen's data (Table 134) show loading rates in that year which approach those of the mid-1970's. Data cited below show river phosphorus concentrations which also are similar and periphyton standing crops which are comparable to the "problem" times of the mid-1970's.

6.5.1.2 Quantitative Data

Considerable difficulty exists in interpreting the existing periphyton data on the Thompson River. There are a variety of collection, analytical and interpretive differences between the different studies and very large time gaps in the data. Despite this there are some general observations which can be made.

The lack of periphyton biomass data for 1980-1988 is the major shortcoming in evaluating the changes which have occurred since the mid-1970's. A particularly important question is the response of periphyton to the change in phosphorus input. Although Bothwell's assessment indicates that only a minor change should have taken place in periphyton standing crop, a variety of individuals who were familiar with the conditions in 1974-1978, or who took part in the studies at that time, were of the opinion that the 1980-1988 periphyton biomass was only a fraction of what it was in the mid-1970's. No periphyton biomass data were collected from 1980-1988, so no quantitative information is available to provide an objective comparison.

Some conclusions on the following areas can be drawn:

1. Artificial versus natural substrates. It is clear that natural substrates support much higher biomass than artificial substrates. In the only data sets where both collection techniques were used, the standing crops of natural substrates were anywhere from 2 to 50 times greater. The variation is very wide but the average difference is about 20 fold. Thus, some of the data from Langer and Nassichuk (1975), the Weyerhaeuser ambient data (1977 - 1979) and much of the Ministry of Environment data, are of limited value and can only be used for very approximate comparisons of different locations at the same time and a very gross inter-study comparison or time comparison. None of the artificial substrate data are a good indicator of what the algal biomass in the river was like when the samples were taken. The most valuable data are the samples taken from natural substrate and reported in Langer and Nassichuk (1975) and in the Ministry of Environment data for 1976 - 1977 (Table 135) and 1989.

2. Upstream/downstream patterns of growth. The data of Langer and Nassichuk, also reported in Olan (1975) (see Table 136) and the Ministry of Environment data, all indicate that the algal biomass is higher in the lower river than either the North or South Thompson River. Bothwell and Daley (1981) reported that growth rates were also higher in the Lower Thompson than at sites above the confluence. Bothwell and Daley demonstrated that the higher growth rates were coincident with higher available phosphorus levels.

3. Quantification. Because of the use of artificial substrates, quantified estimates of algal biomass on natural substrates in the river are rare. A second problem is the measurement units used. The standard, conventional measurement of biomass is chlorophyll a. However, chlorophyll may be measured as total chlorophyll (e.g. chl a, b, c, etc.) or include the chlorophyll degradation products, phaeophytins. Often these details are not given. However, it seems clear that in 1973 - 1974 (Langer and Nassichuk) and 1976 - 1977 (Ministry of Environment data), the biomass measured on natural substrates was very high during the period of optimal growth (March and April) and exceeded 250 mg/m^2 chlorophyll a (Table 135).

   Even more difficult problems exist with other quantification techniques. Dry weight or ash-free dry weight have both been used. Unfortunately, their correlations with chlorophyll a are very poor. Biomass values given in Langer and Nassichuk (1975) are predominantly from artificial substrates as is the Weyerhaeuser data from the late

1970's. Data from 1989 (British Columbia Ministry of Environment) include ash-free dry weight and corresponding chlorophyll a values. Both chlorophyll-a and ash free dry weights from natural substrates were more than an order of magnitude larger than from artificial substrates.

4. Time trends. In examining the data set as a whole, there are some indications that there has been a reduction in algal biomass over the period of record. However, the data are too ambiguous to come to form a definitive conclusion. The different sites, different methods and different times make an evaluation difficult. The data in Table 135 represent the best baseline from which to determine whether there has been a change over time in the amount of periphyton in the river. From those data, there is no convincing indication that there has been a change.

Table 136 is modified from Olan (1974) and shows a typical data set which can be used to draw a number of conclusions about the Thompson River. As Olan noted, the downstream sites (Savona, Walhachin) have a higher standing crop than the upstream sites (Chase, McLure). The surprising fact is that the amounts of average biomass from these Plexiglas substrates is relatively low; the highest samples in terms of peak biomass are in the 20 mg/m^2 range and would, on that basis, using present criteria (which are based on biomass on natural substrates), not be considered a problem. Table 135 shows a summary of averages (monthly biomass) for the periphyton for 1973-1980 from artificial substrates as chlorophyll a only (chlorophyll plus phaeophytin would increase the values by 25-40%). What this summary table shows is that mean monthly chlorophyll a values at Savona and Walhachin were at times very high for artificial substrates (30-60 mg/m^2 March and April 1977), but still not comparable with nuisance levels on natural substrates (>50 mg/m^2, see Nordin 1985, Welch et al. 1988). It would appear that the data expressed in this way may be useful for comparison of periods or for long-term trends, but is not useful for comparison to provisional water quality criteria which are based on biomass from natural substrates. What the data do show is a very wide range of variability - on a monthly basis or a yearly basis for any individual site, and no particular year to year change in biomass. What has particular interest is that there seems to be no difference in periphyton biomass between the years prior to the removal of the winter sewage discharge from the city of Kamloops (1974-75) and the later years (1976 and following) when this nutrient source was curtailed. This gives some support to the contention in Bothwell et al. 1989 (noted above) that no response in algal accumulation would be expected unless the nutrient input reduction were substantial (>90%). One other point from the data is that here appear to be higher biomass accumulations in the month of March, on average, than other months. Table 138 shows a summary of Table 137. The comparison is somewhat confounded by high biomass at Chase. This site appears to have been inappropriately chosen because, in several years, low flows left sampling plates in back eddies where accumulations became very high (see Langer and Nassichuk 1975, p. 25). Also it has been noted (Derksen pers. comm.) that the benthic invertebrate community was significantly changed in years of dominant runs of Adams River sockeye. For periphyton, there also seems to be an effect. The standing crop in 1979 (a year with a large return) is relatively high reflecting the nutrients released by the salmon carcasses. In comparing upstream and downstream sites, it is easily seen that the Savona and Walhachin sites have consistently higher biomass than the upstream sites, generally 2-10 times the biomass.

There is a considerable amount of other information for algal biomass in terms of dry weight or ash-free dry weight (volatile solids) which appears to show the same kinds of patterns as the chlorophyll a. A correlation analysis between chlorophyll and ash-free dry weight was done to evaluate the latter as an indicator of algal biomass rather than chlorophyll a. The ash-free dry weight measurement has the advantage of providing an estimate of dead algal cells, algal mucilage and other material, as well as living algal tissue, which may all affect water use.

Table 139 gives a summary of the Langer and Nassichuk (1975) data with correlations between total chlorophyll (including phaeopigments and called "total pigments") and ash free dry weight (volatile solids). The correlation varies considerably between stations from an r^2 of zero at Chase to an r^2 of 0.2 at Savona. This would indicate that the two are not closely related and that both measurements might need to be used to evaluate algal biomass. Correlations were also calculated between dry weight and both total chlorophyll and volatile solids.

A ratio for total pigments (chlorophyll a+b+c+ phaeopigments) to volatile solids was also calculated with results ranging from 0.2% to 0.7% of the volatile solids depending on the site (Table 139). Horner et al. (1983) reported that 0.5 to 1% of the volatile solids (ash free dry weight) corresponds to chlorophyll a. If, for the Thompson River, the chlorophyll a concentration only is considered, the ratios are obviously somewhat lower (Chase 0.09%, McLure 0.2%, Savona 0.2%, Walhachin 0.4%). What this appears to reflect is a community structure (primarily diatoms) in which many species have large amounts of gelatinous sheath material thus causing low chlorophyll to volatile solids ratios.

The above data address the problem of setting water quality objectives for periphyton biomass. Several questions should be considered. These include what biomass measurement should be used (chlorophyll a, total chlorophylls (a+b+c), chlorophyll plus phaeophytin, dry weight, volatile solids); what the objectives levels should be for specific water uses; and how the measurements should be taken (artificial/natural substrates). With regard to the first question, the preferred choice appears to be chlorophyll a since this appears to be the most commonly used biomass indicator, particularly in defining problem levels of periphyton biomass (e.g., Welch et al. 1988). However, as noted above, some measure of non-photosynthetic material (volatile solids/ash-free dry weight/carbon content estimate) which contributes to aesthetics or visually observable biomass, oxygen depletion or cementation problems should be taken into account.

The criteria values selected must also take into account the sampling technique. As noted above, algal biomass from natural substrates rather than artificial substrates has a number of advantages (better measurement of in situ biomass, realistic community structure).

Recently, another interpretation of the nutrient/algae story of the Thompson River was presented. Bothwell et al.(1991) have put forward an alternative hypothesis to account for the massive growth of periphyton which occurred in the early 1970's and its subsequent decline. The basis of this view is as follows. The original conclusions of the Federal-Provincial Thompson River Task Force (1975) as well as Bothwell and Daley (1981), were that the periphyton community responded to the inputs of additional nutrients from the sewage treatment plant and the expanded pulpmill. The factor not considered at that time was that periphyton may reach high biomass for reasons other than an increase in nutrient supply. Grazing by benthic invertebrates, and the removal of grazing pressure, could result in a response similar to increased nutrients.

The expansion of the Weyerhaeuser pulpmill in 1971 (startup early 1972) was a major one. The initial start-up of the mill resulted in a number of spills of toxic materials during the winter and spring of 1972. More documentation is needed for these events. The presence of these pulpmill wastes caused either direct toxicity or, more likely, triggered an avoidance response (drift) by a component of the benthic invertebrates of the river. The combination of a substantial reduction in grazing pressure and a coincident stimulation of periphyton by increased nutrients resulted in the massive periphyton accumulations in the winter of 1972-73 and following winters.

The periphyton accumulations, and other changes such as the noticeable colour increase and foaming, were relatively sudden changes and were coincident with the pulpmill expansion start-up.

The problem of heavy algal mats persisted for several years because it may have taken an especially long time for the invertebrate community to recover. The recolonization rates in the lower Thompson would be expected to be relatively long since recovery is largely determined by downstream drift of organisms and the presence of Kamloops Lake isolates in this reach from upstream populations.

Unfortunately, the lack of data or even qualitative observations prevent the evaluation of this view. The major change from the previous interpretation that nutrients were the key, to the assumption that grazing invertebrates were the key to the algal problems, is supported by some indirect evidence. Derksen (1988) has documented the increases in stream invertebrate numbers (especially Trichoptera, and Ephemeroptera) and these groups would be expected to be important algal grazers.

In response to an increase in the numbers of stream grazers, a concurrent reduction in algal standing crop might be expected. Data collected in 1989 show a possible reduction in the amount of algal biomass between the 1970's and 1989 (Table 140-142). The reduction in natural substrate algal standing crop appears, on face value, to be significant. However, the question remains as to whether this is attributable to increased grazing pressure. It is also coincident with perhaps a 20-50% reduction in phosphorus input and so, *if* it is a real change (discussed below), to which cause is it attributable? Theoretically, if Bothwell's earlier work is extrapolated, the change in algal biomass should have been almost undetectable based on the documented reduction in phosphorus. Derksen (1988) has made a similar observation that there was no difference between the algal biomass in 1979 and 1980 after removal of the sewage treatment plant winter phosphorus input and the algal biomass in 1974 and 1975 when sewage phosphorus was being added to the river. Based on the Thompson River experience, it appears that there is need to evaluate the tools of the regulatory agencies

Bothwell (pers. comm.) proposed that an experiment be designed to evaluate the effect of additional nutrients on the lower Thompson by allowing the City of Kamloops to discontinue tertiary treatment for a specified period and discharge during the low flow period. This strategy has been previously proposed to assess the effects of nutrients on the Cheakamus River (University of Victoria/Ministry of Environment 1989). If Bothwell's views are correct, the effect of the increased phosphorus on the system should be negligible. The critical role of invertebrate grazing would also be tested by this technique. Bothwell has reported periphyton growth rates (u) of 0.3/d at $6^{o}C$ which, if ungrazed, would result in large periphyton standing crops. In most cases, the standing crop of algae is an equilibrium established between growth and grazing and physical limitation. If grazing pressure were to decrease by a minor amount (even 10-20%), biomass accumulations over even a short time (two weeks) would very quickly increase. A more sophisticated model could be used to test this possibility, but it would seem that if a major spill of toxic materials did occur, and a significant effect did occur through toxicity or avoidance by induction of drift response, the lower grazing pressure could account for the dramatic increase in algal biomass in the early 1970's.

Because of the lack of data noted previously for algal standing crop in the 1980's, a program was undertaken in 1989 by the B.C. Ministry of Environment also by Environment Canada (Bothwell pers. comm.) to provide additional data to use as a base of comparison to the data collected in the 1970's.

The data for the spring 1989 sampling are summarized in Table 141. It appears to show that, after relatively low biomass in February and March, a marked increase occurred in March, with biomass levels in the same range as data given in Langer and Nassichuk (1975). As noted above, there appears to be a reduction in biomass but considering the unusual hydrologic regime of 1988-89, the analytical differences, the annual variability and other factors, the differences between 1989 and the 1970's data are not as significant as it might appear. The periphyton biomass in 1989 was particularly noticeable at Walhachin and appears to indicate that relatively high algal standing crops were present, as occurred in the 1970's. The major difference appears to be that there is no perception that a problem existed in 1989 (no public complaints)! The difference is probably due to the reduced fishing activity (fishing closures). Initial complaints in the 1970's came from fishermen who complained about the lack of footing on the slimy rocks and fouling of fishing gear. There may also be fewer complaints possibly due to an acceptance over time of an increase in periphyton biomass as being a normal appearance of the river.

The nutrient concentrations (Table 142) in 1989 appear to be relatively high (again difficult to compare directly), but seem to be similar to the 1970's partly due to the very low flows of the winter of 1988-89.

From the 1989 data (Table 140), it appears that a much wider difference in periphyton biomass between artificial and natural substrates existed than with the earlier data of Langer and Nassichuk. It is unclear, therefore, if a set ratio between results gathered with artificial substrates or from natural rock substrates can be used.

The existing environmental data can be used to shed light on a number of questions but, because of the fragmented nature of the data, few firm conclusions can be drawn. The obviously important question of the quantitative effect of the two major discharges (pulpmill and sewage treatment plant) on the algal biomass of the lower Thompson is, at this time, unanswered.

6.5.1.3 Objectives

The criteria developed for British Columbia suggest that values greater than 50 mg/m^2 chlorophyll a on natural substrates exceed desirable biomass levels for recreation and aesthetics (Nordin 1985). For protection of aquatic life, 100 mg/m^2 was proposed. In examining the data for Savona and Walhachin (section 6.5.1.2), it would appear that levels equivalent to these (i.e., 20 and 40 mg/m^2 on artificial substrates using a factor of 2.5) were often exceeded in the early and mid-1970's. Equivalent criteria for volatile solids would probably be in the 6-7 g/m^2 range for recreation and 12-15 mg/m^2 for protection of aquatic life. A study on the coastal Cheakamus River system (University of Victoria/Ministry of Environment 1989) proposed periphyton objectives of 25 g/m^2 and 50 g/m^2 (as ash free dry weight) for aesthetics and fisheries respectively.

An earlier review of the Thompson River data was done in establishing the 1985 criteria. It was concluded that the periphyton biomass that existed in the mid-1970's exceeded that which was generally acceptable to the public, and that 50 mg/m^2 chlorophyll a was a reasonable threshold for acceptance by the public for recreational use. The criterion for aquatic life (100 mg/m^2 chlorophyll a) was also partially based on the Thompson River data and the perception that a change had occurred in the benthic invertebrate community. This, presumably, was due to the effects of the increased algal biomass changing the environmental conditions sufficiently to cause changes in the community structure of the stream invertebrates.

Since that time, it has been suggested that the changes in the invertebrate community may have been caused by other factors. As well, some studies on other rivers have been reported which indicate that levels of periphyton standing crop comsidered very high (100 mg/m^2) may not negatively affect benthic invertebrate communities or fish communities (Perrin et al 1987, Perrin and Johnston 1985, Johnson et al. 1990). There is still concern, however, that risk of intra-gravel oxygen depletion, interference with spawning, changes in food availability and habitat structure for benthic invertebrates, or creation of reservoirs of nutrients or pathogens could occur at periphyton densities of greater than 100 mg/m^2.

For the Thompson River, maintaining the aesthetics and recreational quality of the river remain as concerns. The objectives proposed below are keyed to that water use rather than the more difficult, and presumably less sensitive use, as aquatic life habitat. Rather than using a two-level biomass criterion for algal periphyton using both chlorophyll a and volatile solids or ash free dry weight as measurement techniques, it would appear that using chlorophyll a, with its background of data both here and in the scientific literature, would provide the best measurement of periphyton biomass.

For algal biomass measured as chlorophyll a, the objective value is 50 mg/m^2 on natural substrates, using multiple subsamples (replicates) (6-10) to account for the inherent variability of stream periphyton.

This objective apply to all areas of the lower Thompson below Kamloops Lake.

6.5.2 COLOUR IN THE THOMPSON RIVER: DISCUSSION AND WATER QUALITY OBJECTIVES

The issue of aesthetics with regard to the water quality, specifically colour, of the Thompson River is one which has continued for more than 20 years. In contrast to many other problems, there is general consensus that the source of the problem is the pulp mill. The data reasonably demonstrate that the pulp mill contributes a significant amount of colour to the lower Thompson River. The mill has spent considerable time and effort to reduce the amount of colour it discharges to the environment; however, it remains a concern in this case as it does in many other pulp mills around the world. In this system, the problem appears to be confined largely to the period of low flow in the river. The number of complaints related to colour in the river appears to have decreased over the years but it is unclear whether this is a result of an improvement over time or public acceptance of the situation or changes in river use.

Colour was identified as one of the major sources of concern in the early 1970's. In examining the colour data, the dominant factor is the changes which have occurred at the pulpmill.

The first problem is the variety of methods for colour measurement which have been used at various times in monitoring the Thompson River. Four different methods of colour analysis have been used for the Thompson River. In very simple terms, the differences between the methods are as follows. "Apparent" colour is measured on an untreated sample and measures both suspended and dissolved materials in the sample. "True" colour is the method specified in most drinking water standards. The analysis is done on a filtered (or centrifuged) sample so that only dissolved (and colloidal) substances are measured. Both True and Apparent colour are measured in reference to a Pt-Co scale. "TAC" colour (Total Absorbance Colour) measures integrated absorbance on a pH- adjusted, filtered sample over wavelengths of 400-700 nm. It is suggested (CCREM 1987) that one unit of TAC colour is equivalent to 2 units of colour using Pt-Co standards, but this does not appear to be true for the Thompson River (see below). Single wavelength colour ("SWC") (465 nm) is measured on a filtered and pH-adjusted sample, and is particularly applicable to pulp mill effluent and has also been used by Weyerhaeuser for some ambient monitoring.

In an attempt to correlate the different colour measurement techniques, data from the Ministry of Environment, the Federal Provincial Study, and Weyerhaeuser were compiled so the data were summarized. Insufficient data were available for corresponding stations and dates to provide paired comparisons or to derive correlations which could be used confidently. The summary and results are given in Tables 143-151. Using these data, a number of examinations were made. One of the first questions was the correlation between different colour measurement units. In general, the correlations between the different types of colour measurement were poor. For McLure, there was a reasonable correlation between True colour and TAC colour ($r^2 = 0.863$), but data for Savona ($r^2 = 0.234$) and Spences Bridge ($r^2 = 0.085$) were much worse (Figure 19). Correlations for other combinations of measurements were not possible because of the lack of coincident measurements of different types on the same date.

Table 143 indicates, on a very simple comparative basis, that the difference between the relatively high colour of the North Thompson and the low colour of the South Thompson is significant. A comparison of the North Thompson and the Lower Thompson at Savona shows the latter to be somewhat higher due to the input of pulpmill effluent. The difference between Apparent and True colour indicates that much of the colour in the North Thompson is due to suspended material. The best time to evaluate colour in the lower Thompson is in the low flow period when the added colour of the effluent would be most clearly manifested. This is also the period when most public complaints about colour in the river are received.

Derksen (1988) evaluated winter colour data for 1978 to 1984 to examine the effect of the Weyerhaeuser Canada's colour reduction program which began in the fall of 1980. He concluded that for Savona and Walhachin, there seemed to be little significant change caused by the colour reduction program. The data cited by Thut (1988) in his Table 1 (reproduced as Table 151) might indicate that some decrease was achieved; however, since river flow has such a substantial effect on the dilution of the effluent, it is unclear if a reduction in river colour has occurred as a result of efforts to reduce colour in the pulp mill effluent.

In the context of this report, it is important to consider the effects on the environment that colour may cause. The basis of the concerns are primarily aesthetic (no direct toxic aspects) and are confined temporally (to low flow periods) and spatially (to specific sections of the river downstream from the lake). These factors become the basis for assessing the effects.

The section of the Thompson River above Kamloops Lake and below the mill discharge is obviously the area most affected by colour in the discharge. Few data have been obtained in this area; however, Olan (1975) shows colour values as high as 268 TAC units downstream from the diffuser in the spring low flow period (Table 148). Because there are few, if any, uses affected in this area, no objective for colour was set for this area.

Concern over colour has been expressed for the lower Thompson. The most consistent data set which is available is the ambient monitoring carried out by Weyerhaeuser as a requirement of its permit. A summary of these data are given in Table 149. What the data (SWC colour) show is a fairly consistent increase between either of the upstream stations and the two lower river stations. During the October to April low flow period, there is a consistent difference of 2 to 7 colour units based on the difference between the average upstream colour and the average downstream colour (Table 152). For particular dates, the upstream/downstream difference can exceed 10 units (North and South Thompson in comparison to Savona or Walhachin). Thut (1988) indicates that the difference for 1987/88 was generally 7-8 units. Table 150 summarizes the Kamloops Lake colour data. It shows that there is considerable interannual variation and the data for 1975 have high values for the low flow period (typically 15-45 SWC colour units)

Water Quality Objectives for Colour

The concern for the Thompson River is that the amount of colour should not limit uses of the river water. The primary complaints have arisen with regard to aesthetics, but drinking water is also a major consideration. The Guidelines for Canadian Drinking Water Quality (1989) specify a maximum of 15 True Colour Units. This is also the working criterion for both drinking water and recreation (Pommen 1989) for British Columbia, and it would be appropriate as an objective for the Thompson River (all reaches except the initial dilution zone downstream from the mill discharge).

Existing data can be reviewed from a number of sources, some of which have already been discussed. One of the larger considerations is the naturally high colour in the North Thompson system during early freshet. It may be that high values of colour are caused by land use activities in the basin (forestry, twin tracking of railway lines, general land clearing). There is some perception that colour has increased over time. Using the Weyerhaeuser data as an example, 8 of the 50 samples (16%) taken in the October to April period from 1977 to 1988 from the North Thompson exceeded 15 SWC colour units. The numbers of samples which exceed 15 at Savona and Walhachin in the same period is approximately the same (16%); however, the units are different and the frequency distribution is quite different with only two values exceeding 15 TCU since October 1981 (March and April 1988). This latter observation may indicate that the colour from the mill is having less impact since the initiation of colour removal, particularly since the flows in the 1987 to 1989 period have been very low and the effect of added colour would have been expected to be higher.

It would seem that a maximum of 15 TCU would appear to be a reasonable water quality objective for colour for the Thompson system. The only exception would be if the natural colour of the North Thompson River exceeded 15 TCU, then the Lower Thompson should not be more than 5 TCU greater than the mean of the North and South Thompson since they contribute approximately equal volumes to the Lower Thompson. For example, if the North Thompson were 18 TCU and the South Thompson were 8 TCU, the lower Thompson should not exceed: (18 x 0.6) + (8 x 0.4) +5 = 14 + 5 = 19 TCU, where 0.6 and 0.4 are the proportions of flow contributed by the North and South Thompson Rivers respectively. The only area where this objective would not apply would be the initial dilution zone of the pulpmill.

6.5.3 CHLORINATED ORGANIC COMPOUNDS IN THE THOMPSON RIVER: DISCUSSION OF WATER QUALITY OBJECTIVES

A major concern for the lower Thompson, is the potential contamination of the water, sediments and biota by chlorinated organic compounds originating from the bleaching process in the mill. For this reach of the river between Kamloops Lake and the confluence with the Fraser, the same provisional objectives apply: in water (0.2 pg/L 2,3,7,8-TCDD TEQ), in fish tissue (1.0 pg/g 2,3,7,8-TCDD TEQ (ww)), and in sediments (0.7 pg/g 2,3,7,8-TCDD TEQ (dw)).

6.5.4 RESIN ACIDS IN THE LOWER THOMPSON RIVER: DISCUSSION OF WATER QUALITY OBJECTIVES

Another group of compounds which are of environmental concern are resin acids. Resin acids are extracted during the pulping process and are present in pulp mill effluent. Ontario Environment has reviewed the toxicity of resin acids and produced a criteria document (Taylor et al. 1988). The provisional objective concentrations below are specified for dehydroabietic acid (DHA - a common resin acid and the most persistent of the group) and for total resin acids. Both sets of values are keyed to environmental pH. Their summary is given below.

RECEIVING WATER pH	CONCENTRATION (ug/L) DHA	Total Resin Acids
5.0	1	1
5.5	2	3
6.0	2	4
6.5	4	9
7.0	8	25
7.5	12	45
8.0	13	52
8.5	14	60
9.0	14	62

6.5.5 BIOLOGICAL PATHOGENS IN THE LOWER THOMPSON RIVER: DISCUSSION AND WATER QUALITY OBJECTIVES

One of the observations which is made for all the river reaches in the Thompson system is that bacterial contamination appears to be widespread and has a variety of potential sources. On the North and South Thompson, it appears that the primary sources are agricultural. On the lower Thompson, the sources are likely a combination of agricultural and domestic sewage discharges - both from sewage treatment plants and septic tank/tile fields.

The standard measure of bacterial contamination is the use of fecal coliform bacteria. There are a variety of shortcomings in using these indicators of potential human health hazards. Warrington (1988) has previously reviewed some of the problems associated with the use of indicator organisms. In the Thompson River basin area, the fecal coliform results represent a mixture of bacteria from human and animal feces. The fecal bacteria from animals are less of a risk to human health than fecal bacteria from humans. Thus, for those areas with high fecal coliform concentrations, a lower risk to human health might be expected if animals are the source of the fecal coliforms.

Fecal coliform testing may not be an accurate indicator of human health risk downstream from the Weyerhaeuser pulpmill. Klebsiella sp. is often in high concentration in pulpmill effluent. This bacterium is enumerated as part of the fecal coliform test, but does not pose risk to contact recreation or drinking water. Klebsiella is of concern in the aerosol form; for instance, close to aeration lagoons.

Warrington (1988) made a number of recommendations for sampling to protect against potential human fecal contamination. He recommended to monitor for Escherichia coli as well as fecal coliforms at all locations where water intakes occur. Bathing beaches have less stringent quality standards, but should be monitored for a wider range of indicators, including E. coli, enterococci, and fecal coliforms. Sampling might also be expanded to include Pseudomonas aeruginosa if the circumstances warrant. Current standards for the Ministry of Health (which has the jurisdiction in this area) for water intakes is to use fecal coliforms only. Present draft federal recreational water guidelines (Guidelines for Canadian Recreational Water Quality. 1990) recommend only fecal coliforms.

For the lower Thompson from Kamloops Lake to the confluence with the Fraser, it is proposed that the fecal coliform bacteria density not exceed 10/100 mL, (calculated as 90th percentile) for areas near water intakes to permit the use of the water for drinking after disinfection only. For areas where body contact recreation occurs, concentration of E. coli should not exceed 2000/L (geometric mean). A minimum of 5 weekly samples should be collected in a 30 day period for comparison with these objectives.

6.5.6 BIOLOGICAL COMMUNITY OR ECOSYSTEM OBJECTIVES

There are efforts from a number of jurisdictions to attempt to use what are presently called "ecosystem objectives". The concept is to use community structure or functional attributes of biological systems as indicators of environmental stability or health. To do this requires a detailed understanding of all the organisms in a particular ecosystem and the factors which affect them. For the Thompson River, this level of comprehension is not yet available. However, one biological indicator component which has already proved to be a useful indicator in the lower Thompson River is the population of stoneflies. These are very distinctive animals which spend much of their lives in the larval stage in the river and thus are subject to the changes in water quality. In the summer, the adults emerge and can be seen clinging to the cottonwood trees along the river especially in the Savona and Walhachin areas. One of the comments by fishermen and others using the river in the 1970's, when there were problems with heavy algal accumulations and concern about the general condition of the river, was that the annual emergence of the stoneflies was greatly reduced. Plecopterans are often regarded as relatively sensitive components of the stream benthic invertebrate community and would seem to be a potential indicator of the relative health of the overall biological community. A simple approach would be to define a base level of numbers of organisms in particular sites. This has been done for Lake Erie using the mayfly Hexagenia (Reynoldson et al. 1989). For the lower Thompson River, with an absence of detailed data on population numbers and annual variation, this particular approach will have to wait until more data are gathered before ecosystem or biological objectives can be used. However, this should be one of the goals for the future in this watershed.

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WATER QUALITY DATA TABLES

The following tables are summaries of the water quality data for stations along the Thompson River system. Many of the water quality characteristics are abbreviated for the purposes of fitting into the table. The full name and the units used with each characteristic are as follows:

colour true - true colour units
oil and grease - mg/L
pH - pH units
residue 105 (total solids) - mg/L
residue F 105 (dissolved solids) - mg/L
residue NF 105 (suspended solids) - mg/L
residue NF 550 (suspended organic solids) - mg/L
oxygen dissolved - mg/L
turbidity - nephelometric turbidity units (NTU)
settleable solids - mg/L
colour TAC - TAC colour units
colour SWC - SWC colour units
alkalinity - mg/L
total organic carbon TOC - mg/L
total inorganic carbon (TIC) mg/L
chloride - mg/L
cyanide - mg/L
fluoride - mg/L
hardness - mg/L
ammonia (NH_3) - mg/L
nitrate plus nitrite ($N0_3$/NO_2) - mg/L
nitrate - mg/L
nitrite - mg/L
nitrogen, total - mg/L
nitrogen organic - mg/L
nitrogen Kjeldahl - mg/L
Biological oxygen demand, five day (BOD) - mg/L
Chemical oxygen demand (COD) - mg/L
phenols, total - mg/L
ortho phosphorus (P) mg/L
total dissolved phosphorus - mg/L
total phosphorus - mg/L
silica - mg/L
sulphate - mg/L
surfactants - mg/L
tannins and lignins - mg/L
carbon, inorganic (IO) - mg/L
sulphide - mg/L
resin acids - mg/L
mercaptans - mg/L
arsenic - mg/L
boron - mg/L
cadmium - mg/L
calcium - mg/L
chromium - mg/L
copper - mg/L

iron - mg/L
lead - mg/L
magnesium - mg/L
manganese - mg/L
mercury - mg/L
molybdenum - mg/L
nickel - mg/L
potassium - mg/L
sodium - mg/L
zinc - mg/L
aluminium - mg/L
cobalt - mg/L
barium - mg/L
vanadium - mg/L
fecal coliforms - MPN/100mL (most probable number)
total coliforms - MPN/100 mL (most probable number)
bioassay - % effluent in 96h LC50 test
specific conductance - µmhos/cm or µS/cm
toxicity - 96-h LC_{50}

APPENDIX TABLE

Monitoring Sites with Minimal Data (not summarized or discussed in report text)

0600104	Island Creek (monitoring site for Dekalb Mine PE 00405) - 1 sample 1976.
0601032	Dekalb Mine - tail pond supernat. (monitoring site for Dekalb Mine PE 00405) - 2 samples 801203 and 810323
0601033	Dekalb Mine - tail pond seepage (monitoring site for Dekalb Mine PE 00405) 2 samples 801203 and 810323
0603002	Kamloops LK opposite Cherry Bi. - 3 samples 721016 and 730417 (2 same day)
0603003	Kamloops Lake South Tranquille School (monitoring site Kamloops Lagoon PE 00399) - 1 sample 721016
0600537	Tranquille Road at mouth (monitoring site for Tranquille School PE 01643) - no data
0600538	Tranquille Road at school (monitoring site for Tranquille School PE 01643) - 2 samples 750828 and 751030
0600539	Tranquille Road above school (monitoring site for Tranquille School PE 01643) - 2 samples 750828 and 751030
0600207	Bowers Brook (monitoring site for Afton Mines PE 03904) - 2 samples 771206 and 780615
0603054	Ned Roberts Lake at outlet (close to Afton Mines PE 03904) - 3 samples 760602, 760920 and 770615
0601051	Afton Mines influent to aerator (monitoring site for Afton Mines PE 3904) - 1 sample, 770920
0600168	Peterson Ck. below Jocko Lake - 5 samples, 760406, 760621, 780406, 780510, 790301
0603061	Jocko Lake at center - 3 samples, 761101, 770427, 780426
0603062	Jocko Lake near inlet - 2 samples, 770427, 780426

0603068	Bowers Lake at center - 2 samples, 770621 @ different times
0600349	Kamloops Lagoon - 3rd cell NW mon. well (monitoring site Kamloops Lagoon PE 00399) - no data
0600188	Reichold Chem. near Kamloops - 2 samples, 720421, 730124
0603000	Paul Lake near parking lot - 1 sample, 820421
0603065	Paul Lake near 5 cabins - 1 sample, 820421
0603066	Paul Lake at water intake - 1 sample, 820421
0603085	Paul Lake at exit culvert - 1 sample, 820421
0601036	On insert 4 map - name of station ?- no data
0600516	Woods Creek, upstream Pukaist Creek (monitoring site Lornex Mine PE 00376) - 1 sample, 740418
0600517	Pukaist Creek, above Woods Creek (monitoring site Lornex Mine PE 00376) - 1 sample, 740418
0600518	Pukaist Creek at water guage (monitoring site Lornex Mine PE 00376) - 2 samples, 740418 and 740516
0600519	Pukaist Creek below Lornex Tlg. (monitoring site Lornex Mine PE 00376) - 3 samples, 740418, 740516, 760311
0600241	Savona: Dey's Cafe- 1 sample, 830131
0603001	Kamloops Lake opposite Copper Creek - 3 samples, 721016 and 730418 (different depth)
0603036	Little Shuswap Lake at inlet - 1 sample, 750723
0603037	Little Shuswap Lake at SE end - 2 samples, 750723 (2 depths)
0603038	Little Shuswap Lake at NE end - 2 samples, 750723 (2 depths)
0603039	Little Shuswap Lake at Center - 3 samples, 750723 (3 depths)
0603040	Little Shuswap Lake at pier - 2 samples, 750723 (2 depths)
0603041	Little Shuswap Lake at outlet - 1 sample, 750723
0600234	Nicoamen River near mouth - 4 samples, 780816, 780928, 800619, 800806
0600052	Inkikuh Creek near mouth (monitoring site for Lornex Mine PE 00376) - 2 samples, 740528, 750731
0600058	Duffy Creek near mouth - 1 sample, 750622
0603078	Venables Lake - 2 samples, 780418, 780928
0603088	Barnes Lake at outlet? - no data
0603053	Duffy Lake at east end - 3 samples, 770519, 780517, 780621
0603056	Six Mile Lake at West End - 4 samples, 770405 (2 loc.), 780423, 790502
0603057	McConnell Lake at Center

- 4 samples, 761103 (2 depths), 770510, 780524

0603058 McConnell Lake at North End
- 2 samples, 770510, 780524

0603059 Pass Lake at Center
- 5 samples, 761118 (2 depths), 770509 (2 loc.), 780531

0603060 Pass Lake at North End
- 2 samples, 770509, 780531

0603070 Red Lake - middle
- 4 samples, 780207, 780823, 790925, 811124

0600165 Thompson River, Ashcroft?- no data

0600541 Tranquille River at Bridge #3
- 2 samples, 750828, 751030

0600184 Six Mile Creek above Six Mile Lake
- 1 sample, 760622

0600185 Six Mile Creek below Six Mile Lake
- 1 sample, 760622

0603002 Kamloops Lake opposite Cherry Bluff
- 3 samples, 721016, 730417 (2 depths)

0600420 Area of Cherry Creek?- no data

0600421 Area of Cherry Creek- no data

0600540 Tranquille River at scout camp
- 2 samples, 750828, 751030

0600113 Campbell Creek at BarnhartVale
- 4 samples, 740529, 750320, 750702, 760727

0600323 Chase: Matley Well (monitoring site for Chase STP PE 06293) - no data

0600247 Calling Lake Road Diversion (monitoring site for Lornex Mine PE 00376)
- no data

0600257 Sampling well, Gulf Oil NE (monitoring site for Gulf Oil PE 00419)
- no data

0600240 Ashcroft STP Dom. Water (monitoring site for Ashcroft STP PE 00420)
- 1 sample, 830131

0910209 Thompson River control (monitoring site for Kamloops Pulp PE 00144)
- no data

0910210 Kamloops Pulp predischarge (monitoring site for Kamloops Pulp PE 00144) - no data

0910143
144
145 Kamloops Lake Stations monitoring site for Weyerhaeuser PE 01199
146
147 - no data
148
149

0910150 South Thompson River (monitoring site for Weyerhaeuser PE 01199)
- no data

0910151 North Thompson River (monitoring site for Weyerhaeuser PE 01199)
- no data

0910152
153

154
155
156 Thompson River Stations (monitoring site for Weyerhaeuser PE 01199
157
158 - no data
159
160
161
0900240 Thompson River at Lytton
- 5 samples, 720802, 740521, 750717, 750721, 770804
0900241 Thompson River above Rock
- 2 samples, 740521, 740821
0900242 Thompson River at Big Horn Frt.
-1 sample, 740522
0900243 Thompson River below N & S Conf.
- 1 sample, 740521
0900250 Thompson River at Savona Bridge
- 3 samples, 740522, 750721, 790710
0900342 Thompson River at Ashcroft
- 1 sample, 750721
0900343 Thompson River at Spences Bridge
- 1 sample, 750921
0900415 Thompson River at Goldpan Park
- 1 Sample, 760610
0920140 Thompson River - Shaw Springs
- no data
0900246 North Thompson: North Kamloops
- 3 samples, 740522, 740821, 760611
0900340 North Thompson at Heffley
- 1 sample, 750720
0910151 North Thompson River
- no data
0910150 South Thompson River
- no data
0900244 South Thompson at Fort Kamloops
- 1 sample, 740521
0900245 South Thompson Br. to Jasper
- 1 sample, 740821
0900344 South Thompson at Kamloops
- 1 sample, 750722
0900345 South Thompson at Chase
- 2 samples, 750722, 790710
0603150 Vidette Lake at South End
- 2 samples, 830511 (2 depths)
0600175 Alkali Creek above Hughes Lake
- no data
0600059 Brussels Creek near mouth
- no data
0600262 Guerin Creek above landfill
- 1 sample, 800610
0603132 Community Lake at Center
- no data
4150066 Lac Du Bois Site No. 1

TABLE 1
FLOW DATA FOR SOUTH THOMPSON RIVER AT CHASE (08LE031)

year	mean annual discharge (m^3/s)	(10^6 dam^3)	% of mean discharge
1971	335	10.6	116
1972	381	12.0	132
1973	256	8.1	89
1974	346	10.9	120
1975	296	9.3	102
1976	415	13.1	144
1977	245	7.7	85
1978	312	9.8	108
1979	216	6.8	75
1980	268	8.5	92
1981	359	11.3	124
1982	378	11.9	131
1983	352	11.1	122
1984	321	10.2	112
1985	292	9.2	101
1986	300	9.4	103
1987	246	7.8	85
1988	284	9.0	99
1989	295	9.3	102
1990	353	11.1	122
mean	289	9.1	100

TABLE 2
VILLAGE OF CHASE, SEWAGE EFFLUENT CHARACTERISTICS
(PE 6293) (DATA FROM 1983 AND 1984)

Characteristic	Mean Value	n	minimum	maximum	standard deviation
pH	7.6	4	7.5	8.0	0.22
Res 105	199.5	4	101	296	95.9
Res F 105	108	2	88	128	28.3
Res NF 105	13.0	3	7.0	13.0	6.0
Spec. Cond.(uS)	377.5	4	162	580	226.9
Diss. Oxygen (Mg/L)	11.2	2	10.0	12.4	1.7
Flow (m^3/d)	613.7	1			
Chloride	17.2	4	4.9	31.1	14.1
Ammonia N	15.6	4	3.2	15.6	14.2
Nitrate/Nitrite N	1.6	4	0.05	5.5	2.6
Nitrate N	1.6	4	0.04	5.5	2.6
Nitrite N	0.027	4	0.005	0.077	0.034
Organic N	3.0	4	1.0	5.1	1.7
Kjeldahl N	18.6	4	5.0	35.8	15.5
Total N	20.2	4	5.0	36.6	17.0
B.O.D.	<12.7	4	<10	21	5.5
Total Diss. P	3.5	4	0.8	6.2	3.0
Total P	3.7	4	0.9	6.5	3.2
Sulphate	24.0	4	13	34	11.4
Sodium	43.4	2	41	45.8	3.4
Fecal Coliforms (MPN/100mL)	>1455	4	200	>2400	1075
Total Coliforms (MPN/100mL)	4875	4	700	14000	6135

All units in this table and the following are generally mg/L but see information prec the tables section on pages 101-102 for details of units.

TABLE 3
VILLAGE OF CHASE
SEWAGE EFFLUENT MONITORING WELLS WATER CHEMISTRY

Characteristic	CURRIE 0600430		MUTCH 0600431		SMITH 0600432		TRONSEN 0600433	
	mean		mean		mean		mean	
pH	8.3	n=2	8.1	n=24	8.0	n=24	8.1	n=23
Res 105	206	n=2	241	n=18	332	n=18	247	n=17
Res F 105	218	n=1	288	n=1	228	n=1		
Res NF 105	1.0	n=2	1.4	n=17	1.8	n=16	1.3	n=8
Spec. Cond.	339	n=2	395	n=24	520	n=24	403	n=23
Chloride	1.4	n=8	8.1	n=24	1.6	n=7		
Ammonia N	0.02	n=2	0.18	n=18	0.43	n=18	0.25	n=17
Nitrate/Nitrite	0.030	n=2	0.047	n=18	0.023	n=18	0.022	n=17
Nitrate N	0.030	n=2	0.047	n=2	0.023	n=18	0.022	n=17
Nitrite N	<0.005	n=2	<0.005	n=18	<0.005	n=18	0.006	n=17
Organic N	0.145	n=2	0.073	n=18	0.070	n=18	0.054	n=17
Kjeldahl N	0.340	n=2	0.249	n=18	0.490	n=18	0.299	n=17
Total N	0.360	n=2	0.294	n=18	0.50	n=18	0.308	n=17
B.O.D.	<10	n=2	<10	n=18	<10	n=18	<10	n=17
Total Diss. P	0.088	n=2	0.056	n=18	0.038	n=18	0.048	n=17
Total P	0.091	n=2	0.077	n=18	0.114	n=18	0.079	n=17
Sulphate			17.8	n=8	26.1	n=8	19.0	n=7
Sodium			7.6	n=5	8.7	n=5	7.1	n=4
Fecal Coliforms (MPN)	<2	n=3	<2	n=18	<2	n=18	<2	n=17
Total Coliforms (MPN)	<2	n=3	<2	n=19	<2	n=19	<2	n=18

TABLE 4
EFFLUENT QUALITY SUMMARY FOR CONAGRA RESEARCH, KAMLOOPS
(PE 04579) 1982

Characteristic	Mean Value	n	minimum	maximum	standard deviation
pH	7.6	7	7.3	7.8	0.2
Res 105	382	4	310	474	76.9
Res NF 105	62.5	4	31	114	37.5
Spec. Cond.	526.6	7	357	730	132.6
NH_3 N	3.312	3	0.121	8.92	4.87
Nitrate/Nitrite N	0.155	4	<0.02	0.43	0.191
Nitrate N	0.14	3	<0.02	0.38	0.207
Nitrite N	0.024	3	0.005	0.047	0.021
Organic N	1.54	3	0.63	2.0	0.791
Kjeldahl N	4.38	4	1.52	11.0	4.46
Total N	4.42	4	1.54	11.0	4.44
B.O.D.	14.0	4	<10.0	19.0	4.7
Ortho P	0.599	2	0.158	1.04	0.624
Total Diss. P	0.487	3	0.169	1.12	0.548
Total P	0.951	3	0.379	1.62	0.626

TABLE 5
WATER QUALITY - CONAGRA SAMPLING WELL (0600357)(1979-1980)

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Oil & Grease	2.7	4	1.6	4.5	1.4
pH	7.7	5	7.5	7.9	0.15
Res 105C	1587	4	836	1938	507
Res NF 105	271	4	184	399	103
Spec. Cond.	1772	5	911	2050	484
Chloride	14.7	2	13.7	15.6	1.3
Fluoride	0.3	2	0.3	0.2	0.04
Ammonia N	0.23	5	0.06	0.40	0.15
Nitrate/Nitrite N	0.17	5	0.36	0.07	0.12
Nitrate N	0.14	4	0.04	0.32	0.12
Nitrite N	0.02	4	<0.005	0.02	0.016
Organic N	1.2	5	0.52	2.0	0.7
Kjeldahl N	1.4	5	0.92	2.0	0.57
Total N	1.5	5	0.98	2.0	0.47
B.O.D.	<43.5	4	<10	144	67.0
Ortho P	0.055	3	0.018	0.100	0.041
Total Diss. P	0.064	3	0.027	0.108	0.040
Total P	0.343	3	0.266	0.510	0.097
Sulphate	554	3	235	716	276
Fecal Coliforms (MPN)	<2	1			
Total Coliforms (MPN)	<2	1			

TABLE 6

EFFLUENT QUALITY SUMMARY FOR LAFARGE CANADA, KAMLOOPS

(PE 00365) 1973 - 1982

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Colour True	6	10	5	15	3.2
Oil & Grease	1.1	17	<1	2.4	0.4
pH	7.6	9	7.3	7.8	0.2
Res 105	60.9	7	50	72	8.2
Res NF 105	27.1	2	7	47.2	28.4
Spec. Cond.	86.8	10	73	101	10.8
Sampling Temp.	8.7	11	2	20.5	6.0
Diss Oxygen	6.7	6	5.2	10.2	1.8
Turbidity	1.5	7	0.8	3	0.7
Flow (m^3/d)	0.021	137	0.005	0.034	0.008
Colour TAC	2.8	11	<1	6	1.5
Alkalinity Total	35.0	7	30.9	38.5	3.7
Organic Carbon	3.8	11	1	12	3.3
Hardness	37.2	6	33.6	41.3	3.8
NH_3-N	0.01	1			
NO_2/NO_3 N	0.06	1			
Nitrate N	0.05	11	<0.02	0.07	0.02
Nitrite N	<0.005	11	<0.005	L0.005	0.0
Kjeldahl N	0.10	11	0.03	0.21	0.05
Ortho P	0.003	1			
Total Diss. P	0.008	11	0.004	0.013	0.003
Total P	0.013	10	0.009	0.021	0.004
Silica Diss.	5.2	11	4.1	5.8	0.5
Tot. inorganic carbon	7.2	11	6	10	1.3
Calcium Diss.	11.7	6	10.6	12.9	0.9
Copper Diss.	0.006	3	0.002	0.01	0.004
Iron Diss.	<0.1	3	<0.1	<0.1	0.0
Lead Diss.	<0.001	2	<0.001	<0.001	0.0
Magnesium Diss.	2.2	2	2.2	2.2	0.0

TABLE 7

A. EFFLUENT MONITORING SUMMARY PE 1502, FINNING EQUIPMENT 1974-1978

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Oil & Grease	38.6	47	2.4	617	104.5
pH	6.9	48	4.9	8.8	0.7
Res 105	222	47	3	3170	548
Organic Carbon	45.6	46	1	606	91.4
Inorganic Carbon	29.0	40	10	133	20.9
Sediment Carbon mg/g dry	160	6	20	625	238

B. MONITORING WELL RESULTS FOR SITE 0600089 (FINNING TRACTOR)

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Oil & Grease	4.9	59	0.4	42	7.0
pH	7.8	59	7.1	8.7	0.4
Res 105	1030	6	680	1692	458
Res NF 105	98.3	11	6	395	118
Spec. Cond.	1405	6	1040	2060	500
Turbidity	98.5	2	92	105	9.2
Organic Carbon	20.4	52	0	120	26.5
Fluoride	0.42	3	0.40	0.46	0.03
Ammonia N	1.17	2	0.79	1.57	0.56
Total N	1.2	4	0.67	2.0	0.56
Total P	0.1	3	0.041	0.176	0.069
Inorganic Carbon	137	46	7	240	66
Sodium	255	2	151	358	146
Sediment Carbon mg/g dry	137	46	7	240	66

TABLE 8
WATER QUALITY SUMMARY. SAMPLING WELL, KAMLOOPS MEAT
0600093 1976-1979

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Oil & Grease	5.5	7	1.2	16.7	5.5
pH	7.9	19	7.4	8.4	0.3
Res 105	155.5	11	114	192	26.9
Res NF 105	57.2	11	15	134	42.7
Spec. Cond.	168	19	123	301	49
Turbidity	78.5	6	52	100	16.7
Alkalinity	58.5	7	46	74	8.6
Organic Carbon	2	2	<1	3	1.4
Chloride	7.2	4	6.3	7.8	0.6
Fluoride	0.2	5	0.16	0.21	0.02
Hardness	60	5	49	79	11.8
Ammonia N	0.5	4	0.1	0.9	0.3
Nitrate/Nitrite N	0.04	10	<0.02	0.07	0.02
Nitrite N	0.019	3	<0.005	0.044	0.021
Kjeldahl N	0.8	11	0.15	2.0	0.56
B.O.D.	10.3	10	<10	13	0.9
Total P	0.05	10	0.027	0.114	0.03
Calcium Diss.	14.4	4	12.4	17.6	2.5
Fecal Coliforms (MPN)		3	<2	L20	
Total Coliforms (MPN)		3	<2	20	

TABLE 9
EFFLUENT QUALITY SUMMARY FOR STORM SEWER XE 0600501
KAMLOOPS MEAT EFFLUENT 1972-73

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Colour (true)	35	2	30	40	7.1
Oil & Grease	1.2	2	L1	3	0.2
Res 105	133	2	96	170	52
Res NF 105	47	1			
Spec. Cond.(Field)	362	2	300	423	87
Organic Carbon	28	2	15	40	18
Ammonia N	29	1			
Nitrate N	0.025	2	<0.02	0.03	0.007
Nitrite N	0.010	2	0.009	0.010	0.001
Total N	27.0	2	23.0	31.0	5.7
B.O.D.	14	2	L10	18	5.6

TABLE 10
EFFLUENT QUALITY SUMMARY FOR STORM SEWERS DRAINING INTO THE THOMPSON AND SOUTH THOMPSON RIVER 1977-1979

Characteristic	XE 06019		XE 06015		XE 06021	XE 06022		XE 06023	
Oil & Grease	8.3	(1)	8.8	(1)	no data	6.7	(1)		
pH	7.7	(4)	7.5	(6)		7.6	(1)	7.9	(1)
Res 105	1084	(1)	1128	(4)		1438	(1)	416	(1)
Res NF 105	513	(3)	159	(5)		1232	(1)	166	(1)
Spec. Cond.	155	(4)	1211	(0)		294	(1)	445	(1)
Turbidity	28.5	(2)	145	(4)					
Colour TAC	4	(2)	18	(4)					
Alkalinity	41	(1)	69	(3)					
Chloride	23.9	(2)	483	(3)		32	(1)	102	(1)
Fluoride	0.98	(1)	0.72	(3)					
Hardness	52	(1)	113	(3)					
Ammonia N	-		0.15	(3)					
Nitrate/Nitrite N	0.08	(2)	0.35	(4)					
Kjeldahl N	0.31	(2)	1.4	(4)					
Ortho P	0.013	(2)	0.7	(4)					
Total P	0.598	(3)	1.2	(5)		3.4	(1)	0.37	(1)
Copper (Total)	0.065	(2)	0.045	(2)					
Lead (Total)	0.053	(2)	0.1	(2)					
Zinc (Total)	0.047	(2)	0.065	(2)					
Fecal Coliforms (MPN)	77.7	(3)	529	(11)		13	(1)	L2	(1)
Total Coliforms (MPN)	240	(2)	4820	(11)		170	(1)	L2	(1)

XE 0601901	is 3rd Ave East at River to S. Thompson
XE 0601501	Tranquille Road storm drain to Thompson River
XE 0602101	no data
XE 0602201	is at West R. Road to S. Thompson
XE 0602301	is 8th Street to S. Thompson

