CHEMICAL AND BIOLOGICAL CHARACTERISTICS

OF THE

NICOLA/COLDWATER WATERSHED

INCLUDING NICOLA LAKE

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TABLE OF CONTENTS

. . . /2

L I S T O F F I G U R E S

COLDWATER-NICOLA

INTRODUCTION

A one year intensive study on the water quality of the Nicola-Coldwater watershed was completed in early 1979. The objectives of the study were to:

1) Determine the basic water quality of the Nicola River
2) Determine the effect of the Merritt STP on the Coldwater and Nicola Rivers prior to plant upgrading in late 1979.
3) Determine the basic limnology of Nicola Lake.

Physical Description

The Nicola River originates on an elevated plateau south of the City of Kamloops. It flows in a westerly direction through a combination of forested and open range land and enters the northeast Nicola Lake. Nicola Lake is a long, large (2516 hectares), relatively deep ($\bar{x}$ depth = 23.5 m) body of water, quite intensively utilized for recreation purposes.

Nicola River exits from the south end of the lake and flows in a southerly direction through mainly open, intensively used rangeland. From the lake to the Town of Merritt, excessive amounts of the river water are utilized for irrigation purposes. The Nicola River joins the Coldwater River at the west end of the town of Merritt. The Coldwater River is of a distinctly different nature than the Nicola River. It rises in mountainous terrain south of Merritt and prior to its confluence with the Nicola could be characterized as a distinctly oligotrophic, fast water river.

The Town of Merritt discharges 3 000 m^3 of 2^o treated sewage into the Coldwater River approximately 100 m upstream of the confluence with the Nicola. The Nicola, after its confluence with the Coldwater, flows in a westerly direction through mainly agriculture land to its confluence