For locations see Figure 6.
Results are averages and the bracketed values are the number of samples

TABLE 11
WATER QUALITY OF CHASE CREEK (0600065)
(1972 - 1977)

Characteristic	Mean Value	n	maximum	minimum	standard deviation
Colour (true)	21.4	7	60	5	23.4
pH (lab)	8.1	13	8.4	7.5	0.25
Res 105 Total	198	12	346	144	53.9
Res F 105	151.2	12	192	100	31.6
Res NF 105	12	2	22	2	14.1
Spec. Cond. (Lab)	238	15	294	97	59.3
Diss Oxygen (Field)	9.1	7	11.8	6.9	2.0
Turbidity (NTU)	8.6	12	42	0.6	12.8
Colour (TAC)	14	4	32	7	12.0
Total Alkalinity	93.8	11	131	36.5	32.2
Chloride	1.1	1			
Fluoride	0.19	1			
Hardness	103.2	9	138	41.4	32.4
Nitrate N	<0.055	9			
Nitrite N	all <0.005	9			
Kjeldahl N	0.255	11	0.410	0.130	0.144
Total N	0.205	12	0.550	0.120	0.147
Ortho P	0.010	6	0.016	0.007	0.003
Total P	0.046	12	0.206	0.015	0.056
Silica	16.7	5	17.8	15.2	0.99
Sulphate	19.0	10	27.3	8.8	5.9
Tannin & Lignins	0.6	6	1.4	0.1	0.48
Copper (Total)	<0.004	4	0.010	<0.001	0.004
Lead (Total)	<0.002	4	0.002	0.001	0.001
Zinc	<0.009	4	0.020	<0.005	0.007
Total Coliforms (MPN)	350	1			

TABLE 12
WATER QUALITY FOR THE SOUTH THOMPSON AT CHASE
(STATION 0600136) 1973-1984

Characteristic	Mean Value	n	minimum	maximum	standard deviation
pH (lab)	7.7	99	7.3	8.0	0.13
Res 105C	68.6	38	46	130	17.1
Res NF 105	14.5	5	2	45	18.9
Spec. Cond.	101	95	70	167	17.7
Turbidity	1.7	66	0.3	21	3.1
Colour TAC	3.7	92	<1	18	2.5
Total Alkalinity	38.2	18	29.3	54.1	7.0
Organic Carbon	2.3	49	<1	8	1.6
Chloride	0.5	30	<0.3	1.7	0.2
Hardness	41.3	21	32.6	62.6	7.1
Ammonia N	0.007	26	<0.005	0.021	0.003
Nitrate/Nitrite N	0.053	37	<0.02	0.09	0.026
Nitrate N	0.047	23	<0.02	0.08	0.022
Nitrite N	all <0.005	23			
Organic N	0.086	26	<0.01	0.19	0.046
Kjeldahl N	0.105	60	<0.01	0.260	0.062
Total N	0.152	60	<0.03	0.330	0.071
Ortho P	0.003	30	<0.003	0.007	0.001
Total Diss. P	0.006	92	<0.003	0.106	0.011
Total P	0.011	96	0.003	0.121	0.015
Silica	5.25	30	4.1	6.5	0.63
Sulphate	6.9	29	<5	9.2	1.2
Inorganic Carbon	8.9	49	5	13	2.2
Resin Acids	0.63	8	<0.5	1.5	0.35
Chlorophyll mg/m^2	4.0	333	<0.3	108.0	11.0
Arsenic	all <0.0005	7			
Cadmium (Total)	all <0.0005	4			
Calcium	13.0	22	10.1	18.5	1.9
Copper (Total)	0.004	6	<0.001	0.014	0.005
Iron (Diss)	all <0.1	6			
Lead (Total)	<0.002	7	<0.001	0.003	0.001
Mercury (Total)	all <0.00005	6			
Molybdenum (Total)	0.0006	4	<0.00005	0.0009	0.00002
Potassium (Diss)	0.9	10	0.8	1.1	0.1
Sodium (Diss)	2.0	10	1.1	2.6	0.5
Zinc (Total)	0.009	9	<0.005	0.040	0.011
Fecal Coliforms	17.4	17	<2	170	40.1
Total Coliforms	21.8	11	<2	79	24.5
Algal Biomass (mg/m^2)	14.9	434	<1	126	16.5

TABLE 13
WATER QUALITY FOR THE SOUTH THOMPSON AT PRITCHARD
(STATION 0600001) 1971-1975

Characteristic	Mean Value	n	minimum	maximum	standard deviation
Colour true	5.3	31	<5	10	1.2
pH	7.6	16	7.1	8.0	0.2
Res 105C	59	34	48	120	16.8
Res NF 105	3.8	19	<0.5	16.5	3.8
Spec. Cond.	83.7	21	73	150	16.0
Turbidity	1.6	29	0.5	6.7	1.6
Colour TAC	3	15	<1	8	2
Alkalinity	35.0	31	30.2	54.5	4.1
Organic Carbon	3.2	23	<1	10	2.5
Chloride	0.5	21	<0.3	0.7	0.008
Fluoride	all <0.1	19			
Hardness	37	30	31	62	5.4
Ammonia-N	0.02	4	<0.01	0.05	0.01
Nitrate-N	0.05	28	<0.02	0.09	0.02
Nitrite-N	all 0.005	28			
Kjeldahl-N	0.117	29	<0.01	0.52	0.111
Ortho-P	0.004	15	<0.003	0.017	0.004
Total Diss. P	0.005	14	<0.003	0.020	0.004
Total P	0.012	34	0.004	0.078	0.013
Silica	5.3	14	4.1	8.0	0.9
Chromium (Total)	all <0.005	17			
Copper (Total)	0.003	18	<0.001	0.020	0.005
Lead (Total)	0.020	18	<0.001	0.105	0.03
Zinc (Total)	0.009	18	<0.005	0.020	0.005

TABLE 14
WATER QUALITY FOR MONTE CREEK AT MONTE CREEK STATION
(STATION 0600062) 1972-1976

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour true	31	7	10	60	17
pH	8.3	8	7.7	8.6	0.3
Res 105	348	11	174	494	110
Res F 105	350	10	110	472	112
Res NF 105	10	1			
Spec. Cond.	483	11	142	700	201
Oxy. Diss.	7.6	6	6.2	10.5	1.6
Turbidity	3.7	10	0.5	11	3
Colour TAC	43	1			
Alkalinity	267	10	67	351	89
Carbon organic	11	4	9	14	2
Hardness	198	8	57	264	69
NO_2/NO_3 N	1.3	2	0.05	2.6	1.8
Nitrate N	0.17	8	<0.02	0.44	0.15
Nitrite N	0.006	8	<0.005	0.01	0.002
Nit. Kjel	0.55	10	0.23	1.07	0.29
Nit. Total	0.95	10	0.32	3.67	1.01
Total Diss. P.	0.225	1			
Total P.	0.22	10	0.16	0.29	0.05
Silica Diss.	25.9	3	24.6	27.1	1.3
Sulphate Diss.	25.9	4	12.3	32.8	9.5
Tannin & Lignins	0.9	1			
Carbon IO	54	2	42	65	16
Calcium Diss.	31.9	7	10.8	42.3	11.0
Copper Diss.	0.0013	4	0.001	0.002	0.0005
Copper Total	0.005	4	0.001	0.013	0.005
Lead Total	0.002	4	0.001	L0.003	0.0012
Magnesium Diss.	27.3	6	8	39.5	12
Magnesium Total	36.5	4	26.6	42	6.9
Manganese Total	0.04	3	0.03	0.05	0.01
Molybdenum Diss.	0.0025	2	0.0015	0.0034	0.0013
Zinc Total	0.0053	4	<0.005	0.006	0.0005

TABLE 15
WATER QUALITY SUMMARY - CAMPBELL CREEK NEAR MOUTH
(STATION 0600061) 1972-1984

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour true	41.1	9	10	60	16.2
pH	8.4	10	8.3	8.5	0.08
Res 105C	425	15	282	584	115
Res NF 105	22.9	6	3	38	15.7
Spec. Cond.	550	13	348	819	195
Oxy. Diss.	9.3	7	7.1	12.4	1.9
Turbidity	14.4	13	1.1	100.	26.4
Colour TAC	29.3	3	23	36	6.5
Alkalinity Total	255	13	166	390	83.6
Organic Carbon	13.6	5	11	15	1.9
Hardness	237	10	158	348	72
Ammonia N	0.072	2			
Nitrate/Nitrite N	0.42	7	0.05	0.91	0.32
Nitrate N	0.40	7	0.09	0.76	0.22
Nitrite N	0.007	10	<0.005	0.015	0.003
Kjeldahl N	1.03	14	0.52	2.58	0.57
Total N	1.5	13	0.8	2.9	0.7
Total Diss. P	0.11	4	0.1	0.12	0.008
Total P	0.17	15	0.04	0.41	0.094
Silica	18.6	3	17.0	19.7	1.4
Sulphate	53	8	24	105	35
Copper Total	0.016	7	0.005	0.030	0.008
Zinc Total	0.015	6	<0.005	0.050	0.017
Fecal Coliforms	23	2	23	23	0
Total Coliforms	134	2	49	220	121

TABLE 16
WATER QUALITY SUMMARY FOR PETERSON CREEK
(STATION 0600055 - AT MOUTH) 1972-1979

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	19.1	11	<5	50	14.5
Oil & Grease	6.1	11	<1	21.5	6.7
pH	8.3	17	7.4	8.7	0.4
Res 105	732	20	72	2604	603
Res NF 105	315	7	10	1644	601
Spec. Cond.	869	20	150	1650	469
Turbidity	85	19	2	680	167
Colour TAC	13.9	7	7	25	6.6
Total Alkalinity	189	20	39	387	127
Organic Carbon	60	8	7	325	108
Chloride	22.1	7	14	44	10.5
Fluoride	0.38	9	0.1	1.3	0.35
Hardness	427	12	43	901	263
Ammonia N	0.13	2	0.017	0.24	0.16
Nitrate N	0.142	11	L0.02	0.40	0.146
Nitrite N	0.018	12	L0.005	0.122	0.035
Kjeldahl N	0.713	19	0.015	2	0.55
Total N	0.864	19	0.019	2.21	0.612
B.O.D.	22.5	2	<10	35	17.7
C.O.D.	133.1	2	47.1	219	121.5
Phenol	0.015	5	0.003	0.051	0.02
Ortho-P	0.18	11	0.055	0.9	0.248
Total Diss. P	0.56	7	0.091	2.39	0.71
Total P	0.66	20	0.063	2.80	0.71
Silica	13	5	12	14.2	0.86
Sulphate	163	14	12	431	159
Surfactants	0.22	5	0.07	0.46	0.15
Tannins & Lignins	1.0	9	0.3	2.1	0.7
Inorganic Carbon	58.5	4	13	82	31
Boron (Diss.)	both <0.1	2			
Calcium (Diss.)	76.3	11	14.2	140	36.5
Chromium (Diss.)	all <0.0005	4			
Copper (Total)	0.039	12	0.003	0.160	0.047
Copper (Diss.)	0.006	6	0.004	0.011	0.003
Iron (Total)	16.7	5	0.4	77.7	34.1
Iron (Diss.)	both <0.1	2			
Lead (Diss.)	0.005	6	0.001	0.012	0.004
Lead (Total)	0.151	12	0.003	0.75	0.249
Manganese (Total)	0.12	7	<0.01	0.46	0.18
Manganese (Diss.)	0.023	4	<0.02	0.03	0.005
Sodium (Diss.)	47.4	2	31.2	63.6	22.9
Zinc (Total)	0.078	12	0.005	0.3	0.096
Zinc (Diss.)	0.012	5	<0.005	0.03	0.011
Fecal Coliforms	493	4	<2	1600	755
Total Coliforms	<2	1			

TABLE 17
WATER QUALITY SUMMARY FOR THE SOUTH THOMPSON AT PIONEER PARK (STATION 0600135) 1973-1984

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.7	119	7.4	8.0	0.14
Res 105	62.8	54	48	90	10.0
Res 550	58.2	14	52	64	3.5
Res NF 105	6.3	8	2	13	3.5
Spec. Cond.	88.0	122	72	145	12.8
Turbidity	2.2	51	0.8	6.0	1.2
Colour TAC	3.4	77	<1	10	1.8
Alkalinity	34.4	40	30.8	44.7	3.3
Organic Carbon	2.2	59	<1	13	2.0
Chloride	0.4	48	<0.3	1.2	0.2
Hardness	37.2	38	32.2	58.6	5.3
Ammonia N	0.009	23	<0.005	0.021	0.005
Nitrate N	0.040	48	<0.002	0.09	0.021
Nitrite N	0.005	61	<0.005	0.07	0.008
Organic N	0.12	23	0.03	0.35	0.06
Kjeldahl N	0.12	83	<0.01	0.56	0.081
Total N	0.150	81	<0.02	0.63	0.089
Ortho P	0.003	29	<0.003	0.004	0.001
Total Diss. P	0.004	83	<0.003	0.019	0.003
Total P	0.013	85	0.005	0.033	0.006
Silica	4.9	44	4.2	5.9	0.43
Sulphate	6.7	47	<5	20.1	2.5
Inorganic Carbon	8.2	34	4	11	1.5
Chlorophyll a (mg/m^2)	0.4	9	<0.3	1.0	0.2
Arsenic (Total)	all <0.005	8			
Cadmium (Total)	all <0.0005	5			
Calcium (Total)	12	47	10.3	14.9	1.1
Mercury (Total)	all <0.00005				
Molybdenum (Total)	0.0006	3	<0.0005	0.0007	0.0001
Sodium (Diss.)	1.9	23	1.2	4.1	0.5
Zinc (Total)	0.005	10	<0.005	0.007	0.0006
Fecal Coliforms	24.5	7	<2	130	46.6
Total Coliforms	97.4	16	<2	540	147.4
Algal Biomass (mg)	8.0	18	1.7	26.8	7.3

TABLE 18
EFFLUENT QUALITY SUMMARY FOR SOUTH THOMPSON RIVER, KAMLOOPS (STATION 0920104), 1967 - 1974

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour AP.	5	41	0	10	3
pH	7.6	42	7.0	7.9	0.3
Res. F 105	44	1			
Res. NF 105	34	2	29	38	6
Res. NF 550	29	2	21	38	11
Spec. Cond.	85	42	74	99	7
Oxygen, Diss.	11.2	3	9.7	12.0	1.3
Turbidity	1.2	41	0.1	4.8	1.0
Alkalinity	33	42	29	38	2
Organic Carbon	4.5	4	2.8	6.0	1.3
Chloride, Diss.	0.3	35	0.1	1.3	0.3
Fluoride, Total	0.09	25	0.01	0.19	0.04
Hardness	37.6	42	31.2	43.8	3.3
NO_3 N	0.1	14	0.0	0.2	0.04
NO_2/NO_3 N	0.078	35	<0.002	0.904	0.147
Kjeldahl N Both	0.1	2			
Total P	0.0095	16	<0.0033	0.163	0.0048
Silica, Diss.	5.8	35	4.6	7.7	0.7
Sulphate, Diss.	6.8	42	3.8	10.6	1.4
Carbon I0	6.9	3	4.9	9.7	2.5
Free CO_2, Diss.	2.3	34	0.8	7.1	1.7
Bicarbonate, Total	40	27	35	46	3
Carbonate, Total All	0.0	26			
Arsenic, Diss. Both	0.005	2			
Cadmium, Total All	0.001	3			
Calcium, Diss.	11.8	42	L3.2	14.0	1.7
Chromium, Total	0.0	1			
Copper, Total	0.0012	5	0.001	0.002	0.004
Iron, Diss.	0.01	16	<0.0	0.06	0.01
Iron, Total	0.10	2	0.08	0.12	0.03
Lead, Total	<0.0046	5	<0.001	<0.01	0.005
Magnesium, Diss.	1.0	42	0.8	9.7	1.3
Manganese, Diss.	0.01	1			
Manganese, Total All	0.01	3			
Mercury, Total All	0.00005	3			
Molybdenum, Total	0.017	3	0.0006	0.05	0.028
Nickel, Total	0.002	3	0.001	0.004	0.002
Potassium, Diss.	0.85	42	0.6	1.8	0.23
Sodium, Diss.	1.57	42	0.9	2.6	0.39
Zinc, Total	0.0016	5	<0.0	0.006	0.003
Barium, Total Both	0.1	2			

TABLE 19
COMPARISON OF MEAN WATER QUALITY OF THE SOUTH THOMPSON RIVER AT CHASE (0600136) AND AT KAMLOOPS (0600135)
DATA FOR 1973 - 1984 (SEE TABLES 17 AND 12 for details)

Characteristic	Chase	Kamloops	Increase (?)
pH	7.7	7.7	
Residue 105	68.6	62.8	
Res. NF 105	14.5	6.3	
Spec. Cond.	101	88	
Turbidity	1.7	2.2	X
Colour TAC	3.7	3.4	
Alkalinity	38.2	34.4	
Organic Carbon	2.3	2.2	
Chloride	0.5	0.4	
Hardness	41.3	37.2	
Ammonia N	0.007	0.009	X
Nitrate/Nitrite N	0.053	0.040	
Organic N	0.086	0.120	X
Total P	0.011	0.013	X
Silica	5.3	4.9	
Sulphate	6.9	6.7	
Inorganic Carbon	8.9	8.2	
Calcium	13	12	

TABLE 20
TIME COMPARISON OF MEAN WATER QUALITY FOR THE SOUTH THOMPSON AT PIONEER PARK
(bracketed data are sample size, range and standard deviation respectively)

Characteristic	1973-1975	1977-1980	1981-1984	1985-1988
pH	**7.5** (77,4.4-8.6,0.6)	**7.7** (19,7.4-8.0,0.2)	**7.8** (29,7.6-7.9,0.1)	**7.8** (22,7.5-7.8,0.1)
Res. Total	**57.7** (24,48-90,9)	**62.8** (5,56-78,9)	**70.7** (14,60-80,5)	**64** (22,48-78,8)
Res. filterable	**52** (24,46-80,6.7)	**52** (4,52-66,6)		**58** (n=1)
Spec. Cond.	**89.3** (87, 55-200,21)	**92.6** (19,79-145,16)	**93.8** (29,91-96,2)	**87.5** (22,76-99,7)
Turbidity	**1.9** (30,0.8-5.2,1)	**2.1** (9,0.8-3.1,0.7)		**2.6** (5,1-6,2)
Colour TAC	**3.3** (39,1-7,3.2)	**3.8** (12,2-7,1.2)	**4.8** (8,1-10,3)	
Alkalinity(total)	**33.2** (24,31-45,3)	**36.7** (4,35-39,1.6)		
T.O.C.	**2.9** (32,1-13,2)		**1.3** (4,1-2,0.5)	
T.I.N.	**0.113** (n=41)	**0.135** (n=14)	**0.127** (n=15)	**0.091** (n=22)
Total N	**0.139** (39,.03-.32,.06)	**0.192** (12,0.1-0.3,.05)	**0.201** (15,.12-.43,.07)	
TIC	**7.7** (20,6-11,8)	**7.5** (2,7-8)	**10.2** (6,10-11,0.4)	
Fecal Coliforms	(16,2-350,83)	**35**		**2.7** (6,2-6,0.6)
Chloride	**0.5** (12,.3-1.2,.3)	**0.6** (2,.5-.6)	**0.5** (4,.3-.6,.2)	**0.5** (6,.5-.6,.03)
Hardness	**36.1** (23,33-59,5)	**37** (3,35-40,3)		
Ammonia N	**14** (3,9-21,6)	**12** (3,7-15,12)	**6** (8,5-11,2)	**8** (7,5-11,2)
Nitrite/Nitrate N		**50** (12,20-70,17)	**74** (15,60-80,6)	**52** (19,20-80,23)
Nitrate N	**49** (23,20-90,19)		**74** (14,60-80,6)	
Silica	**4.8** (39,4.2-5.9,5)			
Sulphate	**6.5** (19,5-20,3)	**6.3** (3,5.7-7,0.6)	**6.8** (14,6-7.5,.4)	**6.4** (21,5.4-8.6,1)
Calcium	**11.4** (23,10-14,1)	**11.5** (3,10.8-12.5,0.9)	**13.2** (14,12-14,.6)	**12.5** (14,11-14,0.9)
Sodium		**2.2** (7,1.6-4.1,0.9)	**1.9** (14,1.7-2.0,.1)	**1.6** (2,1.5-1.6)
Total Diss. P	**4** (30,3-19,3)	**5** (12,3-8,2)	**5** (12,3-15,3)	**4** (6,3-5,1)
Total P	**12** (43,5-33,7)	**12** (16,8-19,4)	**15** (14,10-23,4)	**10** (22,4-26,6)

TABLE 21
ANNUAL HYDROLOGIC PATTERN OF VARIATION FOR THE SOUTH THOMPSON RIVER

YEAR	MEAN ANNUAL DISCHARGE (08LE031)		% OF AVERAGE DISCHARGE (289 m^3
	m^3/s	10^6 dam^3	
1971	335	10.6	
1972	381	12.1	
1973	256	8.1	
1974	346	10.9	
1975	296	9.3	
1976	415	13.1	
1977	245	7.7	
1978	312	9.8	
1979	216	6.8	
1980	268	8.5	
1981	359	11.3	
1982	378	11.9	
1983	352	11.1	
1984	321	10.2	
1985	292	9.2	
1986	300	9.4	
1987	246	7.7	
1988	284	9.0	
1989	295	9.3	
1990	353	11.1	

TABLE 22
FLOW OF NORTH THOMPSON RIVER AT MCLURE (086LB064)

YEAR	MEAN ANNUAL DISCHARGE		% OF AVERAGE DISCHARGE
	m^3/s	10^6 dam^3	
1970	311	9.8	72
1971	446	14.1	103
1972	483	15.3	112
1973	379	12.0	88
1974	453	14.6	105
1975	423	13.3	98
1976	535	16.9	124
1977	359	11.3	83
1978	393	12.4	91
1979	330	10.4	76
1980	405	12.8	94
1981	452	14.2	105
1982	514	16.2	119
1983	429	13.5	99
1984	452	14.2	105
1985	387	12.2	90
1986	400	12.6	93
1987	360	11.4	84
1988	386	12.2	90
1989	393	12.4	92
1990	455	14.3	106
MEAN	428	13.5	100

TABLE 23
EFFLUENT QUALITY SUMMARY FOR PAUL LAKE HOLDINGS
PE 04357 1982 - 1984

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.4	8	7.2	7.6	0.13
Res 105	518.9	9	292	700	123.5
Res NF 105	119.7	9	9	330	107.2
Spec. Cond.	688.2	9	470	891	149.2
Oxygen Diss.	1.4	3	0.2	3.5	1.9
Set. Solids	10.5	1			
Chloride Diss.	24.8	2	22.8	26.9	2.9
NH_3 N	8.3	2	2.0	14.5	8.8
NO_2/NO_3 N	0.84	2	0.08	1.6	1.07
Nitrate N	0.145	2	0.07	0.22	0.106
Nitrite N	0.695	2	0.02	1.38	0.969
Organic N	14.65	2	8.0	21.29	9.40
Kjeldahl N	22.65	2	22.0	23.3	0.92
Total N	23.45	2	22.0	24.9	2.05
B.O.D.	74	7	<10	135	45.3
Total Diss. P	5.79	2	3.85	7.72	2.74
Total P	9.2	2	5.3	13.1	5.52
Sulphate Diss.	54.5	2	51	58	4.9
Sodium Diss.	50.2	2	47.9	52.4	3.2
Fecal Coliforms (M.P.N.)	127000	2	14000	G240000	159810
Total Coliforms (M.P.N.)	200000	2	160000	G240000	56569

TABLE 24
WATER QUALITY SUMMARY FOR PAUL CREEK BELOW SAMPLING WELL
(STATION 0600355) 1979
(MONITORING SITE FOR PAUL LAKE HOLDINGS [PE 04357])

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	8.5	4	8.4	8.6	0.1
Res. 105	211	4	204	218	6
Res. F 105	211	2	206	216	7
Res. NF 105	2	2	1	3	1
Spec. Cond.	333	5	329	340	4
Oxygen Diss.	9.5	3	9.1	10	0.5
NH_3 N	0.0177	3	0.017	0.018	0.0006
NO_2/NO_3 N All	<0.02	4			
Nitrate N	<0.02	1			
Nitrite N	<0.005	1			
Organic N	0.39	3	0.35	0.44	0.05
Kjeldahl N	0.39	4	0.31	0.46	0.06
Total N	0.39	4	0.31	0.46	0.06
Total Diss. P.	0.008	4	0.007	0.009	0.001
Total P	0.012	5	0.010	0.013	0.001
Carbon I0	36	4	35	38	1
Fecal Coliforms	35	4	22	49	14
Total Coliforms	145	4	79	280	95

TABLE 25
EFFLUENT MONITORING SUMMARY FOR PE 357, KAMLOOPS WESTSYDE
1982 - 1984

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.0	3	6.8	7.3	0.3
Res. 105	425	2	404	446	29.7
Spec. Cond.	690	3	659	700	27.2
B.O.D.	152	2	131	173	29.7
Total P	11.4	1			

TABLE 26
EFFLUENT WATER QUALITY SUMMARY FOR BALCO MILL, KAMLOOPS
PE4856 1983

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	8.1	1			
Spec. Cond.	1260	1			
Alkalinity	523	1			
NH_3 Diss.	<0.005	1			
NO_2/NO_3 Diss.	0.1	1			
Nitrate Total	<0.02	1			
Nitrite Diss.	0.099	1			
Organic N	2.14	1			
Kjeldahl N	2.14	1			
Total N	2.24	1			

TABLE 27
EFFLUENT QUALITY SUMMARY FOR THREE STORM SEWERS DRAINING INTO THE NORTH THOMPSON RIVER 1977 - 1979
Average values with number of measurements given in brackets.

Characteristic	XE 6016		XE 6017		XE 6018	
Oil & Grease	5.8	(1)	17.2	(2)	7.9	(1)
pH	7.4	(4)	7.7	(3)	7.7	(3)
Res. 105	1674	(4)	635	(2)	144	(3)
Res. NF 105	708	(4)	243	(2)	11	(3)
Spec. Cond.	1586	(4)	2589	(3)	229	(3)
Turbidity	578	(3)			9.1	(3)
Colour TAC	61	(3)	16	(1)	5.3	(3)
Alkalinity	98	(2)			35	(3)
Chloride	419	(4)	765	(3)	41	(3)
Fluoride	0.55	(3)	0.14	(1)	1.2	(3)
Hardness	121	(3)	229	(1)	43.6	(3)
Ammonia N	0.19	(2)			0.007	(2)
Nitrate/Nitrite N	0.33	(3)	1.2	(1)	0.076	(3)
Kjeldahl N	5.7	(3)	4	(1)	0.1	(3)
Ortho P	0.53	(3)	0.019	(1)	0.003	(3)
Total P	1.9	(1)	0.035	(1)	0.017	(3)
Copper Total	0.09	(1)			0.001	(1)
Lead	0.5	(1)			L0.001	(1)
Zinc	0.22	(1)			L0.005	(1)
Fecal Coliforms	588	(4)	387	(3)	8	(3)
Total Coliforms	4836	(8)	1601	(3)	8	(3)

XE 6016 is XE 06061601 Sydney Avenue
XE 6017 is XE 06061701 Richmond Avenue
XE 6018 is XE 60661801 Kingston Street

TABLE 28
WATER QUALITY SUMMARY FOR THE NORTH THOMPSON RIVER AT MCLURE
(STATION 0600002) 1966 - 1980

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour (Apparent)	9.6	101	<5	50	7.6
Colour (True)	6.5	34	<5	20	3.4
pH	7.6	154	6.9	8.1	0.2
Res. 105	74.1	53	50	362	41.9
Res. NF 105	29.6	23	<1	190	40.4
Res. NF 550	25.3	13	<1	61	20.1
Spec. Cond.	90.8	16	45	169	21.6
Turbidity	3.9	157	0.2	26	4.7
Colour (TAC)	5.2	44	<1	19	3.9
Alkalinity	36.3	146	17.4	60.8	9.3
Organic Carbon	3.8	51	<1	31	4.7
Chloride	0.3	134	<0.1	2.5	0.3
Fluoride (Diss.)	all <0.1	19			
Fluoride (Total)	0.08	54	0.04	0.21	0.04
Hardness	40.6	142	19.2	66.1	9.6
Ammonia	0.065	38	0.003	0.2	0.05
Nitrate/Nitrite N	0.093	110	<0.005	0.31	0.05
Nitrite N	all <0.005	33			
Kjeldahl N	0.127	55	<0.01	0.25	0.1
C.O.D.	3.6	20	<0.5	19.5	4.6
Ortho P	<0.003	49	<0.002	0.006	0.001
Total Diss. P	0.004	67	<0.001	0.02	0.003
Total P	0.011	86	<0.002	0.051	0.009
Silica	5.4	115	2.9	8.4	1.5
Chlorophyll a (mg/m^2)	3.8	70	<0.3	24.8	4.0
Arsenic (Total)	All <0.005	4			
Cadmium (Total)	All <0.001	7			
Calcium (Diss.)	12.8	143	<0.5	20.3	3.1
Chromium (Total)	All <0.005	19			
Copper (Diss.)	0.007	42	<0.001	0.05	0.011
Lead (Total)	0.006	32	<0.001	0.064	0.011
Mercury (Total)	All <0.00005	9			
Molybdenum (Total)		8	<0.0002	0.001	
Sodium	1.5	112	0.5	3.1	0.6
Zinc (Diss.)	0.008	37	<0.001	0.05	0.01
Aluminum (Diss.)	0.05	6	0.03	0.14	0.04
Barium (Diss.)	Both 0.1	2			
Fecal Coliforms	7.6	8	<2	23	8.0
Total Coliforms	18.8	4	<2	33	13
Biomass (mg)	273.2	106	29.1	1615	288

TABLE 29

WATER QUALITY SUMMARY FOR THE NORTH THOMPSON RIVER AT NORTH KAMLOOPS (STATION 0600164) 1965 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour (Apparent)	6.3	61	<5	20	2.9
pH	7.6	160	4.4 (?)	8.1	0.4
Res. 105	77.1	53	48	152	18.9
Res. 550	79.6	14	62	130	17
Res. NF 105	10.3	13	4	30	7
Res. NF 550	18	5	4	58	22.5
Spec. Cond.	96.2	160	54	139	20.5
Turbidity	2.6	99	<0.1	26	3.5
Colour TAC	6.8	53	2	21	4.6
Alkalinity	34.8	98	21	54	6.1
Organic Carbon	2.1	48	<1	6	1.5
Chloride	0.46	105	0.1	3	0.43
Fluoride (Total)	0.14	46	<0.05	1.1	0.19
Hardness	39	88	23.2	60.8	6.6
Ammonia-N	0.048	50	0.002	0.2	0.050
Nitrate/Nitrite N	0.078	94	<0.001	0.904	0.094
Nitrate N	0.085	27	<0.02	0.136	0.029
Nitrite N	All <0.005	39			
Kjeldahl N	0.136	66	0.01	0.28	0.099
C.O.D.	3.3	24	<0.5	21.1	4.4
Ortho P	0.004	35	<0.002	0.023	0.004
Total Diss. P	0.009* (.0056)	71	<0.002	0.218*	0.026
Total P	0.014	90	<0.002	0.111	0.016
Silica	5.6	81	3	7.7	0.94
Sulphate (Diss.)	7.5	102	3.8	12.5	1.9
Tannin & Lignin	0.24	9	0.2	0.3	0.05
Inorganic Carbon	8.7	41	3	14	2.5
Arsenic (Diss.)	All <0.005	6			
Arsenic (Total)	All <0.005	10			
Cadmium (Total)	All <0.001	9			
Calcium	12.6	106	<0.5	18.9	2.4
Copper (Total)	0.004	21	<0.001	0.02	0.005
Lead (Total)	0.003	23	<0.001	0.011	0.003
Mercury (Total)	All <0.00005	12			
Molybdenum (Total)	<0.007	8	<0.0002	<0.05	0.017
Sodium	1.8	83	0.9	3	0.5
Zinc (Total)		24	<0.001	0.022	0.005
Fecal Coliforms	14.2	27	<2	130	29
Total Coliforms	69.1	22	<2	920	193.9

* Without the questionable 0.218 of 66/12/11, the mean would be 0.005

TABLE 30
WATER QUALITY SUMMARY FOR JAMIESON CREEK NEAR MOUTH
(STATION 0600119) 1974 - 1976

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	8.1	11	7.7	8.3	0.2
Res. 105	148	8	98	230	45
Res. F 105	144	8	94	226	46.7
Spec. Cond.	225	11	143	362	70
Turbidity	1.4	6	0.6	3.8	1.2
Colour TAC	4.2	5	1	9	3.2
Alkalinity	98	8	63	143	29
Chloride	0.6	4	0.3	0.9	0.3
Hardness	106	7	68	172	39
Nitrate/Nitrite N	0.07	4	<0.02	0.15	0.062
Nitrate N	0.038	4	<0.02	0.08	0.028
Nitrite N	All <0.005	4			
Kjeldahl N	0.091	8	0.01	0.24	0.071
Total N	0.136	8	<0.02	0.27	0.074
Total Diss. P	0.003	5	<0.003	0.004	0.0004
Total P	0.006	8	<0.003	0.013	0.003
Silica	11.8	4	11.3	12.5	0.62
Sulphate	22.6	6	10.9	47.3	14.3
Calcium	32.8	7	23	48.6	10.1
Copper (Diss.)	0.001	4	<0.001	0.003	0.001
Lead (Diss.)	All <0.001	3			
Molybdenum (Diss.)	0.001	3	0.0005	0.0015	0.0005
Molybdenum (Total)	0.0012	3	0.001	0.0016	0.0003
Sodium	3.8	3	2.5	4.9	1.2
Zinc (Diss.)	0.006	4	<0.005	0.001	0.002
Fecal Coliforms	3.5	4	<2	5	1.7

TABLE 31
WATER QUALITY SUMMARY FOR HEFFLEY CREEK AT HIGHWAY 5
(STATION 0600182) 1976 - 1978

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	8.4	7	8.3	8.5	0.07
Res. 105	393	4	280	442	76
Res. NF 105	7	2	6	8	1.4
Spec. Cond.	561	7	398	643	111
Turbidity	3.1	4	1.2	6.5	2.4
Colour TAC	4	4	1	10	4
Alkalinity	222	5	179	240	24
Hardness	292	4	206	330	58
Nitrite/Nitrate N	0.147	3	0.04	0.2	0.092
Kjeldahl N	0.165	4	0.12	0.21	0.039
Total N	0.325	4	0.25	0.38	0.056
Total Diss. P	0.014	4	0.01	0.02	0.004
Total P	0.022	4	0.015	0.027	0.006
Silica	14.9	1			
Fecal Coliforms	15	2	13	17	2.8

TABLE 32
WATER QUALITY SUMMARY FOR NOBLE CREEK AT THE MOUTH
(STATION 0600118)

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour (True)	30	1			
pH (Field)	8.3	5	7.7	8.8	0.4
pH (Lab)	8.3	11	7.8	8.5	0.2
Res. 105	863	8	186	1506	395
Res. NF	4.7	3	3	6	1.1
Spec. Cond. (F)	1050	4	260	1540	564
Spec. Cond. (L)	1075	12	224	1570	371
Oxygen (Diss.)	11.2	6	8.8	12.5	1.5
Turbidity	1.6	6	0.6	4.2	1.4
Colour TAC	3.2	5	1	6	1.9
Alkalinity	181	8	84	220	42
T.O.C.	1.3	3	<1	2	0.6
Chloride	1.25	4	0.7	1.8	0.5
Fluoride	0.17	3	0.14	0.21	0.04
Hardness	598	7	109	934	253
Nitrate N	108	4	20	190	70
Kjeldahl N	101	8	50	190	41
Total N	204	8	70	380	80
Total Diss. P	11	5	4	33	12
Total P	13	8	5	34	10
Silica	16.9	4	15	18.8	1.8
Sulphate	424	6	206	540	129
Calcium	117	7	31	183	50
Copper (Diss.)	<0.002	4	<0.001	0.004	0.001
Molybdenum (Diss.)	0.0036	3	0.002	0.006	0.001

TABLE 33

PAUL CREEK - COMPARISON OF MEAN WATER QUALITY AT THREE SITES

	ABOVE LAKE 0600305 1977-1979	LAKE OUTLET 0600134 1975-1979	AT HWY 5 0600070 1975-1979
pH	8.3	8.4	8.4
Res. 105	271	234	393
Res. NF	15	3.7	10
Spec. Cond.	419	367	
Oxygen (Diss.)	10.3	10	
Turbidity	2.8	2.2	7.5
Colour (TAC)	8	7	6.1
Organic Carbon	7	7.7	3.6
Chloride	1.1	2.1	3.5
Nitrate N	30	<20	11
Nitrate/Nitrite N	40	<20	40
Kjeldahl N	330	400	200
Ortho P	14	<3	15
Total Diss. P	18	8	19
Total P	26	15	40
Fecal Coliforms	42	9	84
Total Coliforms	93	8	423

TABLE 34
WATER QUALITY SUMMARY FOR PAUL CREEK ABOVE PAUL LAKE
(STATION 0600305) 1977 - 1979

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	8.3	9	8.2	8.4	0.1
Res. 105	271	8	244	316	26
Res. NF 105	15	3	10	19	5
Spec. Cond.	419	10	370	474	37
Oxygen (Diss.)	10.3	5	9.5	11.2	0.7
Turbidity	2.8	2	1.4	4.2	2.0
Colour TAC	8	2	6	10	3
Alkalinity	219	2	205	232	19
Organic Carbon	7	5	4	11	3
Chloride (Diss.)	1.1	2	0.8	1.4	0.4
Fluoride (Diss.)	0.15	1			
Hardness	225	2	215	234	13
NH_3 N	0.018	5	0.013	0.023	0.004
NO_2 & NO_3 N	0.04	7	0.02	0.08	0.02
Nitrate N	0.03	1			
Nitrite N	<0.005	1			
Organic N	0.26	4	0.09	0.36	0.12
Kjeldahl N	0.33	7	0.1	0.49	0.12
Total N	0.37	7	0.14	0.56	0.13
Ortho P	0.014	2	0.011	0.017	0.004
Total Diss. P	0.018	5	0.013	0.026	0.004
Total P	0.026	8	0.02	0.03	0.003
Carbon IO	51	5	44	62	7
Arsenic (Total)	0.0065	2	<0.005	0.008	0.002
Calcium (Total)	55.8	2	52.9	58.6	4.0
Copper (Total)	0.002	2	<0.001	0.003	0.001
Iron (Total)	0.2	1			
Lead (Total)	Both <0.001	2			
Molybdenum (Total)	0.0008	1			
Zinc (Total)	<0.005	1			
Fecal Coliforms	42	5	17	79	24
Total Coliforms	93	5	33	240	88

TABLE 35
WATER QUALITY SUMMARY FOR PAUL CREEK AT PAUL LAKE OUTLET
(STATION 0600134) 1975 - 1979

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	1.3	1			
pH	8.4	21	7.6	8.7	0.3
Res. 105	234	15	202	384	57
Res. NF 105	3.7	7	<1.0	14	4.7
Spec. Cond.	367	22	322	560	78
Oxygen (Diss.)	10	12	8	12	1
Turbidity	2.2	8	0.6	7.3	2.2
Colour TAC	7	8	4	11	2
C.D.C.	520	2	377	663	202
Alkalinity	179	8	149	256	42
Organic Carbon	7.7	9	4.0	16.0	3.5
Chloride (Diss.)	2.1	8	1.1	3.7	1
Fluoride (Diss.)	0.19	2	0.19	0.2	0.01
Hardness	196	8	160	284	51
NH_3 (Diss.)	0.057	6	0.015	0.254	0.097
NO_2/NO_3 N	All <0.02	13			
Nitrate N	Both <0.02	2			
Nitrate N	Both <0.02	2			
Nitrite N	All <0.005	4			
Organic N	0.42	5	0.32	0.56	0.1
Kjeldahl N	0.4	15	0.2	0.81	0.14
Total N	0.4	15	0.2	0.81	0.14
Ortho P	All <0.003	3			
Total Diss. P	0.008	14	<0.003	0.019	0.004
Total P	0.015	16	0.005	0.031	0.008
Silica (Diss.)	8.2	3	6.4	9.1	1.5
Sulphate (Diss.)	44.9	4	25	90.1	30.8
Tan. & Lig (Total)	0.4	3	0.3	0.5	0.1
Carbon I0	39	9	34	65	10
Arsenic (Total)	Both <0.005	2			
Cadmium (Total)	Both <0.0005	2			
Calcium (Diss.)	42.1	5	33.8	67	14
Caldium (Total)	38.5	1			
Chromium (Diss.)	<0.005	1			
Copper (Diss.)	<0.001	2	<0.001	0.001	
Copper (Total)	0.002	5	<0.001	0.003	0.001
Iron (Diss.)	<0.1	2	<0.1	0.1	
Iron (Total)	0.25	4	0.1	0.4	0.13
Lead (Diss.)	<0.001	1			
Lead (Total)	0.002	5	<0.001	0.004	0.001

TABLE 35 (continued)

WATER QUALITY SUMMARY FOR PAUL CREEK AT PAUL LAKE OUTLET
(STATION 0600134) 1975 - 1979

Characteristic	Mean Value	n	minimum	maximum	deviation
Magnesium (Diss.)	16.8	1			
Magnesium (Total)	23.5	2	18.7	28.3	6.8
Molybdenum (Total)	0.0011	2	0.0009	0.0013	0.0003
Potassium (Diss.)	3.1	2	2.7	3.4	0.5
Sodium (Diss.)	12.3	2	8.7	15.8	5
Zinc (Diss.)	Both <0.005	2			
Zinc (Total)	0.009	5	<0.005	0.015	0.004
Fecal Coliforms	2.0	9	<2.0	2.0	
Fecal Coliforms	4.0	8	<2.0	7	2.3

TABLE 36
WATER QUALITY SUMMARY FOR PAUL CREEK AT HIGHWAY 5
(STATION 0600070) 1972 - 1979

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour true	10	9	5	30	8.3
Oil & grease	<1.0	5	<1.0	1.2	0.09
pH	8.4	25	8.1	8.6	0.1
Res 105	393	24	228	598	104
Res NF 105	10	7	2	24	8.1
Spec. Cond.	563	28	353	701	120
Turbidity	7.5	17	0.9	55	12.5
Colour TAC	6.1	9	3	9	1.8
Alkalinity	226	16	167	286	35.5
Organic Carbon	3.6	12	<1	7	2.1
Chloride	2.1	7	2.0	3.1	2.7
Flouride	0.28	4	0.23	0.33	0.046
Hardness	271	13	133	381	69
Ammonia N	0.011	4	0.007	0.014	0.003
Nitrate N	0.04	12	<0.02	0.110	0.03
Kjeldahl N	0.2	24	0.06	0.51	0.10
Ortho P	0.015	6	0.008	0.022	0.005
Total Diss. P	0.019	12	0.008	0.033	0.006
Total P	0.040	25	0.016	0.174	0.03
Silica	16.7	6	14.1	18.5	1.6
Sulphate	95	13	27	195	49
Copper (Total)	0.004	8	<0.001	0.010	0.003
Lead (Total)	0.002	8	<0.001	0.003	0.001
Molybdenum	0.002	2	0.0021	0.0024	0.00002
Fecal Coliform	83.5	10	7	230	83.5
Total Coliform	423.3	9	130	1100	423.3

TABLE 37
WATER QUALITY SUMMARY FOR PAUL LAKE AT EAST END
(STATION 0603023) 1974 - 1979

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour (True)	20	1			
pH	8.3	16	7.8	8.6	0.2
Res. 105	217	6	208	224	6
Rés. F 105	215	6	206	222	6
Spec. Cond.	346	17	331	358	6
Oxygen (Diss.)	9.6	8	8.3	10.4	0.8
Turbidity	0.6	6	0.3	1	0.3
Colour TAC	5	7	4	7	1
C.D.C.	374	3	366	380	7
Alkalinity	156	6	152	161	4
Organic Carbon	8	12	1	24	6
Chloride (Diss.)	1.2	6	1	1.3	0.1
Cyanide (Total)	Both <0.01	2			
Hardness	167	6	160	170	4
NH_3 N	0.016	2	0.013	0.019	0.004
NO_2/NO_3 N	All <0.02	9			
Nitrate N	0.03	5	<0.02	0.07	0.02
Nitrate N	All <0.02	4			
Nitrate N	All <0.005	9			
Kjeldahl N	0.34	14	0.27	0.39	0.04
Total N	0.35	14	0.27	0.39	0.04
Ortho P	0.003	11	<0.003	0.008	0.002
Total Diss. P	0.006	10	0.003	0.007	0.001
Total P	0.01	14	0.006	0.02	0.004
Silica (Diss.)	9.3	6	9	10	0.4
Sulphate +	26.4	6	25.1	27.3	1
Surfacants(Total)	All <0.003	3			
Carbon I0	39	12	36	42	2
Chlorophyll a (mg/m^2)	1.6	6	1.0	2.6	0.05
Arsenic (Diss.)	<0.005	1			
Arsenic (Total)	<0.005	1			
Cadmium (Total)	Both <0.0005	2			
Calcium (Diss.)	37.1	6	36.1	38.6	0.7
Copper (Total)	Both <0.001	2			
Iron (Total)	0.1	2	<0.1	0.1	
Magnesium (Diss.)	17.6	3	17	18	0.6
Lead (Total)	Both <0.001	2			
Mercury (Total)	Both <0.00005	2			
Potassium (Diss.)	2.48	5	2.4	2.5	0.04
Sodium (Diss.)	7.5	5	7.3	7.7	0.2
Zinc (Total)	0.006	2	<0.005	0.007	0.001
Fecal Coliforms	Both <2.0	2			
Total Coliforms	2	1			

TABLE 38
WATER QUALITY SUMMARY FOR PAUL LAKE AT NORTH END
(STATION 0603024) 1974 - 1979

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour (True)	15	1			
pH	8.4	16	7.9	8.5	0.2
Res. 105	217	6	210	224	5
Res. F 105	215	6	208	222	5
Spec. Cond.	345	17	332	356	6
Oxygen (Diss.)	9.5	8	8.2	10.5	0.8
Turbidity	0.5	6	0.2	0.7	0.2
Colour TAC	5.7	6	5	7	0.8
Alkalinity	156	6	151	160	4
Organic Carbon	7	12	2	15	4
Chloride	1.2	6	1	1.3	0.1
Cyanide (Total)	Both <0.01	2			
Hardness	166	6	160	170	4
NH_3 N	Both <0.17	2			
NO_2/NO_3 N	All <0.02	9			
Nitrate N	0.04	5	<0.02	0.14	0.05
Nitrate N	All <0.02	4			
Nitrite N	All <0.005	9			
Kjeldahl N	0.37	14	0.29	0.45	0.05
Total N	0.38	14	0.29	0.49	0.06
Ortho P	0.004	11	<0.003	0.018	0.005
Total Diss. P	0.006	10	<0.003	0.007	0.001
Total P	0.012	14	0.007	0.025	0.005
Silica (Diss.)	9.3	6	9	10	0.4
Sulphate (Diss.)	26.4	6	25.1	27.6	1
Surfacan (Total)	All <0.03	3			
Carbon IO	38	12	35	42	2
Chlorophyll a	0.0016	6	0.001	0.0027	0.0006
Arsenic (Diss.)	<0.005	1			
Arsenic (Total)	<0.005	1			
Cadmium (Total)	Both <0.0005	2			
Calcium (Diss.)	37.1	7	35.8	38.3	0.8
Copper (Total)	Both <0.001	2			
Iron (Total)	Both <0.1	2			
Lead (Total)	Both <0.001	2			
Magnesium (Diss.)	17.7	3	17	18.1	0.6
Mercury (Total)	Both <0.00005	2			
Potassium (Diss.)	2.48	5	2.4	2.5	0.04
Sodium (Diss.)	7.5	5	7.2	7.7	0.2
Zinc (Total)	0.006	2	<0.005	0.007	0.001
Fecal Coliforms	Both <2.0	2			
Total Coliforms	<2.0				

TABLE 39
WATER QUALITY SUMMARY FOR PAUL LAKE AT SOUTH END
(STATION 0603025) 1974 - 1982

Characteristic		Mean Value	n	minimum	maximum	deviation
Colour (True)		9	4	5	15	5
pH		8.3	21	7.8	8.6	0.2
Res. 105		218	10	210	224	5
Res. 550		123	3	120	126	3
Res. F 105		216	7	208	222	6
Res. NF 105	All	1.0	3			
Res. NF 550	All	<1.0	3			
Spec. Cond.		349	22	328	378	11
Oxygen (Diss.)		9.5	9	8.4	10.4	0.9
Turbidity		0.6	10	0.3	0.8	0.2
Colour TAC		5.9	7	5	8	1.1
Alkalinity		159	9	150	168	5
Organic Carbon		6	16	<1	17	4
Chloride (Diss.)		1.3	8	1.1	1.5	0.1
Cyanide (Total)	Both	<0.01	2			
Hardness		167	7	160	169	3
NH_3 (Diss.)		0.013	5	<0.005	0.022	0.008
NO_2/NO_3 N		0.03	12	<0.02	0.09	0.02
Nitrate N		0.06	6	<0.02	0.17	0.06
Nitrate N	All	<0.02	4			
Nitrite N	All	<0.005	10			
Organic N		0.31	3	0.28	0.33	0.03
Kjeldahl N		0.34	18	0.24	0.44	0.05
Total N		0.36	18	0.24	0.61	0.07
C.O.D.		26	3	13	48	19
Ortho P		0.006	15	<0.003	0.023	0.006
Total Diss. P		0.008	14	0.003	0.022	0.005
Total P		0.014	18	0.007	0.022	0.008
Silica (Diss.)		9.9	10	8.9	11.7	0.9
Sulphate (Diss.)		26.2	7	25.5	27.6	0.7
Surfacan (Total)	All	L0.03	3			
Carbon I0		39	16	35	44	3
Chlorophyll a (mg/m˝)		2.0	10	1.0	M3.3	1.0
Arsenic (Diss.)		<0.005	1			
Arsenic (Total)		<0.005	1			
Cadmium (Total)	All	<0.0005	3			
Calcium (Diss.)		34.4	7	35.7	38.2	0.8
Copper (Total)	All	<0.001	3			
Iron (Total)		0.15	2	<0.1	0.2	0.07
Lead (Total)		0.001	3	<0.001	0.001	0.0
Magnesium (Diss.)		17.9	3	17.1	18.5	0.7
Mercury Total	Both	<0.00005	2			
Nickel (Total)		<0.01	1			
Potassium (Diss.)		2.5	7	2.4	2.6	0.7
Zinc (Total)		0.012	3	<0.005	0.027	0.013
Fecal Coliforms	All	<2.0	3			
Total Coliforms		<2.0	1			

TABLE 40
WATER QUALITY SUMMARY FOR PAUL LAKE AT WEST END
(STATION 0603026) 1974 - 1979

Characteristic		Mean Value	n	minimum	maximum	deviation
Colour True		10	1			
pH		8.4	16	8.0	8.6	0.2
Res. 105		218	6	210	226	5
Res. F 105		216	6	208	224	5
Spec. Cond.		344	17	328	352	6
Oxygen (Diss.)		9.6	8	8.6	10.5	0.6
Turbidity		0.5	6	0.3	0.8	0.2
Colour TAC		5.8	6	5	8	1.1
Alkalinity		156	6	150	160	4
Organic Carbon		7	12	1	23	5
Chloride (Diss.)		1.2	6	1.1	1.3	0.1
Cyanide (Total)	Both	<0.01	2			
Hardness		156	6	109	169	24
NH_3 N	Both	0.19	2			
NO_2/NO_3 N	All	<0.02	9			
Nitrate N		0.04	5	<0.02	0.11	0.04
Nitrate N	All	<0.02	4			
Nitrite N	All	<0.005	9			
Kjeldahl N		0.39	14	0.26	0.77	0.12
Total N		0.40	14	0.26	0.77	0.12
Ortho P		0.004	11	<0.003	0.016	0.004
Total Diss. P		0.006	10	0.004	0.008	0.001
Total P		0.011	11	0.005	0.029	0.006
Silica (Diss.)		9.2	6	8.8	10.1	0.5
Sulphate (Diss.)		26.3	6	25.5	28.1	0.9
Surfacan (Total)	All	<0.03	3			
Carbon IO		39	12	35	43	2
Chlorophyll a (mg/m^3)		1.8	6	1.0	2.4	0.6
Arsenic (Diss.)		<0.005	1			
Arsenic (Total)		<0.005	1			
Cadmium (Total)	Both	<0.0005	2			
Calcium (Diss.)		37.3	6	35.7	38.1	1.0
Copper (Total)	Both	<0.001	2			
Iron (Total)		0.15	2	<0.1	0.2	0.07
Lead (Total)	Both	<0.001	2			
Magnesium (Diss.)		17.7	3	16.9	18.1	0.7
Mercury (Total)	Both	<0.00005	2			
Potassium (Diss.)		2.48	5	2.4	2.5	0.04
Sodium (Diss.)		7.6	5	7.2	7.8	0.3
Zinc (Total)		0.005	2	<0.005	0.005	
Fecal Coliforms	Both	<2	2			
Total Coliforms		<2	1			

TABLE 41
TIME-BASED COMPARISON OF MEAN WATER QUALITY FOR THE NORTH THOMPSON RIV
AT NORTH KAMLOOPS (STATION 0600164)

Characteristic	1973-1976		1977-1980		1981-1984		1985-1988	
pH	7.3	(n=83)	7.8	n=18	7.9	n=30	7.7	n=22
Res. Total	68.3	(n=32)	74.6	n= 7	98.3	n=14	71.5	n=22
Res. NF	11.8	(n=32)	8.3	n= 4			14.1	n=19
Spec. Cond.	96.6	(n=91)	103.7	n=17	119.1	n=30	90.6	n=22
Turbidity	4.0	(n=44)	3.9	n= 7			5.8	n= 5
Colour TAC	4.9	(n=31)	7.0	n=12	12.7	n=10		
Alkalinity	35.4	(n=31)	45.4	n= 4				
Organic Carbon (Total)	2.0	(n=25)	1.5	n= 2	2.7	n= 9		
Kjeldahl N (Total)	0.114	(n=31)	0.126	n=15	0.143	n=16	0.074	n=22
Nitrogen (Total)	0.192	(n=33)	0.225	n=14	0.247	n=16		
Sulphate	6	(n= 4)	7.7	n= 3	9.4	n=15	7.5	n=21
Inorg. Carbon (Total)	8	(n=29)	10.3	n= 3	11	n= 6		
Chloride	0.6	(n=28)	1.4	n= 4	0.6	n= 7	0.7	n=16
Ammonia N	0.007	(n= 8)	0.016	n= 3	0.008	n=10	0.006	n=22
NO_3 and NO_2 N	0.066	(n= 5)	0.103	n=15	0.104	n=16	0.109	n= 3
NO_3 N	0.088	(n=24)			0.104	n=16	0.109	n= 3
Calcium	12.2	(n=39)	13.9	n= 4	15.7	n=14	13.7	n=14
Copper (Diss.)	0.001	(n=11)						
Sodium	1.7	(n=14)	2	n= 7	2.5	n=15		
Dissolved P.	0.006	(n=30)	0.004	n=16	0.005	n=15	0.003	n=22
Total P	0.016	(n=37)	0.009	n=16	0.021	n=15	0.013	n=22
Fecal Coliforms			21.3	n=17			9.1	n= 6

TABLE 42
THE AVERAGE MONTHLY MAXIMUM, MEAN AND MINIMUM FLOWS
FOR THE NORTH AND SOUTH THOMPSON RIVERS COMBINED
(FROM DERKSEN 1988) (m^3/s)

	maximum	minimum	mean
January	140	60	90
February	110	30	70
March	160	25	80
April	500	250	300
May	2400	525	1400
June	3200	1750	2450
July	2600	1450	2000
August	1600	850	1150
September	950	500	650
October	625	300	400
November	525	240	340
December	275	140	210

TABLE 43
SUSPENDED SOLIDS IN WEYCAN EFFLUENT 1977 - 1985 (kg/d)

	SEAM/WeyCan	Derksen
1976		11418* Annual mean
1977	7842	7218*
1979	11145	10982*
1980	11136	
1981	10653	
1982	9704	
1983	-	
1984	11980	
1985	9080	
1986	13518	
1987	12823	
1988	17125	
1989	13574	
1990	10168	
1991	9254	

* data cited in Derksen (1980)

TABLE 44
B.O.D. IN WEYCAN EFFLUENT 1976 - 1987(kg/d)

	SEAM/WeyCan	Derksen
1976		4764* Annual mean
1977	4151	4600*
1979	6108	6209
1980	4142	
1981	3327	
1982	3338	
1983	-	
1984	-	
1985	2842	
1986	4734	
1987	2837	
1988	3957	
1989	3021	
1990	3550	
1991	4248	

* data cited in Derksen (1980)

TABLE 45

SUMMARY OF BIOASSAY RESULTS FOR WEYERHAEUSER EFFLUENT

YEAR	SAMPLING DATE	SPECIES	LOADING DENSITY (g/L)	PERCENT SURVIVAL 96h PROVINCIAL 90% CONC.	PERCENT SURVIVAL 96h PROVINCIAL 100% CONC.	PERCENT SURVIVAL 96h FEDERAL 65% CONC.
1980	January 7	Rainbow	0.40	100	100	-
1980	December 15	Trout	0.40	100	-	100
1981	February 18		0.60	100	100	-
1981	May 11		0.70	100	100	-
1981	October 19		0.20	100	100	-
1981	December 7		0.40	100	100	-
1981	December 17		0.50	100	100	-
1982	January 19		0.40	100	100	-
1982	February 9		0.50	100	100	-
1982	March 8		0.60	100	100	-
1982	September				100 (8 tests)	
1982	October				100 (9 tests)	

Testing done by EPS Environment Canada Toxicity Lab.

1983	March	5 tests	average LC_{50} of 82% (range 70 - 100%)
	April	2 tests	100% survival at 100% effluent concentratio
	June		100% survival at 90% effluent
	July		as above
	August		as above
	October	6 tests	100% survival at 90% effluent
	December	1 test	100% survival at 90% effluent
1984	February	2 tests	100% survival at 90% and 100% effluent
	May	daily tests	10th - 31st, 1 result at LC_{50} at 94% all others at >100%
	June	12 tests	100% LC_{50} values of 88, 79, 84 and 68%
	July	14 tests	13 were 100%, one 78% at 90% effluent
	September		100% survival at 90% concentration
	October		as above
	November		as above
	December		as above
1985	January		100
	February		>90
	March		>100
	April		>100
	May		no test (mill shutdown)
	June		100
	July		100
	August		100
	September		100
	October		100
	November		100
	December		100

TABLE 45
SUMMARY OF BIOASSAY RESULTS FOR WEYERHAEUSER EFFLUENT
(continued)

YEAR	SAMPLING DATE	SPECIES	LOADING DENSITY (gm/l)	% SURVIVAL 96hr 100% CONC.		96 hr LC_{50} % effluent
1986	January 15	Rainbow Trout	0.75	100		>100
1986	February 21		0.30	100		>100
1986	March 14		0.52	60	87% conc. - 100	>100
1986	May 2		0.25	90		>100
1986	May 28		0.25	80		>100
1986	June 13		0.25	80		>100
1986	July 9		0.55	100		>100
1986	August 28		0.85	100		>100
1986	October 1		0.52	100		>100
1986	October 16 (Sample A)		0.52	0	65% conc. - 100	80.6
1986	October 16 (Sample B, diluted)		0.52	100		>100
1986	October 22		0.52	100		>100
1986	November 5		0.67	100		>100
1986	December 6		0.67	100		>100

Testing done by B.C. Research

YEAR	SAMPLING DATE	WHO	SPECIES	LOADING DENSITY (gm/l)	PERCENT SURVIVAL 96hr 100% CONC.	90% CONC.	REMARKS
1983	February 3	IEC Beak	Rainbow	0.23		30	
1983	February 10	IEC Beak	Rainbow	0.23		0	(0% survival at 72 hr)
1983	February 17	IEC Beak	rainbow	0.48		0	(0% survival at 48 hr)
		BC Research	rainbow	0.80	90		(96h LC_{50} >100%)
		E.P.S.	rainbow	?		0	(0% survival at 24hr)
1983	February 24	IEC Beck	rainbow	0.48		0	(0% survival at 48hr) (96h LC_{50} 67.
		BC Research	rainbow	0.80	40		(96h LC_{50} 98.
		E.P.S.	rainbow	?			(96hr LC_{50} 80

TABLE 46a

MEAN ANNUAL COLOUR DISCHARGED FROM WEYERHAEUSER (1977 - 1981)

	mg/L	kg/d x 10^3
1977	1876	315
1978	1042	338
1979	1831	322
1980	1723	323
1981	1451	256
1984		278
1985		333

TABLE 46b

MONTHLY DATA FOR COLOUR IN WEYERHAEUSER EFFLUENT 1984 - 1985)

kg/d x 10^3 (SWC units converted on basis 1 unit = 1 mg/L)

	1984	1985
January	721	305
February	-	308
March	-	364
April	168	323
May	271	277
June	296	374
July	282	362
August	277	405
September	255	330
October	291	322
November	370	291
December	299	-

TABLE 47

MEASURED COLOUR IN TREATED EFFLUENT FROM WEYERHAEUSER, 1973 - 1986

		1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Jan	True diss	2050*	2139	1423	1584	1833	1478	1456	1868	1234	1187	1441	1873	2182	1880
	TrueTotal	2370	1890												
	TAC Diss.	1461	1520	1180	1295	1125	1152	1200	1130	700	872	1280	1344	1548	1349
Feb		1594*	1245	1495	1770	2013	1685	1814	1751	1349	1378	1952	--	2132	2021
		1843	1974												
		1160	930	1300	1317	1465	1437	1640	1123	1100	784	1396		1515	1440
Mar		1524*	1867	1600	1800	2095	1864	1860	1605	1379	1218	1625	--	2531	2043
		1878	2197												
		1180	1340	1220	1296	1680	1463	1490	1370	900	912	1181		1778	1522
Apr		2007*	1564	1571	1564	1529	2245	1887	1643	1499	995	1628	1247	2399	2073
		2320	1717				2031								
		1433	1140	1497	1186	1117	1590	1353	750	1075	765	920	9311	6911	476
May		1971*	1084	1578	2024	1912	1738	1984	1757	1601	1365	1751	1775	2078	2051
		2279	1844												
		1408	830	1423	1640	1301	1255	1770	1040	1000	800	1264	1300	1479	1462
Jun		1829*	1352	1700	1957	2329	2011	2440	1656	1548	1405	1908	2001	2657	2168
		2115	2098												
		1315	1000	1230	1555	1810	1460	2815	1000	1001	1035	1367	1429	1862	1539
								(1718)							
July		2019*	1973	1695	1925	2016	1941	1717	1689	1449	1074	1795	1794	2520	2094
		2334	1608												
		1441	1410	1227	1379	1439	1800	1500	1222	1064	81	1150	1292	1500	1000
August		1490*	1382	--	2010	2064	1925	1617	1942	--	1584	1481	1745	2556	2097
		1722	1888												
		1091	1020		1382	1600	1471	1810	800		1153	1085	1260	1795	1492
								(1175)							
September		715	1324	--	1339	1244	1889	1600	1796	1443	1611	1659	1750	2465	2184
		1117	2072												
		580	1220		992	929	1380	1164	1293	950	2240	1050	1263	1735	1549
(1171)															
October		1715	1168	978	1838	1773	2029	1921	1667	1535	1659	1919	1972	2215	2466
		1995													
		1240	1310	1523	1220	1350	1880	1400	1250	1121	1203	3756	1330	1570	1400
			(879)	(753)											

Table 47 continued **MEASURED COLOUR IN TREATED EFFLUENT FROM WEYERHAEUSI 1973 - 1986**

November	2715	1404	1867	1871	1424	1780	1758	1478	1645	1411	1260	2425	2021	2259
	2665													
	1900	1355	1414	1343	1048	1283	1200	1100	1194	1039	940	1709	1000	1599
December	1541*	1513	1934	2091	2084	1799	1836	1486	1289	1740	1462	2200	?	2257
	1782													
	1125	1300	1584	1726	1880	1800	1060	1089	890	1256	1073	1560		1598
						(1295)								

Notes: All values are monthly averages. All underscored values are calculated based on the equation TAC=108+0.66SWC where TAC=colour TAC dissolved and SWC=colour true dissolved. In the equation, SWC values should be in the range 900-1900 units but this has been disregarded. Assumption made that true diss. colour is 86.5% of true total colour. "?" indicates poor data. "--" indicates no value because of mill shutdown

TABLE 48

CALCULATED ANNUAL LOADS (kg) OF PHOSPHORUS FROM THE WEYERHAEUSER PULPMILL

YEAR	Total Dissolved Phosphorus (TDP)		Total Phosphorus (TP)	
1974	17232		39146	
1975	14330		32879	
1976	38586		51100	
1977	36704	5 year mean	52500	5 year mean
1978	44678	1976-80	46550	1976-1980
1979	35480	40339	36400	47460
1980	46249		50750	
1981	24400		40648	
1982	13146		40755	
1983	22095	5 year mean	53200	5 year mean
1984	18489	1982-86	60200	1982-86
1985	19126	18201	57750	56440
1986	18150		55193	
1987	25771	5 year mean	60401	5 year mean
1988	36512	1987-91	78831	1987-91
1989	18480	22090	48684	52924
1990	17016		42601	
1991	12670		34101	

year	% tdp/tp	
1974	44	
1975	44	
1976	76	
1977	70	
1978	96	mean
1979	97	1976-80
1980	91	86%
1981	60	
1982	32	
1983	42	mean
1984	31	1982-86
1985	33	34%
1986	33	
1987	42	
1988	46	mean
1989	38	1987-91
1990	40	41%
1991	37	

There are several complicating factors involved in interpreting these data. The total phosphorus data cited above is from Table 50. The annual loads were calculated excluding some of the monthly "calculated" values - thus only real measurement data were used.

The data for dissolved phosphorus needs to be evaluated in the context of at least one and perhaps more, methodological changes. This may be the major factor in the significant changes in proportions of TDP:TP. What appears to have happened is that there was an increase in TP in the periods 1976-80 and 1983-86. Between these two periods, two things changed. First the production increased and and the volume of effluent decreased due to the water reduction program initiated at the mill. This obviously resulted a concentration increase in TP.The environmental significance of the change in loading as well as the proportion of available P are not known since the the bioavailability of the P once it enters the river system is not known.

TABLE 49
AMBIENT PHOSPHORUS (UG/L) DATA FROM WEYERHAEUSER ANNUAL RIVER STUDIES SUMMARY

		Jan.	Feb.	March	April	Oct.	Nov.	Dec.
1973	Savona					7	4	
	Walhachin					5	5	
1974	Savona	5	4	5	5	4	5	5
	Walhachin	4		4	5	5	4	4
1975	Savona	5	5	5				
	Walhachin			5				
1977	Savona					3	4.7	6
	Walhachin					3.5	4	5.5
1978	N. Thompson						ice on river	
	S. Thompson							5
	Savona	6	6.5	5.7	4			5
	Walhachin	4	5	5.7	4			7.5
1979	N. Thompson	ice on river				7.0	5.0	8
	S. Thompson	ice on river		13.0	<5	<7.0	5.0	8
	Savona	6.2	<5	10.5	<5	17.5	<5	5.3
	Walhachin	5	5	5.8	6.7	6.0	5.3	6.4
1980	N. Thompson	ice	<5	7.5	5.0			3.6
	S. Thompson	6.3	<5	8.0	7.0			4.8
	Savona	7.5	5.7	9.5	23.0			3.9
	Walhachin	9.5	<5	7.0	10.0			4.4
1981	N. Thompson	3.3	3.3	2.8	5.1	1.6	2.1	2.9
	S. Thompson	1.9	2.7	2.5	3.1	2.3	1.8	1.3
	Savona	3.2	4.3	3.2	4.4	2.9	2.1	2.6
	Walhachin	3.3	3.7	2.6	4.2	2.9	2.1	3
1982	N. Thompson	2.6	4.2	1.6	5.7		5.1	1
	S. Thompson	0.6	4.4	1.4	2.9		3	1.3
	Savona	2.7	2.9	2.7	2.9		1.7	1.2
	Walhachin	2.4	2.9	4.6	3.4		1.4	1.6
1983	N. Thompson	1	9.8	1.8	1.4	3.4		1.4
	S. Thompson	1	1.8	0.7	1	3		1.2
	Savona	1.7	3.3	2.2	2.6	2.8		2.2
	Walhachin	1.5	2.4	1.9	1.7	3		2
1984	S. Thompson	1.7			1	<1	2.3	2.4
	Savona	3			2.6	3.5	3.7	3.5
	Walhachin	2			2.9	1.2	5.2	3.2

TABLE 49 (continued)

AMBIENT PHOSPHORUS DATA FROM WEYERHAEUSER ANNUAL RIVER STUDIES - SUMMARY

		Jan.	Feb.	March	April	Oct.	Nov.	Dec.
1985	N. Thompson			2.0	5.0	2.4	1.2	
	S. Thompson	7.5		2.1	1.7	1.4	<1.0	1.2
	Savona	5.1		4.2	5.6	2.1	1.5	1.4
	Walhachin	5.6		6.3	5.9	1.5	1.9	<1.0
1986	N. Thompson	3.6	4.0	3.4	1.0	<1.0	1.2	3.6
	S. Thompson	1.1	2.0	1.8	1.0	<1.0	<1.0	1.6
	Savona	1.1	3.1	4.1	3.7	<1.0	2.6	2.8
	Walhachin	1.3	1.9	5.8	3.9	<1.0	1.9	3.8
1987	N. Thompson	1.4	4.4	<1.0	1.3	<1.0	<1.0	<0.1
	S. Thompson	1.6	3.0	<1.0	<1.0	<1.0	<1.0	<1.0
	Savona	2.8	4.7	3.3	1.7	1.6	1.1	1.8
	Walhachin	1.8	5.7	3.2	2.6	1.4	1.2	1.0
1988	N. Thompson	<1.0	ns	1.4	<1.0	<1.0	<1.0	<1.0
	S. Thompson	1.3	1.5	<1.0	<1.0	<1.0	<1.0	<1.0
	Savona	1.8	1.5	1.5	1.7	<1.0	<1.0	<1.0
	Walhachin	6.1	1.6	1.8	<1.0	<1.0	<1.0	<1.0
1989	N. Thompson	<1.0	<1.0	<1.0	<1.0	ns	<1.0	1.0
	S. Thompson	<1.0	<1.0	<1.0	<1.0	ns	<1.0	1.0
	Savona	<1.0	<1.0	1.0	<1.0	ns	1.6	3.0
	Walhachin	<1.0	<1.0	1.0	<1.0	ns	1.4	3.0
1990	N. Thompson	1.0	<3.0	<3.0	1.5	ns	<1.0	1.0
	S. Thompson	<1.0	<3.0	<3.0	1.0	ns	<1.0	2.5
	Savona	2.0	3.0	<3.0	1.0	ns	1.5	3.5
	Walhachin	2.5	3.0	<3.0	1.0	ns	2.0	4.5

- the data are total dissolved phosphorus in ug/L <u>except</u> winter 1985 and following which is ortho P in ug/L

TABLE 50

SUMMARY OF WEYERHAEUSER PHOSPHORUS INPUT DATA FROM 1973-1991
(data from EQUIS and SEAM and WEYCAN)

NOTES:

-numbers following month are the number of days/month that flow data was collected - assuming this to be the number of operational days/month.

-months that are missing data (or shutdown) for five or more days have been noted with a * and the length of time shutdown is noted.

1.* 731010 ---> 731021
2.* 750707 ---> 751015
3.* 770401 ---> 770405 + 770406 ---> 770412
4.* 770901 ---> 770913
5.* 810713 ---> 810901
6.* 820329 ---> 820426
7.* 820702 ---> 820719
8.* 821015 ---> 821103
9.* 821224 ---> 830103
10.* 830426 ---> 830509
11.* 831018 ---> 831103
12.* 831115 ---> 831126
13.* 840201 ---> 840410
14.* 850430 ---> 850515
15.* 860516 ---> 860521

- this symbol "--->" indicates where the Weyerhaeuser monthly effluent reports started.
- numbers indicated "#" are calculated values - determined from regression equation derived from known total phosphorus and total dissolved phosphorus values.
- "--" indicates no data at all because Weyerhaeuser was not operational for these months.
- "?" indicates not sure what happened this month - have no monthly report, but do not know if Weyerhaeuser was operational at all.
- numbers indicated with "+" are calculated values - determined from the mean total phosphorus and total dissolved phosphorus values given in correlation (these months had no phosphorus data).
- numbers indicated with "**" are calculated values - determined from regression equation (numbers shown are approximate because total P results are less than total dissolved P).

DATE			Flow (m^3/day)	Total Diss. Phosphorus P (mg/L)	Total Diss Loading P (kg/day)	Total Diss Loading (kg/month)	Total Phosphorus (mg/L)	Total P Loading (kg/day)	Total P Loading (kg/mont
							0.706**	145.0**	4350.0
1973	Sept	30	205410	0.229	47.0	1410.0	0.231	47.4	1422.0
							0.779**	148.3**	2817.7*
	Oct.	19	190351	0.317	60.3	1145.7	0.280	53.3	1012.7
							1.512**	264.8**	7679.2*
	Nov.	29	175151	1.191	208.6	6049.4	0.540	94.6	2743.4
	Dec.	30	168657	0.471	79.4	2382.0	0.909#	153.3#	4599.0#

TABLE 50 (continued) SUMMARY OF WEYERHAEUSER PHOSPHORUS INPUT DATA

DATE			Flow (m^3/day)	Total Diss. Phosphorus P (mg/L)	Total Diss Loading P (kg/day)	Total Diss Loading (kg/month)	Total Phosphorus (mg/L)	Total P Loading (kg/day)	Total P Loading (kg/mont
1974	Jan.	31	176344	0.377	66.5	2061.5	0.552	97.3	3016.3
	Feb.	28	178566	0.393	70.2	1965.6	0.445	79.5	2226.0
							0.859**	152.0**	4712.0*
	Mar.	31	176908	0.412	72.9	2259.9	0.357	63.2	1959.2
	Apr.	30	177703	0.236	41.9	1257.0	0.660	117.3	3519.0
	May	31	185593	0.189	35.1	1088.1	1.050	194.9	6041.9
	June	30	200095	0.115	23.0	690.0	0.392	78.4	2352.0
	July	28	198240	0.260	51.5	1442.0	0.584	115.8	3242.4
	Aug.	31	221802	0.192	42.6	1320.6	0.418	92.7	2873.7
	Sept	30	220236	0.127	28.0	840.0	0.344	75.8	2274.0
	Oct.	31	184915	0.147	27.2	843.2	0.456	84.3	2613.3
	Nov.	30	198366	0.304	60.3	1809.0	0.528	104.7	3141.0
	Dec.	29	177440	0.323	57.3	1661.7	0.610	108.2	3137.8
1975	Jan.	31	203298	0.206	41.9	1298.9	0.480	97.6	3025.6
	Feb.	28	193648	0.208	40.3	1128.4	0.576	111.5	3122.6
	Mar.	31	186536	0.432	80.6	2498.6	0.900	167.9	5204.9
	Apr.	30	169180	0.296	50.1	1503.0	0.476	80.5	2415.0
	May	31	192763	0.257	49.5	1534.5	0.704	135.7	4206.7
	June	30	204828	0.193	39.5	1185.0	0.675#	138.3#	4149.0#
	* July	5	160674	0.639	102.7	513.5	1.049#	168.3#	842.5#
	* Aug.	0	---	---	---	---	---	---	---
	* Sept	0	---	---	---	---	---	---	---
							0.892**	160.5**	2728.5*
	* Oct.	17	179970	0.451	81.2	1380.4	0.296	53.3	906.1
	Nov.	30	187775	0.231	43.4	1302.0	0.644	120.9	3627.0
	Dec.	31	164084	0.389	63.8	1977.8	0.700	114.9	3561.9
1976	Jan.	31	160021	0.495	79.2	2455.2	0.732	117.1	3630.1
	Feb.	29	171713	0.606	104.1	3018.9	0.650	111.6	3236.4
	Mar.	31	183928	0.752	138.3	4278.0	1.144#	210.4#	6522.4#
	Apr.	30	181034	0.420	76.0	2280.0	0.615	111.3	3339.0
	May	29	174135	0.410	71.4	2070.6	0.692	120.5	3494.5
	June	30	187752	0.648	121.6	3648.0	0.712	133.7	4011.0
	July	31	181160	0.790	143.1	4436.1	1.176#	213.0#	6603.0#
	Aug.	31	186578	0.679	126.7	3927.7	0.768	143.3	4442.3
	Sept	28	190327	0.460	87.6	2452.8	0.899#	171.1#	4790.8#
	Oct.	30	184663	0.329	60.8	1884.8	0.630	116.3	3605.3
	Nov.	30	169543	0.800	135.6	4068.0	1.184#	200.7#	6021.0#
	Dec.	30	172714	0.785	135.6	4068.0	0.822	142.0	4260.0

TABLE 50 (continued) SUMMARY OF WEYERHAEUSER PHOSPHORUS INPUT DATA

DATE			Flow (m^3/day)	Total Diss. Phosphorus (mg/L)	Total Diss P Loading (kg/day)	Total Diss P Loading (kg/month)	Total Phosphorus (mg/L)	Total P Loading (kg/day)	Total P Loading (kg/month)
							1.069**	188.4**	5840.4**
1977	Jan.	31	176231	0.662	116.7	3617.7	0.426	75.1	2328.1
							1.285**	242.6**	6792.8**
	Feb.	28	188759	0.592	111.7	3127.6	0.552	104.2	2917.6
	Mar.		169405	0.691	117.1	3630.1	0.792	134.2	4160.2
3*	Apr.	20	166385	0.667	111.0	2220.0	1.073#	178.5#	3570.0#
	May	31	189573	0.654	124.0	3844.0	0.770	146.0	4526.0
	June	30	184400	0.788	145.3	4359.0	0.810	149.4	4482.0
	July	28	183000	0.589	107.8	3018.4	1.007#	184.3#	5160.4#
	Aug.	27	177024	0.671	118.8	3207.6	0.690	122.1	3296.7
4*	Sept	18	150037	0.510	76.5	1377.0	0.941#	141.2#	2541.6#
							0.893**	100.3**	2607.8**
	Oct.	26	112309	0.453	50.9	1323.4	0.460	51.7	1344.2
	Nov.	30	159880	0.465	74.3	2229.0	0.904#	144.5#	4335.0#
	Dec.	31	140265	1.093	153.3	4752.3	3.000	420.8	13044.8
1978	Jan.	31	160180	0.709	113.6	3521.6	1.108#	177.5#	5502.5#
	Feb.	29	172931	-.333	57.6	1612.8	0.624	107.9	3021.2
							1.183**	222.0**	6660.0**
	Mar.	30	187639	0.798	149.7	4491.0	0.788	147.9	4437.0
							1.295**	241.4**	7242.0**
	Apr.	30	186432	0.793	147.8	4434.0	0.684	127.5	3825.0
	May	31	166118	0.688	114.3	3543.3	1.090#	181.1#	5614.1#
	June	30	190591	0.858	163.5	4905.0	0.876	166.9	5007.0
	July	31	188611	0.644	121.5	3766.5	0.716	135.0	4185.0
	Aug.	31	195604	0.376	73.5	2278.5	0.599	117.2	3633.2
							1.057**	195.5**	5865.0**
	Sept	30	184979	0.658	119.9	3597.0	0.529	97.9	2937.0
							1.378**	265.0**	7155.0**
	Oct.	27	192287	1.031	198.2	5351.4	0.876	168.4	4546.8
	Nov.	29	178041	0.617	109.9	3187.1	1.031#	183.6#	5324.4#
							1.114**	207.1**	6213.0**
	Dec.	30	185950	0.716	133.1	3993.0	0.697	129.6	3888.0
							0.872**	146.6**	4544.6**
1979	Jan.	31	168114	0.428	72.0	2232.0	0.112	18.8	582.8
	Feb.	28	176692	0.566	100.0	2800.0	0.664	117.3	3284.4
							1.031**	180.9**	5607.9**
	Mar.	31	175472	0.617	108.3	3357.3	0.513	90.0	2790.0
	Apr.	30	164766	0.647	106.6	3198.0	0.780	128.5	3855.0
							1.174**	197.3**	5327.1**
	May	27	168063	0.787	132.3	3572.1	0.740	124.4	3358.8
	June	30	177281	0.342	60.6	1818.0	0.437	77.5	2325.0
	July	30	191558	0.536	102.7	3081.0	0.592	113.4	3402.0
							1.108**	152.9**	4587.0**
	Aug.	30	138003	0.708	97.7	2931.0	0.716	98.8	2964.0
	Sept	30	191691	0.600	115.0	3450.0	1.017#	194.9#	5847.0#
	Oct.	28	185109	0.233	43.1	1206.8	0.604	111.8	3130.4
	Nov.	30	185583	0.694	128.8	3864.0	0.728	135.1	4053.0
							1.142**	195.1**	6048.1**
	Dec.	31	170811	0.750	128.1	3971.1	0.720	123.0	3813.0

TABLE 50 (continued)
SUMMARY OF WEYERHAEUSER PHOSPHORUS INPUT DATA FROM 1973-1991

DATE			Flow (m^3/day)	Total Diss. Phosphorus P (mg/L)	Total Diss P Loading (kg/day)	Total Diss P Loading (kg/month)	Total Phosphorus (mg/L)	Total P Loading (kg/day)	Total P Loading (kg/month)
							1.062**	181.2**	5617.2**
1980	Jan.	31	170606	0.654	111.6	3459.6	0.504	86.0	2666.0
	Feb.	29	174006	0.847	147.4	4274.6	1.030	179.2	5196.8
	Mar.	31	186253	0.608	113.2	3509.2	0.948	176.6	5474.6
	Apr.	30	185974	0.726	135.0	4050.0	0.860	159.9	4797.0
	May	31	197522	0.902	189.2	5524.2	0.980	193.6	6001.6
	June	29	175387	0.820	143.8	4170.2	0.870	152.6	4425.4
	July	31	198722	0.709	140.9	4367.9	1.108#	220.2#	6826.2#
							1.190**	252.7**	7333.7**
	Aug.	31	212391	0.785	166.7	5167.7	0.720	152.9	4739.9
	Sept	30	188231	0.713	134.2	4026.0	1.111#	209.1#	6273.2#
	Oct.	27	196205	0.565	110.9	2994.3	0.695	136.4	3682.8
	Nov.	30	179788	0.413	74.3	2229.0	0.610	109.7	3291.0
	Dec.	31	148760	0.518	77.1	2390.1	0.724	107.7	3338.7
1981	Jan.	31	170450	0.298	50.8	1574.8	0.458	78.1	2421.1
	Feb.	28	170657	0.545	92.0	2604.0	0.624	106.5	2982.0
	Mar.	31	185172	0.695	128.7	3987.7	0.852	157.8	4891.8
							1.282**	223.7**	6711.0**
	Apr.	30	174623	0.916	159.9	4797.0	0.855	149.3	4479.0
	May	28	182074	0.428	77.9	2182.2	0.657	119.6	3348.8
	June	30	188662	0.474	89.4	2682.0	0.737	139.0	4170.0
*	July	12	146868	0.296+	43.5+	522.0+	0.760+	111.7+	1340.4+
5*	Aug.	0	---	---	---	---	---	---	---
	Sept.	30	177800	0.277	49.3	1479.0	0.538	95.6	2868.0
	Oct.	31	169052	0.296+	50.0+	1550.0+	0.760+	128.5+	3983.5+
	Nov.	30	186819	0.296+	55.0+	1650.0+	0.760+	141.2+	4236.0+
--->	Dec.	31	173070	0.256	44.3	1373.3	0.689	119.3	3698.3
1982	Jan.	31	165868	0.143	23.7	734.7	0.862	143.0	4433.0
	Feb.	28	171352	0.375	64.3	1800.4	0.853	146.2	4093.6
6*	Mar.	26	176936	0.309#	54.7#	1531.6#	0.802	141.9	3973.2
*	Apr.	5	153258	0.128#	19.6#	98.0#	0.224	34.4	172.0
	May	31	174126	0.255	44.4	1376.4	0.757	131.8	4085.8
	June	30	179730	0.342#	61.5#	1845.0#	0.908	163.2	4896.0
7*	July	14	164392	0.195	32.1	449.4	0.447	73.5	1029.0
	Aug.	31	175132	0.293#	51.3#	1590.3#	0.750	131.4	4073.4
	Sept	30	170726	0.368	62.8	1884.0	0.806	137.6	4128.0
8*	Oct.	14	169770	0.344#	58.4#	817.6#	0.915	155.3	2174.2
*	Nov.	28	144040	0.300#	43.2#	1209.6#	0.774	111.5	3122.0
9*	Dec.	23	172082	0.419#	72.1#	1658.3#	1.156	199.0	4577.0

TABLE 50
SUMMARY OF WEYERHAEUSER PHOSPHORUS INPUT DATA FROM 1973-1991
(continued)

DATE			Flow (m^3/day)	Total Diss. Phosphorus (mg/L)	Total Diss Loading P (kg/day)	Total Diss Loading (kg/month)	Total Phosphorus (mg/L)	Total P Loading (kg/day)	Total P Loading (kg/month)
1983*	Jan.	29	150710	0.620	93.4	2708.6	1.032	155.6	4512.4
	Feb.	28	138792	0.501#	69.5#	1946.0#	1.419	196.9	5513.2
	Mar.	31	138164	0.490#	67.7#	2098.7#	1.382	191.0	5921.0
10*	Apr.	25	137192	0.736	100.9	2522.5	1.384	189.9	4747.5
*	May	23	157422	0.376#	59.2#	1361.6#	1.017	160.1	3682.3
	June	30	149802	0.377#	56.5#	1695.0#	1.019	152.6	4578.0
	July	31	149234	0.666	99.4	2081.4	0.929	138.7	4299.7
	Sept	30	156452	0.570	89.2	2676.0	1.062	166.1	4983.0
11*	Oct.	17	165526	0.397#	65.7#	1116.9#	1.084	179.5	3051.5
12*	Nov.	17	101175	0.172#	17.4#	295.8#	0.374	37.8	642.6
	Dec.	27	129040	0.297#	38.3#	1034.1#	0.763	98.5	2659.5
1984	Jan.	30	145740	0.366#	49.0#	1470.0#	0.888	129.4	3882.0
*	Feb.	0	---	---	---	---	---	---	---
13*	Mar.	0	---	---	---	---	---	---	---
*	Apr.	21	132624	0.116#	15.4#	323.4#	0.185	24.6	516.6
	May	31	152628	0.462#	70.5#	2185.5#	1.293	197.3	6116.3
	June	30	147112	0.536#	78.9#	2367.0#	1.531	225.2	6756.0
	July	31	155074	0.426#	66.1#	2049.1#	1.176	182.3	5651.3
	Aug.	31	158036	0.539#	85.2#	2641.2#	1.540	243.4	7545.4
	Sept	30	145174	0.341#	49.5#	1485.0#	0.906	131.6	3948.0
	Oct.	27	148148	0.451#	66.8#	1803.6#	1.257	186.2	5027.4
	Nov.	30	15824	0.447#	68.3#	2049.0#	1.243	189.9	5697.0
	Dec.	29	136684	0.534#	73.0#	2117.0#	1.524	208.3	6040.7
1985	Jan.	30	160878	0.318#	51.2#	1536.0#	0.830	133.5	4005.0
	Feb.	28	143754	0.420#	60.4#	1691.2#	1.157	166.3	4656.4
	Mar.	31	143592	0.463#	66.5#	2061.5#	1.297	186.5	5781.5
	Apr.	28	134712	0.444#	59.8#	1674.4#	1.234	166.2	4653.6
14*	May	18	132552	0.311#	41.2#	741.6#	0.808	107.1	1927.8
	June	30	140814	0.476#	67.0#	2010.0#	1.337	188.3	5649.0
	July	31	141538	0.576#	81.5#	2526.5#	1.657	234.6	7272.6
	Aug.	31	158226	0.483#	76.4#	2368.4#	1.361	215.3	6674.3
	Sept	27	131836	0.335#	44.2#	1193.4#	0.887	116.9	3156.3
	Oct.	31	146066	0.348#	50.8#	1574.8#	0.927	135.4	4197.4
	Nov.	30	145386	0.402#	58.4#	1752.0#	1.101	160.0	4800.0

TABLE 50 SUMMARY OF WEYERHAEUSER PHOSPHORUS INPUT DATA (continued)

1986

Month	# days	Flow m3/d	TDP mg/l	TDP kg/d	TDP kg/mo	TP mg/l	TP kg/d	TP kg/mo
Jan.	29	146545	0.403	59	1711	1.351	198	5742
Feb.	27	146929	0.470	69	1863	1.116	164	4428
Mar.	31	143533	0.300	43	1333	1.233	177	5487
Apr.	30	147520	0.291	43	1290	0.902	133	3990
May	25	145505	0.254	37	925	0.900	131	3275
June	30	155100	0.374	58	1740	1.161	180	5400
July	31	154992	0.503	78	2418	1.219	189	5859
Aug.	31	163846	0.372	61	1891	0.995	163	5053
Sept.	30	161578	0.303	49	1470	0.817	132	3960
Oct.	30	153145	0.235	36	1080	0.816	125	3750
Nov.	27	136091	0.265	36	972	0.963	131	3537
Dec.	31	145727	0.323	47	1457	1.043	152	4712

1987

Month	# days	Flow m3/d	TDP mg/l	TDP kg/d	TDP kg/mon	TP mg/l	TP kg/d	TP kg/mo
Jan.	31	143326	0.579	83	2573	1.158	166	5146
Feb.	28	146629	0.402	59	1652	1.248	183	5124
Mar.	31	138376	0.506	70	2170	1.142	158	4898
Apr.	30	141507	0.360	51	1530	1.350	191	5730
May	28	138182	0.275	38	1064	1.020	141	3948
June	30	135891	0.486	66	1980	1.045	142	4260
July	31	149669	0.528	79	2449	1.109	166	5146
Aug.	31	141311	0.644	91	2821	1.168	165	5115
Sept.	30	148621	0.505	75	2250	1.312	195	5850
Oct.	28	143695	0.675	97	2716	1.434	206	5768
Nov.	30	141160	0.503	71	2130	1.141	161	4830
Dec.	28	137584	0.632	87	2436	1.214	167	4676

1988

Month	# days	Flow m3/d	TDP mg/l	TDP kg/d	TDP kg/mon	TP mg/l	TP kg/d	TP kg/mo
Jan.	31	162725	0.283	46	1426	1.217	198	6138
Feb.	29	160222	0.811	130	3770	1.535	246	7134
Mar.	30	164522	0.620	102	3060	1.507	248	7440
Apr.	28	163012	0.638	104	2912	1.485	242	6776
May	31	151637	0.363	55	1705	1.431	217	6727
June	30	151051	1.013	153	4590	2.542	384	11520
July	31	138328	0.810	112	3472	1.843	255	7905
Aug.	31	158805	1.222	194	6014	1.631	259	8029
Sept.	30	145810	?	?	?	?	?	?
Oct.	27	145720	0.563	82	2214	2.745	400	10800
Nov.	30	147420	0.672	99	2970	2.008	296	8880
Dec.	29	136370	1.107	151	4379	1.892	258	7482

1989

Month	# days	Flow m3/d	TDP mg/l	TDP kg/d	TDP kg/mon	TP mg/l	TP kg/d	TP kg/mo
Jan.	31	147558	0.996	147	4557	1.471	217	6727
Feb.	28	109989	0.300	33	924	1.318	145	4060
Mar.	30	115128	0.235	27	810	1.068	123	3690
Apr.	28	127927	0.242	31	868	0.633	81	2268
May	31	156306	0.281	44	1364	1.056	165	5115
June	30	158472	0.196	31	930	0.827	131	3930
July	31	167014	0.305	51	1581	0.964	161	4991
Aug.	31	166885	0.246	41	1271	1.061	177	5487
Sept.	29	169019	?	?	?	?	?	?
Oct.	27	158184	0.398	63	1701	0.733	116	3132
Nov.	30	171185	0.386	66	1980	0.701	120	3600
Dec.	29	151810	0.566	86	2494	1.291	196	5684

1990

Month	# days	Flow m3/d	TDP mg/l	TDP kg/d	TDP kg/mon	TP mg/l	TP kg/d	TP kg/mo
Jan.	31	159135	0.207	33	1023	0.622	99	3069
Feb.	28	163523	0.318	52	1456	0.936	153	4284
Mar.	31	150041	0.100	15	465	0.880	132	4092
Apr.	30	165002	0.279	46	1380	0.897	148	4440
May	31	147659	0.217	32	992	0.413	61	1891
June	27	151416	0.291	44	1188	0.786	119	3213
July	30	154824	0.659	102	3060	1.350	209	6270
Aug.	31	163547	0.342	56	1736	0.905	148	4588
Sept.	26	146969	0.313	46	1196	0.483	71	1846
Oct.	26	134639	0.379	51	1326	0.661	89	2314
Nov.	30	146238	0.390	57	1710	0.786	115	3450
Dec.	28	139900	0.379	53	1484	1.058	148	4144

1991

Month	# days	Flow m3/d	TDP mg/l	TDP kg/d	TDP kg/mon	TP mg/l	TP kg/d	TP kg/mo
Jan.	31	144100	0.298	43	1333	0.805	116	3596
Feb.	28	145000	0.193	28	784	0.676	98	2744
Mar.	31	148600	0.249	37	1147	0.888	132	4092
Apr.	13	143400	0.356	51	663	0.746	107	1391
May	31	137700	0.203	28	868	0.595	82	2542
June	31	?	?	?	?	?	?	?
July	31	154800	0.472	73	2263	1.298	201	6231
Aug.	31	159000	0.233	37	1147	0.516	82	2542
Sept.	13	54100	?	?	?	?	?	?
Oct.	31	135700	0.435	59	1829	0.774	105	3255
Nov.	30	137800	0.319	44	1320	1.147	158	4740
Dec.	28	129100	0.364	47	1316	0.821	106	2968

TABLE 51
EFFLUENT QUALITY SUMMARY FOR WEYERHAEUSER, KAMLOOPS
PE 1199, 1972 - 1983

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True Diss.	1689	2829	205	6200	352.7
Colour True Total	1958	617	100	3400	470.2
Oil & Grease	10.1	62	0.2	53.6	8.7
pH	7.3	3342	3.7	9.6	0.25
Res. 105	1643	107	718	2954	351.1
Res. 550	1362	1			
Res. NF 105 (kg/day)	10743	650	739	37186	5222
Res. NF 105 (Total)	43.6	168	1.4	130	30.7
Res. NF 550 (Total)	13	41	3	27	5.4
Res. NF VO (Total)	46	41	15	76	17
Spec. Cond.	2153	143	910	3390	369.2
Oxygen, Diss.	3.6	2822	0	11	1.6
Turbidity	17.7	30	0.8	30	10.1
Flow (m^3/day)	177780	3352	0	463000	34936
Tot. setteable solids (mg/L)	0.13	679	0	2	0.16
Colour TAC	1306.6	132	81	3880	391
Alkalinity, Total	165.1	56	92.4	441	52.3
Organic Carbon	157	85	64	346	37.4
Chloride, Diss.	456.3	66	131	646	130.9
Cyanide, Total	0.01	5	<0.01	<0.01	0
Fluoride, Diss.	0.11	6	0.1	0.13	0.01
Hardness, Diss.	423.9	28	181	552	93.1
NH_3 N (method 1)	0.63	21	0.05	1.47	0.42
NH_3 N (method 2)	0.78	29	0.13	6	1.09
NO_2/NO_3 N	0.04	25	<0.02	0.11	0.03
Nitrate N	0.79	115	0	7.18	1.67
Nitrite N	0.016	34	<0.005	0.063	0.014
Nit. Organic Total	3.0	42	0.85	6.28	1.22
Kjeldahl N, Total	5.3	199	1.0	29	2.4
BOD (kg/day)	4328	1915	41	33963	2782.7
BOD Total	30	116	<10	117	16.7
COD Total	410	29	126	556	92.8
Phenol, Total	0.842	62	0.012	1.78	0.230
Ortho P, Diss.	0.211	70	<0.003	2.2	0.271
Total Diss. P	0.546	429	0.004	2.33	0.348
Total P	0.637	119	0.112	3.0	0.306
Silica, Diss.	9.4	30	7.0	10.9	1.1
Sulphate, Diss.	166.5	97	<8	313	53.2
Surfactant, Diss.	0.38	5	0.08	0.95	0.38
Tannin. & Lignin total	62.1	56	20	200	25.9
Tot. inorg. carbon	42.9	67	15	86	13.3
Sulphide, Total	0.23	140	0	9.6	0.86
Res. Acid, Total	0.901	47	0	2.6	0.689
Mercaptan, Total	0.33	106	0	9.6	1.15
Arsenic, Total	0.007	38	<0.005	0.021	0.004

TABLE 51 (continued)
EFFLUENT QUALITY SUMMARY FOR WEYERHAEUSER, KAMLOOPS
PE 1199, 1972 - 1983

Characteristic	Mean Value	n	minimum	maximum	deviation
Boron, Total	0.086	5	0.03	0.1	0.031
Cadmium, Total	0.00054	8	<0.0005	0.0008	0.00011
Calcium, Diss.	162.4	22	61.4	203	29.7
Calcium, Total	0.032	5	0.005	0.12	0.049
Chromium, Diss.	0.013	21	<0.005	0.11	0.024
Copper, Diss.	0.017	5	0.005	0.04	0.014
Copper, Total	0.014	10	0.007	0.02	0.005
Iron, Diss.	0.7	4	0.6	0.8	0.12
Iron, Total	1.0	9	0.6	1.7	0.3
Lead, Diss.	<0.001	4	<0.001	<0.001	0
Lead, Total	0.006	10	<0.001	0.017	0.005
Magnesium, Diss.	4.0	3	3.6	4.5	0.5
Magnesium, Total	4.3	2	3.9	4.7	0.6
Manganese, Total	0.66	8	0.55	0.83	0.10
Mercury, Total	0.00012	16	<0.00005	0.00028	0.00008
Molybdenum, Total	0.00058	9	<0.0005	0.0008	0.00013
Nickel, Total	0.01	4	<0.01	0.01	0
Potassium, Diss.	6.3	5	5.5	8.1	1.1
Sodium, Diss.	328	59	203	602	61.9
Zinc, Diss.	0.067	6	0.04	0.11	0.026
Zinc, Total	0.059	27	0.02	0.11	0.019
Aluminum, Total	0.59	4	0.33	0.91	0.244
Cobalt, Total	<0.001	1	<0.001	<0.001	
Barium, Total	<0.5	1	<0.05	<0.05	
Vanadium, Total	<0.001	1	<0.001	<0.001	
Fecal Coliforms, MPN	<15.5	4	<2	<20	9.0
Total Coliforms, MPN	1485	4	<20	3500	1750.2
Bioassay, LC 50% effl	99	20	0	100	3.1
Product (tonnes/d)	925.9	1283	0	1452.4	352.4
$Cl_2C_2Cl_2$	<1.0	2	<1.0	<1.0	0
$ClChcCl_2$	<1.0	2	<1.0	<1.0	0
CCl_4	<1.0	2	<1.0	<1.0	0
$CHBr_3$	<1.0	2	<1.0	<1.0	0
$ClBr_2CH$	<1.0	2	<1.0	<1.0	0
$BrCl_2CH$	<1.0	2	<1.0	<1.0	0
$CHCl_3$	8.5	2	5	12	4.9

TABLE 52
PHOSPHORUS LOADING ESTIMATES FOR CITY OF KAMLOOPS

1970 - 1972	105 kg/d	Total P
	80 kg/d	Total Dissolved P
1973 - 1974	135 kg/d	Total P
	105 kg/d	Total Dissolved P
1978	no discharge Dec 1977 to April 13 1978	
	20 kg/d?	Dissolved P in Dec to Mar (exfiltration
	95 kg/d	Dissolved P in April to November
1979	no discharge Dec 1979 to Mar 15 1979	
	30 kg/d	Total P April to November
	20 kg/d	Dissolved P April to November
1980	no discharge December 1979 to March 1980	
	20 kg/d	Total P in April to November
	15 kg/d	Dissolved P in April to November
1981		No discharge Dec 1980 to March 1981
1983		Limited discharge December to March
	16 kg/d	Total P in April to November
	14 kg/d	Dissolved P in April to November
1985		Winter discharge and rapid infiltration river)

TABLE 53
KAMLOOPS POPULATION ESTIMATES

YEAR	CITY POPULATION	SEWERED POPULATION
1971	44155	36765
1976	58310	44535
1981	64048	51030
1984	64610	51688 (Estimate)
1985	62912	50329 (Estimate)
1986	61213	48970 (Estimate)

TABLE 54(a)
SUMMARY - CITY OF KAMLOOPS, SEWAGE TREATMENT PLANT - MEASURED EFFLUENT PHOSPHORUS CONCENTRATIONS IN CELL 4 AND SURFACE DISCHARGE FLOWS 1974 - 1984

Month	Parameter	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Jan. -	Tot P (mg/L)	5.34	5.15	5.83								
	Tot Diss P (mg/L)			5.49								
	Flow ($m^3/d \times 10^3$)											
February	TP		5.75	5.93	5.62							
	TDP		5.30	5.63	5.27							
	flow			5.46	2.05							
March	TP					1.79	0.97	0.64	0.90	0.77	0.97	0.87
	TDP		5.42	5.31		1.18	0.68	0.31	0.35	0.66	0.30	0.45
	flow			5.91			6.82		21.14			
April	TP		5.67	5.92		1.04	0.59	0.58	0.67	0.61	0.83	0.51
	TDP		5.07	5.67		0.51	0.14	0.17	0.37	0.34	0.34	0.16
	flow						3.41	17.46	16.63	23.00		
May	TP		5.80		0.72	0.57		0.78	1.84	1.28	0.83	0.59
	TDP		5.12		0.59	0.10		15.99	0.68	1.11	0.51	0.15
	flow								23.95	22.48		
June	TP		6.19		0.85		1.87	1.28	1.34	1.31		
	TDP		5.83		0.68		1.14	0.45	1.24	0.72		
	flow				1.45		17.14		15.88			
July	TP		6.13		2.44	0.61		1.24	0.76	1.43	1.71	
	TDP		5.60		1.32	0.23		0.85	0.71	1.29	1.06	
	flow							19.62	37.28	21.92		
August	TP		6.12			0.75	1.32	1.81	1.32	1.21	1.72	
	TDP					0.59	1.11	1.00	1.17	1.07	0.91	
	flow							18.05	15.52	22.50		
September	TP		6.72		1.13	0.81	1.23	1.67	1.50		2.55	
	TDP				0.60	0.25	1.00		1.34		1.14	
	flow						16.72	18.26	20.61			
October	TP		5.99		1.26	1.07	1.45	0.96			1.56	
	TDP				0.40	0.57	1.15	0.69			0.56	
	flow						24.68	19.50				
November	TP	4.98	5.52	4.00	0.84	0.60	1.61	1.14	0.55	1.72	0.53	
	TDP	4.34	5.12	3.66	0.08	0.33		0.46	0.43	0.43	0.13	
	flow							17.99	25.45	27.01		
December	TP	4.80	5.72	4.00								
	TDP	4.42	5.35	3.66								

TABLE 54(b)

EFFLUENT QUALITY SUMMARY FOR STATION 0601045

CITY OF KAMLOOPS, SEWAGE TREATMENT LAGOONS INFLUENT (1972 - 1982)

(continued)

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	40.2	5	33.1	457	5.2
pH	7.3	17	7.0	7.8	0.2
Res. 105	451	17	250	682	105
Res. NF 105	199	17	84	404	79
Spec. Cond.	516	17	394	689	68
Flow	20761	384	10180	30562	2777
Colour TAC	57	4	40	73	14
Organic Carbon	107	7	82	144	20
Hardness	535	3	50.4	59.3	5.1
Ammonia N	24.1	6	19.2	38.5	6.7
NO_2+NO_3 N	0.029	14	<0.02	0.120	0.026
Kjeldahl N	40.3	14	33	54	6.8
B.O.D.	177	17	119	288	50
C.O.D.	341	4	298	414	51
Phenols	0.039	4	0.030	0.052	0.01
Ortho P	4.75	11	2.65	6.12	0.95
Total P	7.50	16	5.87	9.75	1.22
Arsenic, Total	0.006	3	<0.005	0.007	0.001
Cadmium, Total	0.002	3	0.001	0.003	0.001
Chromium, Total	0.011	4	0.007	0.014	0.003
Copper, Total	0.16	5	0.13	0.19	0.28
Lead, Total	0.057	4	0.04	0.09	0.057
Mercury	Both 0.00025	2			
Molybdenum	0.001	3	0.008	0.0014	0.0003
Zinc	0.15	5	0.13	0.17	0.02
Aluminum	Both 0.5	2			

TABLE 55
WATER QUALITY SUMMARY FOR CITY OF KAMLOOPS, SEWAGE LAGOONS THIRD CELL, BEFORE ALUM, SITE 0601052 (1976 - 1983)

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.4	12	7.1	8.0	0.2
Res. 105	331	11	306	394	30
Res. NF 105	51	12	24	106	23
Spec. Cond.	532	12	493	558	21.0
Colour TAC	81	3	45	107	32
Organic Carbon	61	3	54	64	6
Ammonia N	21.4	5	16.5	25	3.7
NO_2+NO_3 N	Both <0.02	2			
Kjeldahl N	29.2	10	25	32	2.6
B.O.D.	57	12	20	83	21
Ortho P	5.01	8	3.47	558	0.68
Total P	5.8	12	7.0	4.6	0.6
Fecal Coliforms	580620	13	20000	1600000	603360
Total Coliforms	1149900	13	49000	3500000	1145200

TABLE 56
WATER QUALITY SUMMARY FOR CITY OF KAMLOOPS, SEWAGE LAGOONS FOURTH CELL, AFTER ALUM, SITE 0601054 (1978 - 1982)

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.0	18	6.8	7.5	0.2
Res. 105	305	13	234	408	47
Res. NF 105	12.3	18	5	27	5.9
Spec. Cond.	592	18	437	741	73
Colour TAC	58.2	7	34	68	10.1
Ammonia N	22	2	17	27	7
NO_2+NO_3 N	0.079	11	<0.02	0.45	0.13
Kjeldahl N	24.1	11	18.1	28	2.6
B.O.D.	29.3	14	12	37	6.4
Ortho P	0.412	12	0.089	0.646	0.17
Total P	0.699	18	0.403	1.21	0.211
Total Diss. P	0.367	18	0.141	0.719	0.197
Sulphide	2.5	4	<0.5	3.5	1.3
Aluminum	0.5	3	0.23	0.74	0.3
Fecal Coliforms	111820	22	8000	790000	170350
Total Coliforms	228050	22	<20000	1300000	306340

TABLE 57
EFFLUENT QUALITY SUMMARY FOR CITY OF KAMLOOPS LAGOON OUTFALL
PE 399, 1971 - 1983

Characteristic		Mean Value	n	minimum	maximum	deviation
Colour True		47	6	40	60	8
Oil & Grease		4.4	40	0.7	16	3.7
pH		7.4	136	6.4	8.3	0.3
Res. 105		300	91	252	400	25
Res. 550		211	4	196	220	11
Res. NF 105		26	139	0.6	125	18
Spec. Cond.		527	134	411	618	46
Turbidity		20	31	3.6	52	14
Colour TAC		56	26	16	88	18
Total Alkalinity		141	26	17.8	194	35
Organic Carbon		28	40	14	53	9
Chloride		27	33	23	35	3
Cyanide	All	<0.01	7			
Ammonia N		18.9	65	2.2	25.9	5.4
NO_2/NO_3 N		0.78	50	<0.02	10	2.1
Kjeldahl N		20	68	6	29	6
B.O.D.		22.5	125	1.2	80	16
C.O.D.		91	9	36	143	39
Ortho P		1.99	84	0.012	5.46	2.13
Total Diss. P		1.47	163	0.064	6.85	1.74
Total P		1.86	191	0.29	6.72	1.71
Sulphide		0.80	45	<0.03	5.2	1.1
Arsenic, Diss.		0.006	16	<0.005	0.015	0.002
Cadmium, Total		<0.0013	4	<0.0005	<0.01	0.003
Chromium, Diss.	All	<0.005	13			
Copper, Total		0.015	20	0.002	0.070	0.018
Lead, Total		0.036	34	<0.001	0.120	0.036
Manganese, Total		0.0325	12	0.02	0.05	0.009
Mercury, Total		0.0000656	9	<0.00005	0.00012	0.0000255
Molybdenum, Total		<0.0015	12	<0.0005	<0.01	0.0027
Nickel, Total		<0.014	9	<0.01	<0.05	0.013
Potassium, Diss.		9.8	4	9.5	10	0.22
Sodium, Diss.		43.3	7	40.2	46.6	2.23
Zinc, Total		0.053	19	0.005	0.21	0.052
Aluminum, Total		0.84	16	0.29	2.1	0.54
Cobalt, Total		<0.0028	4	<0.001	<0.01	0.048
Barium, Total		<0.5	1	<0.5	<0.5	
Vanadium, Total		0.0065	2	0.003	<0.01	0.0049
Fecal Coliforms MPN		51635	94	<2	1600000	183160
Total Coliforms MPN		51559	89	20	920000	135720

TABLE 58

WATER QUALITY SUMMARY FOR MONITORING WELLS ADJACENT TO CITY OF KAMLOOPS SEWAGE TREATMENT LAGOON, FOURTH CELL, (1979 data)

Characteristic	Mean Value	n	minimum	maximum	deviation
0600348 (North)					
pH	7.9	3	7.6	8.2	0.3
Res. 105 C	320	1			
Res. NF 105	46.5	2	39	54	10.6
Spec. Cond.	650	3	505	930	242
Organic Carbon	55	2	<1	10	6.3
Ammonia N	8.2	1			
NO_2/NO_3 N	5.9	3	0.12	16.6	9.3
Kjeldahl N	7.6	3	1	11	5.7
B.O.D. Both	<10	2			
Total Diss. P	0.015	3	0.010	0.019	0.005
Total P	0.103	3	0.045	0.183	0.071
Fecal Coliforms	<74	3	<2	<200	
0600350 (Northwest)					
pH	71	1			
Res. 105	592	1			
Res. NF 105	282	1			
Spec. Cond.	460	1			
Organic Carbon	14	1			
NO_2/NO_3-N	<0.020	1			
Kjeldahl N	4	1			
B.O.D.	<10	1			
Total Diss. P	0.323	1			
Total P	0.896	1			
Total Coliforms	70	1			

TABLE 59
WATER QUALITY SUMMARY FOR MONITORING WELLS ADJACENT TO CITY OF KAMLOOPS SEWAGE TREATMENT LAGOON, FOURTH CELL, (1979 data)

Characteristic	Mean Value	n	minimum	maximum	deviation
0600344 (West)					
pH	7.6	3	7.2	8.0	0.4
Spec. Cond.	860	3	728	977	125
Organic Carbon	42	2	39	45	4.2
Ammonia N	2.16	2	2.11	2.20	0.06
NO_2/NO_3 N	0.27	3	L0.02	0.03	0.006
Kjeldahl N	4.3	3	3	6	1.5
B.O.D.	<12.5	2	<10	15	3.5
Total Diss. P	0.024	3	0.019	0.034	0.008
Total P	0.336	3	0.100	0.799	0.4
Fecal Coliforms	<69	3	<2	<200	113
Total Coliforms	526	3	69	1300	673
0600347 (Northeast)					
pH	7.7	3	7.3	8.2	0.4
Res. 105 C	546	1			
Res. NF 105	160	2	61	258	
Spec. Cond.	669	4	549	963	197
Turbidity	44	1			
Organic Carbon	14.7	3	6	22	8.1
Ammonia N	9.9	2	9.4	10.4	0.7
NO_2/NO_3 N	0.032	4	<0.02	0.06	0.018
Kjeldahl N	10.75	4	4	17	5.3
B.O.D.	10.7	3	<10	12	1.2
Total Diss. P	0.094	4	0.005	0.265	0.116
Total P	1.01	4	0.052	1.63	0.46
Total Coliforms	<10	3	<2	20	9.1

TABLE 60(a) CITY OF KAMLOOPS (PE 399) 1989 SEWAGE INFLOW

m^3/d (monthly averages)

J	22049
F	22923
M	22702
A	22271
M	22636
J	22555
J	24154
A	24642
S	24437
O	23356
N	22304
D	22048
mean	23006 or 8397 dam^3/year

(b)1989 River discharge(monthly volume) TP mg/L TP input to river

	River discharge (monthly volume)	TP mg/L	TP input to river
July	493,698 m^3	1.6	790 kg
August	446,455	1.2	545 kg
Sept.	499,403	1.1	566 kg
Oct.	791,833	1.0	792 kg
Nov.	791,094	1.6	1267 kg
	3022 dam^3	1.3	3960 kg

TABLE 61(a) EFFLUENT DISCHARGED BY RAPID INFILTRATION (E206334) 1989

	flow (month)	total P conc (mg/L)	fecal coliforms	total coliforms
J	165339	0.56	<1	4
F	220346	0.66	4	11
M	207712	0.80	34	60
A	142905	1.18	11	26
M				
J				
J				
A				
S				
O				
N	229176	1.16	5	20
D	107516	-	28	14
	1073 dam^3	0.87		

(b)Effluent disposed of by spray irrigation (E206335) flow by month (m^3)

M	429858
J	374288
J	326205
A	391096
S	224535
O	78064

TABLE 62. KAMLOOPS SEWAGE TREATMENT PLANT BIOASSAY (rainbow trout)

March	1982	77.5% (% effluent conc. 96h LC_{50})
April	1983	62.5%
May	1983	89 %
Sept.	1983	82 %
Nov.	1987	100 %
Jan.	1988	100 %
Jan.	1989	100 %
July	1989	89 %
August	1989	100 %
Oct.	1989	100 %
Nov.	1989	100 %

TABLE 63. CITY OF KAMLOOPS SEWAGE EFFLUENT (PE 399)

Effluent (E206334) BOD and Suspended Solids 1989

	BOD (mg/L)	ss (mg/L)
J		
F	4.8	1.0
M	7.4	4
A	<10	4
M		
J		
J		
A	7	6.8
S		
O	4.5	3.8
N	6.8	9
D		

TABLE 64

GROUND WATER QUALITY SUMMARY FOR GULF OIL (PE 419)

SAMPLING WELL (0600192) EAST, 1973 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	6.8	49	0	87.3	14.6
pH	7.3	56	6.7	8.0	0.4
Res. 105 C	426	41	200	1480	259
Res. NF 105	152	41	2.6	931	188
Spec. Cond.	465	8	372	645	100
Organic Carbon	10.8	4	6	17	4.9
Chloride	10.9	6	7.9	15.6	2.8
Cyanide	<0.007	33	<0.0001	<0.05	0.009
Ammonia N	0.88	47	0	3.77	1.0
Kjeldahl N	4	4	3	5	1.2
B.O.D.	10.1	53	2	49	8.9
C.O.D.	36.8	54	0	123	25.9
Phenol	0.23	48	0	8	1.1
Total P	0.24	3	0.184	0.34	0.08
Inorganic Carbon	65.7	3	52	88	19.5
Sulphide	0.15	44	0	0.9	0.21
Lead, Total	0.05	51	0	0.39	0.067
Mercury, Total	0.0001	3	<0.00005	0.0003	0.00001

TABLE 65
GROUND WATER QUALITY SUMMARY FOR GULF OIL (PE 419)
SAMPLING WELL (0600101) WEST, 1973 - 1982

Characteristic		Mean Value	n	minimum	maximum	deviation
Oil & Grease		4.2	79	0	24.6	5.8
pH		7.7	83	6.7	8.5	0.5
Res. 105		268	70	106	492	80
Res. NF 105		72	67	3	358	67
Spec. Cond.		345	20	313	390	21
Turbidity		107	4	28	304	132
Alkalinity		183	6	177	190	4.9
Organic Carbon		6.8	11	2	15	4.1
Chloride		4.3	16	1.7	12.2	3.2
Cyanide		<0.009	54	<0.0002	0.091	0.01
Ammonia N		0.54	69	0	3.1	0.74
NO_2/NO_3 N		0.024	10	<0.02	0.06	0.012
Kjeldahl N		2.0	13	1	3	0.5
B.O.D.		8.2	71	<2	45.1	5.7
C.O.D.		23.8	75	0	81.6	16.6
Phenol		0.19	77	0	4.4	0.7
Total P		0.056	11	0.01	0.34	0.096
Sulphate	All	<5.0	13			
Sulphide		0.22	70	0	7.0	0.94
Arsenic	All	<0.005	11			
Cadmium	All	<0.005	5			
Lead, Total		0.04	71	0	0.24	0.05
Mercury, Total		0.00006	6	<0.00005	0.0001	0.00002
Molybdenum, Total		0.006	6	<0.0005	0.03	0.011
Cobalt		0.025	6	<0.005	0.13	0.051
Vanadium		<0.001	6	<0.001	0.001	0

TABLE 66

EFFLUENT WATER QUALITY SUMMARY FOR GULF OIL SKIM POND DISCHARGE (STATION 0601053) (1978 DATA)

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	51.3	4	8.7	166	76.6
pH	9.2	4	9.0	9.3	0.12
Res. 105	1296	4	666	1676	453
Res. NF 105	23.5	4	9	36	14
Spec. Cond.	2347	4	1550	3250	751
Organic Carbon	79	3	71	88	8.5
Chloride	749	4	346	890	269
Kjeldahl N	107	4	20	198	73
B.O.D.	416	4	268	576	135
C.O.D.	715	4	667	895	100
Phenol	13.3	4	3	20	7.3
Total Diss. P	1.80	4	1.32	2.74	0.65
Sulphide	217	4	160	280	59.4
Arsenic, Total	0.010	3	0.009	0.012	0.002
Cadmium, Total	All 0.0005	3			
Lead, Total	0.011	3	0.005	0.020	0.008
Mercury, Total	0.0006	2	0.0006	0.00065	0.00003
Molybdenum, Total	0.0013	3	0.0009	0.0017	0.0004
Aluminum, Total	0.37	3	0.15	0.6	0.22
Cobalt	Both <0.005	2			
Vanadium	0.0065	2	0.002	0.011	0.006

TABLE 67

EFFLUENT QUALITY SUMMARY FOR GULF OIL EAST LAGOON (STATION 0601002), 1973 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	22.5	366	0.7	382	23.8
pH	8.0	361	6.2	9.6	0.9
Res. 105	1102	360	94	7070	803
Res. NF 105	122	359	4	2740	239
Spec. Cond.	1725	8	1530	1980	141
Cyanide	0.027	313	<0.0003	2.2	0.13
Ammonia N	21.8	356	0	75.9	16.9
Kjeldahl N	49.5	6	42	62	6.9
B.O.D.	123	95	22	448	86
C.O.D.	275	96	39	934	151
Phenol	11.2	359	0	110	15.6
Total Diss. P	2.15	7	1.29	2.86	0.61
Sulphate	391	5	226	578	147
Arsenic, Total	0.011	4	0.01	0.013	0.001
Lead, Total	0.059	356	0	0.27	0.43

TABLE 68
EFFLUENT QUALITY SUMMARY FOR GULF OIL WEST LAGOON (STATION 0601001), 1971 - 1982

Characteristic		Mean Value	n	minimum	maximum	deviation
Oil & Grease		48.5	393	1.0	2390	150.2
pH		8.9	384	6.6	11.4	0.6
Res. 105		908	379	198	3978	327
Res. NF 105		56	377	2	1400	110
Spec. Cond.		1871	13	700	3500	870
Organic Carbon		123	7	78	184	37
Chloride		566	9	39	1350	455
Cyanide, Total		0.053	328	<0.001	1.6	0.14
Ammonia N		33	379	0	565	44
Kjeldahl N		116	5	8	245	87
B.O.D.		227	101	26	990	150
C.O.D.		386	98	91	1110	160
Phenol		51.7	381	0.1	350	78.2
Total Diss. P		3.13	10	0.35	15	7.2
Sulphate		156	6	129	181	19
Sulphide		34.5	382	0.05	371	46.8
Arsenic, Total		0.011	9	<0.005	0.022	0.006
Boron, Diss.		0.4	3	0.1	0.8	0.4
Cadmium, Total	All	<0.0005	6			
Lead, Total		0.060	379	0	0.3	0.05
Mercury, Total		0.0013	8	0.0002	0.0027	0.0009
Molydbenum, Total		0.002	5	0.001	0.003	0.001
Zinc, Total		0.19	7	0.09	0.43	0.12
Aluminum, Total		0.52	7	0.17	1.0	0.3
Cobalt	All	<0.005	3			
Vanadium		0.024	7	0.003	0.1	0.03

TABLE 69
EFFLUENT QUALITY SUMMARY FOR GULF OIL, API DISCHARGE
PE 00419, 1972 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	3051.7	380	3.3	940000	48293.0
pH	9.06	384	6.5	12.75	0.82
Res. 105 Total	1114.0	380	150.0	20278.0	1328.1
Res. NF 105	218.82	375	1.59	20262.0	1096.3
Res. NF 550	16.0	2	7.0	25.0	12.7
Res. NF VO	23.5	2	21.0	26.0	3.5
Spec. Cond.	1708.7	16	1330.0	2440.0	342.6
Sampling Temp.	17.1	14	3.5	29.0	9.4
Oxygen, Diss.	1.62	10	0.3	9.4	2.8
Turbidity	35.7	3	28.0	51.0	13.3
Colour TAC	92.7	3	62.0	126.0	32.1
Alkalinity, Total	354.5	5	109.0	656.0	225.7
Total Organic Carbon	75.6	5	67.0	93.0	11.1
Chloride, Diss.	248.51	14	5.2	562.0	136.52
Cyanide, Total	0.331	332	<0.001	6.1	0.627
Fluoride, Diss.	0.175	2	0.12	0.23	0.078
NH_3 N	79.12	373	0	1870	123.24
NO_2/NO_3 N	0.02	6	L0.02	0.02	0
Organic N	4.7	3	3.0	7.0	2.1
Kjeldahl N	50.1	8	39.0	66.0	9.9
Nitrogen, Total	52.8	5	43.0	66.0	10.7
B.O.D.	599.4	105	51.0	3170	567.2
C.O.D.	1057.3	98	102.0	7290	1109.9
Phenol	52.1	383	0.016	1770	130.8
Ortho P	1.83	1	1.83	1.83	0
Total Diss. P	2.44	12	0.14	3.92	0.92
Total P	3.42	12	1.96	4.77	0.89
Silica, Diss.	18.4	2	18.0	18.7	0.5
Sulphate, Diss.	205.3	9	175.0	278.0	34.9
Carbon IO	33.6	5	26.0	43.0	6.2
Sulphide, Total	109.8	373	0.06	699.0	107.1
Arsenic, Total	0.010	11	<0.005	0.015	0.004
Boron, Diss.	0.47	3	0.3	0.6	0.15
Cadmium, Total	0.0005	9	<0.0005	<0.0005	0
Calcium, Diss.	41.7	1			
Calcium, Total	33.9	4	28.4	42.1	6.6
Chromium, Total	0.008	11	<0.005	0.03	0.008
Copper, Total	0.04	11	0.02	0.09	0.02
Iron, Total	0.08	382	0	1.91	0.12
Magnesium, Total	8.3	2	7.9	8.7	0.6
Manganese, Total	0.04	4	0.04	0.05	0.005
Mercury, Total	0.00048	10	0.0002	0.00096	0.00027
Molybdenum, Total	0.011	5	0.005	0.0015	0.007

TABLE 69 (continued)

EFFLUENT QUALITY SUMMARY FOR GULF OIL, API DISCHARGE PE 00419, 1972 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Nickel, Total	0.015	11	L0.01	0.03	0.007
Potassium, Total	7.7	2	7.0	8.3	0.9
Sodium, Diss.	206.2	9	126.0	328.0	65.4
Zinc, Total	0.065	10	0.012	0.1	0.029
Aluminum, Total	0.095	4	0.07	0.12	0.021
Cobalt	<0.005	5	<0.005	L0.005	
Vanadium, Total	0.014	9	0.002	0.044	0.015
Coliforms Total MPN	110	1			

TABLE 70

WATER QUALITY SUMMARY FOR THOMPSON RIVER, KAMLOOPS LAKE (STATION 0920167), 1973 - 1974

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	21	5	10	30	9
pH	7.5	5	7.3	7.7	0.2
Spec. Cond.	93	5	66	144	30
Oxygen, Diss.	11.5	4	10.7	12.5	0.9
Turbidity	8.1	5	3.4	21.0	7.5
Alkalinity	40	5	25	59	13
Organic Carbon	5.0	5	1.2	9.0	2.8
Hardness	41.1	4	30.2	57.7	11.9
NO_3 N	0.1	1			
Sulphate, Diss.	10.8	2	8.6	13.0	3.1
Surfactants, Total All	0.1	3			
Carbon IO	6.0	5	4.8	7.3	1.1
Bicarbonate	49	5	31	72	16
Carbonate All	0.0	5			
Calcium, Diss.	12.8	4	9.5	17.4	3.4
Chromium, Total	0.0015	2	0.001	0.002	0.001
Copper, Total	0.004	4	0.002	0.009	0.003
Iron, Total	0.59	3	0.43	0.68	0.14
Lead, Total	0.003	3	0.002	0.005	0.002
Magnesium, Diss.	2.3	4	1.6	3.5	0.9
Manganese, Diss.	0.001	1			
Manganese, Total	0.036	3	0.024	0.050	0.013
Potassium, Diss.	1.0	4	0.8	1.5	0.3
Sodium, Diss.	2.8	4	1.2	6.1	2.3
Zinc, Total	0.010	3	0.001	0.022	0.011

TABLE 71

WATER QUALITY SUMMARY FOR GUERIN CREEK AT MISS. FLAT ROAD (STATION 0600056), 1972 - 1980

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	10	2	5	15	7
Oil & Grease	2.9	1			
pH	8.5	6	8.3	8.6	0.2
Res. 105	3791	7	1522	12740	3966
Res. NF 105	2628	3	62	7715	4405
Spec. Cond.	2570	6	1940	3150	38.6
Oxygen, Diss.	8.2	2	6.8	9.8	2.2
Turbidity	377.6	5	2.2	1800	795.3
Colour TAC	11	3	7	16	4.6
Alkalinity	343.1	5	38.5	485	194.9
Organic Carbon	22.5	2	7	38	21.9
Chloride, Diss.	130.5	2	103	158	38.9
Fluoride, Diss.	0.26	1			
Hardness	1011	3	636	1210	325
NO_3 N	0.184	4	0.038	0.324	0.156
NO_2/NO_3 N	0.61	5	0.36	0.84	0.20
Nitrate N	0.69	3	0.39	0.86	0.26
Nitrite N	0.013	4	0.008	0.017	0.004
Organic N	0.56	4	0.18	1.0	0.34
Kjeldahl N	0.76	8	0.23	1.67	0.44
Nitrogen, Total	1.42	8	0.59	2.28	0.58
B.O.D. Both	10	2			
C.O.D.	16.6	1			
Ortho P	0.020	2	0.014	0.025	0.008
Total Diss. P	0.040	3	0.021	0.051	0.016
Total P	0.129	8	0.051	0.222	0.065
Silica, Diss.	17.1	1			
Sulphate, Diss.	1081	6	621	1380	254
Surfacan, Total	<0.03	1			
Carbon I0, Total	110	1			
Manganese, Total	2.24	2	0.27	4.2	2.78
Calcium, Diss.	111.9	3	71.6	147	38.0
Calcium, Total	98	2	76	120	31
Chromium, Diss. Both	<0.005	2			
Chromium, Total	0.015	1			
Copper, Diss.	0.006	2	0.001	0.01	0.006
Copper, Total	0.049	4	0.008	0.16	0.074
Iron, Diss.	<0.1	1			
Iron, Total	2.3	2	1.8	2.8	0.7
Lead, Diss. Both	<0.001	2			
Lead, Total	0.062	4	<0.001	0.23	0.112
Magnesium, Diss.	177	3	111	222	59
Magnesium, Total	154	2	57	250	136
Nickel, Total	0.01	1			
Potassium, Diss.	16.8	1			
Sodium, Diss.	213	1			
Zinc, Diss.	0.03	1			

TABLE 71
WATER QUALITY SUMMARY FOR GUERIN CREEK AT MISS. FLAT ROAD (STATION 0600056), 1972 - 1980 (continued)

Characteristic	Mean Value	n	minimum	maximum	deviation
Zinc, Total	0.24	4	0.05	0.74	0.34
Fecal Coliforms MPN	28	2	7	49	27
Total Coliforms MPN	600	2	280	920	453

TABLE 72
MORPHOMETRY OF KAMLOOPS LAKE

AREA (A)	52.07 km^2
VOLUME (V)	3.70 km^3
LENGTH (l)	25 km
MEAN DEPTH (z)	71 m
MAXIMUM DEPTH (z_m)	143 m
ELEVATION OF DATUM	336.2 m
LITTORAL AREA (<6m)	10%

TABLE 73
KAMLOOPS LAKE HYDROLOGIC DATA

AVERAGE ANNUAL INFLOW	720 m^3/s
MEAN WATER EXCHANGE TIME	60 days
RANGE	20 - 340 days

TABLE 74
EFFLUENT QUALITY SUMMARY FOR BCG, BCBC, TRANQUILLE SPRAY IRRIGATION
PE 164301, 1971 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	99	5	40	200	60.5
Oil & Grease	9.4	11	0.2	22.5	9.1
pH	7.5	42	6.9	8.2	0.3
Res. 105	375	20	254	480	53
Res. NF 105	53.0	54	4.4	284	43.2
Res. NF 550	5.8	1			
Spec. Cond.	454	24	327	605	77
Oxygen, Diss.	7.9	9	3.8	15.7	3.6
Turbidity	17.3	11	9.8	30	6.2
Chlorine, Resid.	0.4	6	0	0.9	0.3
Colour, TAC	50	5	35	63	12
Alkalinity, Total	76	11	112	240	39
Organic Carbon	55	15	9	87	22
Chloride, Diss.	35	16	20.1	54.2	7.7
Hardness, Diss.	72.7	3	71.2	75.4	2.3
NH_3 N	7.5	11	4.2	12.2	2.7
NH_3 N	9.3	9	<0.01	18	6.1
NO_2/NO_3 N	0.09	9	0.02	0.35	0.11
Nitrate N	0.07	12	<0.02	0.28	0.08
Nitrate, Total	0.03	6	<0.02	0.05	0.01
Nitrite, Diss.	0.026	17	<0.005	0.126	0.034
Nitrite, Total	0.005	1			
Organic N, Total	7.69	17	3.5	13.78	2.63
Kjeldahl N, Total	15	13	9	22	4.2
Nitrogen, Total	15.8	21	9.2	24.1	4.4
B.O.D.	39.3	59	<0.5	112	25.3
C.O.D.	138.6	2	69.1	208	98.2
Phenol, Total	0.122	8	0.007	0.318	0.127
Ortho P, Diss.	3.6	12	1.7	6.4	1.4
Ortho P, Total	4.3	1			
Diss. P, Total	3.2	13	1.9	5.0	0.8
Total P	4.6	22	2.3	7.1	1.5
Silica, Diss.	27.3	3	26.3	28.4	1.1
Sulphate, Diss.	<12.7	14	<5	22	5.4
Sulphate, Total	6.8	1			
Surfacan, Diss.	0.6	5	0.1	1.3	0.5
Surfacan, Total	0.99	6	0.12	2.06	0.78
Tan & Lign, Diss.	1.6	1			
Tan & Lign, Total	3.1	10	1.5	6	1.6
Carbon I0, Total	37.8	6	25	46	7.8
Sulphide, Total	<1.1	10	<0.5	4.2	1.2
Arsenic, Diss.	<0.005	2	<0.005	<0.005	0
Arsenic, Total	0.007	10	0	0.025	0.007
Calcium, Diss.	16.3	1			
Chromium, Total	<0.009	10	<0.005	0.02	0.006
Copper, Total	0.015	2	0.01	0.02	0.007

TABLE 74
EFFLUENT QUALITY SUMMARY FOR BCG, BCBC, TRANQUILLE SPR. IRR.
PE 164301, 1971 - 1982

(continued)

Characteristic	Mean Value	n	minimum	maximum	deviation
Iron, Total	0.5	2	0.05	0.05	
Lead, Total	0.006	2	0.003	0.009	0.004
Magnesium, Diss.	7.4	1			
Mercury, Total	0.00006	2	<0.00005	0.00007	0.00001
Molybdenum, Total	0.00055	2	0.0005	0.0006	0.00007
Nickel, Tital	0.01	1			
Zinc, Total	0.05	11	0.02	0.14	0.03
Aluminum, Total	0.07	1			
Fecal Coliforms	4164	45	<2	49000	11062
Total Coliforms	114310	14	<2000	540000	165110

TABLE 75
EFFLUENT QUALITY SUMMARY FOR BCG, BCBC, TRANQUILLE SPR. IRR.
PE 164302, 1973 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	98	10	30	250	69
Oil & Grease	5.4	8	2.3	11.7	3.2
pH	7.5	52	7.1	8.3	0.2
Res. 105	362	36	290	460	43
Res. NF 105	50	61	13	180	28
Spec. Cond.	504	55	340	635	79
Oxygen, Diss.	5.2	25	1.2	12.3	3.0
Turbidity	19.4	29	8.5	53	9.9
Chlorine, Resid.	0.6	14	0	1.6	0.4
Set. Slds.	0.15	2	<0.1	<0.2	0.07
Colour TAC	52	23	32	109	20
Alkalinity, Total	175	29	115	217	28
Organic Carbon	51	27	16.4	57.2	8.3
Hardness, Diss.	98.5	16	65.2	120	12.5
NH_3 N	9.7	17	5.0	14.5	3.0
NH_3 N	11	7	4	16	4
NO_2/NO_3 N	0.04	9	0.02	0.1	0.02
Nitrate N	0.03	20	<0.02	0.08	0.02
Nitrite N	0.027	27	<0.005	0.155	0.036
Organic N, Total	6.9	24	0.5	11	2.4
Kjeldahl N, Total	15.8	22	10	20	2.7
Nitrogen, Total	16.6	28	10	24	3.2
B.O.D.	33.2	55	13	78	15.3
C.O.D.	141	7	102	184	32

TABLE 75 (continued)
EFFLUENT QUALITY SUMMARY FOR BCG, BCBC, TRANQUILLE SPR. IRR.
PE 164302, 1973 - 1982

Characteristic	Mean Value	n	minimum	maximum	deviation
Phenol, Total	0.20	10	0.04	0.56	0.19
Ortho P, Diss.	3.5	21	2.2	5.1	0.8
Total Diss. P	4.1	25	2.5	5.6	0.8
Total P	4.7	30	2.9	6.6	0.9
Silica, Diss.	29.7	15	25.7	34.8	2.5
Sulphate, Diss.	14.8	24	<5.0	21.9	5.0
Surfacan, Total	0.86	5	0.11	1.45	0.63
Tan & Lign, Total	3.7	14	2.0	12.5	2.7
Carbon IO, Total	51	22	11	130	25
Sulphide, Total	0.6	16	<0.5	2.0	0.4
Res. Acid, Total	<0.5	2	<0.5	<0.5	0
Arsenic, Diss.	0.005	12	<0.005	0.006	0.0002
Calcium, Diss.	17.7	5	16.3	20.4	1.7
Chromium, Diss.	<0.005	5	<0.005	<0.005	0
Copper, Total	0.0195	4	0.013	0.03	0.0076
Iron, Total	0.43	4	0.3	0.6	0.126
Lead, Total	0.0045	4	0.002	0.008	0.0026
Magnesium, Diss.	11.2	1			
Manganese, Diss.	0.02	1			
Molybdenum, Total	0.0016	2	0.001	0.0021	0.008
Nickel, Diss.	<0.01	1			
Zinc, Diss.	0.03	5	0.014	0.05	0.02
Zinc, Total	0.05	7	0.04	0.05	0.005
Fecal Coliforms	57000	33	<2	1600000	278450
Coliforms, Total	794510	21	79	9200000	2051100

TABLE 76
WATER QUALITY SUMMARY FOR BCG, BCBC, TRANQUILLE SPR. IRR.
PE 164303, 1983 - 1984

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.6	3	7.2	8.0	0.4
Res. 105	464	2	430	498	48
Res. NF 105	76	2	75	77	1.4
Spec. Cond.	688	3	552	793	124
NH_3, Diss.	7.6	2	0.6	14.6	9.9
NO_2/NO_3 N	0.63	2	0.37	0.89	0.37
Nitrate N	0.245	2	0.24	0.25	0.007
Nitrite N	0.387	2	0.121	0.652	0.375
Organic N, Total	8.0	1			
Kjeldahl N, Total	23.0	1			
B.O.D.	61.7	3	44.0	87.0	22.5
Ortho P	5.4	1			
Total Diss. P	5.22	3	2.95	6.9	2.04
Total P	6.28	3	4.22	7.8	1.85
Sulphate, Diss.	14.7	1			
Coliforms, Total	22500	2	22000	23000	707

TABLE 77
GROUND WATER QUALITY SUMMARY FOR TRANQUILLE SCHOOL
BACKGROUND MONITORING WELL 0601007, 1974 - 1976

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.9	16	7.1	8.6	0.5
Res. 105	347	6	328	368	16
Spec. Cond.	511	20	444	545	26
Turbidity	7.6	5	0.4	19	8.8
Colour TAC	2.3	3	1	4	1.5
Alkalinity, Total	251	6	241	254	5
Organic Carbon	<1.9	7	<1	4	1.2
Chloride	3.7	12	2.9	5.1	0.6
Hardness	258	6	253	264	4.6
Ammonia N	0.011	2	0.006	0.015	0.006
NO_2+NO_3 N	3.1	8	2.4	3.6	0.5
Nitrate N	3.7	6	3.2	4.0	0.3
Nitrite N	All <0.005	6			
Kjeldahl N	0.19	6	0.1	0.27	0.2
Ortho P	0.056	2	0.048	0.064	0.011
Total P	0.076	7	0.055	0.087	0.011
Silica	30.4	3	29.4	31.7	1.2
Inorganic Carbon	66.2	6	62	72	3.9
Sulphide	All L0.5	3			
Fecal Coliforms	<41	6	<2	<200	
Total Coliforms	All <2	6			

TABLE 78. GROUND WATER QUALITY SUMMARY FOR TRANQUILLE SCHOOL SAMPLING WELL 0601008, 1974 - 1978

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.9	33	7.6	8.3	0.22
Res. 105C	552	7	180	1378	412
Spec. Cond.	336	35	251	429	52
Oxygen, Diss.	2.3	15	1.1	4.0	0.9
Turbidity	175	4	22	460	195
Colour TAC	2.3	6	1	4	1.2
Alkalinity, Total	160	12	123	221	27
Organic Carbon	22	10	1	52	18
Ammonia N	1.6	6	0.5	3.1	1.0
NO_2+NO_3 N	0.122	19	L0.02	1.15	0.276
Kjeldahl N	2.5	17	0.9	7.0	1.5
Ortho P	All <0.003	3			
Total Diss. P	0.004	11	<0.003	0.006	0.001
Total P	0.191	18	0.012	1.77	0.41
Silica	1.8	3	0.8	2.3	0.9
Sulphate	11.1	9	L5	25.2	7.4
Inorganic Carbon	36	9	22	62	12
Sulphide	All <0.5	3			
Fecal Coliforms	43	14	<2	350	103
Total Coliforms	212		<2	1600	458

TABLE 79. EFFLUENT QUALITY SUMMARY FOR SAVONA TIMBER, SAVONA PE 00429, 1974 - 1975

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	1	1			
pH	7.4	1			
Res. 105, Total	65	2	60	70	7.1
Spec. Cond. Total	98.5	2	81	116	24.7
Oxygen, Diss.	5	2	3.5	6.5	2.1
Turbidity	3.3	1			
B.O.D.	<10	2	<10	<10	0
T. Sampling	38	2	36	40	2.8

TABLE 80. EFFLUENT QUALITY SUMMARY FOR SAVONA TIMBER, SAVONA PE 00430, 1972 - 1975

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	1.4	1			
pH	7.3	1			
Res. 105, Total	64.7	3	52	72	11.0
Spec. Cond. Total	97	3	82	117	18.0
T. Sampling	28.3	2	22	36	7.1
Oxygen, Diss.	6.55	2	4.7	8.4	2.6
Turbidity	7.4	1			
B.O.D.	10	3	<10	<10	

TABLE 81
EFFLUENT QUALITY SUMMARY FOR SAVONA TIMBER, SAVONA
PE 00431, 1973 - 1974

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	1200	1			
pH	7.25	2	3.9	10.6	4.7
Res. 105, Total	7168	2	4256	10080	4118.2
Spec. Cond. Total	1825	2	440	3210	1958.7
T. Sampling	13.75	2	11	16.5	3.9
Oxygen, Diss.	0.6	1			
B.O.D.	1594	2	1208	1980	

TABLE 82
GROUND WATER QUALITY SUMMARY FOR WELL SAMPLING - EVANS PROD. SAVONA
STATION 0600098, 1973 - 1976
(MONITORING SITE FOR SAVONA TIMBER, PE 00431)

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	7.5	2	5.0	10.0	3.5
pH	8.4	7	7.5	9.4	0.6
Res. 105	441	5	342	630	112
Res. NF 105	99	1			
Spec. Cond.	456	8	291	765	143
Oxygen, Diss.	2.9	3	2.0	4.0	1.0
Turbidity	80	2	72	88	11
Colour TAC	1.6	5	1.0	4.0	1.3
Alkalinity	144	2	93	196	73
Organic Carbon	<1.0	1			
NO_2/NO_3 N	<0.02	1			
Kjeldahl N	0.5	1			
Total N	0.5	1			
B.O.D.	All <10.0	5			
C.O.D.	<10.0	1			
Phenol, Total	0.0036	5	<0.002	0.005	0.001
Total Diss. P	0.003	1			
Total P	0.021	1			
Sulphate, Diss.	42.5	1			
Tan. & Lign.	0.6	5	0.2	1.4	0.5
Carbon I0	52	1			
Fecal Coliforms	240	1			
Total Coliforms	540	1			

TABLE 83

WATER QUALITY SUMMARY FOR ALKALI CREEK DIVERSION ABOVE CHERRY CREEK (STATION 0600210), 1974 - 1981 (MONITORING SITE FOR AFTON MINES, PE 03904)

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	1.6	20	0.9	4.0	1.0
pH	8.3	32	7.2	8.7	0.3
Res. NF 105	6.5	32	L1.0	15.0	4.0
Spec. Cond.	1031	30	119	1449	328
Fluoride, Diss.	0.22	7	0.17	0.23	0.02
Fluoride, Total	0.21	23	0.13	0.28	0.05
Sulphate, Diss.	288	7	257	342	36
Sulphate, Total	202	24	31	440	99
Arsenic, Diss.	0.0046	6	0.003	<0.005	0.0008
Arsenic, Total	0.009	18	0.00007	<0.02	0.007
Copper, Diss.	0.007	6	0.003	0.01	0.003
Copper, Total	0.005	25	0.001	0.019	0.003
Iron, Diss.	0.022	6	0.002	0.11	0.043
Iron, Total	0.021	25	<0.001	0.05	0.018
Lead, Diss.	0.0016	5	<0.001	0.002	0.0005
Lead, Total	0.0022	23	<0.0005	0.007	0.0018
Mercury, Total	0.0002	30	<0.00005	0.002	0.0004
Molybdenum, Diss.	0.003	1			
Molybdenum, Total	0.005	23	0.002	0.015	0.004
Zinc, Diss.	0.006	4	<0.001	0.016	0.007
Zinc, Total	0.007	23	<0.001	0.05	0.010

TABLE 84
WATER QUALITY SUMMARY FOR BOWERS CREEK
STATION 0600176, 1976 - 1978
(MONITORING SITE FOR AFTON MINES, PE 03904)

Characteristic		Mean Value	n	minimum	maximum	deviation
pH		8.2	9	8.1	8.3	0.1
Res. 105		473	7	316	740	131
Res. F 105		466	7	314	724	127
Spec. Cond.		714	9	476	1020	183
Oxygen, Diss.		10.2	5	8.6	11.5	1.1
Turbidity		3.5	3	1.8	5.9	2.2
Colour TAC		5	4	1	9	4
Alkalinity		263	6	223	300	25
Cyanide, Total	Both	<0.01	2			
Hardness		310	6	217	391	56
NO_2/NO_3 N		0.10	5	<0.02	0.14	0.05
Nitrate N		0.1	1			
Nitrite N		<0.005	5			
Kjeldahl N		0.24	6	0.06	0.33	0.10
Total N		0.33	6	0.06	0.47	0.14
Ortho P		0.016	4	0.008	0.027	0.008
Total Diss. P		0.023	4	0.018	0.033	0.007
Total P		0.041	6	0.013	0.081	0.023
Sulphate, Diss.		86	4	46	130	35
Arsenic, Total	All	<0.005	5			
Cadmium, Diss.	Both	<0.0005	2			
Cadmium, Total	All	<0.0005	7			
Calcium, Diss.		77.7	6	53.8	88.5	12.7
Copper, Diss.		0.0015	2	0.001	0.002	0.0007
Copper, Total		0.003	7	0.001	0.006	0.002
Iron, Diss.	Both	<0.1	2			
Iron, Total		0.34	5	0.2	0.5	0.11
Lead, Diss.	Both	<0.001	2			
Lead, Total		0.002	7	<0.001	0.004	0.001
Magnesium, Diss.		22.5	3	20.0	26.7	3.7
Magnesium, Total		23.5	2	20.0	27.0	4.9
Mercury, Diss.	Both	<0.00005	2			
Mercury, Total	All	<0.00005	6			
Zinc, Diss.	Both	<0.005	2			
Zinc, Total		0.006	7	L0.005	0.01	0.002

Sediment data also collected - not compiled here.

TABLE 85
WATER QUALITY SUMMARY FOR CHERRY CREEK ABOVE AFTON
STATION 0600177, 1974 - 1981
(MONITORING SITE FOR AFTON MINES, PE 03904)

Characteristic		Mean Value	n	minimum	maximum	deviation
Oil & Grease		1.8	25	<1.0	4.0	1.0
pH		8.2	50	7.4	8.5	0.2
Res. 105		187	7	146	230	35
Res. F 105		183	7	138	226	36
Res. NF 105		6.5	41	0.1	85	13.6
Spec. Cond.		349	49	185	700	100
Oxygen, Diss.		10.6	6	9.6	11.6	0.9
Turbidity		0.73	3	0.7	0.8	0.06
Colour TAC		11	4	6	18	5
Alkalinity		147	6	98	178	33
Cyanide, Total	Both	<0.01	2			
Fluoride, Diss.		0.09	9	<0.03	0.14	0.03
Fluoride, Total		0.129	30	0.073	L1.0	0.165
Hardness		146	6	104	171	28
NO_2/NO_3 N		0.05	5	L0.02	0.12	0.04
Nitrate N		<0.02	1			
Nitrite N	All	<0.005	5			
Kjeldahl N		0.20	6	0.11	0.31	0.07
Total N		0.23	6	0.14	0.34	0.08
Ortho P		0.022	4	0.012	0.032	0.008
Total Diss. P		0.024	4	0.015	0.034	0.008
Total P		0.025	6	0.019	0.034	0.005
Sulphate, Diss.		15.5	13	7.2	28.5	5.6
Sulphate, Total		19.9	31	8.0	58.0	11.7
Arsenic, Diss.		<0.004	9	<0.001	<0.005	0.002
Arsenic, Total		0.008	26	0.001	<0.02	0.006
Cadmium, Diss.	Both	<0.0005	2			
Cadmium, Total		0.0009	7	0.0005	0.0031	0.0010
Calcium, Diss.		41.9	6	30.0	48.9	7.9
Chromium, Total		<0.005	1			
Copper, Diss.		0.005	10	<0.002	<0.009	0.002
Copper, Total		0.005	39	0.001	0.021	0.004
Iron, Diss.		0.020	11	<0.001	<0.01	0.038
Iron, Total		0.028	38	<0.001	0.02	0.042
Lead, Diss.		0.002	8	<0.001	0.008	0.002
Lead, Total		0.0029	40	<0.0005	0.018	0.004
Magnesium, Diss.		10.3	3	7.8	12.0	2.2
Magnesium, Total		12.1	2	11.2	13.0	1.3
Mercury, Diss.	Both	<0.00005	2			
Mercury, Total		0.00012	44	<0.00005	0.001	0.0002
Molybdenum, Diss.		0.012	1			
Molybdenum, Total		0.009	29	0.006	0.019	0.003
Zinc, Diss.		0.016	7	<0.002	0.08	0.028
Zinc, Total		0.006	39	<0.001	0.062	0.010

Sediment data available - not compiled here.

TABLE 86
WATER QUALITY SUMMARY FOR CHERRY CREEK BELOW ALKALI CREEK
STATION 0600178, 1973 - 1981
(MONITORING SITE FOR AFTON MINES, PE 03904)

Characteristic		Mean Value	n	minimum	maximum	deviation
Oil & Grease		1.6	29	L1.0	3.1	0.9
pH		8.3	58	6.9	8.5	0.2
Res. 105		380	7	246	538	108
Res. NF 105		28	48	L1	403	80
Spec. Cond.		587	55	342	1000	142
Oxygen, Diss.		10.5	5	8.9	11.8	1.0
Turbidity		5.8	3	1.2	13.0	6.3
Colour TAC		5.8	4	2.0	13.0	5.0
Alkalinity		238	6	166	266	41
Cyanide	Both	<0.01	2			
Fluoride, Diss.		0.11	12	<0.03	0.14	0.03
Fluoride, Total		0.11	34	0.07	0.14	0.02
Hardness		268	6	163	328	59
NO_2/NO_3 N		0.05	5	0.02	0.08	0.02
Nitrate N		0.06	4	0.02	0.08	0.03
Nitrite N	All	<0.005	5			
Kjeldahl N		0.27	6	0.10	0.41	0.11
Total N		0.33	6	0.16	0.47	0.11
Ortho P		0.015	4	0.009	0.025	0.007
Total Diss. P		0.020	4	0.015	0.029	0.006
Total P		0.035	6	0.015	0.059	0.019
Sulphate, Diss.		84	16	33	248	51
Sulphate, Total		70	35	28	114	23
Arsenic, Diss.		<0.004	13	<0.001	<0.005	0.002
Arsenic, Total		0.007	29	0.0008	<0.02	0.006
Cadmium, Diss.	Both	<0.0005	2			
Cadmium, Total		0.0005	7	<0.0005	0.0005	0
Calcium, Diss.		69.0	6	42.2	82.5	15.0
Copper, Diss.		0.004	14	<0.001	0.009	0.002
Copper, Total		0.004	43	<0.01	0.013	0.003
Iron, Diss.		0.034	13	0.007	<0.1	0.031
Iron, Total		0.083	42	<0.001	1.3	0.209
Lead, Diss.		0.002	8	<0.001	0.004	0.001
Lead, Total		0.002	44	<0.0005	0.015	0.003
Magnesium, Diss.		20.3	3	14.1	25.3	5.7
Magnesium, Total		24.3	2	21.5	27.0	3.9
Mercury, Diss.	Both	<0.00005	2			
Mercury, Total		0.00008	50	0.00002	0.00022	0.00006
Molybdenum, Diss.		0.011	1			
Molybdenum, Total		0.008	32	0.001	0.019	0.004
Zinc, Diss.		0.004	7	0.001	0.006	0.002
Zinc, Total		0.008	41	<0.001	0.06	0.012

TABLE 87
WATER QUALITY SUMMARY FOR CHERRY CREEK NEAR KAMLOOPS LAKE
STATION 0600212, 1974 - 1981
(MONITORING SITE FOR AFTON MINES, PE 03904)

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	1.9	25	<0.1	9.6	2.4
pH	84	40	7.9	8.7	0.2
Res. NF 105	35	40	2	297	50
Spec. Cond.	847	40	401	1186	219
Fluoride, Diss.	0.15	10	<0.03	0.19	0.05
Fluoride, Total	0.15	28	0.10	0.19	0.03
Sulphate, Diss.	157	10	62	217	48
Sulphate, Total	172	29	45	334	73
Arsenic, Diss.	<0.004	10	<0.001	<0.005	0.002
Arsenic, Total	0.008	22	0.001	<0.02	0.006
Copper, Diss.	0.006	10	0.002	0.015	0.004
Copper, Total	0.005	31	0.002	0.013	0.003
Iron, Diss.	0.040	9	0.005	0.160	0.049
Iron, Total	0.036	31	0.006	0.188	0.027
Lead, Diss.	0.0018	5	<0.001	0.002	0.0004
Lead, Total	0.006	29	<0.001	0.068	0.013
Mercury, Total	<0.0001	38	<0.0005	0.0006	0.0001
Molybdenum, Diss.	0.014	1			
Molybdenum, Total	0.015	29	0.005	0.023	0.004
Zinc, Diss.	0.002	5	<0.001	0.006	0.002
Zinc, Total	0.007	39	0	0.07	0.013

TABLE 88
WATER QUALITY SUMMARY FOR CHERRY CREEK AT CHERRY CREEK
STATION 0600057, 1972 - 1978

Characteristic		Mean Value	n	minimum	maximum	deviation
Colour True		21	12	5	60	15
pH		8.3	22	8.0	8.5	0.1
Res. 105		600	22	338	948	133
Res. F 105		576	19	310	934	145
Res. NF 105		31	2	2	61	42
Oxygen, Diss.		9.7	12	6.6	13.0	2.2
Turbidity		17	18	1	98	29
Colour TAC		15	7	8	24	6
Alkalinity		316	20	152	534	87
Organic Carbon		9	3	<1	19	9
Chloride, Diss.		8.9	2	8.3	9.5	0.8
Cyanide, Total	All	<0.01	4			
Hardness		363	17	184	488	94
NH_3, Diss.		0.528	1			
NO_2/NO_3 N		0.18	9	0.04	0.44	0.13
Nitrate N		0.20	13	0.03	0.53	0.15
Nitrite N		0.006	17	<0.005	0.012	0.002
Organic N		0.38	1			
Kjeldahl N		0.64	21	0.27	3.0	0.59
Total N		0.82	21	0.34	3.22	0.63
Ortho P		0.048	8	0.022	0.112	0.028
Total Diss. P		0.041	6	0.025	0.056	0.010
Total P		0.123	21	0.018	0.90	0.180
Silica, Diss.		19.6	6	17.0	22.1	1.8
Sulphate, Diss.		157	13	50	264	61
Carbon IO		88	3	70	106	18
Arsenic, Diss.		0.0053	3	<0.005	0.006	0.0006
Arsenic, Total		0.0052	6	<0.005	0.006	0.0004
Cadmium, Diss.		<0.0005	1			
Cadmium, Total	All	<0.0005	6			
Calcium, Diss.		76	17	39	102	19
Chromium, Diss.		<0.005	1			
Copper, Diss.		0.002	9	<0.001	0.004	0.001
Copper, Total		0.008	13	0.001	0.02	0.006
Iron, Diss.		0.11	9	<0.1	0.2	0.03
Iron, Total		1.3	4	0.4	1.8	0.6
Lead, Diss.	All	<0.001	3			
Lead, Total		0.125	13	<0.001	1.6	0.443
Magnesium, Diss.		39.4	9	20.8	54.0	9.7
Magnesium, Total		0.11	7	0.06	0.28	0.08
Mercury, Diss.	Both	<0.00005	2			
Mercury, Total		0.00006	7	<0.00005	0.00015	0.00004
Zinc, Diss.	Both	<0.005	2			
Zinc, Total		0.010	13	<0.005	0.04	0.010

Sediment data collected at this site but not compiled here.

TABLE 89
EFFLUENT QUALITY SUMMARY FOR AFTON MINES, KAMLOOPS
PE 04367, 1977 - 1980

Characteristic	Mean Value	n	minimum	maximum	deviation
pH	7.65	2	7.1	8.2	0.78
Res. 105	746	2	194	1298	781
Res. NF 105	57	2	26	88	44
Spec. Cond.	917.5	2	195	1640	1021.8
Oxygen, Diss.	1.5	1			
Turbidity	22	2			
Colour TAC	50	1			
C.D.C.	2210	1			
Alkalinity	403	1			
Organic Carbon	58	1			
Chloride, Diss.	101	1			
Fluoride, Diss.	0.53	1			
Hardness, Diss.	615	1			
NH_3 N	5.70	2	0.29	11.1	7.64
NO_2/NO_3 N	2.03	2	0.4	3.65	2.30
Kjeldahl N, Total	12	2	6	18	8.5
Total N	14.2	2	10	18.4	5.9
B.O.D.	27	2	12	42	21.2
Ortho P	6.12	1			
Total Diss. P	3.70	2	1.08	6.32	3.71
Total P	4.30	2	1.45	7.12	4.01
Sulphate, Diss.	425	1			
Carbon IO	96	1			
Calcium, Diss.	98	1			
Magnesium, Diss.	90	1			
Potassium, Diss.	19.4	1			
Sodium, Diss.	149	1			

TABLE 90
GROUND WATER QUALITY SUMMARY FOR AFTON MINES PIEZOMETER 3C
STATION 0600213, 1977 - 1981
(MONITORING SITE FOR AFTON MINES, PE 03904

Characteristic	Mean Value	n	minimum	maximum	deviation
Oil & Grease	1.2	16	<0.1	4.0	0.8
pH	7.9	33	7.4	8.2	0.2
Res. NF 105	13.7	33	1.5	68.0	12.1
Spec. Cond.	3911	33	161	5470	1183
Fluoride, Diss.	0.18	11	<0.03	0.26	0.06
Fluoride, Total	0.16	23	0.001	0.19	0.04
Sulphate, Diss.	2375	11	786	3083	887
Sulphate, Total	2267	28	1988	3190	383
Arsenic, Diss.	0.004	10	0.001	0.005	0.002
Arsenic, Total	0.008	18	0.003	<0.02	0.006
Copper, Diss.	0.017	11	0.005	0.032	0.008
Copper, Total	0.008	27	<0.001	0.032	0.008
Iron, Diss.	<0.012	10	<0.001	<0.03	0.013
Iron, Total	0.027	27	0.003	0.104	0.025
Lead, Diss.	0.02	4	0.001	0.047	0.02
Lead, Total	0.068	27	0.001	0.182	0.051
Mercury, Total	0.00009	33	<0.00005	0.0003	0.00006
Molybdenum, Diss.	0.21	1			
Molybdenum, Total	0.019	24	0.01	0.032	0.005
Zinc, Diss.	0.005	5	0.001	0.011	0.004
Zinc, Total	0.017	25	<0.001	0.19	0.036

TABLE 91: GROUND WATER QUALITY SUMMARY FOR AFTON - PIEZOMETER 3B, STATION 0600214, 1977 - 1981 (MONITORING SITE FOR AFTON MINES PE 03904).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil & Grease	1.0	16	<0.1	1.8	0.4
PH	8.0	30	7.2	8.4	0.2
res NF 105	18	30	5	83	16
Specific Cond.	3429	30	1360	6103	1341
Fluoride diss.	0.18	9	L0.03	0.21	0.06
Fluoride total	0.17	17	0.12	0.20	0.02
Sulphate diss.	2228	10	547	3716	1026
Sulphate total	1719	20	737	2955	787
Arsenic diss.	<0.004	10	<0.001	<0.005	0.002
Arsenic total	0.008	15	0.001	<0.02	0.006
Copper diss.	0.016	10	0.003	0.037	0.01
Copper total	0.006	20	<0.001	0.016	0.005
Iron diss.	<0.014	9	<0.001	<0.03	0.012
Iron total	0.054	21	<0.001	0.197	0.062
Lead diss.	0.008	4	<0.002	0.014	0.005
Lead total	0.039	20	0.001	0.11	0.035
Mercury total	<0.00009	30	<0.00005	<0.0002	0.00006
Molybdenum diss.	0.015	1			
Molybdenum total	0.015	19	0.01	0.028	0.004
Zinc diss.	0.006	4	<0.001	0.017	0.008
Zinc total	0.013	18	<0.001	0.04	0.009

TABLE 92. GROUND WATER QUALITY SUMMARY FOR AFTON-PIEZOMETER 3A, STATION 0600215, 1977 - 1981 (MONITORING SITE FOR AFTON MINES PE 03904).

Characteristics	Mean	n	Minimum	Maximum	Std. deviation
Oil and Greese	<1.9	20	<1.0	<5.0	1.3
PH	8.0	35	6.9	8.5	0.3
res NF 105	21.9	35	1.5	141	31.4
Specific Cond.	1733	35	894	4984	773
Fluoride diss.	0.21	10	<0.03	0.34	0.08
Fluoride total	0.26	22	0.17	0.29	0.03
Sulphate diss.	977	10	575	3129	758
Sulphate total	671	24	575	786	69
Arsenic diss.	0.008	10	0.004	0.032	0.008
Arsenic total	<0.008	19	<0.005	<0.02	0.006
Copper diss.	0.012	10	0.002	0.027	0.006
Copper total	0.005	25	<0.001	0.03	0.006
Iron diss.	0.018	9	<0.001	0.052	0.018
Iron total	0.042	25	0.004	0.229	0.046
Lead diss.	0.027	4	<0.002	0.095	0.046
Lead total	0.025	25	0.001	0.063	0.019
Mercury total	0.00009	35	<0.00005	0.00028	0.00007
Molybdenum diss.	0.017	1			
Molybdenum total	0.026	24	0.014	0.038	0.006
Zinc diss.	0.009	4	0.001	0.021	0.005
Zinc total	0.008	25	<0.001	0.025	0.002

TABLE 93. GROUND WATER QUALITY SUMMARY FOR AFTON-PIEZOMETER, A2 W DAM,STATION 0600216, 1977 - 1981 (MONITORING SITE FOR AFTON MINES PE 03904).

Characteristics	Mean	n	Minimum	Maximum	Std. deviation
Oil and Grease	1.2	15	<1.0	2.7	0.6
PH	8.1	29	7.5	8.4	0.2
res. NF 105	367	28	0.5	1829	504
Specific Cond.	3581	30	1990	8900	1555
Fluoride diss.	0.45	10	0.04	0.57	0.15
Fluoride total	0.27	17	0.09	0.55	0.16
Sulphate diss.	513	10	429	614	55
Sulphate total	2152	22	546	4480	1378
Arsenic diss.	0.004	10	0.001	0.005	0.001
Arsenic total	0.007	18	0.003	<0.02	0.005
Copper diss.	0.040	10	0.016	0.082	0.022
Copper total	0.017	21	0.002	0.123	0.025
Iron diss.	0.021	9	0.001	0.052	0.016
Iron total	1.943	21	0.001	37.19(?*)	8.088
Lead diss.	0.011	4	<0.002	0.016	0.006
Lead total	0.045	21	<0.001	0.413	0.091
Mercury total	0.00015	29	0.00005	0.00091	0.00017
Molybdenum diss.	0.047	1			
Molybdenum total	0.024	21	0.018	0.033	0.005
Zinc diss.	0.007	4	<0.001	0.011	0.005
Zinc total	0.044	19	<0.001	0.21	0.068

* dubious

TABLE 94. GROUND WATER QUALITY SUMMARY FOR AFTON WELL #1 SOUTH, STATION 0600222, 1976 - 1979 (MONITORING SITE FOR AFTON MINES PE 03904).

Characteristics	Mean	n	Minimum	Maximum	Std. deviation
Oil and Grease	<1.1	10	<0.1	<2.0	0.5
PH	8.4	12	7.8	9.4	0.4
res NF 105	196	12	<1	944	367
Specific Cond.	1210	11	909	1338	128
Fluoride diss.	0.2	1			
Fluoride total	0.19	11	0.13	0.22	0.03
Sulphate total	393	12	330	437	26
Arsenic diss.	L0.005	1			
Arsenic total	<0.007	11	<0.005	<0.02	0.005
Copper diss.	0.01	1			
Copper total	0.004	11	<0.001	0.011	0.004
Iron diss.	0.042	1			
Iron total	0.050	11	<0.005	0.14	0.039
Lead diss.	0.002	1			
Lead total	0.002	9	<0.001	0.003	0.001
Mercury total	0.00008	12	<0.00005	0.0002	0.00006
Molybdenum diss.	0.026	1			
Molybdenum total	0.008	11	0.006	0.012	0.002
Zinc diss.	0.003	1			
Zinc total	0.006	11	<0.001	0.02	0.006

0600217 Afton - piezometer - 2B West
0600218 Afton - piezometer - 2C W. Dam
0600219 Afton - piezometer - 1A W Dam
0600220 Afton - piezometer - 1B W Dam
0600221 Afton - piezometer - 1C W. Dam
0600223 Afton - Seepage dam piezometer

All of the above stations have data collected at them but since they are piezometers, they have not been summarized.

TABLE 95. EFFLUENT QUALITY SUMMARY FOR AFTON #1, SEEPAGE RECOVERY POND, STATION 0601055, 1979 - 1980 (MONITORING SITE FOR AFTON MINES PE 03904).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
PH	8.3	11	7.7	8.4	0.2
res NF 105	16	11	1	110	32
Spec. Cond.	3073	11	369	4810	1285
Oil and Grease	<1.	1			
Fluoride diss.	0.21	11	0.03	0.5	0.12
Sulphate diss.	1827	11	579	2582	573
Arsenic diss.	0.010	11	<0.005	0.024	0.007
Copper diss.	0.018	11	0.005	0.043	0.011
Iron diss.	0.016	10	<0.001	0.07	0.022
Lead diss.	0.002	6	<0.001	0.002	0.0004
Mercury total	0.00008	11	<0.00005	0.0002	0.00006
Molybdenum diss.	0.013	1			
Zinc diss.	0.005	6	<0.001	0.014	0.006

TABLE 96. KAMLOOPS LAKE - COMPARATIVE WATER CHEMISTRY - STATION C2 (see Figure 12).

		Total P (ug/L)	Total diss P (ug/L)	Kjeldahl N (ug/L)	Nitrate (ug/L)	Ammonia (ug/L)	Colour
1963 (Ward)	May	20/7	6	85	345	L40/L20	
	Oct.	*26/84	8	75	350/610	L20/L10	
1973 (Weyerh.)	April	13.5			88	24	10
	August	14.6/1.6			61/20	12/6	23/10
1974 (NWRI)	April	10	4	125	100	5	5 - 10
	Oct.	5/5	4	75-100	40/160 (Sept)	5	10 - 20
1975 (Weyerh.)	May	7					12.5
	Sept.	14/68	3	166/194			7/18
1976 (Weyerh.)	May	53	35**	355			14.7
	June	48	<20	420/164			13.9/20.5
	Sept.	51.5	<20	825/350			
1978 (Weyerh.)	May	12.6	All <5	208	297	47	12
	Sept.	9.4	6.8	130	268		15.4
1980 (Weyerh.)	April	17.8**	12**	129	417	22	21
	Sept.			130	226		15.2
1982	April	2.5	1.1	628	376	74	12.8
	Sept.	4.7	1.6	1012	269	38	10.2

* Single value represents water column mean, values with slash are surface and deep samples w significant difference between surface and depth samples.

** Data should be viewed with some skepticism (appears to be an error) see section 5.4.1.
The report of Kelso and Derksen (1976)discusses zooplankton data collected to that time

TABLE 97. SUMMARY OF KAMLOOPS LAKE BIOLOGICAL DATA - ZOOPLANKTON

	Dominants	100 foot Vertical Wisconsin Haul biomass (mL)	Horizontal C-B Haul biomass in g/m^3
Ward (1964) Mar. - Nov.	Holopedium, Diaptomus, Cyclops	1.05 (other stations much less)	28.8 (mean B-C & D-E)
1973 (Weyerh.) 1974 April - Oct.		0.6	143
1975 (Weyerh. 1976)		0.5	153
1976 (Weyerh. 1977)		0.2	53
1978 (Weyerh. 1979)	Diaptomus, Cyclops	0.6	
1980 (Weyerh.)	Diaptomus, Cyclops	*	
1982 (Weyerh. 1983)	Diaptomus, Cyclops	*	

* 1980 and 1982 data presented in different form so difficult to compare.
All at Station C-2 or equivalent

Table 98. Summary of Kamloops Lake Biological data - Phytoplankton - Station C2

	Dominant Group or Species	Cell Numbers/mL	Chlorophyll a
1. 1973 (Weyer. 1974) April to July	Diatoms-Achnanthes Tabellaria Fragilaria Asterionella Gomphonema	350 - 550	
2. 1974 (NWRI)	Diatoms Tabellaria Fragilaria Melosira		Mean 1.1 ug/L Peak Sept/ Oct.
3. 1974-75 (EPS)	diatoms - Tabellaria, Fragilaria, Asterionella Melosira	1500 (peak)	3 ug/L Peak (Sept.)
Mar. 74 - Apr. 75			
4. 1978 (Wey. 1979) (Sept.)	cyanobacterium Oscillatoria	360	0.9 ug/L
5. 1980 (Wey. 1981) (Sept.)	diatoms Fragilaria Asterionella	3100	0.5 ug. /L
1982 (Wey. 1983)	diatoms		
April	Fragilaria	3.4	0.2 ug/L
Sept.	Fragilaria	6.0	1.2 ug/L

TABLE 99. WATER QUALITY SUMMARY FOR KAMLOOPS LAKES STATION 0920174 (station "B" no of Tranquille, naquadat site 01BC08LF0001) 1973-1974.
(surface samples only)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour AP	13	48	<5	40	7
pH	7.5	48	7.0	7.9	0.2
res F 105	47	6	36	60	10
res NF 105	18	18	5	32	9
res NF 550	14	18	1	32	9
Specific Cond.	90	48	60	122	16
Oxy. diss.	11.0	45	9.8	12.3	0.8
Turbidity	4.1	48	0.3	15.0	3.7
Alkalinity	34	48	23	40	5
Organic Carbon	5.8	49	2.0	12.6	2.5
Hardness	39.5	41	28.5	47.7	5.6
Sulphate diss.	9.2	15	8.5	9.9	0.5
Surfactant total	all 0.1	29			
Carbon inorganic	7.6	49	4.2	11.7	1.9
Bicarbonate	41	48	29	49	6
Carbonate	0.0	48			
Calcium dis..	12.6	41	9.2	15.7	1.9
Chromium total	0.002	29	0.0	0.005	0.001
Copper total	0.003	37	0.001	0.008	0.001
Iron diss.	0.041	8	0.030	0.057	0.009
Iron total	0.24	29	0.05	0.53	0.15
Lead total	0.002	32	0.001	0.006	0.001
Magnesium diss	1.9	41	1.3	3.8	0.5
Mangnese diss.	all 0.01	11			
Mangnese total	0.01	33	0.005	0.03	0.01
Mercury total	0.004	42	0.0	0.08	0.016
Potasium diss.	0.8	42	0.6	1.1	0.1
Sodium diss.	2.7	42	1.0	5.0	0.2
Zinc total	0.004	30	0.001	0.013	0.003

TABLE 100. WATER QUALITY SUMMARY FOR KAMLOOPS LAKE STATION 0920175(station "C" Battle Bluff, naquadat site 01BC08LF0002), 1973 - 1974.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour app.	11	53	<5	20	4
pH	7.6	53	7.0	7.9	0.2
Res NF 105	9	11	5	16	3
Res NF 550	4	11	<1	10	3
Spec. Cond.	96	53	70	119	14
Oxy. diss.	11.1	48	10.0	12.5	0.7
Turbidity	2.4	53	0.3	8.0	2.1
Alkalinity	36	53	28	46	4
Carbon Organic	5.5	47	2.8	11.1	1.9
Hardness	42.3	39	32.8	47.3	3.7
Sulphate diss.	9.2	21	5.5	9.7	0.9
Surfactants total	All 0.1	32			
Inorganic Carbon	7.6	48	3.7	10.6	1.7
Bicarbonate	44	52	34	56	5
Carbonate	All 0.0	53			
Calcium diss.	13.5	39	10.4	15.0	1.3
Chromium total	0.002	38	0.0	0.006	0.001
Copper total	0.004	44	0.001	0.07	0.010
Iron diss.	0.031	14	0.011	0.057	0.011
Iron total	0.20	24	0.06	0.61	0.15
Lead total	0.004	34	0.001	0.064	0.012
Magnesium diss.	2.1	39	1.5	3.7	0.3
Mangnese diss.	All 0.01	14			
Mangnese total	0.011	33	0.003	0.03	0.006
Potassium diss.	0.90	43	0.7	1.1	0.12
Sodium diss.	3.0	40	1.3	4.3	0.9
Zinc total	0.003	34	0.001	0.009	0.002

TABLE 101. WATER QUALITY SUMMARY FOR KAMLOOPS LAKE STATION 0920176, (station "G" off Frederick, naquadat site 01BC08LF0003)1973 -1974.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour app.	10	24	<5	20	4
pH	7.5	24	6.6	7.8	0.2
Res NF 105	9.8	6	1.0	26	9.0
Res NF 550	7.8	6	<1.0	25	9.0
Spec. Cond.	95	24	69	110	14
Oxy. diss.	11.3	18	10.4	12.2	0.7
Turbidity	2.5	24	0.3	6.5	1.9
Alkalinity	36	20	27	41	4
Organic Carbon	4.6	22	2.3	8.0	1.5
Hardness	41.4	20	32.0	45.8	4.2
Sulphate diss.	9.2	10	8.8	10.2	0.5
Surfactants total	All 0.1	11			
Inorganic Carbon	7.1	22	5.1	9.7	1.3
Bicarbonate	44	20	33	49	5
Carbonate	All 0.0	20			
Calcium diss.	13.4	20	10.9	14.9	1.2
Chromium total	0.001	10	0.0	0.002	0.0007
Copper total	0.004	15	0.001	0.01	0.002
Iron diss.	0.030	5	0.022	0.044	0.008
Iron total	0.16	8	0.06	0.25	0.07
Lead total	0.0011	15	0.001	0.002	0.0003
Magnesium diss.	2.0	20	1.2	3.1	0.4
Mangnese	0.010	20	0.004	0.016	0.003
Potassium diss.	0.9	20	0.7	1.0	0.1
Sodium diss.	3.0	20	1.5	3.9	0.9
Zinc total	0.003	13	0.001	0.006	0.001

TABLE 102. WATER QUALITY SUMMARY FOR KAMLOOPS LAKE, STATION 0920177, (station "D", Copper Creek, naquadat site 01BC08LF0004) 1973 - 1974.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour app.	10	23	L5	20	4
pH	7.5	23	6.0	7.8	0.4
Res NF 105	8	5	2	15	5
Res NF 550	2	5	<1	4	1
Spec. Cond.	93	23	69	107	14
Oxy. diss.	11.2	16	10.1	14.0	1.1
Turbidity	2.4	23	0.2	7.6	2.3
Alkalinity	35	20	26	40	4
Organic Carbon	4.2	23	1.0	8.3	1.7
Hardness	40.4	19	31.6	44.6	4.7
Sulphate diss.	9.3	8	8.7	9.7	0.3
Surfactants	All 0.1	10			
Carbon Inorganic	7.6	23	5.0	10.0	1.7
Bicarbonate	43	20	32	49	5
Carbonate	All 0.0	20			
Calcium diss.	13.2	19	10.5	15.0	1.5
Chromium total	0.002	15	0.0	0.009	0.002
Copper total	0.005	14	0.001	0.013	0.003
Lead total	0.002	14	0.001	0.005	0.001
Magnesium diss.	1.8	19	1.0	2.6	0.4
Mangnese diss.	All 0.01	4			
Mangnese total	0.009	14	0.003	0.02	0.005
Mercury total	0.0279	38	0.00005	0.09	0.0294
Potassium diss.	0.8	19	0.7	1.0	0.1
Sodium diss.	2.8	19	1.3	3.8	0.9
Zinc total	0.005	14	0.001	0.014	0.003

TABLE 103. WATER QUALITY SUMMARY FOR KAMLOOPS LAKE STATION 0920178, (station "E" off Savona station, naquadat site 01BC08LF0005) 1973 - 1974.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation.
Colour app.	9	33	<5	20	4
pH	7.5	33	5.7	8.1	0.4
Res NF 105	7	6	1	12	4
Res NF 550	6	6	<1	10	3
Spec. Cond.	93	33	67	106	14
Oxy. diss	11.5	25	9.9	12.5	1.0
Turbidity	1.9	33	0.3	8.4	2.1
Alkalinity	33	13	27	38	5
Organic Carbon	4.4	31	1.3	8.0	1.5
Hardness	40.6	27	31.0	44.2	4.4
Sulphate diss.	9.7	3	9.5	9.9	0.2
Surfactants	All 0.1	16			
Carbon inorganic	7.7	31	5.5	10.6	1.8
Bicarbonate	41	13	32	47	6
Carbonate	All 0.0	13			
Calcium diss.	13.2	27	10.6	14.5	1.4
Chromium total	0.003	18	0.0	0 .006	0.002
Copper total	0.004	14	0.002	0.007	0.002
Iron diss.	0.025	4	0.007	0.045	0.016
Iron total	0.22	5	0.14	0.27	0.06
Lead total	0.001	14	0.001	0.003	0.001
Magnesium diss.	1.9	28	1.0	2.8	0.4
Mangnese diss.	All 0.01	4			
Mangnese total	0.009	14	0.002	0.015	0.004
Potassium diss.	0.9	23	0.8	1.4	0.1
Sodium diss.	3.0	23	1.2	3.7	0.9
Zinc total	0.004	15	0.001	0.014	0.004

TABLE 104. WATER QUALITY SUMMARY FOR KAMLOOPS LAKE STATION 0920179 (station "X", off Frederick, naquadat site 01BC08LF0006), 1973-1974.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour app.	11	20	<5	20	5
pH	7.6	20	7.4	7.7	0.1
Res NF 105	4.8	5	2.0	9.0	2.8
Res NF 550	4.2	5	4.0	8.0	2.6
Spec. Cond.	94	20	67	105	14
Oxy. diss.	11.2	19	10.0	12.5	0.9
Turbidity	2.3	20	0.3	8.1	2.5
Alkalinity	35	20	27	39	4
Organic Carbon	4.9	20	2.8	7.5	1.3
Sulphate diss.	9.3	10	8.8	9.5	0.3
Surfactant	All 0.1	11			
Inorganic Carbon	7.6	20	5.0	10.1	1.7
Bicarbonate	43	20	32	48	5
Carbonate	All 0.0	20			
Chromium total	0.001	9	0.0	0.002	0.0007
Copper total	0.006	15	0. 001	0.023	0.007
Iron diss.	0.033	5	0.027	0.048	0.009
Iron total	0.23	7	0.09	0.33	0.09
Lead total	0.0013	15	0.001	0.003	0.0007
Mangnese diss.	All 0.01	3			
Mangnese total	0.010	15	0.003	0.02	0.006

Table 105. Water quality summary for Tranquille River at mouth, Station 0600071, 1972-1977.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	16.5	10	5	50	17.0
pH	8.3	25	7.5	9.0	0.35
Res 105	154	18	120	228	27
Res NF 105	3	2	2	4	1.4
Spec. Cond.	205	27	92	273	51
Turbidity	3.9	18	0.4	26	6.7
Colour TAC	17.3	8	6	64	19.3
Total Alkalinity	103	19	44	135	25
Total Organic Carbon	6.4	9	1	18	4.8
Hardness	89.4	14	40	117	21.7
Ammonia - N	0.014	2	0.013	0.015	0.001
NO_2+NO_3 - N	All <0.02	7			
Nitrate - N	0.032	13	<0.02	0.09	0.021
Nitrite - N	All 0.005	13			
Kjeldahl - N	0.213	18	0.020	0.530	0.139
Ortho P	0.042	11	0.023	0.055	0.011
Total P	0.076	19	0.036	0.269	0.051
Silica	19.2	8	16.9	21.0	1.5
Tan & Lign	0.51	9	<0.1	1.6	0.5
Inorg. Carbon	24.4	9	11	34	7.0
Chromium (diss.)	All <0.005	6			
Copper (diss.)	0.0015	7	<0.001	0.002	0.0005
Lead (total)	0.0036	7	<0.001	0.016	0.006
Zinc (total)	0.011	7	<0.005	0.03	0.019
Fecal Coliforms	152	7	L20	350	155
Total Coliforms	325	2	110	540	304

TABLE 106. WATER QUALITY SUMMARY FOR DURAND CREEK NEAR MOUTH (STATION 0600060), 1972-1975

Characteristic	Mean Value	n	minimum	maximum	deviation
Colour True	37	5	10	100	36
pH	8.4	3	8.3	8.6	0.2
Res. 105	471	6	390	568	73
Res. F 105	449	4	346	566	95
Res. NF 105	19	2	3	35	23
Spec. Cond.	557	2	508	605	69
Oxygen, Diss.	8.2	3	7.0	9.8	1.4
Turbidity	1	7	1	27	11
Colour TAC	17	1			
Alkalinity	265	6	207	325	45
Hardness	295	5	243	391	56
NO_2/NO_3 N	0.11	2	<0.002	0.2	0.13
Nitrate N	0.24	4	0.02	0.61	0.27
Nitrite N	0.012	4	<0.005	0.018	0.008
Kjeldahl N	1.40	6	0.29	6.0	2.26
Nitrogen, Total	1.60	6	0.31	6.28	2.32
Ortho P	0.066	1			
Total P	0.264	6	0.104	0.872	0.299
Silica, Diss.	20.6	1			
Sulphate, Diss.	90	3	22	139	61
Calcium, Diss.	53	5	47	65	7
Calcium, Total	49.8	1			
Copper, Diss.	0.004	3	0.001	0.008	0.004
Copper, Total	0.012	2	0.006	0.02	0.007
Iron, Diss.	0.1	3	<0.1	0.1	0
Lead, Diss.	<0.001	1			
Lead, Total	0.002	3	<0.001	<0.003	0.001
Magnesium, Diss.	41.4	3	29.5	55.5	13.1
Magnesium, Total	47.7	3	42.0	58.0	9.0
Manganese, Total	0.04	3	0.01	0.07	0.03
Molybdenum, Diss.	0.0028	1			
Zinc, Total	0.01	3	<0.005	0.02	0.009

Table 107. Flow data for lower Thompson River near Spences Bridge (08LF051)

	Mean Annual Discharge m^3/s	$dam^3 \times 10^6$	% of Mean Discharge
1970	563	17.8	72%
1971	849	26.8	109
1972	930	29.4	119
1973	663	20.9	85
1974	860	27.1	110
1975	758	23.9	97
1976	970	30.7	124
1977	605	19.1	77
1978	728	23.0	93
1979	558	17.6	71
1980	690	21.8	88
1981	833	26.3	107
1982	930	29.3	119
1983	832	26.2	107
1984	808	25.6	103
1985	704	22.2	90
1986	719	22.7	92
1987	628	19.8	85
1988	683	21.6	88
1989	708	22.3	91
1990	864	27.2	111
Mean	775	24.5	100

Table 108. Effluent quality summary for Westcoast Trans., Savona, PE 1758, 1972 - 1982.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	10.5	10	<5	15	3.7
Oil & Grease	1.4	156	0.1	27	2.2
pH	7.33	70	2.75	8	0.68
Res 105 (Total)	56.7	60	0	125	28.0
Res. NF 105	1.4	62	<1	12	1.5
Spec. Cond.	101.4	18	71	212	31.6
Temp. at Sampling.	14.2	416	5	80	6.6
Oxy. diss.	6.9	10	4.2	11.2	2.3
Turbidity	2.0	8	0.8	4.1	1.2
Flow (m^3/d)	7115.4	637	4618	11897	1904.8
Colour TAC	8.9	12	3	16	4.3
Total Alkalinity	33.4	7	27.3	39.7	4.9
Organic Carbon	4.3	10	1	12	3.9
Hardness	37.4	7	31	44	5.5
Nitrate - N	0.089	11	0.04	0.13	0.030
Nitrate - N	<0.005	11	<0.005	<0.005	0.0
N Kjel total	0.181	11	<0.01	0.92	0.281
Ortho P	0.003	2	<0.003	0.003	0.0
Total diss. P	0.006	12	0.003	0.013	0.003
Total P	0.009	12	0.005	0.018	0.003
Silica diss.	5.0	12	3.9	6.3	0.7
Sulphate diss.	8.7	1			
Carbon Inorg. total	7	7	4	10	2.4
TotalResin acids	<0.5	4	<0.5	<0.5	0.0
Calcium diss.	11.9	5	9	14	2.5
Copper diss.	0.004	3	0.002	0.008	0.003
Iron diss.	0.07	3	0.01	<0.1	0.05
Lead diss.	<0.001	3	<0.001	<0.001	0.0
Magnesium diss.	2.2	1			
Mangnese diss.	0.02	1			
Zinc diss.	0.005	1			

Table 109. Effluent quality summary for Westcoast Trans, Savona, Station 0910234, 1974 - 1982 (Monitoring site for Westcoast Trans, Savona, PE 01758).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil and Grease	1.6	67	<1.0	18.0	2.2
pH	7.2	48	2.7	8.0	0.8
Res. 105	48	30	0	100	36
Res. NF 105	2.8	48	<1.0	24.0	3.8

Table 110. Influent quality summary for Ashcroft STP influent station, 0601050, 1977 - 1984. (Monitoring site for Ashcroft STP PE 00420)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	40	1			
pH	7.6	26	7.0	8.2	0.1
Res. 105	389	14	218	466	77
Res. NF 105	189	26	60	298	54
Spec. Cond.	491	14	393	641	72
Oxy. diss.	2.8	4	0.6	5.8	2.2
Turbidity	62	12	20	88	14
Colour TAC	61	11	39	85	14
Alkalinity	185	12	140	234	29
Carbon Organic	118	2	88	147	42
Chloride diss.	21.9	13	16.8	27.8	3.6
Fluoride diss.	0.15	10	<0.10	0.34	0.07
Hardness	52.8	11	42.2	61.1	7.5
NH_3 - N	28.7	5	20.2	45.8	10.8
NO_2/NO_3 - N	0.03	13	<0.02	0.15	0.04
Nitrogen organic	9.8	3	5.0	15.2	5.1
Nitrogen Kjeldahl	38	13	27	61	10
Nitrogen total	38	13	27	61	10
B.O.D.	149	26	56	362	78
Ortho phosphorus	4.0	13	2.8	6.2	1.0
Tot diss. phosph.	4.2	13	2.9	6.5	1.1
Total phosphorus	9.3	25	3.4	19.0	4.7
Silica diss.	11.8	1			

Table 110. Continued. Water quality summary for Ashcroft STP influent Station 0601050, 1977 - 1984, (monitoring site for Ashcroft STP PE 420)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Sulphate diss.	24.7	11	15.7	46.3	8.7
Tannins & lignins	7.5	1			
Carbon inorganic	39	2	35	43	6
Calcium diss.	16.6	11	13.6	18.7	1.9
Calcium total	18.8	9	16.1	21.4	1.6
Copper total	0.38	1			
Magnesium diss.	2.8	11	1.8	3.8	0.7
Molybdenum total	0.03	1			
Potassium diss.	10.0	8	8.3	12.1	1.6
Sodium diss.	30.3	8	20.3	47.4	8.2
Zinc total	0.14	1			
Fecal Coliforms	2350000	11	> 240000	9200000	$2.6X10^6$
Total Coliforms	4047300	11	> 240000	> 24000000	$6.8X10^6$

Table 111. Effluent quality summary for Ashcroft, North area, PE 00273, 1971-1976.

Characteristic	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	41	12	20	60	11
Oil & Grease	5.6	28	0.6	37.7	7.1
pH	7.0	27	6.0	7.6	0.4
Res. 105	404	32	184	3101	513
Res. NF 105	52	23	16	220	51
Spec. Cond.	393	33	240	571	86
Oxy. diss.	1.9	13	0.6	5.2	1.2
Turbidity	19.8	14	7.2	70	4.8
Cl. resid.	0	1			
Colour TAC	55	17	23	156	34
Alkalinity	78.8	11	14.5	173	54.7
Organic Carbon	56	27	16	541	100
Chloride diss.	23.6	25	14.9	29.8	3.9
Hardness	50.1	9	41.0	59.2	6.3
NH_3 - N	11.6	10	0.8	21.8	9.2
NH_3 - N	14	10	2	28	9
NO_2/NO_3 - N	5.0	10	0.1	15.3	6.2
Nitrate - N	4.2	21	<0.02	14.3	5.1
Nitrate - N	1.6	5	0.03	6.5	2.8
Nitrite - N	1.7	20	<0.005	9.4	2.6
Nitrite - N	0.9	5	<0.005	3.1	1.4
Organic N total	6.4	20	2.5	16.6	4.0
Nit. Kjel	16.6	13	3	35	11.3
Nit. total	31.1	25	11.2	185	32.7
B.O.D.	136	33	24	1560	272
C.O.D.	64.8	1			
Phenol total	0.035	23	0.007	0.186	0.043

Table 111. (Continued) Effluent quality summary for Ashcroft, North Area, PE 273, 1971 - 1976

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Ortho P	4.5	18	2.1	9.1	2.1
Total diss. P	5.1	13	3.1	8.9	1.7
Total P	7.5	28	0.3	40.4	6.9
Silica diss.	11.0	17	6.2	17.3	2.8
Sulphate diss.	31.0	7	21.7	48.5	9.3
Surfactants total	0.5	25	<0.03	3.4	0.7
Tannins & lignins	3.2	17	2.0	5.5	1.2
Carbon inorganic	24	15	5	46	15
Sulphide total	<0.5	3	L0.5	L0.5	0.0
Res. acid total	<0.5	1			
Calcium diss.	15.5	5	13.8	17.0	1.4
Chromium diss.	<0.005	1			
Copper diss.	0.025	2	0.02	0.029	0.006
Iron diss.	0.1	2	<0.1	0.1	0.0
Lead diss.	0.0035	2	0.002	0.005	0.002
Magnesium diss.	3.7	1			
Potassium diss.	12.4	1			
Sodium diss.	49.6	1			
Zinc diss.	0.12	2	0.07	0.17	0.07
Fecal Coliforms	744290	7	230000	2200000	809870
Total Coliforms	>2185500	21	> 16090	16090000	3350700

Table 112. Effluent quality summary for Ashcroft, STP outfall, PE 00420, 1973 - 1983.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	89	6	5	300	108
Oil and Grease	59.7	2	46.0	73.3	19.3
pH	7.1	71	4.7	9.1	0.6
Res. 105	343	37	23	2412	370
Res. 550	116	1			
Res. NF 105	36.6	63	4.7	218	49.2
Specific Cond.	396	45	184	604	89
Oxygen diss.	3.1	18	0.3	6.5	1.8
Turbidity	46.4	23	2.3	440	89.9
Chlorine residual	0.45	2	0	0.9	0.64
Settleable Solids.	100	1			
Colour TAC	66	21	10	232	49
Alkalinity	100.8	21	12.4	174	52.7
Organic Carbon	89.9	18	8	380	81.3
Chloride diss.	21.1	28	11.7	35.6	5.5
Cyanide total	0.02	1			
Fluoride diss.	0.49	12	0.16	0.86	0.25
Hardness diss.	51.3	19	31.0	64.6	10.2
NH_3 - N	12.17	18	0.15	20.4	6.17
NO_2/NO_3 - N	4.19	24	<0.02	21.4	7.31
Nitrate - N	0.52	13	<0.02	5.5	1.50
Nitrite - N	0.15	21	<0.005	1.5	0.39
Organic N	5.6	15	<1.0	17.6	5.6
nitrogen Kjeldahl	19	36	2	59	10
nitrogen total	22.0	35	11.3	59.1	9.1

Table 112. (Continued) Effluent quality summary for Ashcroft, STP outfall PE 00420, 1973 - 1983.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
B.O.D.	37.0	65	4.9	281	49.2
C.O.D.	35.3	1			
Phenol	0.023	3	0.007	0.035	0.014
Ortho phosphorus	4.0	22	1.5	8.6	1.8
Total diss. P	4.2	28	0.4	8.9	1.9
Total P	5.5	63	2.0	17.5	2.9
Silica diss.	11.8	13	5.3	22.2	4.3
Sulphate diss.	34.6	18	18.3	59.3	10.2
Surfactants total	6.0	9	1.0	10.8	3.2
Carbon inorganic	25	13	10	45	9.7
Sulphide total	<0.5	3	<0.5	<0.5	0.0
Arsenic total	<0.005	1			
Boron diss.	0.24	1			
Cadium total	0.0029	1			
Calcium diss.	16.7	17	11.8	20.6	2.9
Calcium total	18.5	10	14.3	21.1	2.1
Chromium total	0.006	1			
Copper diss.	0.06	1			
Copper total	0.023	3	0.008	0.04	0.016
Iron diss.	0.3	1			
Iron total	0.06	1			
Lead diss.	0.01	1			
Lead total	0.002	2	<0.001	0.003	0.001
Magnesium diss.	2.7	14	1.7	3.7	0.6
Magnesium total	2.6	2	1.7	3.5	1.3

Table 112. (Continued)Effluent quality summary for Ashcroft, STP outfall PE 420, 1973 - 1983.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Manganese total	<0.01	1			
Mercury total	<0.00005	1			
Molybdenum total	0.0011	2	0.0009	0.0013	0.0003
Nickel total	<0.01	1			
Potassium diss.	8.9	11	4.4	11.9	2.1
Sodium diss.	36.0	14	19.2	52.0	10.8
Zinc diss.	0.12	1			
Zinc total	0.03	2	0.02	0.04	0.01
Aluminum total	<0.02	1			
Cobalt total	<0.001	1			
Barium total	<0.5	1			
Vanadium total	<0.001	1			
Fecal Coliforms	2738000	8	700	9200000	3187300
Total Coliforms	1301700	22	7900	9200000	2049100
$Cl_2C_2Cl_2$	5	1			
$Cl\ CH\ CCl_2$	<1	1			
CCl_4	<1	1			
$CH\ Br_3$	<1	1			
$ClBr_2\ CH$	<1	1			
$Br\ Cl_2\ CH$	<1	1			
$CHCl_3$	5	1			

Table 113. Water quality summary for Pimainus Creek near mouth, Station 0600053, 1972 - 1977 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	23	3	<5	60	32
pH	8.1	6	7.3	8.4	0.4
Res. 105	331	5	118	422	123
Res. NF 105	3.0	2	2.0	3.9	1.3
Spec. Cond.	405	7	85	592	220
Oxy. diss.	9.5	3	7.8	10.8	1.6
Turbidity	2.3	5	0.1	8.9	3.7
Colour TAC	Both 3.0	2			
Alkalinity	136	5	33	173	59
Organic Carbon	1.0	2	<1.0	1.0	0.0
Cyanide total	all <0.01	4			
Hardness	208	4	39	282	113
NO_2/NO_3 - N	0.095	2	0.09	0.10	0.007
Nitrate - N	0.07	3	<0.02	0.11	0.05
Nitrate - N	all <0.005	3			
Nit. Kjel -N	0.10	5	<0.01	0.39	0.16
Nitrogen total	0.17	5	0.10	0.39	0.12
Ortho phosphorus	0.004	1			
Total diss. P	0.007	1			
Total P	0.016	5	0.005	0.052	0.020
Silica diss.	14.2	2	13.8	14.5	0.5
Sulphate diss.	81.0	5	7.2	135.0	58.1
Carbon Inorg.	41.5	2	41	42	0.7
Arsenic diss.	all <0.005	3			
Arsenic total	all <0.005	3			

Total 113. (Continued) Water quality summary for Pimainus Creek near mouth Station 0600053, 1972 - 1977 (monitoring site for Lornex Mine PE 00376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Cadmium diss.	0.0013	1			
Calcium diss.	55.7	4	11.9	75.0	29.5
Copper diss.	0.005	3	0.001	0.008	0.004
Copper total	0.008	3	<0.001	0.02	0.010
Iron diss.	0.2	3	L0.1	0.3	0.1
Iron total	0.09	3	0.04	0.14	0.05
Lead diss.	<0.001	1			
Lead total	0.002	3	<0.001	0.003	0.001
Magnesium diss.	23.0	1			
Magnesium total	22.5	2	22.0	23.0	0.7
Mangnese diss.	Both <0.02	2			
Mangnese total	0.01	3	<0.01	L0.02	0.006
Mercury diss.	<0.00005	1			
Molybdenum diss.	0.0028	3	0.0007	0.0063	
Molybdenum total	0.0059	1			
Potassium diss.	1.6	1			
Sodium diss.	13.1	1			
Zinc diss.	0.0055	2	<0.005	0.006	0.001
Zinc total	0.018	3	0.009	0.03	0.011
Fecal Coliforms	33	1			
Total Coliforms	33	1			

Table 114. Water quality summary for Pukaist Creek near mouth, Station 0600038, 1972 - 1977 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	52.5	4	<5.0	150	65.9
pH	8.4	5	8.2	8.6	0.1
Res. 105	292	6	220	426	86
Res. NF 105	12.8	2	1.5	24.0	15.9
Spec. Cond.	384	6	312	506	67
Oxy. diss.	10.7	3	8.9	12.6	1.9
Turbidity	10.1	6	0.8	18.0	7.1
Colour TAC	10	2	7	13	4
Alkalinity	187	6	135	272	48
Organic carbon	4.5	2	4	5	0.7
Chloride diss.	1.6	1			
Cyanide total	All <0.01	5			
Hardness	189	4	144	246	43
NO_2+NO_3-N	0.13	3	<0.02	0.35	0.19
Nitrate -N	All <0.02	3			
Nitrite -N	All <0.005	3			
Nit. Kjel -N	0.35	6	0.10	0.85	0.27
Nitrogen total	0.40	6	0.10	0.85	0.32
Ortho P	0.076	1			
Total diss. P	0.081	1			
Total P	0.094	6	0.007	0.175	0.056
Silica diss.	27.8	1			
Sulphate diss.	30	6	<5.	140	54
Carbon Inorg.	48	2	46	49	2
Sulphide total	<0.5	1			

Table 114. Continued Water quality summary for Pukaist Creek near mouth, Station 0600038, 1972 - 1977, (monitoring site for Lornex Mine PE 376)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Arsenic diss.	Both <0.005	2			
Arsenic total	All <0.005	5			
Cadium diss.	0.0022	1			
Calcium diss.	46	4	35	60	11
Copper diss.	0.0025	2	0.002	0.003	0.0007
Copper total	0.009	5	<0.001	0.02	0.007
Iron diss.	Both <0.1	2			
Iron total	1.71	4	0.22	4.8	2.12
Lead diss.	<0.001	1			
Lead total	0.002	5	<0.001	0.004	0.001
Magnesium diss.	18.6	2	13.7	23.4	6.9
Magnesium total	17.3	4	13.0	23.4	4.9
Mangnese diss.	Both <0.02	2			
Mangnese total	0.27	5	0.01	1.2	0.52
Mercury diss.	<0.00005	1			
Molybdenum diss.	0.0086	2	0.0074	0.0098	0.0017
Molybdenum total	0.0081	1			
Zinc diss.	0.0055	2	<0.005	0.006	0.0007
Zinc total	0.015	4	<0.005	0.03	0.012
Fecal Coliforms	170	1			
Total Coliforms	350	1			

Sediment data collected but not compiled here.

Table 115. Water quality summary for Pukaist Ck. above Woods Ck. Station 0600108, 1973 - 1977 (monitoring site for Lornex Mines PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil and Grease	4	25	<1	55	11
pH	7.7	21	6.6	8.1	0.3
Res. 105	276	21	99	360	75
Res. NF 105	5	18	2	12	2
Spec. Cond.	287	1			
Oxy. diss.	9.8	25	7.5	11.7	1.2
Colour TAC	57	1			
Alkalinity	125	1			
Cyanide diss.	0.005	24	<0.005	0.006	0.0002
Hardness	129	1			
$N0_2/N0_3$-N	<0.02	1			
Nit. Kjel	0.42	1			
Nit. total	0.42	1			
C.O.D.	24	12	<10	40	9
Total diss. P	0.068	1			
Total P	0.093	1			
Sulphate diss.	11	18	<1	30	8
Sulphide total	0.05	15	<0.05	0.05	0.0
Arsenic diss.	0.009	1			
Arsenic total	0.011	25	<0.005	0.053	0.011
Calcium diss.	31	1			
Copper diss.	0.007	23	0.002	0.025	0.005
Copper total	0.004	3	0.003	L0.005	0.001
Iron diss.	0.887	25	<0.025	2.6	0.738
Iron total	0.8	1			

Table 115. Continued. Water quality summary for Pukaist Ck. above Woods Ck., Station 0600108, 1973 - 1977 (monitoring site for Lornex Mines PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Lead diss.	<0.137	15	<0.025	<1.7	0.424
Magnesium diss.	12.5	1			
Molybdenum diss.	0.08	25	<0.02	0.29	0.07
Molybdenum total	0.1	1			
Zinc diss.	0.016	24	<0.005	0.093	0.020
Zinc total	<0.005	1			

sediment data available but results not tabulated

Table 116. Water quality summary for Woods Ck. above tailings pond, Station 0600109, 1973 - 1981 (monitoring site for Lornex Mines PE 376)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil & Grease	2.1	27	<0.1	18	3.5
pH	7.6	46	6.7	8.3	0.3
Res. 105	131	32	<1	324	68
Res. NF 105	2	39	<1	11	2
Spec. Cond.	4.3	43	3.5	16	4.4
Oxy. diss.	10.7	27	8.1	12.4	1.2
Colour TAC	52	1			
Alkalinity	34.6	1			
Cyanide diss.	0.005	39	<0.005	<0.01	0.001
Cyanide total	Both <0.01	2			
Hardness	15.9	2	<0.005	31.7	22.4
NO_2/NO_3-N	<0.02	1			
Nit. Kjel	0.31	1			
Nit. total	0.31	1			
C.O.D.	19	19	<10	40	11
Diss. total P	0.045	1			
Total P	0.048	1			
Sulphate diss.	4	27	<1	15	3
Sulphide total	0.05	14	<0.005	<0.05	0.01
Arsenic diss.	0.009	2	<0.005	0.013	0.006
Arsenic total	0.009	41	<0.005	0.033	0.006
Calcium diss.	7.1	1			
Copper diss.	0.008	41	0.003	0.032	0.006
Copper total	0.0045	2	0.004	<0.005	0.0007
Iron diss.	0.10	41	<0.01	0.3	0.08

Table 116. (Continued) Water quality summary for Woods Ck. above tailings pond, Station 0600109, 1973 - 1981 (monitoring site for Lornex Mines PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Iron total	0.3	1			
Lead diss.	All <0.025	14			
Magnesium diss.	3.4	1			
Mangnese diss.	0.010	7	<0.01	0.013	0.001
Molybdenum diss.	0.0248	42	0.0005	0.0620	0.0132
Molybdenum total	0.0007	1			
Zinc diss.	0.028	42	<0.005	0.23	0.053
Zinc total	<0.005	1			

sediment data available but results not tabulated

Table 117. Water quality summary for Lornex - H-H Dam Monitoring Well, Station 0600358, 1974 - 1981 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil and Grease	1.7	40	0.068	10.0	1.9
pH	8.0	60	7.6	10.1	0.3
Res. 105	240	44	208	470	40
Res F 105	234	44	204	358	23
Res. NF 105	9	27	0	112	25
Spec. Cond.	364	35	230	452	35
Oxy. diss.	1.4	41	0.7	2.3	0.3
Colour TAC	4	1			
Alkalinity	196	2	186	205	13
Cyanide diss.	0.0051	52	<0.005	<0.01	0.0006
Cyanide total	All <0.01	4			
Hardness	161	2	158	163	4
NO_2/NO_3 -N	<0.02	1			
Nit. Kjel	0.04	1			
Nit. total	0.04	1			
C.O.D.	17	41	<10	110	20
Total diss. P	0.053	1			
Total P	0.065	1			
Sulphate diss.	18	56	11	29	4
Sulphide total	All <0.05	4			
Arsenic diss.	All <0.005	5			
Arsenic total	0.0055	57	<0.005	<0.02	0.002
Cadmium diss.	<0.0005	1			
Cadmium total	<0.0005	1			

Table 117(Continued). Water quality summary for Lornex - H-H Dam Monitoring Well, Station 0600358, 1974 - 1981 (monitoring site for Lornex Mine PE 376)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Calcium diss.	47.0	4	43.1	51.6	4.0
Calcium total	48.8	1			
Copper diss.	0.007	57	<0.001	0.043	0.007
Copper total	0.0013	3	<0.001	0.002	0.001
Iron diss.	0.09	59	<0.01	1.1	0.16
Iron total	0.13	3	0.1	0.2	0.06
Lead diss.	0.021	6	0.002	<0.025	0.009
Lead total	0.002	1			
Magnesium diss.	12.6	2	12.3	12.8	0.4
Mangnese diss.	0.36	7	0.20	0.41	0.07
Mangnese total	0.20	1			
Molybdenum diss.	0.06	59	<0.02	0.16	0.02
Molybdenum total	0.06	3	0.04	0.10	0.03
Potassium diss.	3.6	1			
Sodium diss.	17.9	2	17.4	18.4	0.7
Zinc diss.	0.02	59	<0.005	0.13	0.02
Zinc total	All <0.005	3			

Table 118. Water quality summary for Lornex — J-J Dam Monitoring Well, Station 0600359, 19
- 1977 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil & Grease	1.4	35	<1.0	8.0	1.3
pH	7.8	37	7.3	9.0	0.3
Res. 105	378	37	246	695	74
Res. F 105	373	37	246	681	73
Res. NF 105	6	22	0	80	17
Spec. Cond.	524	30	340	652	71
Oxy. diss.	5.0	36	0.6	12.3	4.6
Turbidity	480	1			
Colour TAC	9	1			
Alkalinity	177	2	170	184	10
Cyanide diss.	0.008	32	<0.005	0.09	0.015
Cyanide total	All <0.01	3			
Hardness	255	2	244	266	16
$N0_2/N0_3$-N	0.12	1			
Nit. Kjel	0.14	1			
Nit. total	0.26	1			
C.O.D.	24	33	<10	110	20
Total diss. P	0.131	1			
Total P	0.161	1			
Sulphate diss.	89	36	13	170	40
Sulphide total	All <0.05	3			
Arsenic diss.	0.009	3	0.007	0.01	0.002
Arsenic total	0.009	36	<0.005	0.03	0.005
Cadmium diss.	<0.0005	1			
Cadmium total	<0.0005	1			
Calcium diss.	67.6	3	62.5	71.4	4.6
Calcium total	72	1			

Table 118. (Continued) Water quality summary for Lornex - J.-J. Dam Monitoring Well, Station 0600359, 1974 - 1977(monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Copper diss.	0.008	35	0.001	0.028	0.006
Copper total	0.004	3	0.002	0.005	0.002
Iron diss.	0.41	36	<0.01	7.7	1.5
Iron total	0.13	3	<0.1	0.2	0.06
Lead diss.	0.145	4	0.001	0.530	0.257
Lead total	0.001	1			
Magnesium diss.	22.0	2	21.3	22.7	1.0
Mangnese diss.	0.17	1			
Mangnese total	0.17	1			
Molybdenum diss.	0.41	36	<0.02	1.2	0.23
Molybdenum total	0.8	3	0.7	0.9	0.1
Sodium diss.	30	1			
Zinc diss.	0.023	35	<0.005	0.15	0.030
Zinc total	Both. <0.005	2			
Fecal Coliforms	<2	1			

Table 119. Water quality summary for Lornex L-L dam monitoring well, Station 0600324, 1977 - 1981 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil and Grease	1.0	6	<1.0	1.0	0.0
pH	8.0	25	7.8	8.8	0.2
res. 105	330	6	306	354	21
res. NF 105	1	1			
Spec. Cond.	518	6	500	530	11
Oxygen diss.	3.4	6	1.1	8.9	3.1
Cyanide diss.	0.007	23	<0.005	0.042	0.008
Cyanide total	Both. <0.01	2			
C. O. D.	10.5	4	<10	12	1.0
Sulphate diss.	19	23	7	190	38
Arsenic diss.	Both <0.005	2			
Arsenic total	All <0.005	22			
Calcium diss.	45	1			
Copper diss.	0.012	25	0.001	0.038	0.008
Iron diss.	0.124	25	0.009	1.9	0.374
Mangnese diss.	0.014	7	<0.010	0.033	0.009
Molybdenum diss.	0.056	25	0.015	0.370	0.078
Potassium diss.	4.2	1			
Sodium diss.	22	1			
Zinc diss.	0.024	25	<0.005	0.11	0.025
Fecal coliforms	<2.0	1			

Table 120. Water quality summary for Pukaist Ck. below L-L Dam, Station 0600187, 1976 - 1981 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil and Grease	3	4	<1.0	9	4
pH	8.1	14	7.6	8.5	0.3
Res. 105	281	5	205	342	57
Res. NF 105	23	11	2	65	23
Spec. Cond.	459	1			
Oxy. diss.	8.8	6	<1.0	11.8	4.0
Colour TAC	10	1			
Alkalinity	226	1			
Cyanide diss.	All <0.005	13			
Cyanide total	<0.01	1			
Hardness	226	1			
NO_2/NO_3-N	<0.02	1			
Nit. Kjel	0.25	1			
Nit. total	0.25	1			
C.O.D.	19.4	1			
Diss. total P	0.1	1			
Total P.	0.119	1			
Sulphate diss.	11.4	9	<1.0	26.6	7.1
Arsenic diss.	0.005	1			
Arsenic total	0.010	14	<0.005	0.024	0.006
Calcium diss.	56.5	1			
Copper diss.	0.014	14	0.002	0.035	
Copper total	0.003	1			
Iron diss.	0.16	14	0.04	0.47	0.11
Iron total	0.3	1			

Table 120 (Continued). Water quality summary for Pukaist Ck. below L-L Dam, Station 0600187, 1976 - 1981 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Magnesium diss.	20.7	1			
Mangnese diss.	0.16	5	0.02	0.45	0.18
Molybdenum diss.	0.06	14	<0.02	0.21	0.05
Molybdenum total	0.1	1			
Zinc diss.	0.068	14	0.008	0.34	0.116
Zinc total	0.018	1			

Sediment data not compiled.

Table 121. Water quality summary for Lornex tailpond supernatant. Station 0601035, 1973 - 1981 (monitoring site for Lornex Mine PE 00376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Oil and Grease	4	20	<1	44	10
pH	8.7	35	7.6	11.5	1.1
Res. 105	503	19	378	722	102
Res. NF 105	47	15	<1	126	44
Spec. Cond.	897	3	840	940	51
Oxygen diss.	5.1	18	0.5	9.7	2.5
Colour TAC	7	1			
Alkalinity	34	1			
Cyanide diss.	0.792	32	0.006	4.7	1.4
Cyanide total	0.24	3	<0.01	0.68	0.38
Hardness	134	1			
Nit. Kjel.	5	1			
NO_2/NO_3-N	4.55	1			
Nit. total	9	1			
C.O.D.	74	8	31	105	29
Total diss. P	0.004	1			
Total P	0.028	1			
Sulphate diss.	232	23	36	510	128
Sulphide total	All <0.05	7			
Arsenic diss.	0.006	3	<0.005	0.008	0.002
Arsenic total	0.223	32	<0.005	1.44	0.399
Calcium diss.	49.5	2	46.1	52.8	4.7
Copper diss.	0.24	14	0.02	0.92	0.30
Copper total	2.0	22	0.007	12.0	3.3

Table 121 (Continued). Water quality summary for Lornex tailpond supernat. , Station 0601035, 1973 - 1981 (monitoring site for Lornex Mine PE 376).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Iron diss.	0.09	14	<0.01	0.60	0.15
Iron total	0.16	22	<0.01	1.10	0.28
Lead total	All <0.025	7			
Magnesium dis.	4.5	1			
Mangnese diss.	0.08	7	0.05	0.09	0.02
Molybdenum diss.	0.42	14	<0.03	1.70	0.45
Molybdenum total	0.48	22	<0.02	1.80	0.52
Potassium diss.	17.9	1			
Sodium diss.	112	1			
Zinc diss.	0.025	14	<0.005	0.13	0.031
Zinc total	0.021	22	<0.005	0.13	0.029
Fecal coliforms	1.4	7	<1.0	2.0	0.5
Total coliforms	Both <1.0	2			

Table 122. Water quality summary for Thompson River at Savona, Station 0600004, 1971 - 1982 (monitoring site for Kamloops STP PE 399 and Weyerhauser PE 1199).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	7.5	34	<5	15	3.3
pH	7.6	168	6.9	8.0	0.2
Oil and Grease	1.0	28	0.1	2.0	0.3
Res. 105	62	107	42	84	9
Res. 550	55	15	48	64	4
Res. NF 105	2.5	15	<0.5	8.9	2.2
Spec. Cond.	96	173	64	121	15
Oxy. diss.	10.2	59	4.8	13.4	1.8
Turbidity	1.5	82	0.2	8. 8.5	1.3
Colour TAC	8	98	<1.	16	3
Alkalinity	35	79	27	45	4
Organic Carbon	2.4	82	<1.0	10.0	1.8
Chloride diss.	1.9	81	<0.3	3.3	1.0
Cyanide total	<0.01	1			
Fluoride diss.	0.11	18	<0.10	0.18	0.02
Hardness	38.1	76	30.0	47.6	4.7
NH_3-N	1.2	43	<0.005	49.4	7.5
NO_2/NO_3-N	0.10	59	0.01	0.30	0.04
Nitrate -N	0.08	59	<0.02	0.22	0.04
Nitrite -N	<0.005	74	<0.005	<0.005	0.0
Nit. organic	0.10	44	<0.01	0.21	0.05
Nit. Kjeldahl	0.11	112	<0.01	0.30	0.06
Nit. total	0.20	113	0.03	0.41	0.08
C.O.D.	both <10	2			
Phenol total	0.002	17	<0.002	0.003	0.0002

Table 122 (Continued). Water quality summary for Thompson River at Savona, Station 0600004, 1971 - 1982 (monitoring site for Kamloops PE 399 & Weyerhauser PE 1199).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Ortho P	0.003	60	<0.003	0.009	0.0008
Total diss. P	0.005	101	<0.003	0.01	0.0016
Total P	0.008	124	0.004	0.021	0.0027
Silica diss.	4.6	53	3.2	6.5	0.8
Sulphate diss.	7.5	92	<5.0	10.0	1.3
Surfactants total	All <0.03	13			
Tan. & lign. total	0.3	38	0.2	0.6	0.1
Carbon Inorg.	8	65	4	11	2
Res. acid total	0.5	27	<0.5	1.0	0.1
Chl a (periphyton)	0.05	40	0.0004	0.28	0.07
Arsenic diss.	All <0.005	4			
Arsenic total	All <0.005	8			
Cadmium diss.	<0.0005	1			
Cadmium total	All <0.0005	5			
Calcium diss.	12.4	85	9.3	14.9	1.6
Calcium total	12.5	1			
Chromium diss.	All <0.005	5			
Chromium total	All <0.005	13			
Copper diss.	0.006	31	<0.001	0.06	0.014
Copper total	0.003	21	<0.001	0.02	0.006
Iron diss.	0.09	29	0.02	0.10	0.02
Iron total	0.2	6	0.1	0.3	0.1
Lead diss.	<0.001	13	<0.001	<0.003	0.001
Lead total	0.002	21	<0.001	0.006	0.001

Table 122. (Continued) Water quality summary for Thompson River at Savona, Station 0600004, 1971 - 1982, (monitoring site for Kamloops STP PE 00399 & Weyerhauser PE 01199).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Magnesium diss.	2.0	34	1.3	2.6	0.3
Magnesium total	1.9	13	1.1	2.5	0.3
Mangnese diss.	<0.012	5	<0.01	<0.02	0.004
Mangnese total	<0.011	16	<0.01	<0.02	0.003
Mercury diss.	<0.00005	1			
Mercury total	<0.00005	25	<0.00002	<0.00025	0.00004
Molybdenum diss.	0.0005	10	<0.0005	0.0007	0.00007
Molybdenum total	Both<0.0005	2			
Nickel total	<0.01	1			
Potassium diss.	0.9	11	0.8	1.0	0.1
Sodium diss.	3.1	36	1.4	3.7	0.7
Zinc diss.	<0.02	12	<0.005	0.12	0.03
Zinc total	<0.006	22	<0.005	0.016	0.003
Fecal Coliforms	5	36	<2	22	5
Total Coliforms	12	30	<2	110	21

Table 123. Comparison of mean data for sites on the Thompson system.

	South Thompson Pioneer Park 0600135 (1973-84)	North Thompson North Kamloops 0600164(1965-82)	Lower Thompson Savona 0600004(1971-82)
Colour	3.4 (TAC)	6.8(TAC) 6.3(App)	7.5 (True) 8 (TAC)
pH	7.7	7.6	7.6
Res. 105	63	77	62
Spec. Cond.	88	96	96
Turbidity	2.2	2.6	1.5
Tot. Org. Carbon	2.2	2.1	2.4
Chloride	0.4	0.5	1.9
Nitrate (ug/L)	40	78	90
Kjeldahl (ug/L)	120	136	110
Total diss. P(ug/L)	4	5.6	5
Total P(ug/L)	13	14	8
Sulphate	6.7	7.5	7.5
Calcium	12 (total)	12.6 (total)	12.4 (diss)
Sodium	1.9	1.8	3.1
Fecal Coliforms	24.5	14.2	5

There is indication of influence by the pulp mill on chloride and sodium concentrations.

A comparison of additional sites is given below:

	S. Thompson	N.Thompson	Savona	Walhachin	Bonaparte	Ashcroft
nitrate	40	78	90	70	108	80
chloride	0.4	0.5	1.9	1.9	3.0	2.6
pH	7.7	7.6	7.6	7.7	8.5	7.7

Table 124. Water quality summary for Deadman River near mouth, Station 0600117, 1974 - 1982.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	23	3	5	60	32
pH	8.2	25	7.6	8.5	0.3
Res. 105	202	17	144	246	35
Res. NF 105	29	6	<1.0	154	61
Spec. Cond.	281	26	89	395	112
Oxy. diss.	11.2	13	8.9	14.4	1.8
Turbidity	6.1	10	0.5	29.0	10.2
Colour TAC	15	9	3	45	17
Alkalinity	139	17	43	195	55
Organic Carbon	6	15	<1.0	14	6
Chloride diss.	1.0	3	0.5	1.5	0.5
Cyanide diss.	Both <0.01	2			
Fluoride diss.	All <0.1	3			
Hardness	124	13	40	180	56
NH_3 -N	0.007	1			
NO_2/NO_3-N	0.05	8	<0.02	0.11	0.04
Nitrate -N	0.06	7	<0.02	0.16	0.06
Nitrite -N	All <0.005	8			
Nit. Kjel	0.18	13	<0.01	0.44	0.12
Nit. total	0.23	13	0.06	0.44	0.11
Ortho P	0.005	3	<0.003	0.007	0.002
Total diss. P	0.009	8	0.004	0.018	0.005
Total P	0.033	15	0.005	0.181	0.051
Silica diss.	16.7	8	12.6	18.0	1.8
Sulphate diss.	17.3	5	14.6	22.2	3.0
Tan. & lign. total	0.8	8	0.1	1.9	0.7
Carbon inorganic	28	4	9	46	21
Arsenic diss.	<0.005	1			
Arsenic total	<0.049	6	<0.005	<0.250	0.100

Table 124. (Continued) Water quality summary for Deadman River near mouth, Station 0600117, 1974 - 1982.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Boron diss.	<0.1	1			
Cadmium diss.	<0.0005	1			
Cadmium total	<0.002	6	<0.0005	<0.01	
Calcium diss.	27.7	8	9.3	39.5	13.2
Calcium total	34.1	3	26.6	41.5	7.5
Chromium total	0.007	3	<0.005	<0.01	0.003
Copper diss.	0.0015	2	<0.001	0.002	0.001
Copper total	0.006	7	<0.001	0.019	0.006
Iron diss.	<0.1	1			
Iron total	1.5	8	<0.1	8.4	2.9
Lead diss.	Both <0.001	2			
Lead total	0.014	8	<0.001	<0.1	0.035
Magnesium diss.	14.9	3	6.6	19.3	7.2
Magnesium total	12.9	2	9.8	16.0	4.4
Mangnese total	0.03	4	<0.02	0.05	0.02
Mercury total	All <0.00005	7			
Molybdenum total	<0.0021	7	<0.0005	<0.01	0.0035
Nickel total	<0.02	4	<0.01	<0.05	0.02
Potassium diss.	1.4	1			
Sodium diss.	10.0	2	7.4	12.6	3.7
Zinc diss.	<0.005	1			
Zinc total	<0.006	8	<0.005	<0.01	0.002
Aluminum total	0.22	1			
Cobalt total	<0.1	1			
Vanadium total	<0.01	1			
Fecal Coliforms	78.6	5	2.0	350	152.2
Total coliforms	13.5	2	5.0	22	12.0

sediment data not compiled

Table 125. Water quality summary for Thompson River at Walachin, Station 0600163 1975 - 1980 (monitoring site for Weyerhauser PE 1199)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
pH	7.6	82	7.3	8.0	0.1
Res. 105	63	51	48	78	9
Res. F 105	60	51	40	74	9
Res. NF 105	2.5	8	2.0	6.0	1.4
Spec. Cond.	96	82	68	117	14
Oxy. diss.	10.7	44	8.1	13.4	1.5
Turbidity	1.4	42	0.5	4.4	0.8
Colour TAC	7	58	2	13	3
Alkalinity	34.8	42	28.3	42.9	4.0
Carbon Organic	1.9	41	<1.0	5.0	1.1
Chloride diss.	1.9	45	<0.3	3.8	1.1
Cyanide total	<0.01	1			
Fluoride diss.	<0.1	1			
Hardness	38.1	41	30.0	47.4	4.5
NH_3-N	0.006	20	<0.005	0.011	0.002
NO_2/NO_3-N	0.09	37	<0.02	0.14	0.03
Nitrate -N	0.07	28	<0.02	0.13	0.04
Nitrite -N	All <0.005	26			
Nit. Organic	0.11	20	0.01	0.24	0.07
Nit. Kjel	0.11	62	0.01	0.33	0.07
Nit. total	0.19	61	0.05	0.45	0.08
C.O.D.	Both <10	2			
Ortho P	0.003	37	<0.003	0.003	0.0
Total diss. P	0.006	59	<0.003	0.064	0.008
Total P	0.009	62	0.004	0.068	0.008

Table 125. (Continued). Water quality summary for Thompson River at Walachin, Station 0600163, 1975 - 1980,(monitoring site for Weyerhauser PE 1199).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Sulphate diss.	7.4	44	<5.0	9.5	1.5
Tan. & lign.	0.31	11	0.02	0.50	0.14
Carbon Inorg.	8	39	4	11	2
Res. acid	All <0.5	7			
Chl a (periphyton)	0.0324	41	0.0005	0.14	0.0373
Arsenic diss.	All <0.005	3			
Arsenic total	All <0. 005	8			
Cadium total	All <0.0005	5			
Calcium diss.	12.0	36	9.6	14.7	1.3
Copper diss.	0.002	10	<0.001	0.004	0.001
Copper total	0.003	7	<0.001	0.009	0.003
Iron diss.	All <0.1	10			
Iron total	0.13	6	<0.1	0.3	0.08
Lead diss.	Both <0.001	2			
Lead total	All <0.001	9			
Magnesium diss.	2.2	8	1.9	2.6	0.24
Magnesium total	<0.02	1			
Mercury total	All <0.00005	7			
Molybdenum diss.	0.00057	3	<0.0005	0.0006	0.00006
Molybdenum total	0.00073	4	<0.0005	0.0009	0.00017
Nickel Total	<0.01	1			
Potassium diss.	0.92	10	0.9	1.0	0.04
Sodium diss.	3.2	12	2.2	4.1	0.6
Zinc diss.	Both <0.005	2			
Zinc total	All <0.005	10			
Fecal Coliforms	2.5	11	<2.0	8.0	1.8
Total Coliforms	3.2	5	<2.0	8.0	2.7

Table 126. Water quality summary for Thompson River above Ashcroft, Station 0600325, 1973 - 1978.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	7.5	10	<5	15	3.5
pH	7.7	21	7.5	7.9	0.1
Res. 105	71	14	58	90	7
Res. F 105	69	14	56	86	6
Spec Cond.	109	20	80	123	10
Oxy. diss.	11.3	9	5.6	16.3	2.9
Turbidity	1.3	11	0.5	3.2	0.9
Colour TAC	7.8	29	<1.0	15.0	3.2
Alkalinity.	38.7	6	33.0	41.2	3.0
Carbon organic	2.3	28	<1.0	10	1.9
Chloride diss.	2.6	14	1.7	3.1	0.4
Fluoride diss.	<0.1	1			
Hardness	42.3	5	39.9	44.3	1.7
NH_3-N	0.006	14	<0.005	0.01	0.001
NO_2/NO_3-N	0.10	14	0.07	0.12	0.01
Nitrate -N	0.08	15	0.03	0.13	0.03
Nitrite -N	All <0.005	15			
Nit. organic	0.12	14	0.01	0.41	0.10
Nit. Kjel	0.12	29	<0.01	0.41	0.08
Nit total	0.22	29	0.09	0.49	0.08
Ortho P	All <0.003	14			
Total diss. P	0.005	29	0.001	0.007	0.001
Total P	0.011	30	0.006	0.043	0.008
Silica diss.	5.3	20	4.1	7.1	0.8

Table 126.(Continued) Water quality summary for Thompson River above Ashcroft, Station 0600325,1973 - 1978 .

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Sulphate diss.	8.8	14	7.2	10.1	0.7
Carbon Inorg.	9	27	5	12	2
Res. acid	All <0.5	4			
Chlorophyll a	0.014	18	0.0008	0.075	0.021
Calcium diss.	13.3	6	12.6	14.8	0.8
Magnesium diss.	2.4	5	2.0	2.7	0.3
Potassium diss.	All 0.9	5			
Sodium diss.	3.3	5	2.5	3.6	0.5
Total Coliforms	3.5	2	<2	5	2.1
$Cl_2 C_2 Cl_2$	<1.0	1			
$Cl CH C Cl_2$	<1.0	1			
$C Cl_4$	<1.0	1			
$CH BR_3$	<1.0	1			
$Cl Br_2 CH$	<1.0	1			
$Br Cl_2 CH$	<1.0	1			
$CH Cl_3$	1.0	1			

Table 127 Water quality summary for Bonaparte River at mouth, Station 0600329 1978 - 1979.

Characteristics	Mean		n	Minimum	Maximum	Std. Deviation
pH	8.5		18	8.2	8.8	0.2
Res. 105	304		18	242	514	68
Res. F 105	263		18	180	338	47
Spec. Cond.	412		18	247	530	83
Oxy diss.	10.6		15	4.7	14.8	2.8
Turbidity	42		1			
Alkalinity	211		3	189	222	19
Organic Carbon	4.8		12	<1.0	15	3.8
Chloride diss.	2.4		8	1.7	3.4	0.5
Hardness	210		4	195	221	11
NH_3 -N	0.018		17	<0.005	0.061	0.017
NO_2/NO_3 -N	0.07		18	<0.02	0.23	0.07
Nitrate -N	0.06		17	<0.02	0.23	0.08
Nitrite -N	0.005		17	<0.005	0.005	0.0
Nit. organic	0.31		17	0.14	1.07	0.21
Nit. Kjel	0.35		18	0.15	1.08	0.23
Nit. total	0.41		18	0.15	1.11	0.25
Ortho phosphorus	0.04		1			
Total diss. P	0.033		15	0.016	0.061	0.014
Total P	0.082	18	18	0.028	0.437	0.102
Sulphate diss.	34.2		1			
Carbon Inorg.	44		11	32	52	7
Chl a (periphyton)	0.0253		15	<0.0003	0.087	0.0275
Calcium diss.	42.9		4	40.2	46.2	2.5
Magnesium diss.	25.0		4	22.9	25.8	1.4
Fecal coliforms	95		17	8	920	215
Total Coliforms	367		16	33	1600	423

Table 128. Water quality summary for station 0600329, Bonaparte River at mouth for period 1985 - 1988.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
pH	8.5	40	8.3	8.9	0.15
Total res.	305.9	25	218	434	68.3
Res. NF	14.9	35	1	35	15.7
Spec. Cond.	496.5	40	265	770	139.8
Turbidity	2.8	37	0.6	8.1	2.1
Colour TAC	6.0	27	2	27	3.4
Kjeldahl N.	252	17	160	360	66
Fecal Coliforms A*	82.6	16	18	310	81.6
Fecal Coliforms B*	163.3	21	<2	920	228
Total Coliforms B*	949	16	<2	>2400	811
Chloride	3.0	8	1.5	4.5	0.9
Ammonia	13	40	<5	69	16
Nitrate	108	35	<20	390	121
Nitrite	<6	34 (24<MDL)	<5	18	3
Ortho P	22	40	3	64	15
Sulphate	55.7	7	31.7	99	24.5
Aluminum	0.394	17	0.04	1.95	0.5
Arsenic	All < mdl	13			
Cadmium	All but one<mdl	27			
Cobalt	All < mdl (0.1)	27			
Chromium	22/27<mdl (0.01)	5 at 0.01			
Copper	24/27<mdl(0.01)		0.02	0.03	
Calcium (total)	47.0	27	27.7	65.0	11.6

* - Total Coliforms, A - MPN method B - MF method.
mdl is the abbreviation for minimum detection limit

Table 128.(continued) Bonaparte River .

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Iron	0.428	28	0.05	2.68	0.54
Magnesium (t)	26.9	27	12.9	36.9	7.4
Manganese (t)	0.027	27	<0.01	0.08	0.021
Molybdenum	0.012	27	<0.01	0.05	0.007
Sodium	20.3	2	18.8	21.8	
Nickel (t)	<0.05	27 all<mdc			
Diss. P (ug/L)	34	21	13	71	16
Total P (ug/L)	46	40	16	81	16
Lead (total)	<0.1	27, 26<0.1	1 at 0.1		
Vanadium(total)	<0.01	27, 21/27<0.01			
Zinc (total)	<0.01	27, 22/27<0.01			
Periphyton Standing Crop mg/m^2	135.6	85	13.4	309	81.6

Table 129. Comparative mean water quality for Bonaparte River at mouth, 0600329.

Characteristics	1978 - 1979	1985 - 1988
pH	8.5	8.5
Res. 105	304	306
Res. NF (sus. sediments)	41	15
Spec. Cond.	412	497
Turbidity	42 (n=1)	2.8 (n=37, range 0.6-8.1)
Chloride	2.4	3.0
Ammonia	18	13
Nitrate	65 (n=17, range <20-230,SD=80)	108 (n=35, range ,20-390, SD=121)
Nitrite	5	6
Ortho P		22
Sulphate	34.2	56
Calcium	42.9 (diss.)	47
Magnesium	25.0 (diss.)	27
Kjeldahl N	350	252
Dissolved P	33	34
Total P	82 (n=18, range 28-437,SD=102)	46 (n=40, range 16-81, SD=16)

Table 130. Water quality summary for the Nicola River near Spences Bridge, 0600007. (1971-1978)

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour true	8.3	20	<5	30	7.1
pH	8.2	39	7.5	8.9	0.2
Res. 105	146	38	1.2 (error?)	228	38.0
Res. F	130.1	35	68	176	32.6
Res. NF	23.9	8	1.1	142	48.6
Spec. Cond.	203	44	109	292	56.1
Turbidity	8.6	28	0.5	54	12.3
Colour TAC	10.7	10	4	22	6.6
Alkalinity	93.9	30	47	131	26.4
T.O.C.	4.6	27	1	13	2.7
Chloride	1.2	14	0.6	2.1	0.4
Hardness	90	15	49	127	28.2
Ammonia	0.008	12	<0.005	0.013	0.003
NO_2/NO_3-N	0.033	19	<0.02	0.1	0.26
Nitrate -N	0.056	19	<0.02	0.16	0.051
Nitrite -N	<0.005	30	All ex1<.005		
Kjeldahl -N	0.207	38	0.030	0.430	0.093
Ortho P	0.011	16	<0.003	0.023	0.007
Total diss. P	0.0084	17	0.003	0.02	0.005
Total P	0.040	39	0.006	0.325	0.054
Silica	9.1	10	4.3	12.1	2.1
Sulphate	16.1	20	6.0	23.5	58
Tan. & lign.	0.33	6	<0.1	0.6	0.2

Table 130. (Continued) Water quality summary for the Nicola River near Spences Bridges, 0600007.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Carbon Inorg.	22	15	12	30	5.7
Calcium (d)	26	13	14.2	35	7.6
Copper (d)	0.012	15	<0.001	0.07	0.02
Copper (t)	0.004	13	<0.001	0.013	0.004
Iron (d)	0.078	15	<0.02	0.1	0.037
Iron (t)	0.69	11	<0.04	3.3	0.98
Lead (d)	<0.002	11	<0.001	<0.003	0.001
Lead (t)	0.023	7	<0.001	0.09	0.034
Magnesium (d)	7.8	6	7.2	8.2	0.4
Manganese (d)	0.016	10	<0.01	<0.02	0.005
Molybdenum (d)	0.001	3	0.0007	0.0015	0.0004
Potassium	1.5	2	1.3	1.7	
Sodium	8.2	2	7.8	8.6	0.6
Zinc (d)	0.020	14	<0.005	0.1	0.03
Zinc (t)	0.009	12	<0.005	0.03	0.008
Fecal Coliform	47.6	14	<2	240	65.5
Total Coliform	94.2	12	8	350	127.5

Table 131. Water quality summary for Thompson River at Spences Bridge, Station 0600005, 1966 - 1976.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour App	7	78	<5	25	3
Colour true	8	29	<5	15	3
Oil and Grease	1.1	23	<1.0	1.7	0.2
pH	7.7	112	7.0	8.2	0.2
Res. 105	71	38	48	100	11
Res. 550	both 46	2			
Res. NF 105	11.8	16	0.7	36.0	10.9
Res. NF 550	12.0	9	<1.0	25.0	7.6
Spec. Cond.	102	118	72	372	31
Oxy. diss.	9.2	21	5.7	13.2	2.6
Turbidity	2.5	115	<0.1	47.0	4.8
Colour TAC	7.6	21	<1.0	14.0	3.1
Residue fixed	36.4	11	<1.0	62.0	20.3
Alkalinity	38.2	117	27.6	51.9	5.9
Organic carbon	4.1	38	<1.0	23.0	4.0
Chloride diss.	0.9	85	0.2	3.1	0.7
Fluoride diss.	0.09	41	<0.05	0.19	0.04
Hardness	43.2	98	32.0	55.3	6.8
NH_3-N	0.088	22	0.003	0.2	0.054
NO_2/NO_3-N	0.073	74	0.004	0.384	0.057
Nitrate -N	0.08	31	0.04	0.13	0.02
Nitrite -N	All <0.005	31			
Kjeldahl -N	0.11	40	0	<0.50	0.11
Nitrogen total	0.17	39	0.06	0.34	0.07
B.O.D.	< 10	1			
C.O.D.	3.1	15	0.7	<10.0	2.6

Table 131. (Continued) Water quality summary for Thompson River at Spences Bridge, Station 0600005, 1966 - 1976.

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Phenol total	0.0035	17	<0.0005	0.014	0.0035
Ortho P	0.004	36	<0.002	0.03	0.004
Total diss. P	0.005	39	<0.001	0.013	0.003
Total P	0.012	57	<0.002	0.049	0.009
Silica diss.	5.2	93	3.2	7.1	0.8
Sulphate diss.	8.8	100	4.1	27.3	2.7
Sulphate total	7.5	4	5.6	11.8	2.9
Surfacan diss.	0.009	4	0	0.03	0.03
Surfacan total	All <0.003	5			
Tan. & lign total	0.3	14	0.1	0.4	0.1
Carbon Inorg.	8.8	32	5.0	31.0	4.4
Res. acid	0.5	18	<0.5	0.7	0.05
Arsenic diss.	0.005	5	<0.005	0.006	0.0004
Arsenic total	0.002	3	0.0002	<0.005	0.003
Boron diss.	<0.1	1			
Cadmium diss.	<0.0005	1			
Cadmium total	0.0009	5	<0.0005	0.001	0.0002
Calcium diss.	13.2	102	2.4	19.2	2.4
Chromium total	0.0002	1			
Copper diss.	0.017	37	<0.001	0.38	0.062
Copper total		25	<0.001	<0.01	
Iron diss.	0.047	49	<0.001	0.1	0.044
Iron total	0.127	8	0.036	0.25	0.075
Lead diss.	<0.01	34	<0.001	<0.05	
Lead total	<0.003	23	<0.001	<0.01	
Magnesium diss.	2.6	13	1.7	3.2	0.5

Table 131. (Continued) Water quality summary for Thompson River at Spences Bridge, Station 0600005, 1966 - 1976 .

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Magnesium total	2.3	13	1.7	3.2	0.5
Manganese diss.	All <0.01	13			
Mangnese total	0.01	37	<0.01	0.03	0.003
Mercury total	<0.00004	9	<0.00002	<0.00005	
Molybdenum diss.	0.0007	10	<0.0005	0.001	0.0002
Molybdenum total	<0.0009	6	<0.0002	<0.05	
Nickel total	0.0015	4	<0.001	0.003	0.001
Potassium diss.	0.85	2	0.8	0.9	0.07
Potassium total	0.8	76	0.1	1.1	0.2
Sodium diss.	2.2	82	0.9	5.3	0.9
Zinc diss.	0.011	33	<0.001	0.08	0.014
Zinc total	<0.005	25	<0.001	<0.01	
Aluminum diss.	0.02	7	<0.01	0.03	0.01
Cobalt total	0.001	4	<0.001	0.001	0.0
Silver total	All <0.01	3			
Barium diss.	0.1	2	<0.1	0.1	0.0
Barium total	Both <0.1	2			
Selenium total	0.0001	2	<0.0001	0.0001	0.0

ARCR 1254	P,P - DDT
ARCR 1269	DIELDRIN
ALDRIN	ENDRIN
BHC - TOT	HEPTCLOR
CLRD - TOT	METOXCLR
P,P - DDE	ENDSLFAN
P, P - DDD	ARCR 1248

All only have 1 sample taken 74-04-17 and all results were below detection limits

Table 132. Summary of water quality data for the Thompson River at Spences Bridge 1984 - 1988 (E 206586).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Colour (Apparent)	9.7	73	5	25	4.2
pH	7.1	109	6.4	8.2	0.4
Res. NF	5.8	30	< 1	57	10.2
Spec. Cond.	104.7	115	69.6	135.0	19.3
Turbidity	1.4	75	0.2	19.0	2.3
Res. filt.	68.1	43	44	178	21.7
Chloride	3.1	74	0.5	5.2	1.3
Fluoride	<0.05	74 (42<mdl)	<0.05	<0.1	0.01
Hardness	44.7	71	32.7	52.9	6.6
Ammonia -N	0.006	36(21<mdl)	<0.005	0.01	0.001
Total N	0.166	70	0.080	0.647	0.070
Silica	4.97	74	3.2	6.6	0.95
Sulphate	9.02	75	4.5	12	2.0
Arsenic	0.0002	44	<0.0001	0.0007	0.0001
Calcium (d)	14.0	71	9.8	16.1	1.8
Cadmium (t)	<0.0004	73 (39<mdl)	<0.0001	<0.001	0.0004
Copper (t)	0.005	72	<0.0005	0.043	0.007
Alkalinity	37.9	73	27.5	44.9	5.4
Iron (t)	0.230	74	0.002	3.0	0.38
Mercury	<0.0005	46(45<mdl)			
Potassium	0.84	74	0.2	1.0	0.14
NO_2/NO_3-N	0.101	71	0.021	0.508	0.06

Table 132. (Continued)Summary of Water quality data for the Thompson River at Spences Bridge, 1984 -1988 (E 206586).

Characteristics	Mean	n	Minimum	Maximum	Std. Deviation
Magnesium (d)	2.3	71	1.2	3.2	0.5
Manganese	0.013	49	<0.002	0.08	0.012
Sodium	3.4	74	0.8	4.8	1.1
Total diss.Phosphorus	0.004	34	<0.003	0.007	0.001
Total P	0.013	74	0.005	0.120	0.015
Lead (t)	0.001	71	<0.0007	0.0059	0.0007
Selenium	0.0002	44	<0.0001	0.0004	
Uranium	0.0005	10	0.0003	0.0007	0.0001
Zinc	0.007	73	<0.0003	0.0620	0.0129

Table 133. Comparison of water quality data for the Thompson River at Spences Bridge for two time periods.
Bracketed numbers are sample size, range and Standard Deviation, respectively.

Characteristics	1966 - 1976	1984 - 1988	Trend
Colour (Apparent)	7 (28,<5-25,3)	9.7(73,5-25,4.2)	+
Res. NF	11.8 (16,0.7-36)	5.8 (30, <1-57,10.2)	-
pH	7.7 (112,7.0-8.2,0.2)	7.1 (109,6.4-8.2,0.4)	-
Spec. Cond.	102 (118,72-372,31)	105 (115,70-155,19)	+
Turbidity	2.5(115,<0.1-47,4.8)	1.4 (75,0.2-19,2.3)	-
Chloride	0.9 (85,0.2-3.1,0.7)	3.1 (74,0.5-5.2,1.3)	+
Hardness	43.2 (98,32-45,6.8)	44.7(71,33-53,6.6)	+
Total Nitrogen	170 (39, 60-340,70)	166 (70,80-647,70)	
Nitrate & Nitrite	73 (74,4-384,57)	101 (71,21-508,60)	+
Calcium (d)	13.2 (102,2-19,2.4)	14.0 (71,10-16,1.8)	+
Sulphate	8.8 (100,4-27,2.7)	9.0 (75, 4-12,2.0)	+
Silica	5.2 (93,3-7,0.8)	5.0 (74,3-7,0.9)	-
Sodium	2.2 (82,0.9-5.3,0.9)	3.4 (74,0.8-4.8,1.1)	+
Total diss. P	5 (39,<1-13,3)	4 (34,<3-7,1)	-
Total P	12 (57,12-49,9)	13 (74,5-120,15)	+

The bracketed numbers are sample size, range, and standard deviation, respectively (n,range,sd).

Table 134. Estimated Winter Phosphorus Loading to Thompson River from Weyerhaeuser Pulpmill and City of Kamloops (1974 to 1988).

Year	Pulpmill (Kg/d) TP	Pulpmill (Kg/d) TDP	City (Kg/d) TP	City (Kg/d) TDP	Combined Total (Kg/d) TP	Combined Total (Kg/d) TDP
1974	101	47	135	104	236	152
1975	110	59	135	104	243	163
1976	146	107	135	104	281	211
1977	150	119	37	26	187	145
1978	133	125	0	0	133	125
1979	104	100	0	0	104	100
1980	145	130	0	0	145	130
1981	120	76	0	0	120	76
1982	131	49	0	0	131	49
1983	152	69	0	0	152	69
1984	172	62	0	0	172	62
1985	165	60	43	10	208	70
1986	156	51	3	1	159	52
1987	167	84	7	2	167	84
1988						

Pulpmill

Total dissolved phosphorus (TDP) and total phosphorus (TP) are taken from Table 50 and are annual average daily loads.

City

TDP: 1974 - 1976 (Non-alum treatment), TDP estimated to be 77% of TP (Wetter 1977, cell #3).

: 1977 Loading determined from Wetter 1977.

: 1985 - 1988 (Alum treatment), TDP estimated to be 23% of TP (Wetter 1977, Cell #4),

Table modified from Derksen (1988).

Table 135. Lower Thompson River Periphyton biomass - natural (rock) substrates.

Savona:

	Chlorophyll a mg/m²	Total Residue g/m²	Volatile residue g/m²
March 24 1976	140	433	97
April 6 1976	280		
April 22, 1976	7.1 (n=2)		
	1976 mean =119		
January 11, 1977	124	32.6	10.0
	80	39.2	13.3
Feb16,1977	90/58		
March 9,1977	91/87		
March 30,1977	260/280		
	1977 mean=134		

Walhachin:

	Chlorophyll a mg/m²	Total Residue g/m²	Volatile residue g/m²
March 24, 1976	140	856	155
April 6, 1976	100		
April 22, 1976	12.9 (n=2)		
	mean=84		
January 11, 1977	57	26	10.1
	78	25.6	7.9
Feb16,1977	120/130		
March 9,1977	43/44		
March 30,1977	56/72		
	mean=75		

Table 136. Algal biomass in the Thompson River, October 1973 - April 1974. Modified from Appendix 3 of Olan (1974). All units are mg/m^2 on plexiglass substrates.

		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
McClure	Chlorophyll a	-	3.5	1.6	1.6	0.1	3.9	0.8
	Chl. + Phaeophytin	-	5.0	2.0	2.3	0.1	5.3	1.1
		Mean chlorophyll a plus Phaeophytin for the period is 2.6 mg/m^2, phaeophytin 37% of chlorophyll a value.						
Chase	Chlorophyll a	3.9	1.1	0.1	0.3	0.7	2.2	0.9
	Chl. + phaeophytin	4.9	1.6	0.1	0.3	0.9	2.6	1.3
		Mean chlorophyll + phaeophytin is 1.5 mg/m^2, phaeophytin 28% of chlorophyll a value.						
Savona	Chlorophyll a	4.9	5.4	2.6	1.8	13.8	1.3	
	Chl. + Phaeophytin	8.1	7.4	3.7	2.0	17.9	1.6	
		Mean chlorophyll + phaeophytin is 6.8 mg/m^2, phaeophytin 36% of chlorophyll a.						
Walhachin	Chlorophyll a	6.3	3.6	0.7	0.7	1.9	20.9	3.4
	Chl. + Phaeophytin	8.8	4.9	1.2	0.8	2.1	24.0	4.3
		Mean chlorophyll + phaeophytin is 3.2, phaeophytin 23% of chlorophyll a.						

Table 137. Mean Chlorophyll a Results (mg/m^2) for artificial substrates.

	CHASE			McCLURE			SAVONA			WALHACHIN		
Date	days of growth	n	Mean	days of growth	n	Mean	days of growth	n	Mean	days of growth	n	Mean
Oct. '73	31	5	4.62							31	6	6.21
Nov. '73	30	7	1.10	30	6	3.43	30	4	8.73	30	3	3.52
Dec. '73	31	5	0.15	31	6	1.86	31	6	7.04	31	5	0.86
Jan. '74	31	10	0.31	31	11	1.60	31	12	2.52	31	11	0.36
Feb. '74	28	11	0.72	28	6	0.05	28	6	1.76	28	8	1.90
Mar. '74	31	12	2.56	31	12	2.51	31	12	1.36	31	12	26.8
Apr. '74	30	12	0.86	30	12	0.75	30	12	1.33	30	12	3.37
Nov. '74	30	8	13.7	30	7	1.41	30	8	11.42	30	8	1.90
Dec. '74	31	7	59.2	31	7	2.52	31	8	13.3	31	8	3.84
Jan. '75	31	8	1.05	31	6	0.25	31	8	1.51	31	8	1.24
Feb. '75	28	8	6.95	28	4	0.01	28	8	4.84	28	8	2.77
Mar. '75	31	7	1.65				31	6	7.31	31	6	12.5
Jan. '77	20	6	0.58									
Jan. '77	15	1	0.80				15	6	0.77	15	6	0.67
Feb. '77	21	6	0.30				21	6	1.45	21	6	4.08
Mar. '77	21	6	0.53	21	4	1.28	21	6	3.83	21	6	4.02
Mar. '77	21	6	1.17	21	6	5.15	21	6	58.8	21	6	30.2
Apr. '77	15	6	1.07	15	6	2.32	14	6	30.6	14	6	40.2
Nov. '77	28	3	91.3									
Dec. '77	28	3	1.10				35	3	13.1	35	3	15.4
Jan. '78	28	3	7.10				28	3	1.91	28	3	7.04
Feb.'78	28	3	15.0				28	3	2.50	28	3	1.29
Mar. '78	29	3	8.40				28	3	6.03	28	3	8.07

Table 137 (continued). Mean Chlorophyll a Results (mg/m^2).

	CHASE			McCLURE			SAVONA			WALHACHIN		
Date	No. of days	n	Mean	No. of days	n	Mean	No. of days	n	Mean	No. of days	n	Mean
Dec. '78	29	4	11.2				27	3	2.66	27	3	3.51
Jan. ' 79	28	3	1.20				28	3	1.51	28	3	0.52
Feb. ' 79	28	2	0.50				28	3	1.01	28	3	5.84
Mar. '79	28	3	1.70				28	3	7.44	28	3	28.4
Apr. '79	28	3	0.90				28	3	7.44	28	3	28.4
										21	3	23.8
Oct. '79							21	3	14.9	21	3	15.68
Oct. ' 79	28	3	28.0	27	3	6.20	21	3	6.62	21	3	12.58
Nov. '79	28	3	32.7	28	3	6.30	27	3	14.8	27	3	13.68.
Dec. '79	36	3	16.4				28	3	6.83	28	3	7.70
Jan. '80	28	3	0.30				28	3	2.44	28	3	2.42
Feb. '80	28	3	2.60				34	3	10.2	34	3	18.5
Mar. '80	26	3	5.10				29	3	15.8	29	3	21.4
Apr. '80	28	2	3.40	21	3	18.20						

1973/1974 - All sites data from Langer and Nassichuk (1975).

1974/1975 - All sites data from Langer and Nassichuk (1975).

1977 - All sites data from BC MOE on EQUIS (microfiche).

1977/1978 - Chase - D. Holmes (Draft) Chase Report.
Savona and Walhachin - Weyerhaeuser Annual Monitoring Report.

1978/1979 - Chase - D. Holmes (Draft) Chase Report.
Savona and Walhachin - Weyerhaeuser Annual Monitoring Report.

1979/1980 - Chase - D. Holmes, Chase Draft Report
McClure - D. Holmes data, on EQUIS microfiche.
Savona and Walhachin - Weyerhaeuser Annual Monitoring Report.

note: unusually high biomass in 1974 and 1975 may be partially due to a dominant and a subdominant run of Adams River sockeye in those years.

Table 138. Summary of Thompson River algal biomass.

	Chase	McClure	Savona	Walhachin	U/S: D/S **
1973-1974	1.5	1.5	5.0	6.2	1:3.7
1974-1975	16.5*	1.0	7.7	4.5	
1977	0.7	3.1	19.1	15.8	1:9.2
1977-1978	24.6*	-	5.9	7.9	
1978-1979	3.1	-	3.2	11.8	1:2.4
1979-1980	12.6*	10.2	10.2	10.3	

- Chlorophyll a in mg/m^2

* - Unusual conditions - See Langer and Nassichuk (1975), (samples poorly located in side pool of river). Sockeye runs in 1974 -75 may also have had some effect (see previous page).

- Data compiled from table 134 (Following).

** - calculated as the sum of Chase + McLure : Savona + Wahlachin

Table 139. *Chlorophyll - Volatile Solids correlation for the Thompson River, 1973 - 1974, values in mg/m^2 (chlorophyll) and g/m^2 (volatile solids).

		Total Pigments mg/m^2	Dry wt. + g/m^2	Ash wt. = g/m^2	Vol. Solids g/m^2
Chase:	Dec n=5	0.19	1.3	0.7	0.7
	Jan. n=10	1.89	1.3	0.5	0.8
	Feb. n=11	1.41	8.0	7.2	1.0
	Mar. n=12	4.08	3.2	4.4	1.2
	Apr. n=12	1.89	2.9	2.6	0.6

Overall correlation between total pigments and volatile solids: $r^2 = 0.000$ (n=50).
Ratio of pigments:vol solids is about 0.2%.

		Total Pigments	Dry wt.	Ash wt.	Vol. Solids
McClure:	December. N=6	4.54	11.9	11.5	0.5
	Jan. n=11	3.45	22.3	20.6	1.7
	Feb. n=6	0.31	4.7	4.3	0.3
	Mar. n=12	5.52	85.6	83.2	2.4
	Apr. n=12	1.75	10.2	9.8	0.4

Correlation: $r^2 = 0.043$, ratio chl a: vol solids 0.3%

		Total Pigments	Dry wt.	Ash wt.	Vol. Solids
Savona:	Dec. n=6	15.6	50.3	47.4	2.8
	Jan. n=12	6.36	1.8	1.8	0
	Feb. n=6	3.55	18.9	17.8	1.1
	Mar. n=12	24.7	53.0	46.5	6.5
	Apr. n=12	2.6	9.6	9.7	0.7

Correlation $r^2 = 0.206$ ratio of chl a:vol solids O.5%.

Table 139 (Continued).*Chlorophyll - Volatile Solids correllation for the Thompson River, 1973 - 1974, values in mg/m^2 (chlorophyll) g/m^2 (vol. solids).

		Total Pigments	Dry wt.	Ash wt.	Vol. Solids
Walhachin:	Dec. n=5	2.48	2.6	2.0	0.6
	Jan. n=11	1.12	1.1	1.0	0.1
	Feb. n=8	2.19	4.7	4.5	0.3
	Mar. n=12	41.4	48.8	43.1	5.8
	Apr. n=12	6.98	8.5	7.6	0.9

Ratio of chl a:volatile solids about 0.7%.

*Should be termed total pigments (chlorophyll a +b + c + phaeopigments)

Chase	total chl/dry weight	$r^2 = 0.010$
	dry weight/vol solids	$r^2 = 0.302$
McLure	total chl/dry weight	$r^2 = 0.043$
	dry weight/vol solids	$r^2 = 0.074$
Savona	total chl/dry weight wt	$r^2 = 0.425$
	dry weight/vol solids	$r^2 = 0.120$

Table 140. Algal standing crop in the Lower Thompson River 1989.

Savona:

Artificial Substrates	Chl a	All < 0.3mg/m^2 (Jan - March) Dry wt. Mean=0.4 g/m^2 n=15 (5<mdl) A.F. dry wt. Mean=0.3 g/m^2 n=15 (9<mdl)
Natural Substrates		Chl. a mean of 52 mg/m^2 (n=6) Dry wt. Mean = 103 g/m^2 n=3 A.F. dry wt. Mean = 68 g/m^2 n=3

Walhachin:

Artificial Substrates	Chl a	9/14 < mdl 0.3 Max. 2.9 mg/m^2 Dry wt. Mean 0.4 g/m^2 n=14 (5<mdl) A.F. Dry wt. Mean 0.3 g/m^2 n=14 (10< mdl)
Natural Substrates		Chl a mean of 20 mg/m^2 (n=6) Dry wt. Mean = 112 g/m^2 n=3 A.F dry wt. Mean = 55 g/m^2 n=3

Table 141.
Periphyton Biomass (as chlorophyll a in mg/m^2) at Walhachin
1976-1977 and 1989. Data from EQUIS and SEAM.

	Substrates	
	Artificial (n)	Natural (n)
76 03 24		140 (1)
76 04 06		100 (1)
76 04 22		13 (2)
77 01 11		68 (2)
77 01 26		0.7 (6)
77 02 16	4.1 (6)	125 (2)
77 03 09	4.0 (6)	43.5 (2)
77 03 30	30 (6)	64.5 (2)
77 04 13	40 (6)	
89 03 23	0.5 (15)	
89 03 02		20.0 (6)

Periphyton biomass (as chlorophyll a in mg/m2) at Savona
1976 - 1977 and 1989. Data from EQUIS and SEAM

	Substrates	
	Artificial (n)	Natural (n)
76 03 24		70 (1)
76 04 06		280 (1)
76 04 22		7.1 (2)
77 01 11		102 (2)
77 01 26	0.8 (6)	
77 02 16	1.5 (6)	
		74 (2)
77 03 09	3.3 (6)	89 (2)
77 03 30	59 (6)	270 (2)
77 04 13	31 (6)	
89 02 02 - 89 03 23	<3 (6)	
89 01 26 - 89 06 23	7.1 (9)	
89 03 02		52.3 (6)

Table 142. Summary of 1989 phosphorus concentrations (ug/L) in the Lower Thompson.

Savona 0600004:

	Total diss. P	Total P	soluble reactive P
January 26	4	7	
February 2	6	8	
February 23	3	6	
March 9	4	9	3
March 16	3	9	

Walhachin:

	Total diss. P	Total P	soluble reactive P
January 26	5	7	
February 2	5	8	
February 27	3	6	
March 9	4	9	3
March 16	3	7	

Table 143. Summary of MOE Colour Data for the Thompson River.

		Mean	Min.	Max	n	90%ile
North Thompson - McClure:						
1966-1974	Apparent	9.6	<5	50	101	20
1971-1977	True	6.5	<5	20	34	10
1973-1980	TAC	5.2	<1	19	44	11
North Thompson - N. Kamloops:						
1974-1976	Apparent	6.1	<5	10	13	10
1973-1976	TAC	4.9	2	12	31	8
1982	TAC	12.7	3	21	10	21
South Thompson - Pioneer Park:						
1973-1982	TAC	3.4	<1	10	77	6
Lower Thompson - Savona:						
1971-1975	True	7.5	<5	15	34	12.5
1973-1984	TAC	7.6	<1	16	98	11
Lower Thompson - Spences Bridge:						
1984-1988	Apparent	9.7	5	25	73	15
1966-1976	Apparent	7.1	<5	25	78	10
1971-1975	True	7.7	<5	15	29	10
1973-1976	TAC	7.6	<1	14	21	11.6

Table 144. Thompson River at McClure - Colour - MOE data summary.

		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	80
January																
	Colour App		5		5	5	5	<5	<5	<5						
	Colour true							<5	5	5	5					
	Colour TAC									6	<1	6	3			
February	App		5	5	5	5	15	5	13.3	<5						
	True							5	5	5						
	TAC									<1						
March			5	5	5	5	5	5	5							
									5	5			5			
										4		1	4			4
April			10	10	30	7.5	<5	10	32.5	30						
								10	5	5	5					
										5	3		12	17		4.3
May			20	20	20	10	10	20	30							
									15	20						
										19	11					
June			15	15	10	7.5	15	25	15							
								10	10	10						
										11						
July			5	5	10	5	15	7.5		15						
									5	10						
										6	8	8				
Aug.		<5		5	5	7	5	10								
								<5	5							
										3						
Sept.			5	5	5	<5	<5	<5	6.8							
									5	<5						
										2		5			3	
Oct			5	10	5	<5	5	<5	15							
								5	5	5						
									<1	3					4	
Nov.			10	10	10	7	<5	<5	<5							
							5	5	5							
											9		5.7		3.3	
Dec.			10	5	5	5	<5	5	5							
							5	5	5							
									4			5	3		1	

Table 145. Thompson River at Savona - Colour - MOE data summary.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Jan.														
Colour true		5	5	10	10									
Colour TAC				9	9	10	10	10	10					
Feb. true			5	5	10									
TAC				8	9.5	9	11	9						6.9
Mar.				5	15									
				10	6	10	10	9.3						5.4
April.		<5	5	10										
				10		8.5	11	12.5				6		4.9
May			10	15										
				13	13							10.6		5.7
June		10	15	10										
				8					10.5					
July			5	10										
				7	5.5	9								
Aug.		5	5	10										
				3	3.8									
Sept.			5	5										
			5	4	3.8	7				5				
Oct.			5											
			4		3.3	8	7							
Nov.	5	5	5	5										
				6	6.8	8	9.7							
Dec.	5	10	5	<5										
			<1	6	9.3	1.0	7.2							

Table 146. Thompson River at Walhachin - Colour - MOE data Summary.

	1975	1976	1977	1978	1979	1980
Jan.						
Colour TAC		10	10	11	9	
February						
Colour TAC		9	11	9.5		
March						
Colour TAC		9	10	9		
April						
Colour TAC		9	10	11.5		
May						
Colour TAC						
June						
Colour TAC						
July						
Colour TAC	5	8				
Aug.						
Colour TAC	3.5					
Sept.						
Colour TAC	4	7				5
October						
Colour TAC	4	7	7			
Nov.						
Colour TAC	6.8	8	6.3			
Dec.						
Colour TAC	9.3	9	7.5			

Table 147. Thompson River at Spences Bridge - Colour - MOE data summary 1966-1976.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Jan.											
Colour app		5	5		5	5		10	5		
Colour true							5	5	10	10	
Colour TAC									8	9	10
Feb. app		5	5	5	10	7.5	5				
true							5	10	10	10	
TAC									10	8	
March			5	5	5		5	10	10		7
								5	5	10	
									12	6	9
April		5	5		10	6		12	15		
									10		
									10		
May		10		10			5				
								15			
										14	
June				5	10	15	25	15			10
									10		
									8		
July		6.7	10		10	7	10	10	5		
							10	5	10		
									7	6	
Aug.	5		<5		<5	5		5			
Sept.			5	5	<5	<5	10	5			7
							5	5	<5		
									4	4	
Oct.	10	5	5		<5	<5	5	5			
								5			
								<1			
Nov.	5	10	5	10			5	10			
						5	10	5	5		
									6		
Dec.	5	5	5		<5		5	5			
						10		5	<5		
								10	7		8

Table 148. Summary of colour data from the Report on the Federal-Provincial study of the Thompson River.

Station No.*	1	2	3	4	5	6	7	8	9	10	11	12
	---	---			---	---			---	---		
Oct. '73												
Colour True	<5	<5	<5	<5	<5	<5	5	5	10	5	5	5
Colour TAC	5	2	4	3	<1	1	<1	1	10	1	1	2
Nov.7 '73	5	5	5	5	<5	<5	5	20	20	5	5	5
	1	1	1	1	1	1	1	14	7	1	1	1
Nov. 29, '73	5	5	5	5	5	5	5	90	30	5	10	7
	1	1	1	2	1	1	2	100	29	7	7	5
Jan. '74	5	5	5	5	<5	5	5	30	80	10	10	10
	2	3	3	5	4	2	1	39	98	10	10	9
Feb. '74		5	5	5	<5	5	5	60	30	5	10	10
		2	4	<1	<1	<1	<1	59	28	8	8	8
March '74	5	5	5	5	5	5	5	80	40	5	10	5
	<1	<1	<1	<1	<1	<1	3	94	42	10	9	9
April 74	10	5	5	5	5	5	200	10	20	5	5	10
	10	10	10	4	<1	1	268	11	18	8	9	7
May 74	-	20	-	-	5	5	10	10	10	15	10	-
	13	19	18	16	3	4	8	4	1	13	12	15
June '74	-	10	-	-	-	-	-	-	10	10	-	-
	7	11	10	9	1	<1	4	4	4	8	8	7
July '74	-	10	-	-	-	-	5	10	10	10	-	-
	4	6	4	-	7	7	5	4	5	7	10	7
Aug.	-	-	5	-	10	10	-	-	-	10	-	-
	1	3	1	6	6	3	4	4	4	3	4	<1
Sept. '74	-	<5	-	-	-	-	-	-	-	-	-	-
	2	2	3	4	5	6	2	3	8	4	4	4

Table 148 (Continued). Summary of Data from the Report on the Federal Provincial Study of the Thompson River.

Station No.	1	2	3	4	5	6	7	8	9	10	11	12
Oct. '74	-	-	-	-	-	-	-	-	-	-	-	-
-	3	3	-	3	4	4	5	13	8	-	-	-
Nov. '74	-	-	-	-	-	-	-	-	-	5	-	-
	4	1	3	3	3	3	4	32	15	6	-	7
Dec. '74	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	1	2	4	2	2	33	26	6	7	7
Jan. '75	-	-	-	-	-	-	-	-	-	-	-	-
	1	<1	1	1	3	1	1	-	23	9	-	-
Feb. '75	-	-	-	-	-	-	-	-	-	10	-	-
	2	-	1	3	3	3	-	-	-	-	12	10
March '75	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	4	3	2	4	-	-	-	6	6	6

*#1. North Thompson River at Albreda.

#2. North Thompson River at McLure.

#3. North Thompson River at Little Fort.

#4. North Thompson River at Kamloops.

#5. South Thompson River at Chase.

#6. South Thompson River at Kamloops.

#7. Thompson River after confluence of N & S Thompson Rivers, but upstream of both Weyerhauser diffuser and Kamloops' lagoons.

#8. Thompson River downstream of Weyerhauser's diffuser, but upstream of Kamloops' lagoons.

#9. Thompson River downstream of both Weyerhauser's diffuser and Kamloops' lagoons (at Kamloops Lake entrance).

#10. Thompson River at Savona.

#11. Thompson River at Walhachin.

#12. Thompson River below Ashcroft

Table 149. Colour in the Thompson River System.
From: Weyerhaeuser Yearly River Reports (single wavelength colour).

	Jan.	Feb.	March	April	Oct.	Nov.	Dec.
'77 North Thompson							
South Thompson							
Savona							10.0
Walhachin							13.0
'78 North Thompson					Ice	On	River
South Thompson					Ice	on	River
Savona	10.4	10.3	14.9	7.2			15.6
Walhachin	12.3	10.4	14.9	14.8			15.6
'79. North Thompson	Ice	on river	12.0	10.5	9.4	12.6	9.5
South Thompson	Ice	on river	8.3	7.0	9.3	11.5	8.8
Savona	15.4	12.9	13.0	13.6	12.8	15.0	13.4
Walhachin	14.7	12.6	16.4	14.2	13.0	14.2	14.4
'80 North Thompson	15.7	11.6	14.0				11.8
South Thompson	10.3	10.7	8.5	6.1			8.4
Savona	20.1	20.0	17.8	16.5			14.7
Walhachin	19.2	18.1	17.7	17.5			15.4
'81 North Thompson	11.8	13.0	16.0	17.5	8.5	9.5	9.5
South Thompson	7.6	11.8	10.0	10.5	7.8	6.6	8.0
Savona	10.3	18.5	17.0	17.0	11.3	10.4	13.8
Walhachin	12.6	15.5	15.8	16.9	11.1	10.8	13.2
'82 North Thompson	8.6	5.0	7.8	15.8	8.0	10.5	7.0
South Thompson	7.2	7.5	5.7	5.5	3.5	7.5	3.5
Savona	12.8	10.5	13.0	10.8	9.5	10.0	8.0
Walhachin	13.1	10.5	12.3	10.8	10.0	12.5	10.5
'83 North Thompson	9.5	13.0	16.5	17.0	8.3	11.0	8.4
South Thompson	8.0	8.0	10.0	7.0	5.3	6.5	4.0
Savona	12.5	14.0	12.5	11.0	8.5	10.5	10.7
Walhachin	13.0	13.5	13.5	11.5	9.3	10.0	10.2

Table 149 (continued). Colour in the Thompson River System, From: Weyerhaeuser annual monitoring reports.

Year	Station	Jan.	Feb.	March	April	Oct.	Nov.	Dec.
'84	North Thompson	5.1			15.3	5.0	4.5	7.9
	South Thompson	4.5			3.5	5.7	3.0	2.8
	Savona	10.1			7.2	8.5	8.0	8.8
	Walhachin	12.7			5.9	9.3	9.3	8.8
'85	North Thompson	Ice	on river	5.0	13.5	10.3	9.2	Ice/river
	South Thompson	3.3	4.3	4.3	4.8	6.0	5.5	3.7
	Savona	10.3	13.0	13.9	11.5	8.6	11.2	13.3
	Walhachin	10.8	13.5	13.8	10.0	9.4	11.4	12.6
'86	North Thompson	8.5	6.5	10.9	12.2	9.3	6.3	8.8
	South Thompson	6.4	12.0	5.0	4.7	6.0	8.0	6.5
	Savona	12.6	14.8	13.0	12.9	11.3	13.8	12.6
	Walhachin	13.5	15.3	13.5	12.7	9.6	13.5	12.3
'87.	North Thompson	3.0	4.5	9.7	10.3	5.4	6.0	9.4
	South Thompson	4.0	4.8	6.0	3.0	3.8	4.0	4.8
	Savona	12.5	11.7	13.7	13.8	9.2	9.9	12.0
	Walhachin	13.5	13.8	11.5	14.8	10.2	11.6	12.0
'88	North Thompson	5.0	-	4.0	21.0	11.0	5.3	6.6
	South Thompson	3.6	5.0	6.0	7.5	4.0	3.5	3.7
	Savona	13.4	14.5	15.4	16.3	10.5	10.6	12.5
	Walhachin	13.3	14.5	15.8	17.0			
'89	North Thompson	4.3	4.5	4.3	3.5		8.5	8.0
	South Thompson	3.0	4.5	3.9	3.5		2.8	4.3
	Savona	11.5	13.3	13.6	12.5		9.5	13.5
	Walhachin						10.0	13.5
'90	North Thompson	5.5	6.5	7.25	23.1		9.0	6.75
	South Thompson	3.5	3.5	3.3	5.5		4.7	3.0
	Savona	13.5	15.0	12.8	15.5		8.75	11.75
	Walhachin	14.5	15.8	12.8	15.6		8.75	11.5
'91	North Thompson	ns	10.7	7.0				
	South Thompson	ns	5.0	3.3				
	Savona	14.0	14.0	13.9				
	Walhachin	14.3	14.0	14.0				

Table 150. Summary of Kamloops Lake Colour Data (SWC units).

<u>1973</u>

Station	Depth (m)	April	May	June	July	Aug.	Sept.	Oct.	Nov.
A_2	0		15	5	10	20	10	11	25
B_2	1	<5	<5	5	5	15	5	13	15
C_1	1								
C_2	1	10	10.5	7.5	15	23	<5	18	11
C_3	1								
C_4	1								
G_2	1	<5	5	10	13	15	10	25	15
X_2	1								
D_2	1	15	<5	10	7.5	15	5	15	35
E_2	1	*5.5	<5	13	20	7.5	<5	25	7.5
F	0	<5	<5	15	18	<5	10	15	15

<u>1974</u>

Station	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A_2	15	20	30	9	12	5	5	20	27
B_2	15	10	20	9	8	<5	9	15	16
C_1	15	5	15	11	9	<5	7	15	
C_2	15	10	15	9	7	5	5	15	20
C_3	15	10	15	9	10	<5	9	15	
C_4									
G_2	10	10	15	10	7	5	7	12	14
X_2	10	10	20	9	6	<5	6	10	15
D_2	10	10	15	7	10	6	5	14	14
E_2	10	5	15	8	10	<5	6	15	14
F	10	10	15	10	7	<5	7	13	14

<u>1975</u>

January	Feb.	March	April	May	June	July	Aug.	Sept	Oct.
22	30	45	23	18	14	12.5	7	6.5	43
19	20	21	18	18	14	10	7	6.5	8
18	20	18	18						
19	20	22	18	10	11	16	18	16	12.5
17	16	20	17						
15	16	17	17	12.5	14	8.5	7	7	7
15	16	19	17						
18	16	21	17	15	14	7.5	7	6.5	7
17	17	19	17	15	14	8.5	7	8.5	13
14	16	18	18	12.5	14				

Table 150 (Continued). Summary of Kamloops Lake Colour Data.

1976

Station	Depth	May	June	July	Aug.	Sept.	Oct.
A_2	0	22	21	12	22	14	32
B_2	1	24	19	12	27	10	22
C_1	1						
C_2	1	15.5	14				
C_3	1						
C_4	1						
G_2	1	19.5	18	12	18	12.5	14
X_2	1						
D_2	1	21.5	22	12	14	14	14
E_2	1	24	21.5	12	14	14	14
F	0						

		1978		1980		1982	
Station	Depth	May	Sept.	April	Sept.	April.	Sept.
A_2	0						
B_2	1	10	24	31	15	11	8
C_1	1	13	20	31	13	11	9.5
C_2	1	10	14	28	13	12	10
C_3	1	10	18	26.5	14	12	10.5
C_4	1	13	14	25	14	11	10.5
G_2							
X_2							
D_2	1	13	18	21.5	14	11.5	11.5
E_2	1	13	15	26.5	19	11.5	12
F	0	14	14	20.5	17	11	10.5

April to November 1973 from Weyerhaeuser Report.
April. 1974 to April 1975 from task force (apparent colour, rel. units).
May 1975 to Sept. 1982 from Weyerhaeuser Reports.
- Weyerhaeuser reports '78, '80 and '82 have dropped A_2 but renamed B_2 to A_2.
. In some reports there were data for A_1, A_2, and A_3, B_1, B_2 and B_3.
but just used the mid lake station values - (A_2 and B_2) were used.
- for site locations see the reports.

TABLE 151
Time Trend for Colour in the Lower Thompson
Mean of Values for Savona and Walhachin (Oct 1 to May 1)

		normalized to mean flow
1978-1979	14.9 ppm (=SWC)	14.2
1979 - 1980	15.5 ppm	10.5
1980 - 1981	15.8 ppm	21.5
1981 - 1982	11.9 ppm	13.0
1982 - 1983	11.9 ppm	15.2
1983 - 1984	9.5 ppm	10.9
1984 - 1985	10.5 ppm	9.6
1985 - 1986	12.5 ppm	11.6
1986 - 1987	12.9 ppm	12.0
1987 - 1988	13.9 ppm	9.9
1988-1989	12.3 ppm	
1989-1990	13.2 ppm	
1990-1991	12.6 ppm	

from Thut (1991)

for full data see Table 149

Table 152. Colour Summary Table - Mean Oct.-April value, SWC colour from Table 142-149.

YEAR	N. Thompson	S. Thompson	Savona	Walhachin
1979-80	12.4	9.3 mean U/S - mean D/S difference is 10.8 - 16.4 =5.6	16.5	16.3
1980-81	14.0	9.7 U/S - D/S = 3.5	15.5	15.2
1981-82	9.2	6.9 U/S - D/S = 3.5	11.8	11.7
1982-83	11.6	6.8 U/S - D/S = 2.4	11.1	12.1
1983-84	9.6	4.8 U/S - D/S = 2.3	9.4	9.6
1984-85	7.2	4.0 U/S - D/S = 5.1	10.6	10.8
1985-86	9.6	8.7 U/S - D/S = 5.1	12.3	12.6
1986-87				
1987-88	8.5	4.8 U/S - D/S = 6.6	13.0	13.5

Table 153
South Thompson River at Chase - TAC Colour
Ministry of Environment Data Summary

Colour TAC	1973	1974	1973	1976	1977	1978	1979	1980	1981	1982
JAN.			<1	3	4	3.5	4.3	3.6		
FEB.		<1	3		5	2.8	5	3		
MAR.		1	2	2	3	6.5	2.7	3.5		
APR.		<1		3	10*	16*	5.5	4		
MAY		3	3							
JUNE		1								
JULY		7	4	5						
AUG.		6								
SEPT.		5	3	5			3			
OCT.	1	4					3.3			
NOV.	1	3	3	4	4		3			
DEC.		4		3	3	4	2.3			

* single value only

Table 154
North Thompson River at Pioneer Park - TAC Colour
Ministry of Environment Data Summary

Colour TAC	1973	1974	1973	1976	1977	1978	1979	1980	1981	1982
JAN.		2	3	3	4					
FEB.		<1	3	2.5	5					
MAR.		<1	4	2	3					
APR.		1		3	3					1.2
MAY		4	4							6.8
JUNE		<1					4			
JULY		7	4.8	6						
AUG.		3	2.8							
SEPT.		6	3.6	7				3		
OCT.	1	4	2.8	4	5.5					
NOV.	<1	3	3.3	5	3					
DEC.	1	2	3	4		3.5				

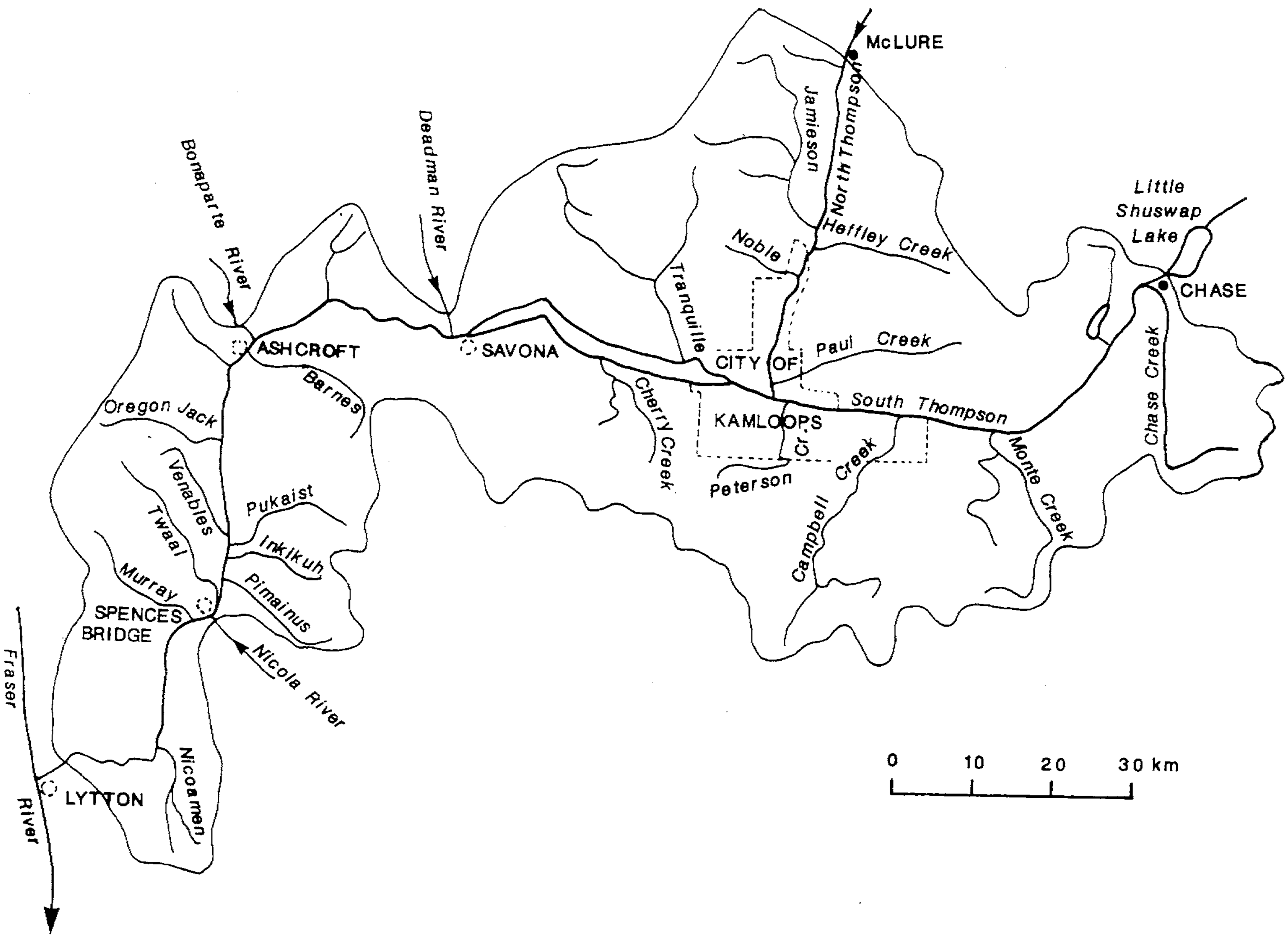
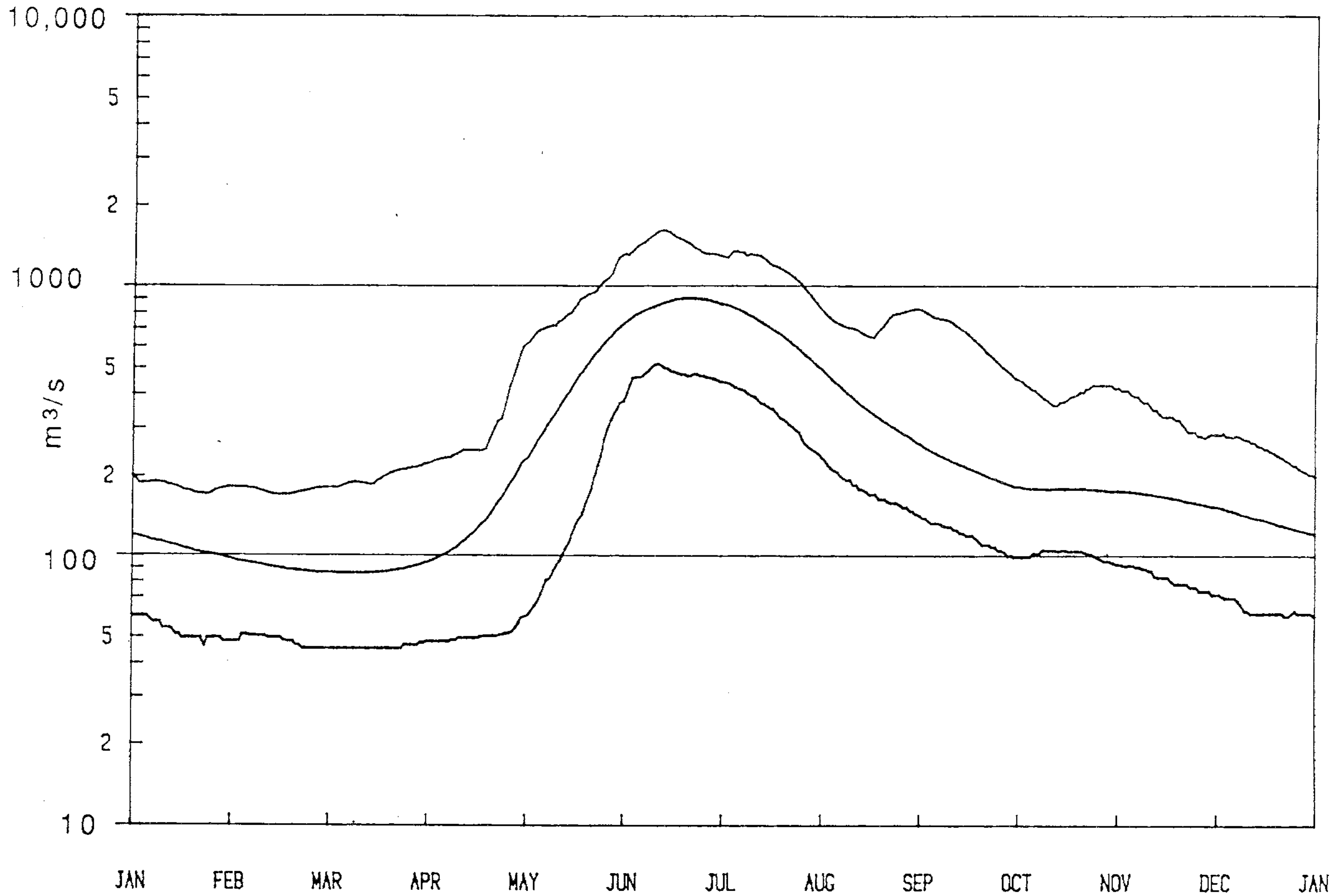


Figure 1. The Thompson River watershed showing the study area.

Figure 2. Hydrograph for the South Thompson at Chase (08LE031). Streamflow envelope 1911-87. The X-axis is an exponential one in cubic meters per second.



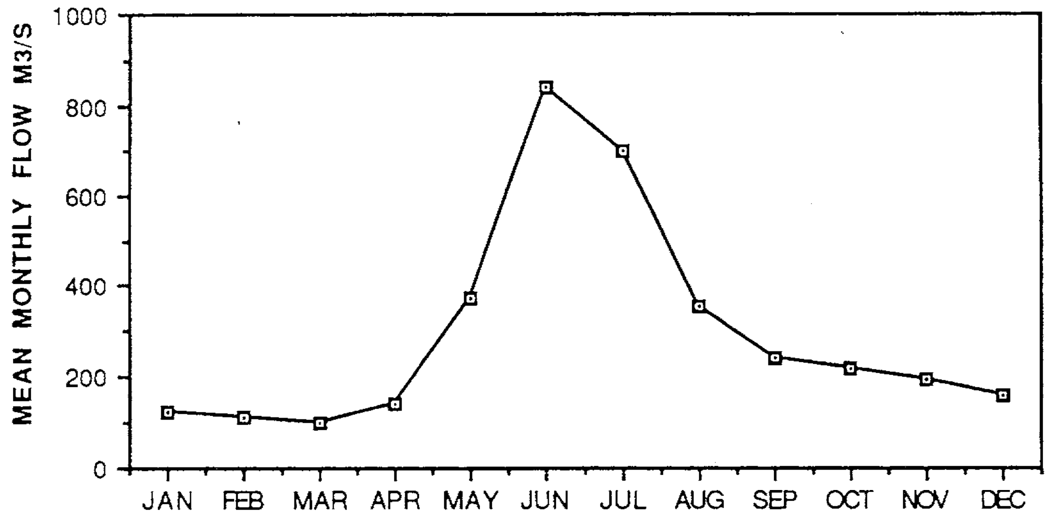
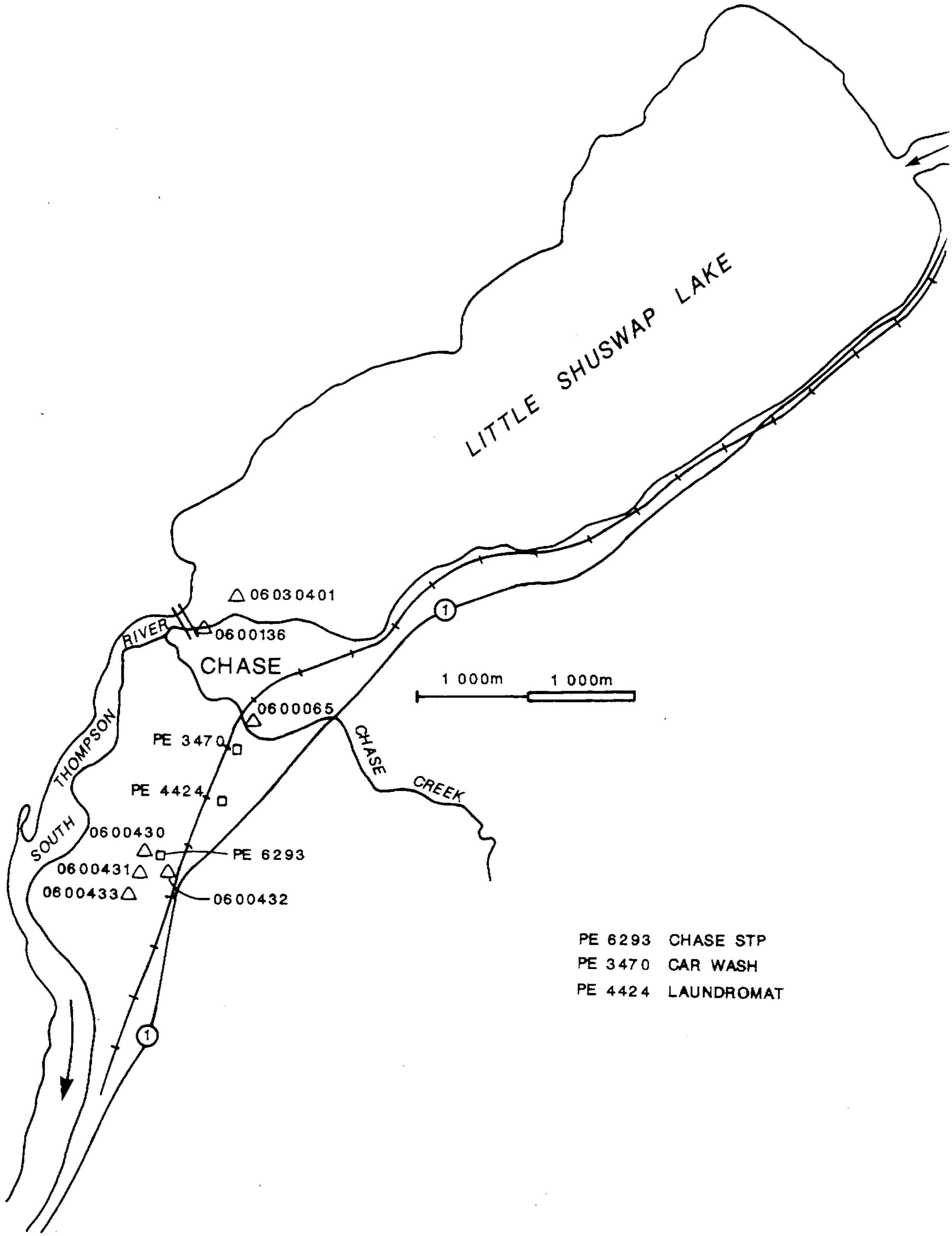


Figure 3. Hydrograph for the South Thompson at Monte Creek (08LE069)

Figure 4. Waste discharges and sampling sites in the Chase area.



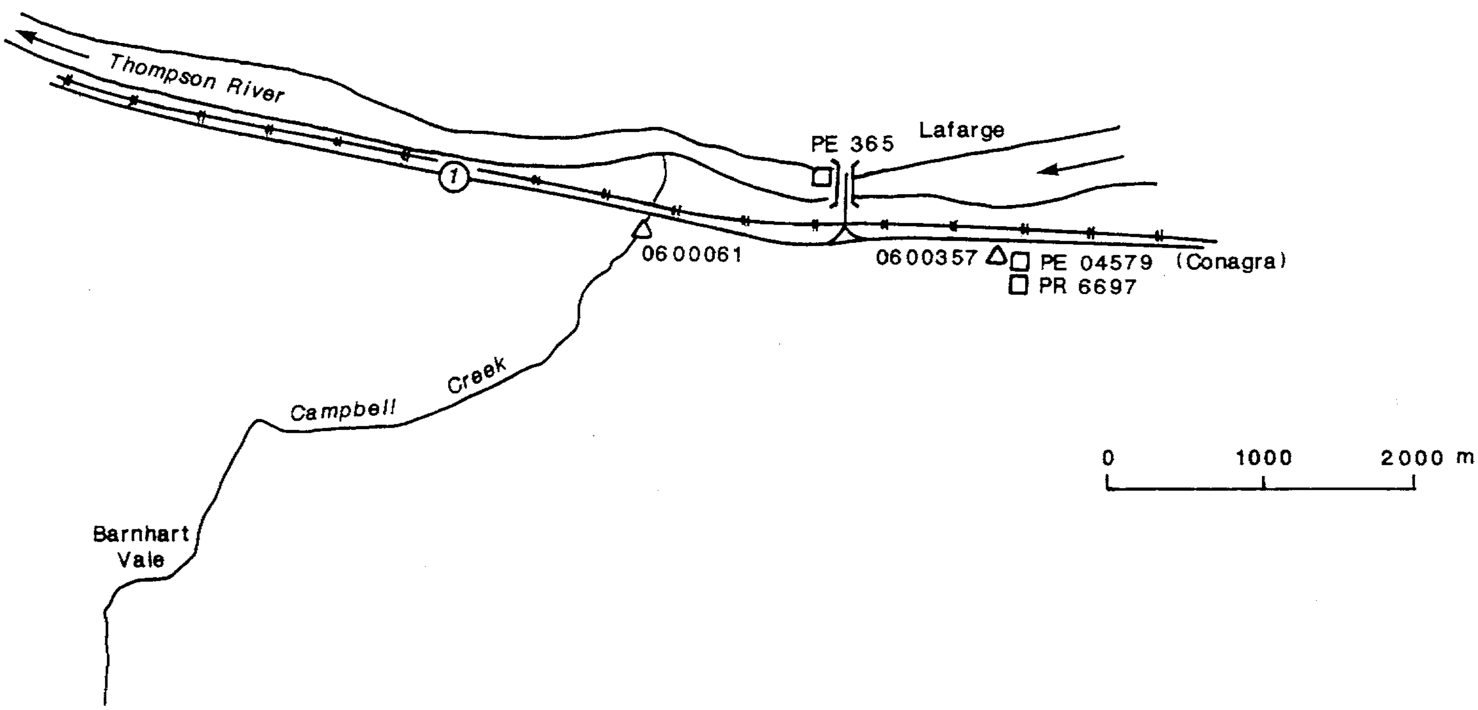


Figure 5. Waste discharges and sampling sites in the Campbell Creek area.

Figure 6. Waste discharges and water quality sites near the confluence of the North and South Thompson Rivers.

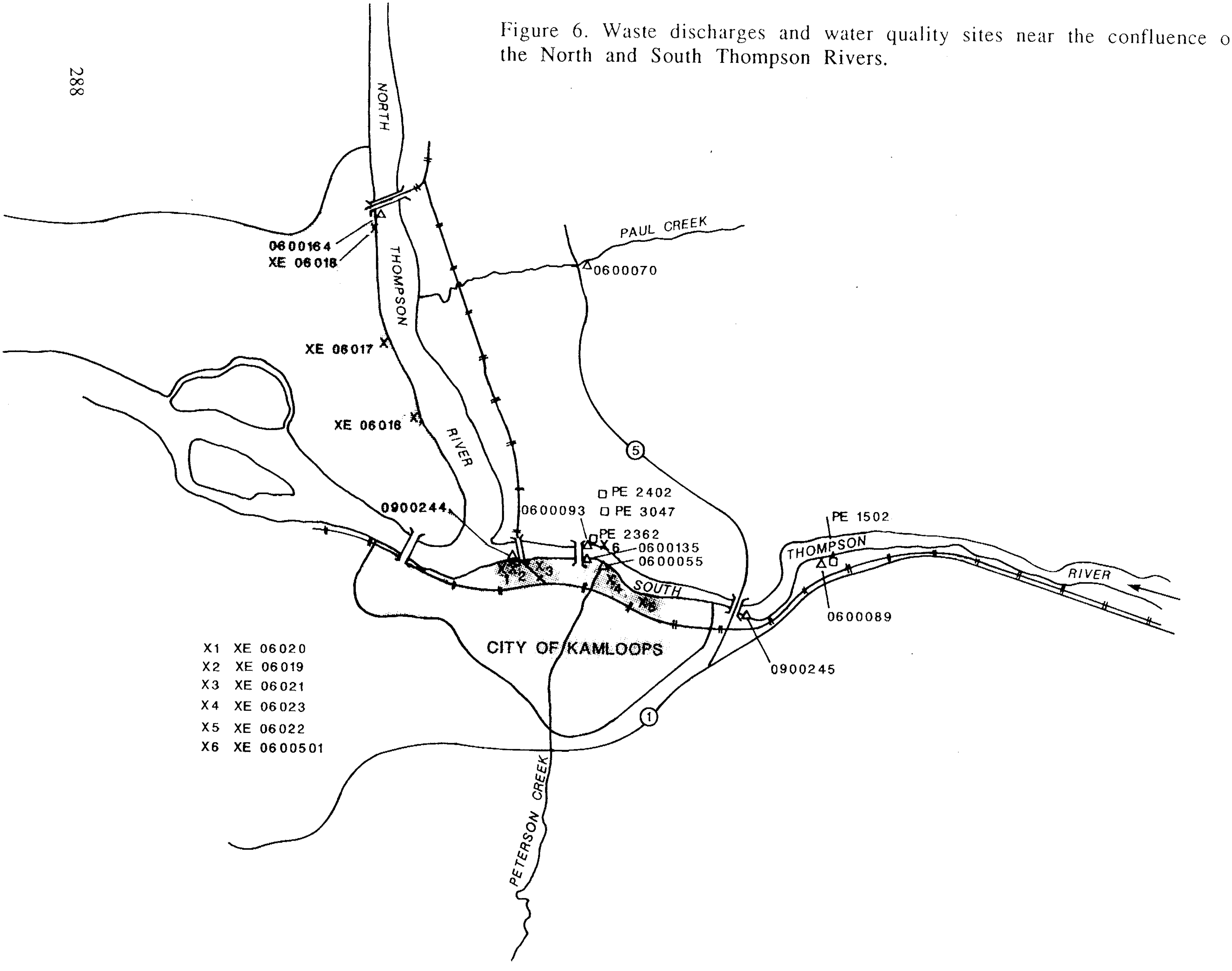
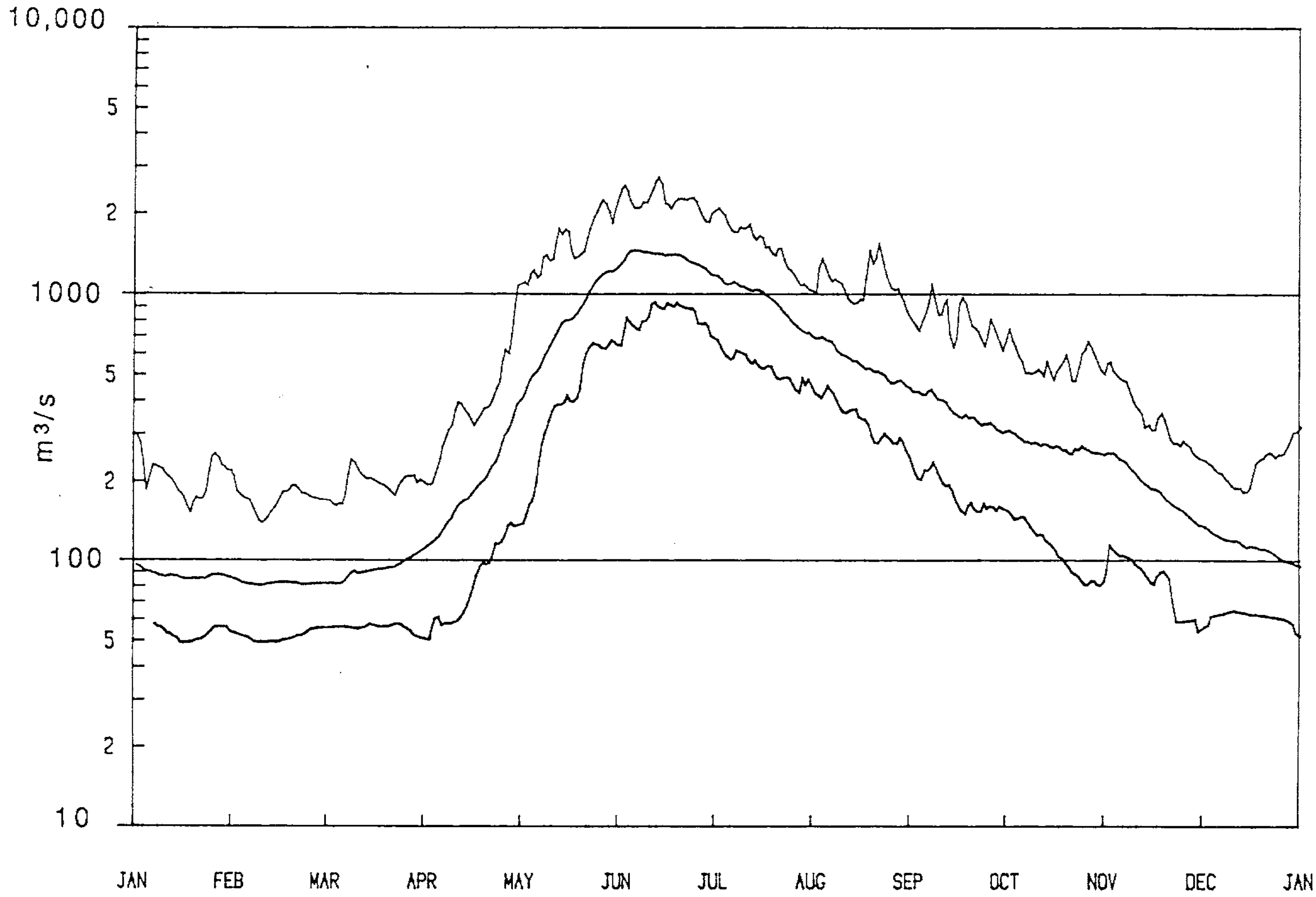


Figure 7. Hydrograph for the North Thompson at McLure (08LB064). Streamflow envelope 1911-87. The X-axis is an exponential one in cubic meters per second.



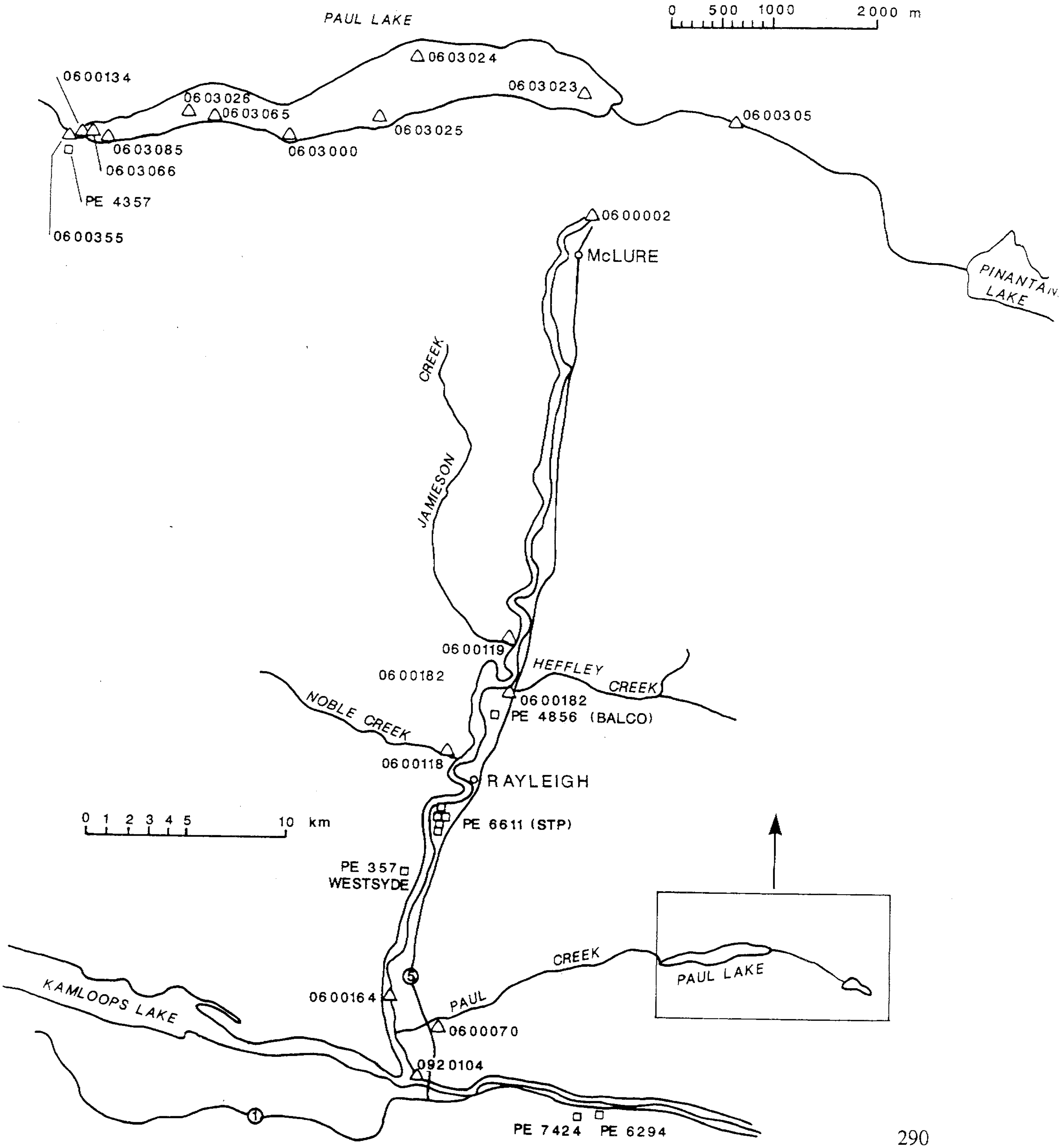
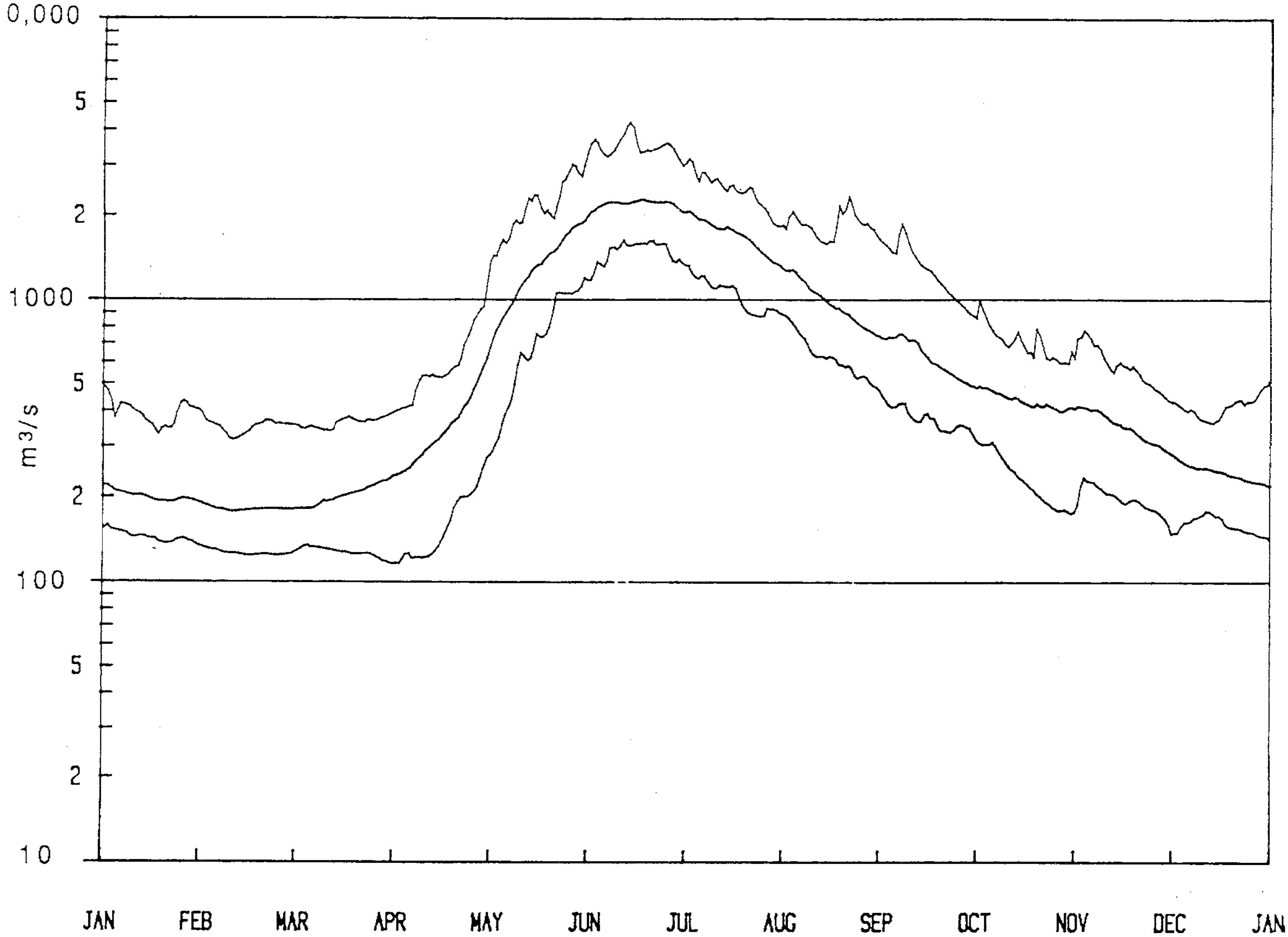


Figure 8. Waste discharges and sampling sites on the North Thompson below McLure.

Figure 9. Calculated hydrograph for the combined flow of the North and South Thompson below the confluence. Streamflow envelope 1911-87. The X-axis is an exponential one in cubic meters per second.



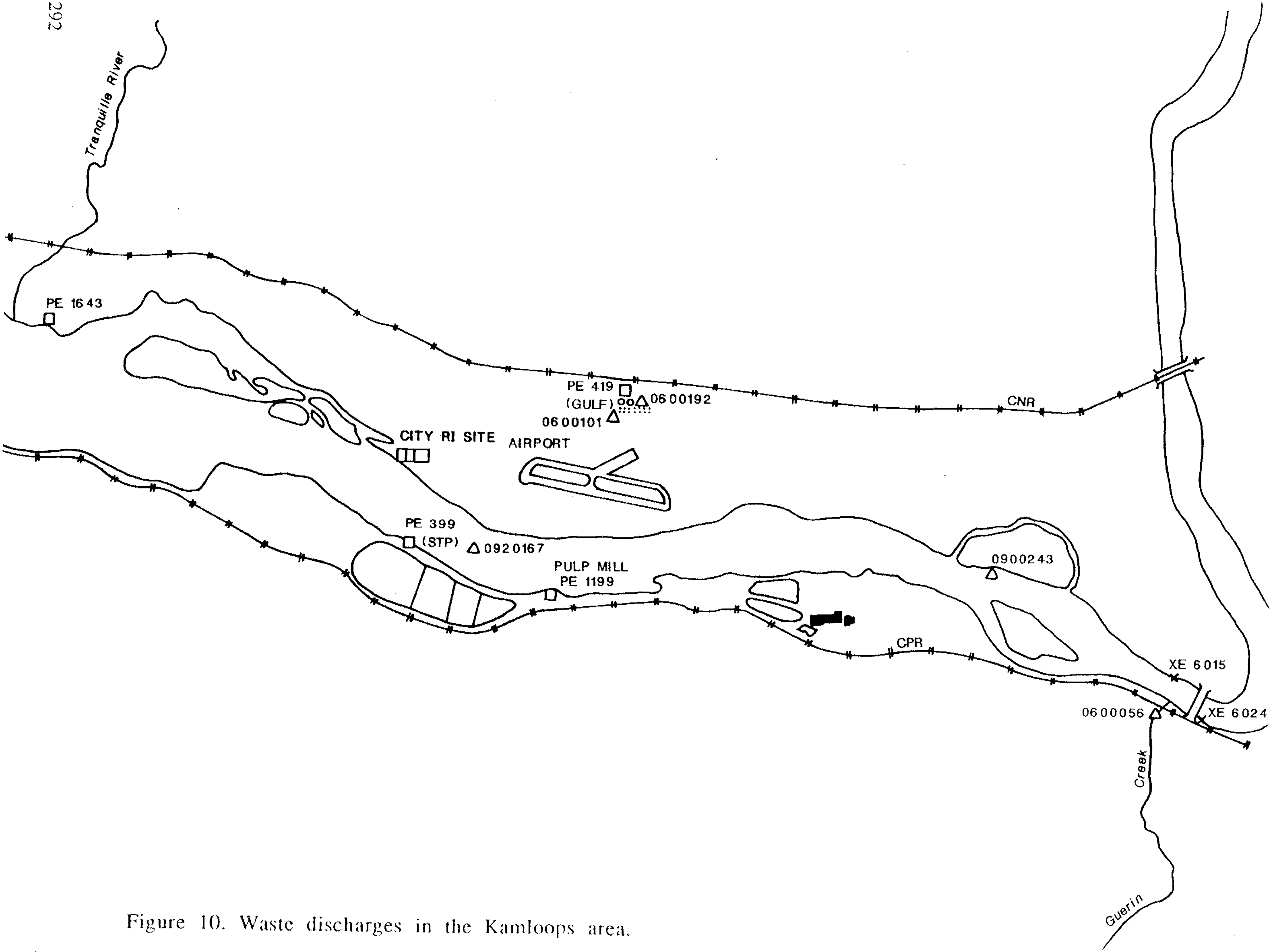


Figure 10. Waste discharges in the Kamloops area.

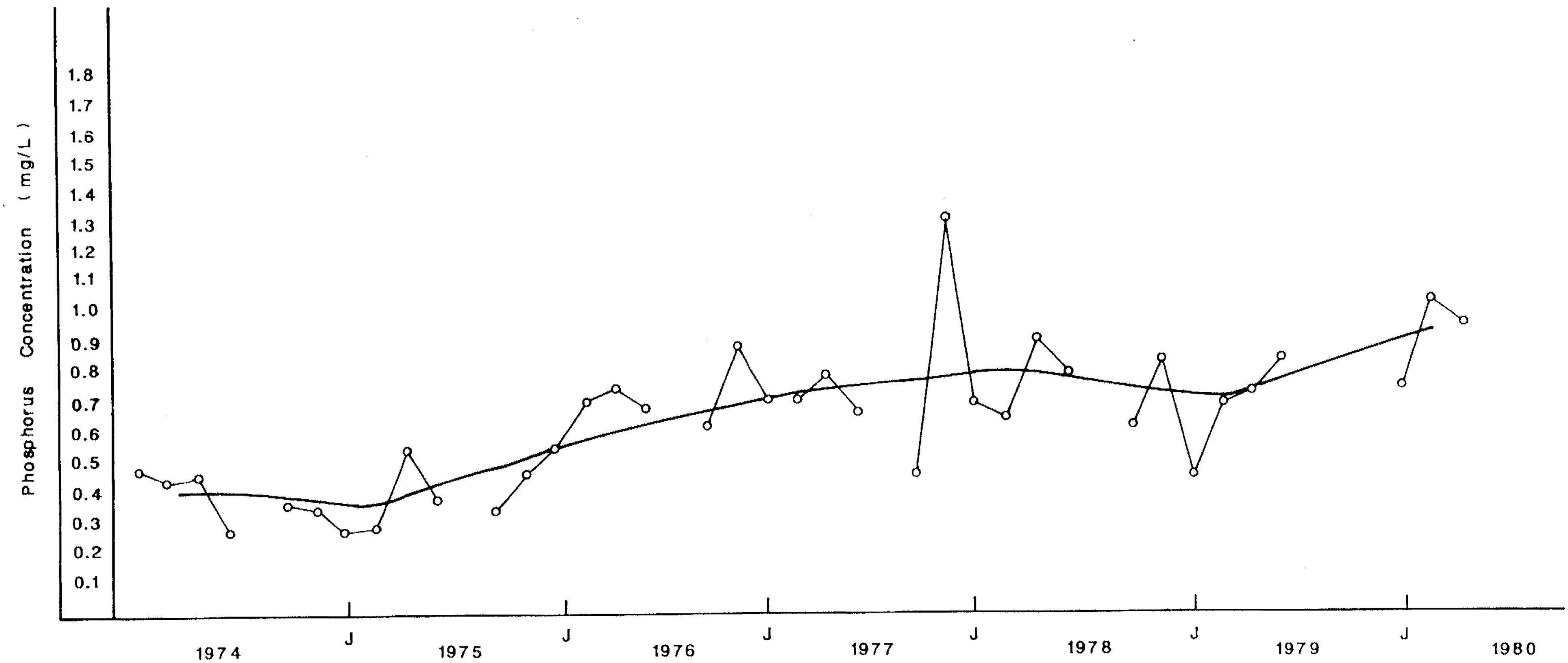


Figure 11. Total phosphorus concentration in the pulp mill effluent 1975-80.

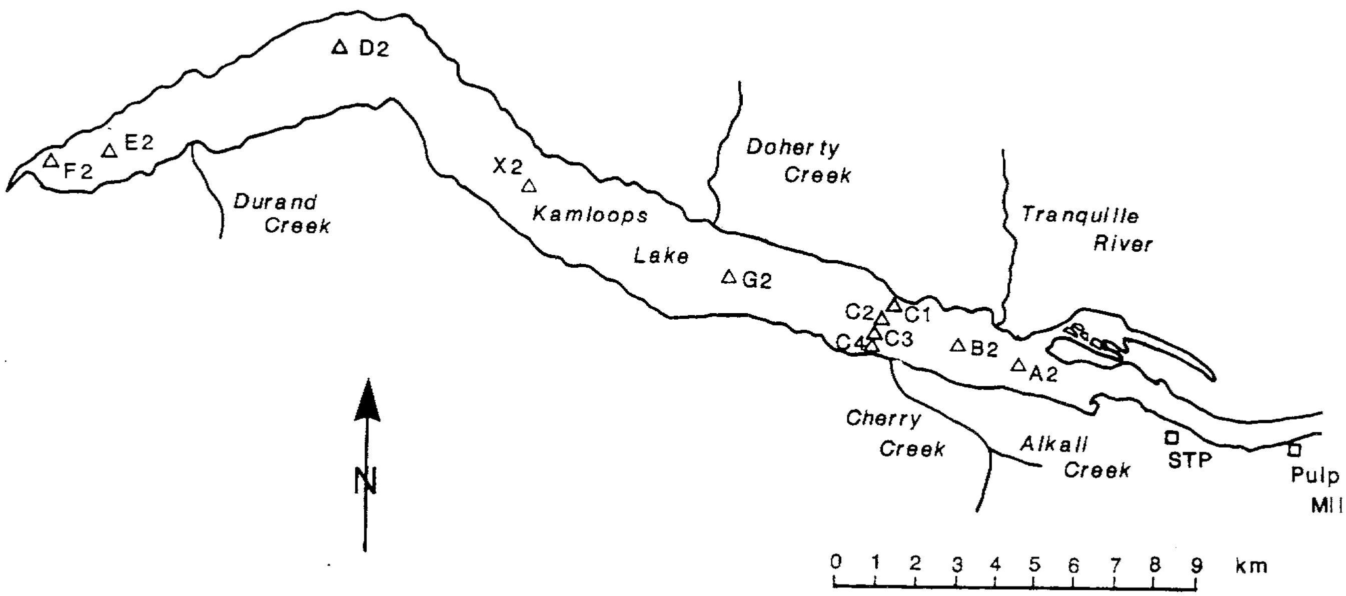
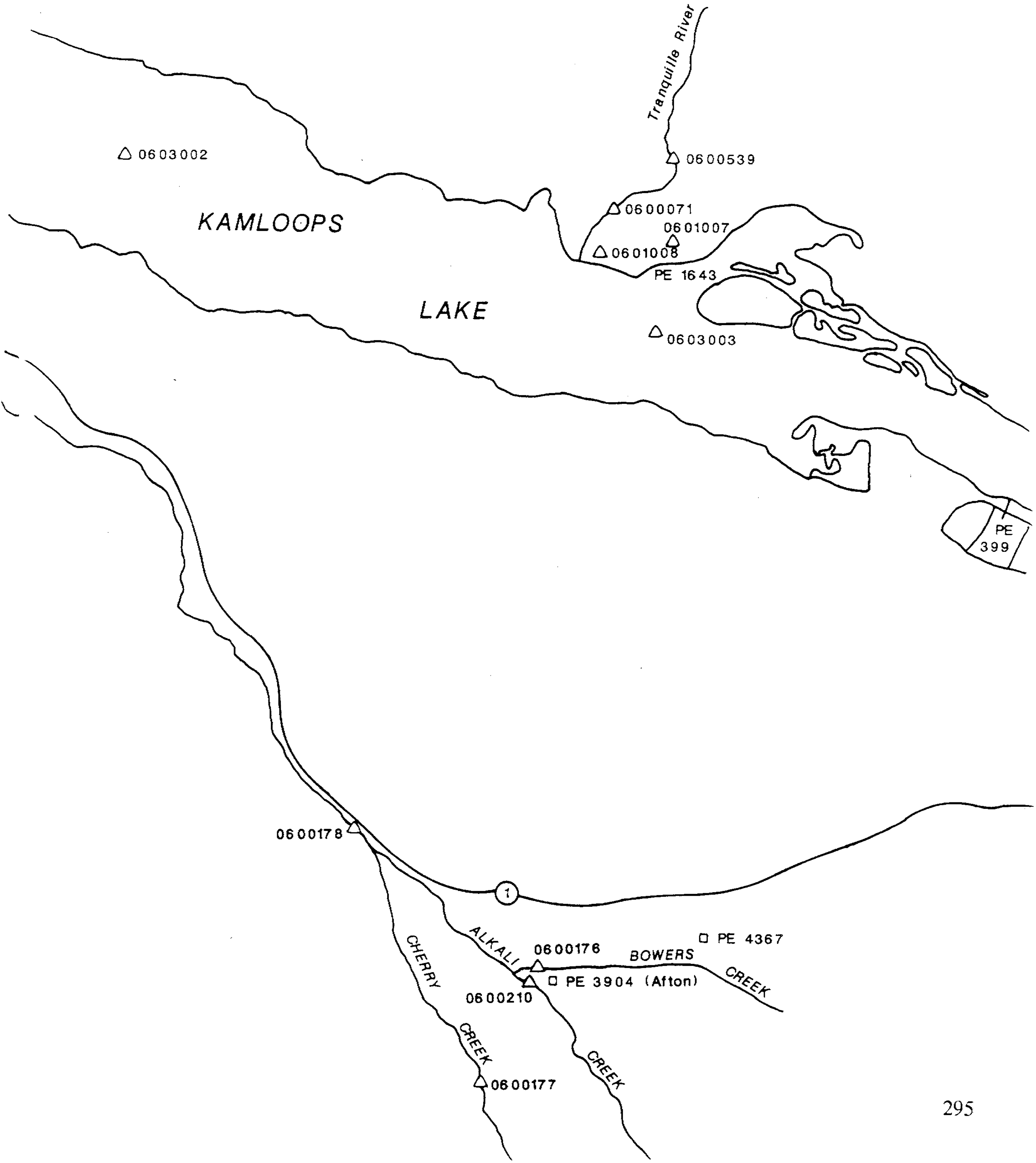


Figure 12. Kamloops Lake monitoring stations.

Figure 13. Waste discharges and monitoring sites, the east end of Kamloops Lake.



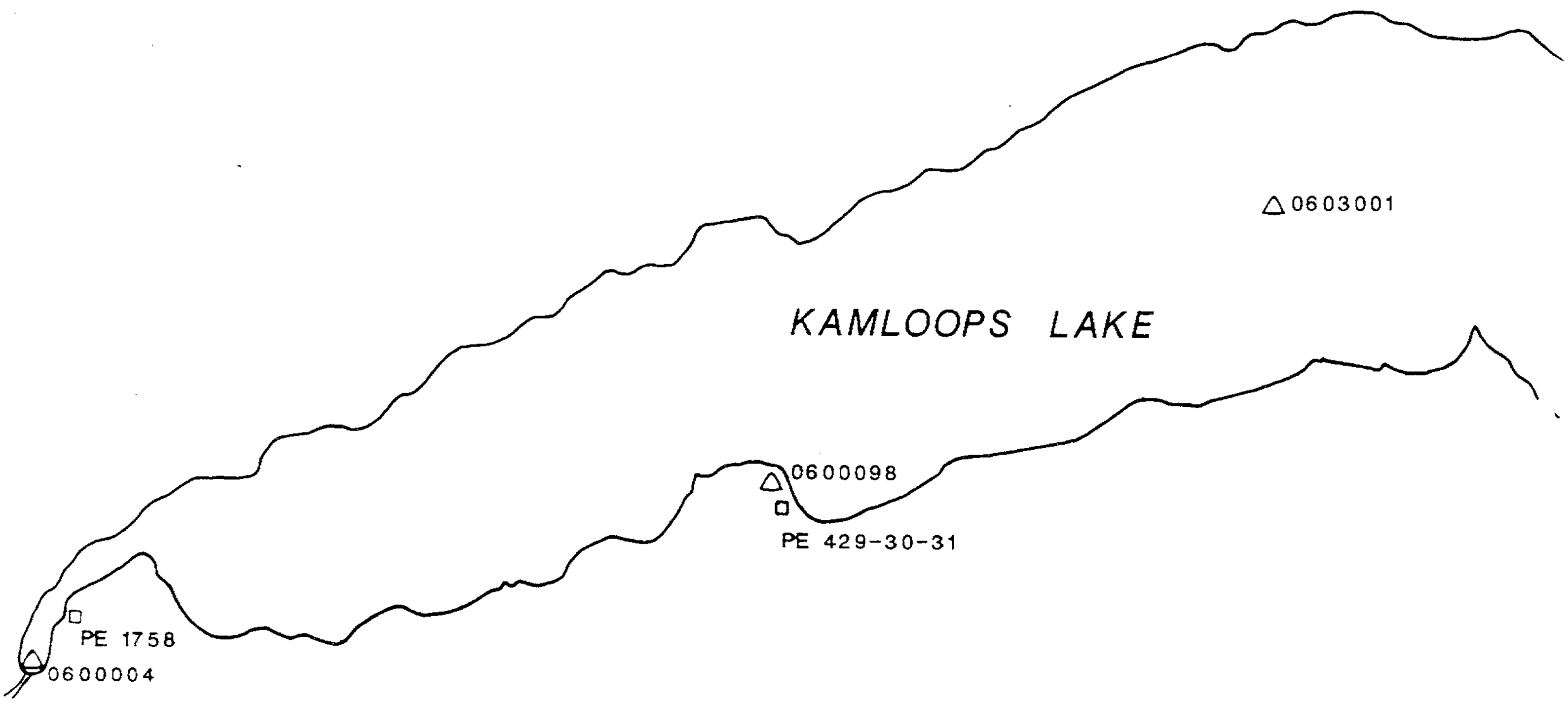


Figure 14. Waste discharges and monitoring sites, the west end of Kamloops Lake.

Figure 15. Hydrograph for the lower Thompson at Savona (08LF033). Streamflow envelope 1911-87. The X-axis is an exponential one in cubic meters per second.

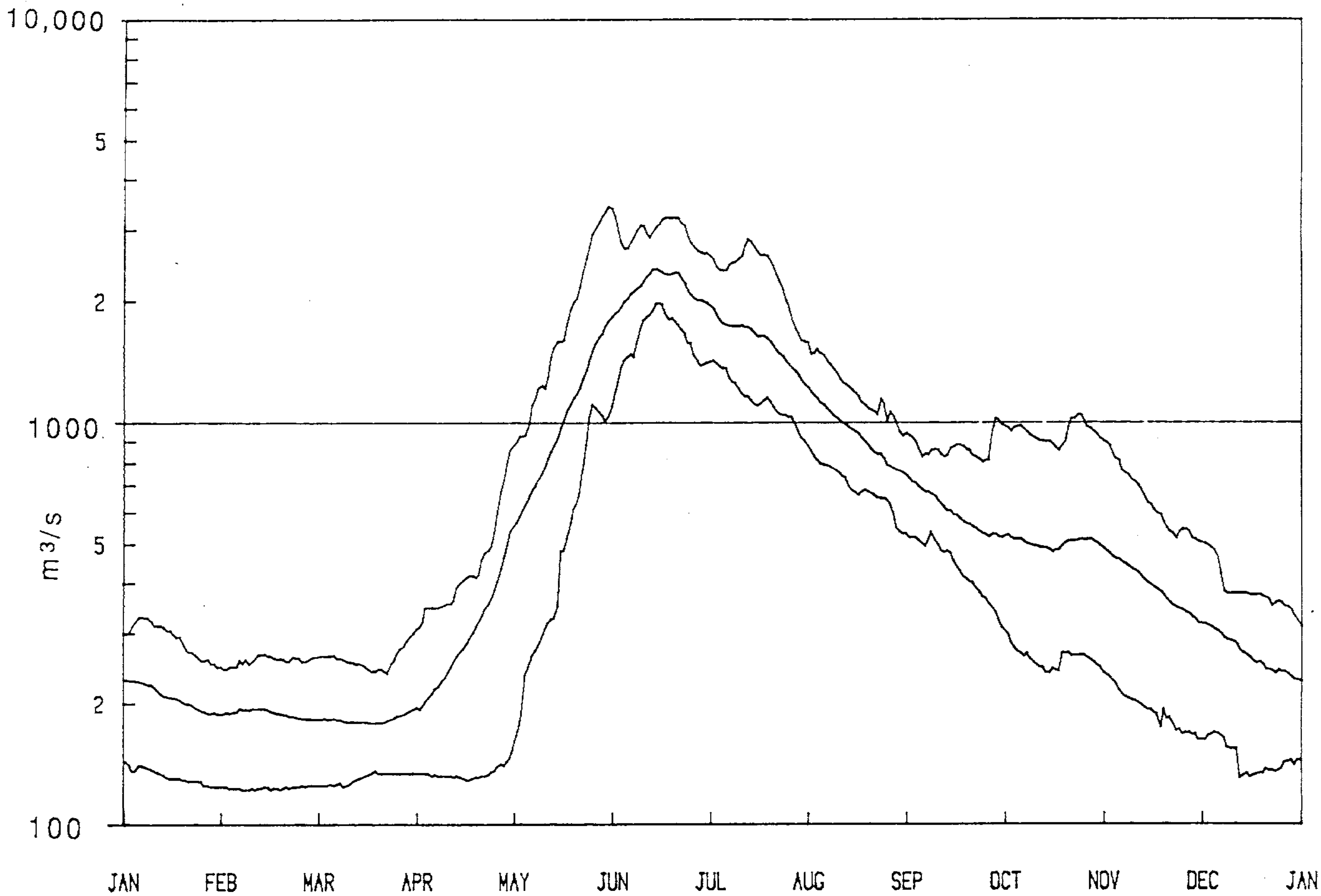
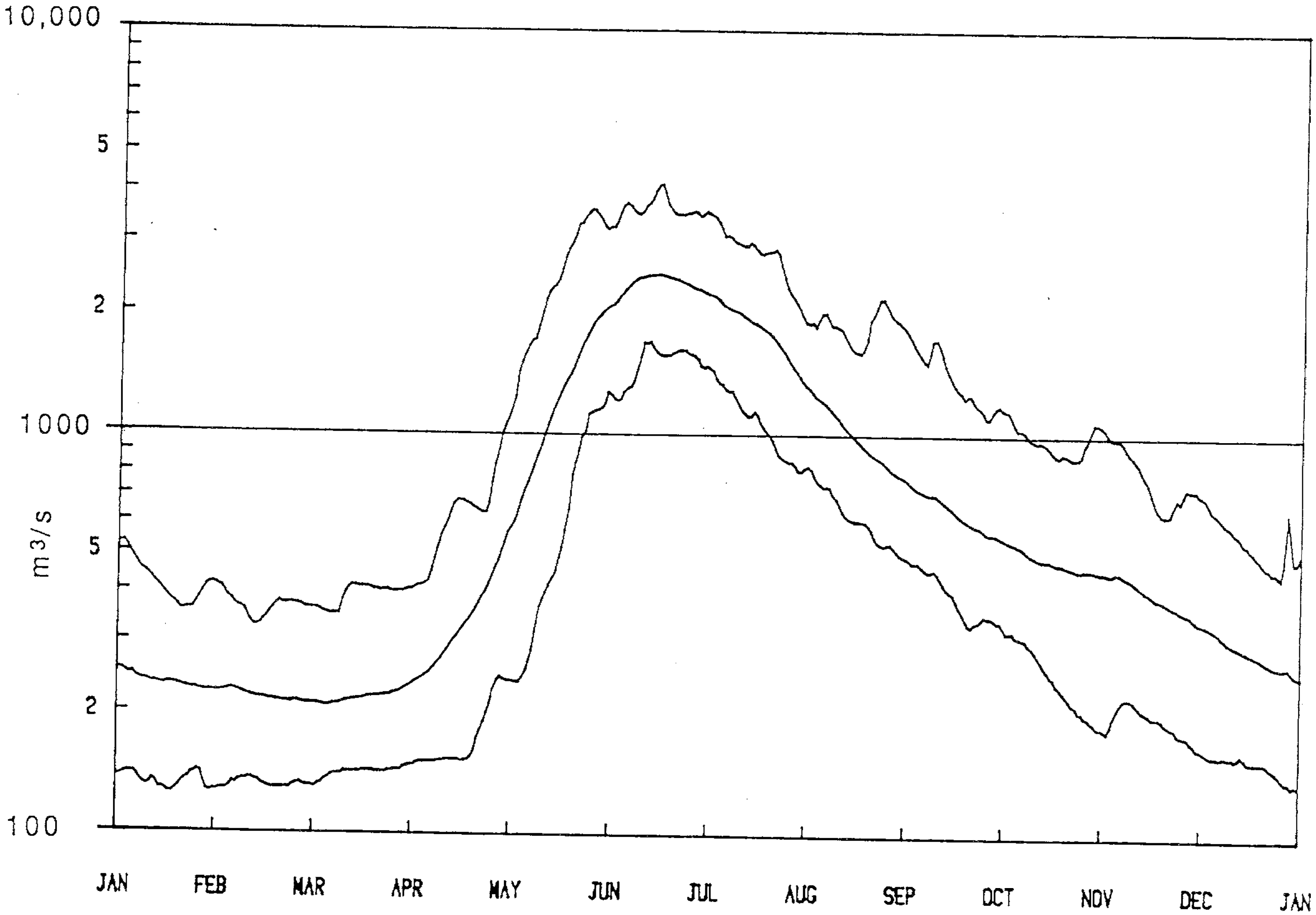


Figure 16. Hydrograph for the lower Thompson at Spences Bridge (08LF051). Streamflow envelope 1911-87. The X-axis is an exponential one in cubic meters per second.



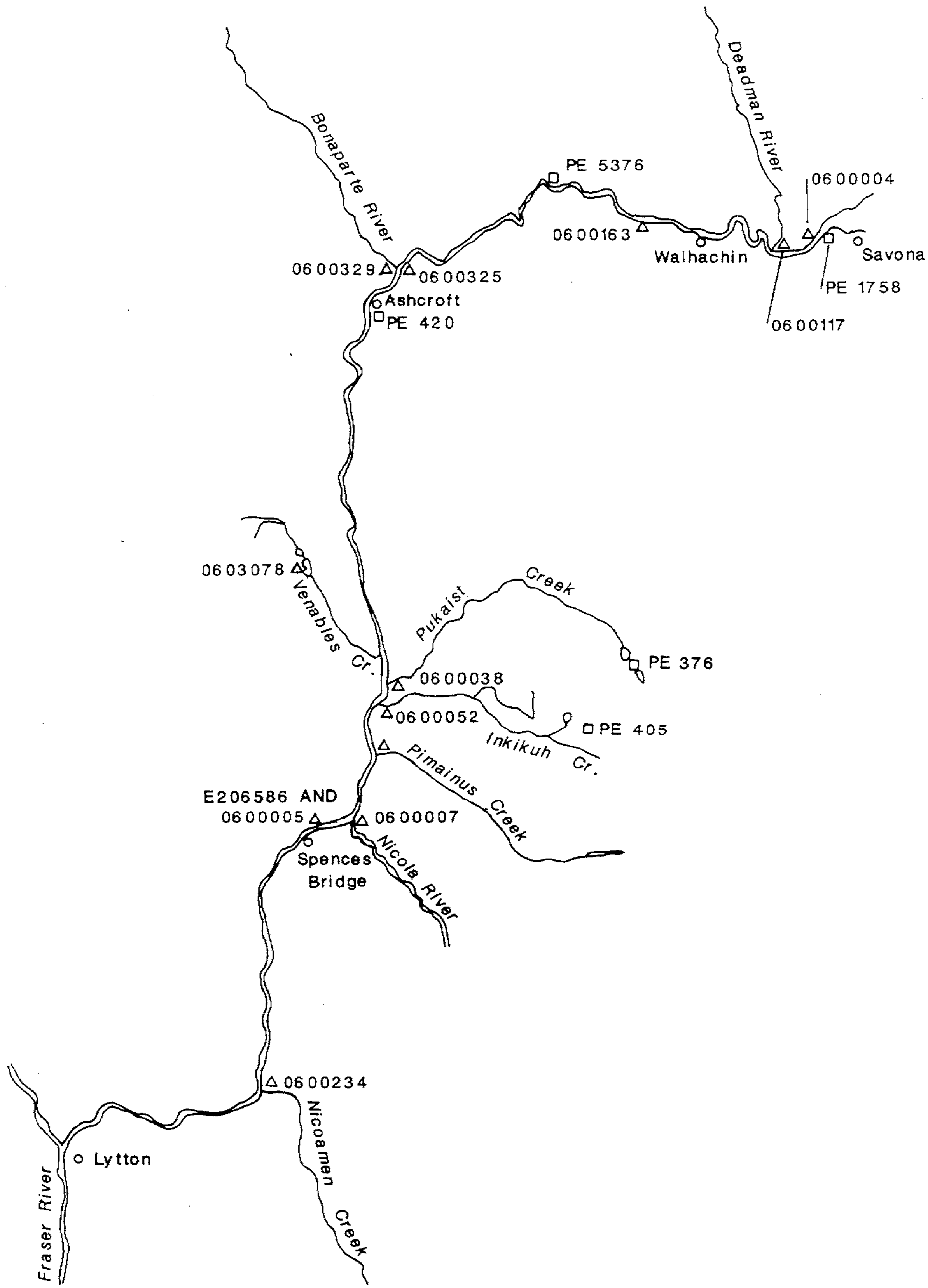


Figure 17. Waste discharges and monitoring sites between Kamloops Lake and the Fraser River.

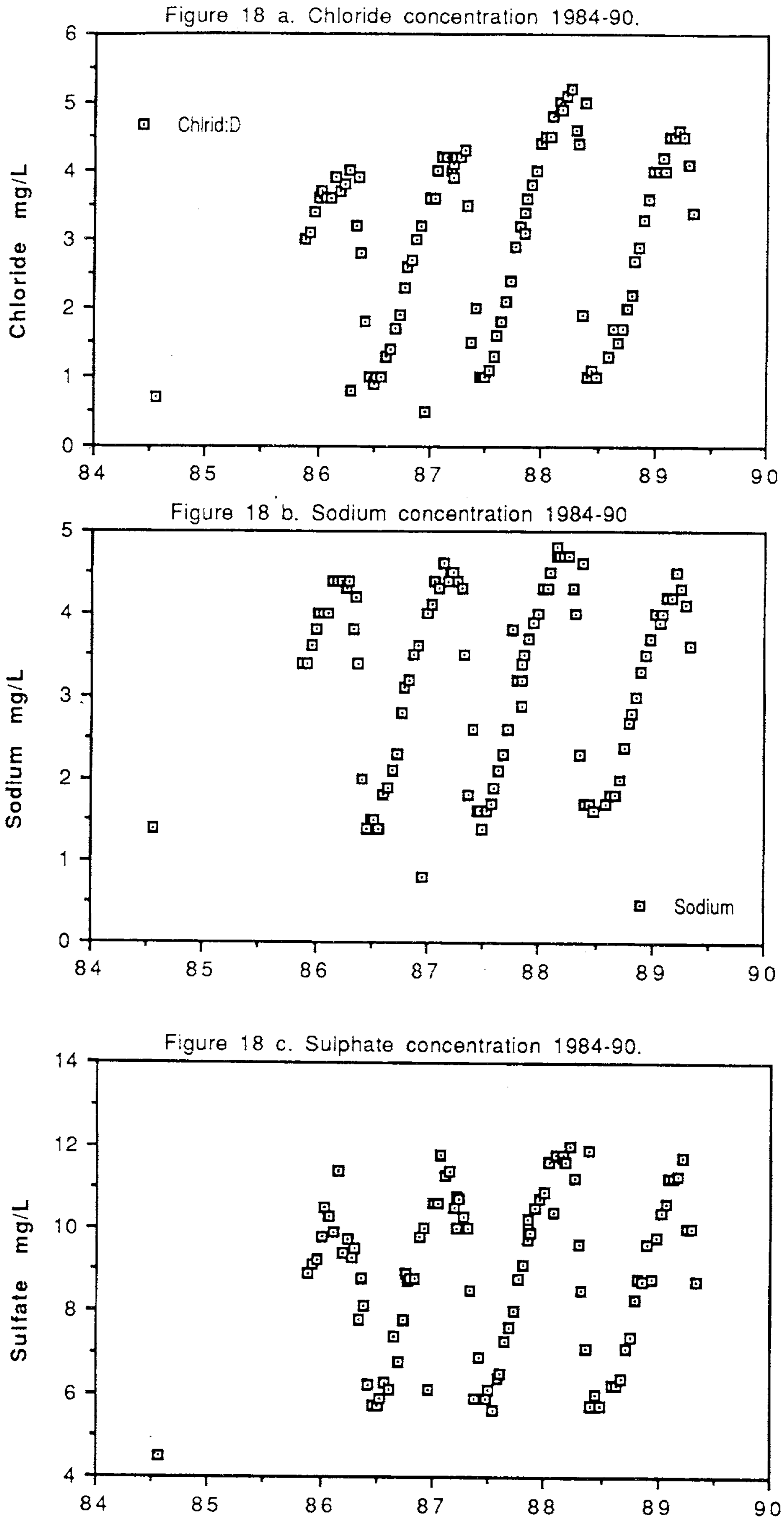


Figure 18. Changes in water quality constituents over time in the lower Thompson River at Spences Bridge.

Figure 18 d. Specific conductance 1984-90.

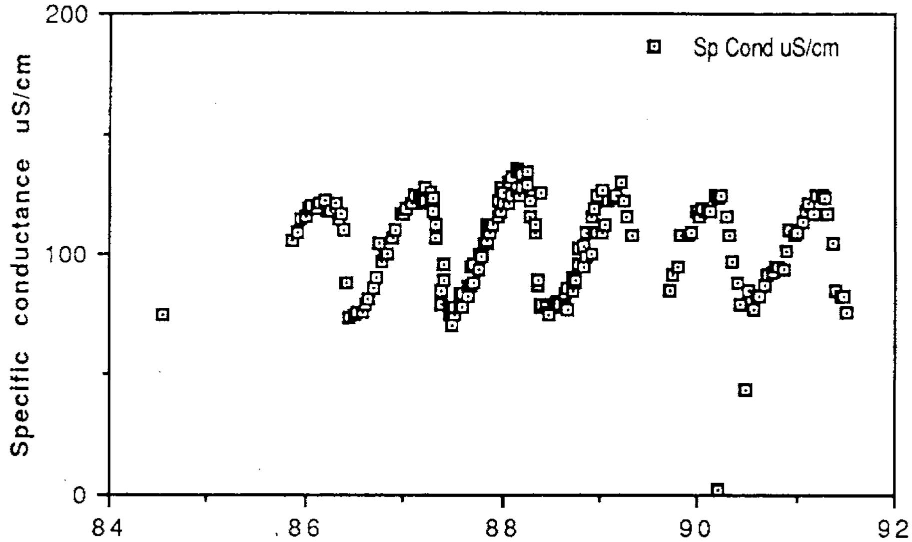


Figure 18 e. Calcium concentration 1984-90.

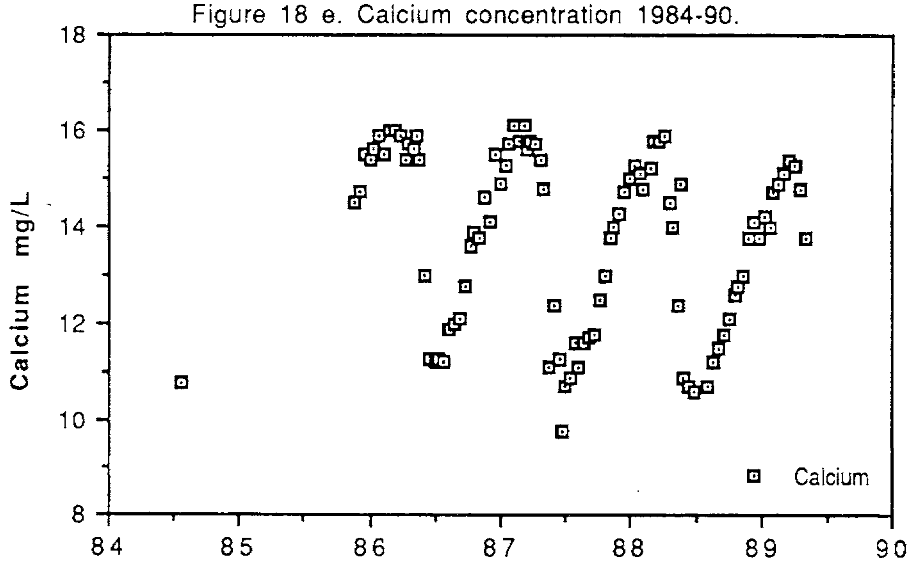


Figure 18 f. Hardness concentration 1984-90.

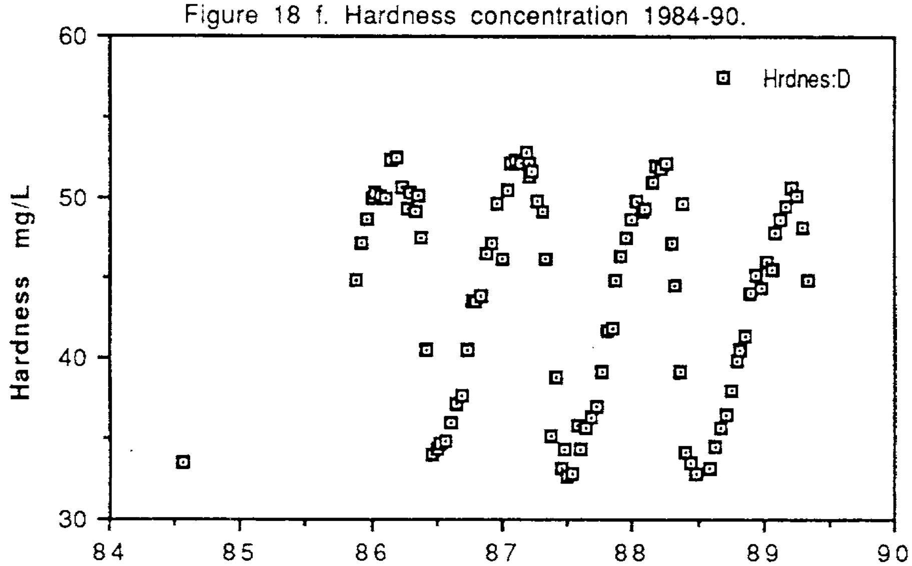


Figure 18 g. Colour values 1984-90.

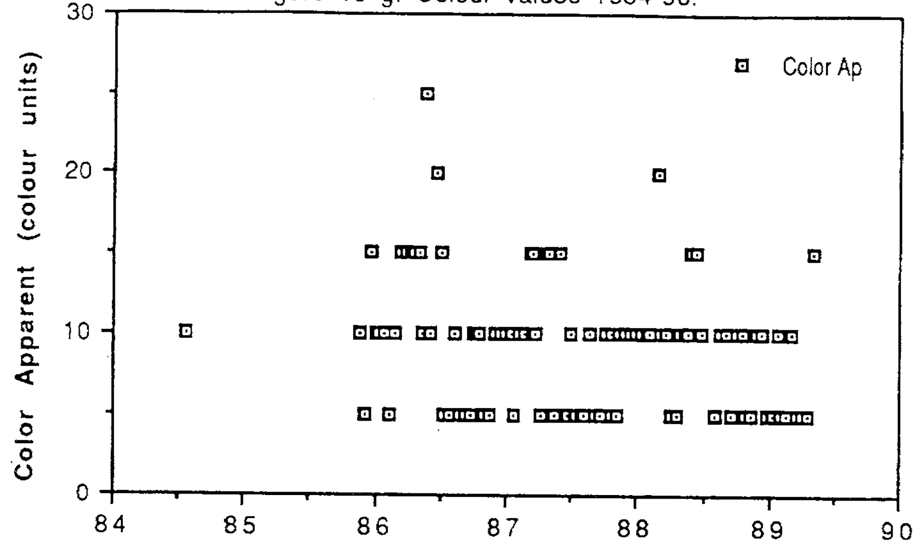


Figure 18 h. Turbidity values 1984-90.

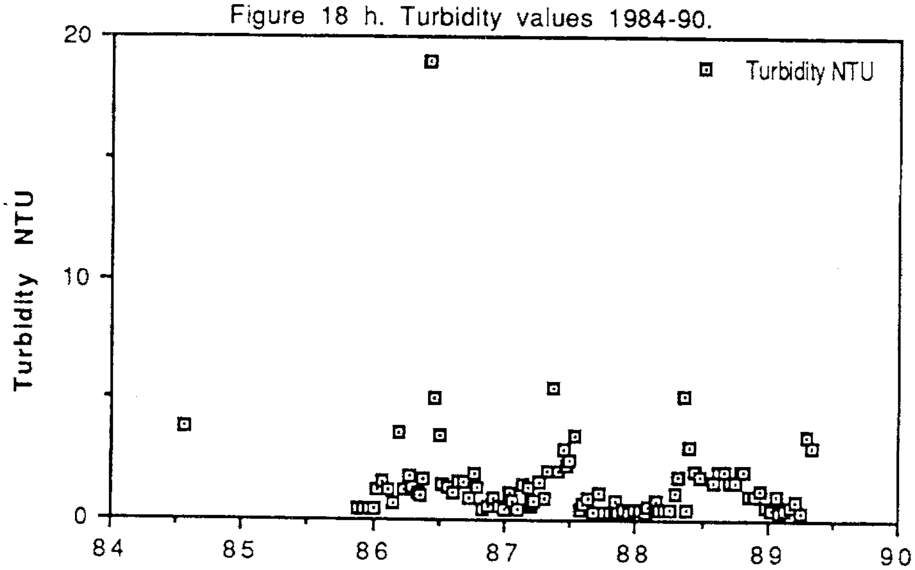


Figure 18 i. Hydrogen ion concentration 1984-90.

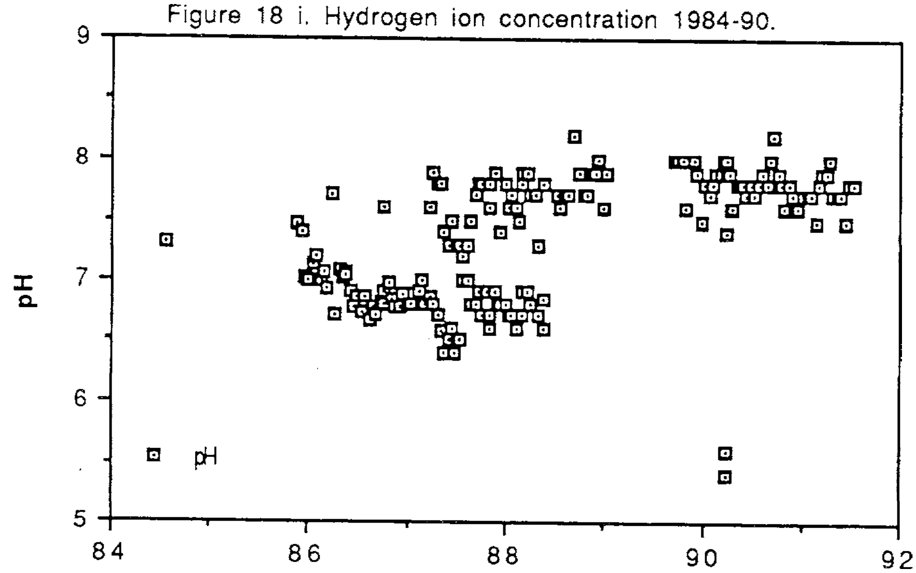


Figure 18 j. Concentration of total dissolved nitrogen 1984-90.

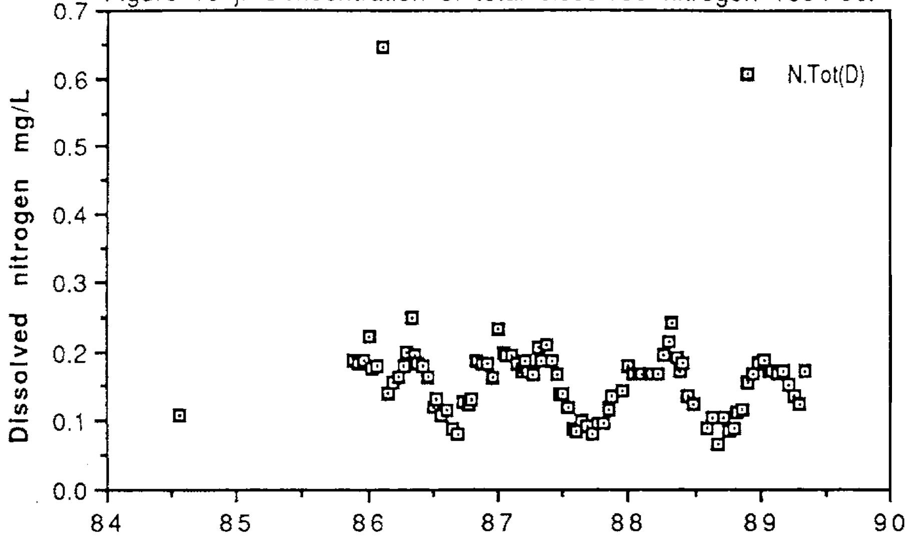


Figure 18 k. Total dissolved phosphorus 1984-90.

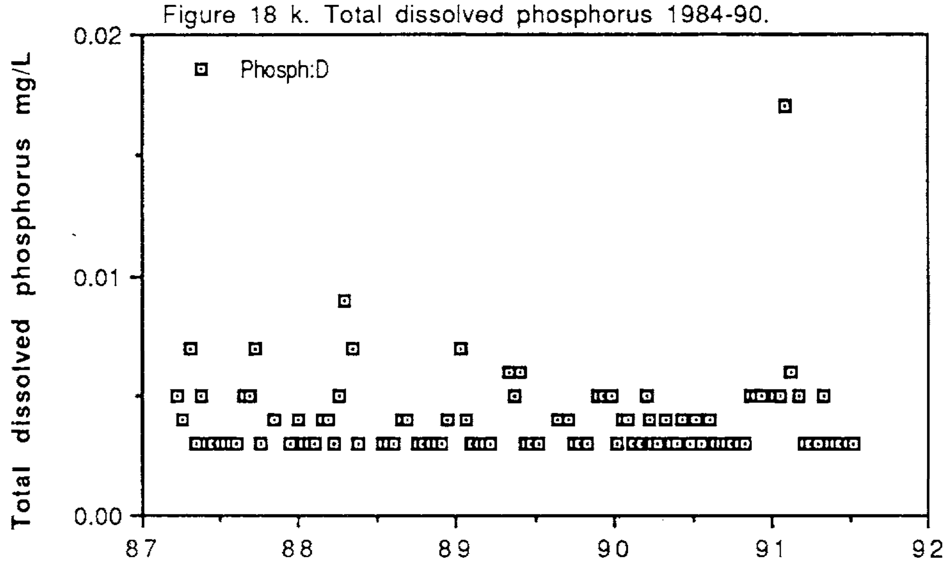


Figure 18 l. Total phosphorus 1984-90.

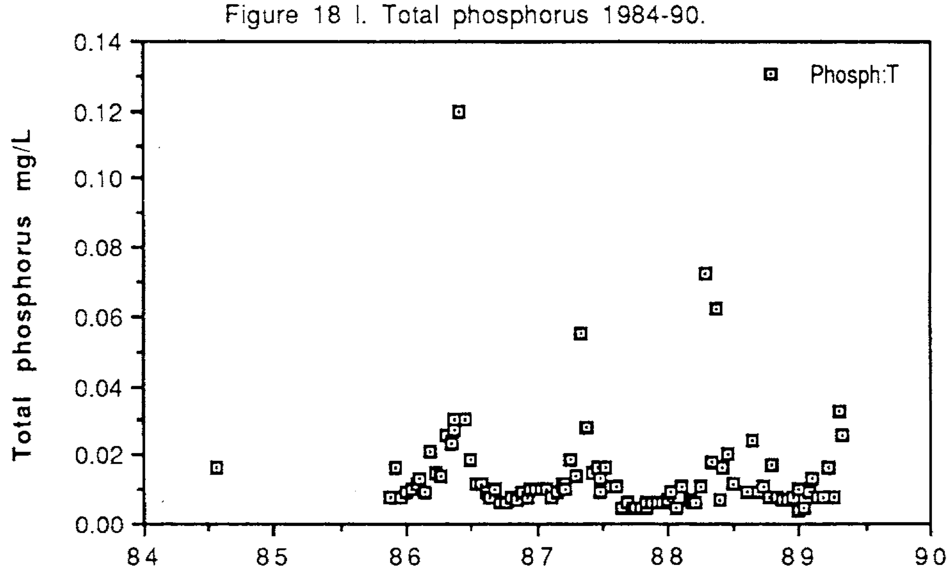


Figure 18 m. Arsenic concentration 1984-90.

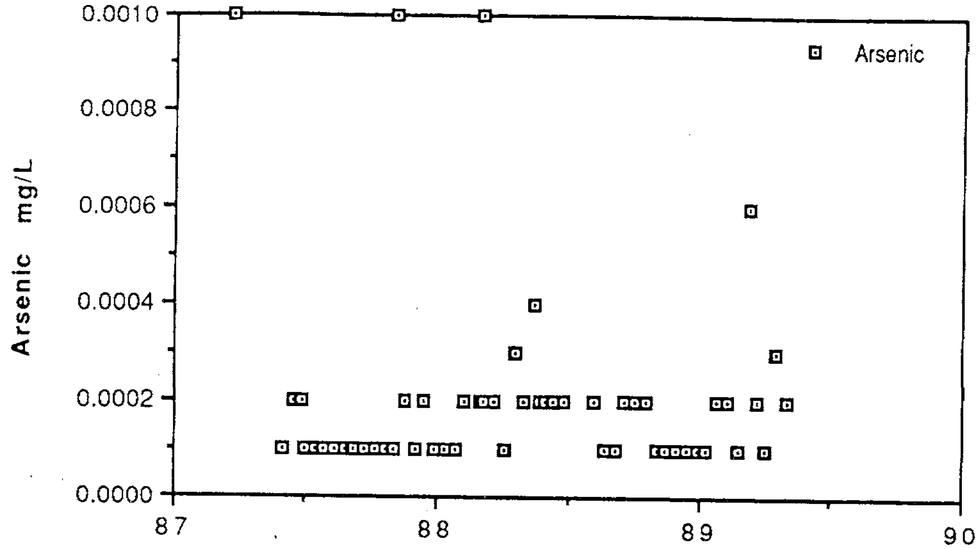


Figure 18 n. Copper concentration 1984-90.

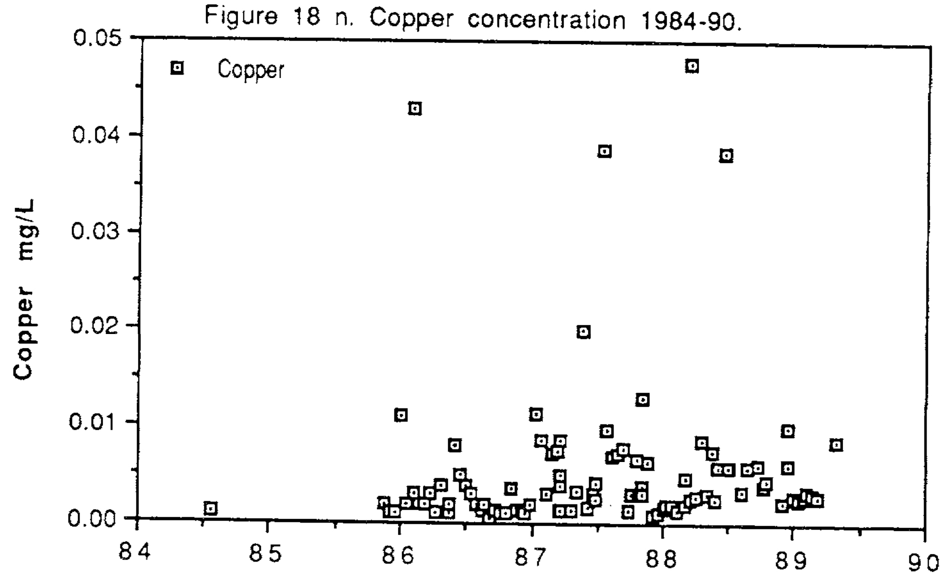


Figure 18 o. Flouride concentrations 1984-90.

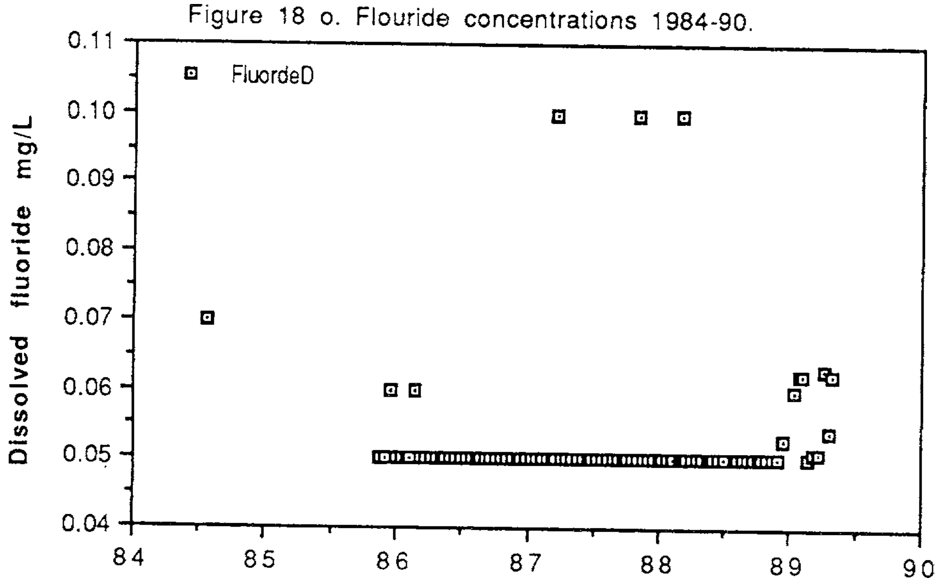


Figure 19 a. Comparison of coincident colour measurement at McLure.

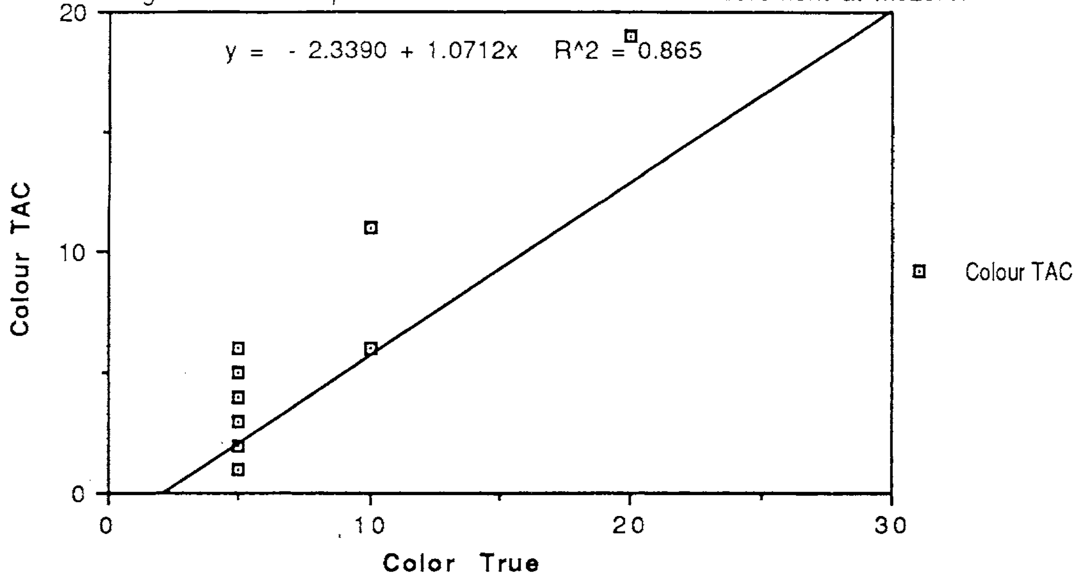


Figure 19b. Comparison of coincident colour measurements at Savona

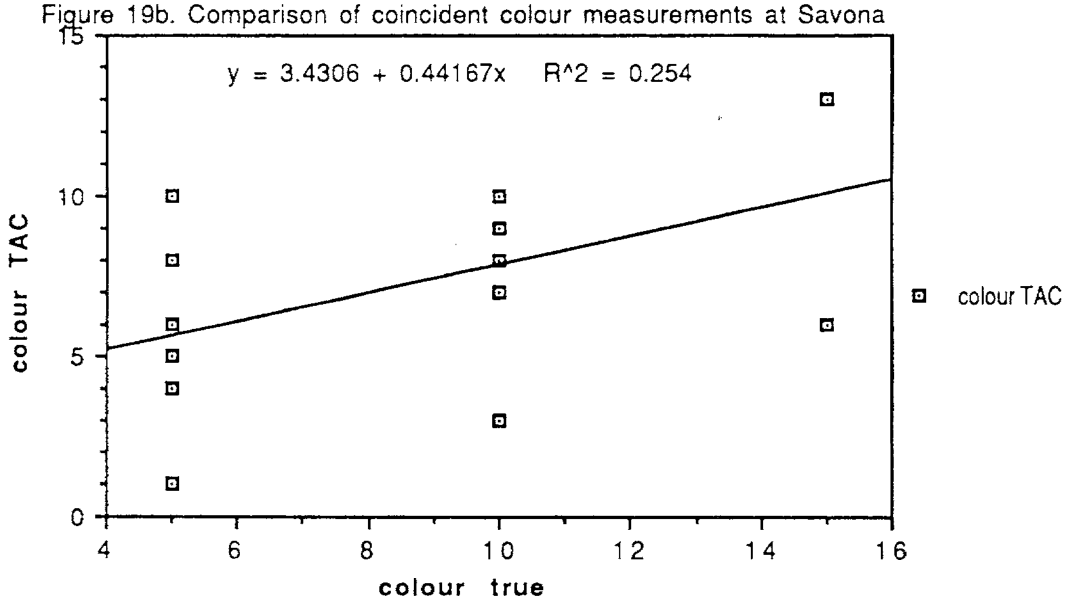


Figure 19 c. Comparison of coincident colour measurement at Spences Bridge.

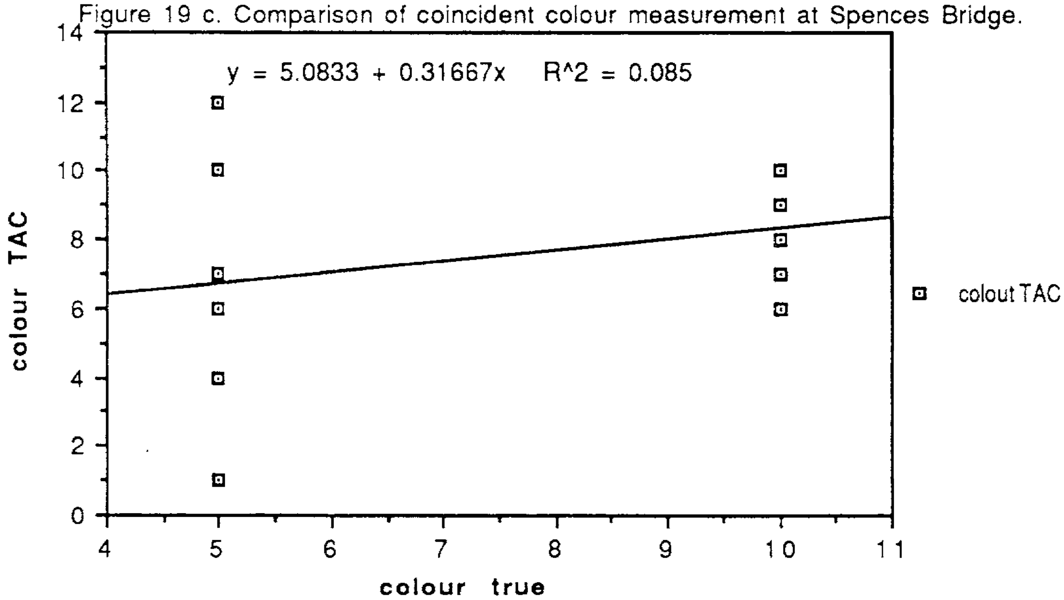


Figure 19. Comparison of colour measurement methods at different sites