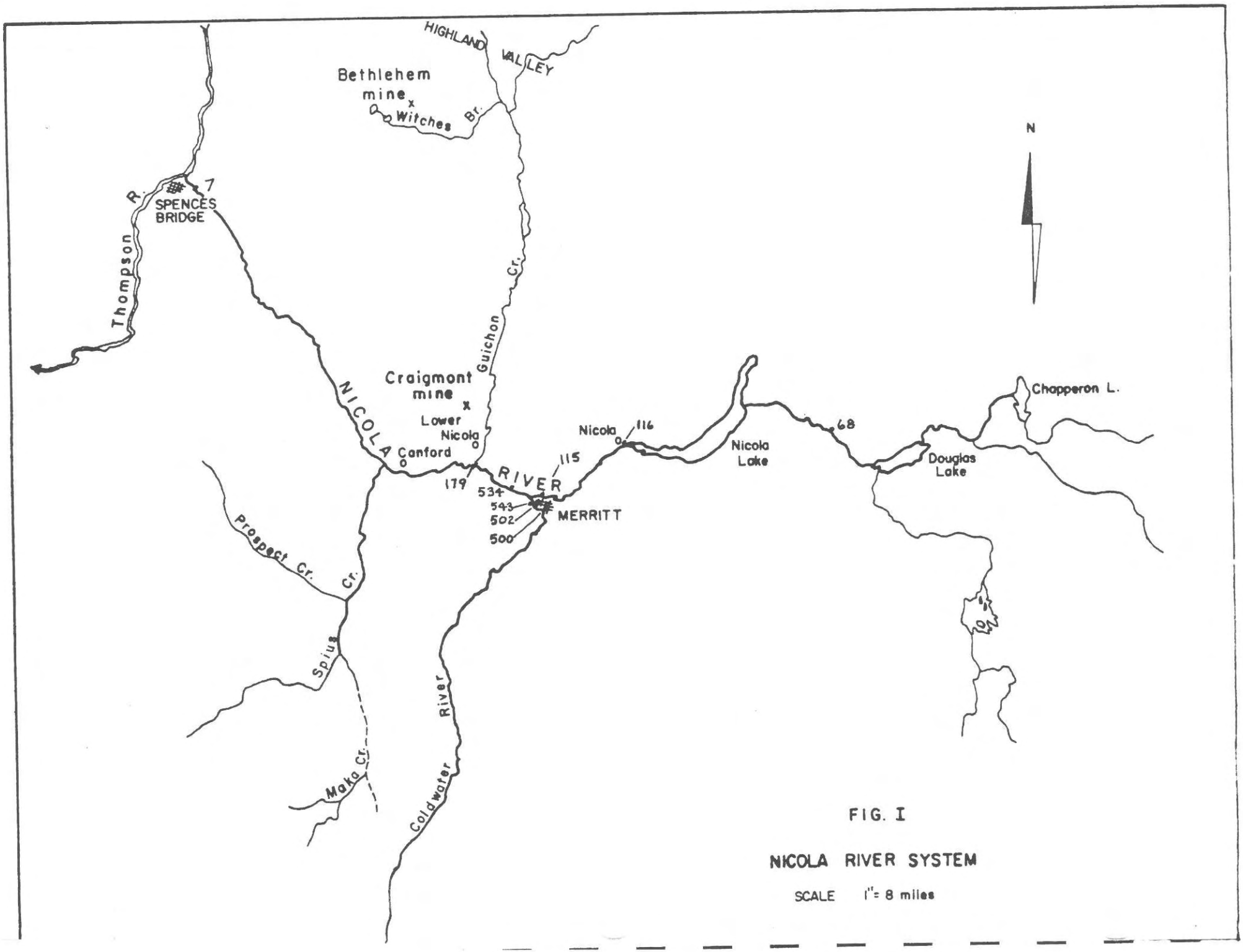

FIG. I

NICOLA RIVER SYSTEM

SCALE 1"= 8 miles

with the Thompson River at Spences Bridge. Throughout most of its length, the Nicola River is slow flowing, meandering type of stream.

METHODS AND MATERIALS

I. NICOLA AND COLDWATER RIVERS

A. Physical

Nine sampling sites were established in the watershed, six on the Nicola River and three on the Coldwater River (Fig. 1).

Flow data were obtained from Water Survey of Canada records from various stations in the watershed. Since most samples were taken in the morning, the determination of loading rates for a particular day included the averaging of the previous day's flow with the particular sampling date flow. If the sampling of all stations took two consecutive days, the loading was based on the flows previous to the first sampling data plus the two sampling dates.

B. Water Chemistry

The sites were sampled biweekly during the active growth seasons and monthly during the winter. All samples were grabs and were analyzed for the following parameters:

pH	Total Nitrogen
Specific Conductance	Kjeldahl Nitrogen
Total Residue	Organic Nitrogen
Filterable Residue	Ammonia Nitrogen
Organic Carbon	Nitrate Nitrogen
Inorganic Carbon	Nitrite Nitrogen
Total Phosphorous	Total Coliforms
Total Dissolved Phosphorous	Fecal Coliforms

Samples were also taken at the same time as the water chemistry samples and analyzed for total and fecal coliforms.

C. Biology

Two concrete blocks, each with two plexiglass plates, were set at six sites to determine periphyton growth. The sites for the periphyton study were chosen to determine the effects of the Merritt STP on the two rivers. After remaining in the river for 2 weeks, the plates were removed from the blocks and all algal growth within a designated area on the plates was scraped into a container. The contents of the containers were split into two aliguots and analyzed for chlorophyll "a" and total and total fixed weights. Some periphyton species identification was also done.

Macroinvertebrate populations were sampled at the same sites using stationary multiple plate samplers. The samples were identified to the genus or species level.

II. NICOLA LAKE

Four sites were sampled biweekly in Nicola Lake in the summer of 1978. The water samples were obtained by immersing a 1" diameter Tygon tube to a depth of 15 metres and removing a column of water. The sample was then composited and analyzed for the following paramters;

pH	Total Nitrogen
Specific Conductance	Kjeldahl Nitrogen
Organic Carbon	Nitrate Nitrogen
Inorganic Carbon	Nitrite Nitrogen
Total Phosphorous	Total Mercury
Total Dissolved Phosphorous	

The water transparency was determined by use of a secchi disc and temperature, oxygen and pH profiles were obtained using a YSI model 54 oxygen meter and a Metrohm pH meter.

RESULTS AND DISCUSSION

I. WATER CHEMISTRY

A. Nicola River

1. Freshet

a) Phosphorous

Total phosphorous concentration showed a steady increase downstream until the confluence with the Thompson River (Fig. 2). The mean concentration at the background station 68 was 0.027 mg/L which rose to a high of 0.128 at station 179 above Guichon Creek but then dropped to 0.032 at station 7, the mouth. A small increase occurred after confluence with the Coldwater. The largest increase occurred between station 534, below the confluence and 179, above Guichon Creek.

Total phosphorous loadings followed a similar pattern to the concentration however, the percent increases were much greater (table 1). There was over a 200% increase between the station above the Coldwater confluence (115) and below it (534). Between 534 and above Guichon Creek, the increase was 186%. The loading then decreased by 50% before the mouth (7).

The large background load of phosphorus is probably the result of agricultural activities in the river headwaters. More data are required to support this contention. The continuous increase prior to the Coldwater confluence is due to agricultural activities bordering the river and its tributaries and domestic shoreline devlopment within the Town of Merritt. The Coldwater River adds a small percent concentration increase but a large load due to the large

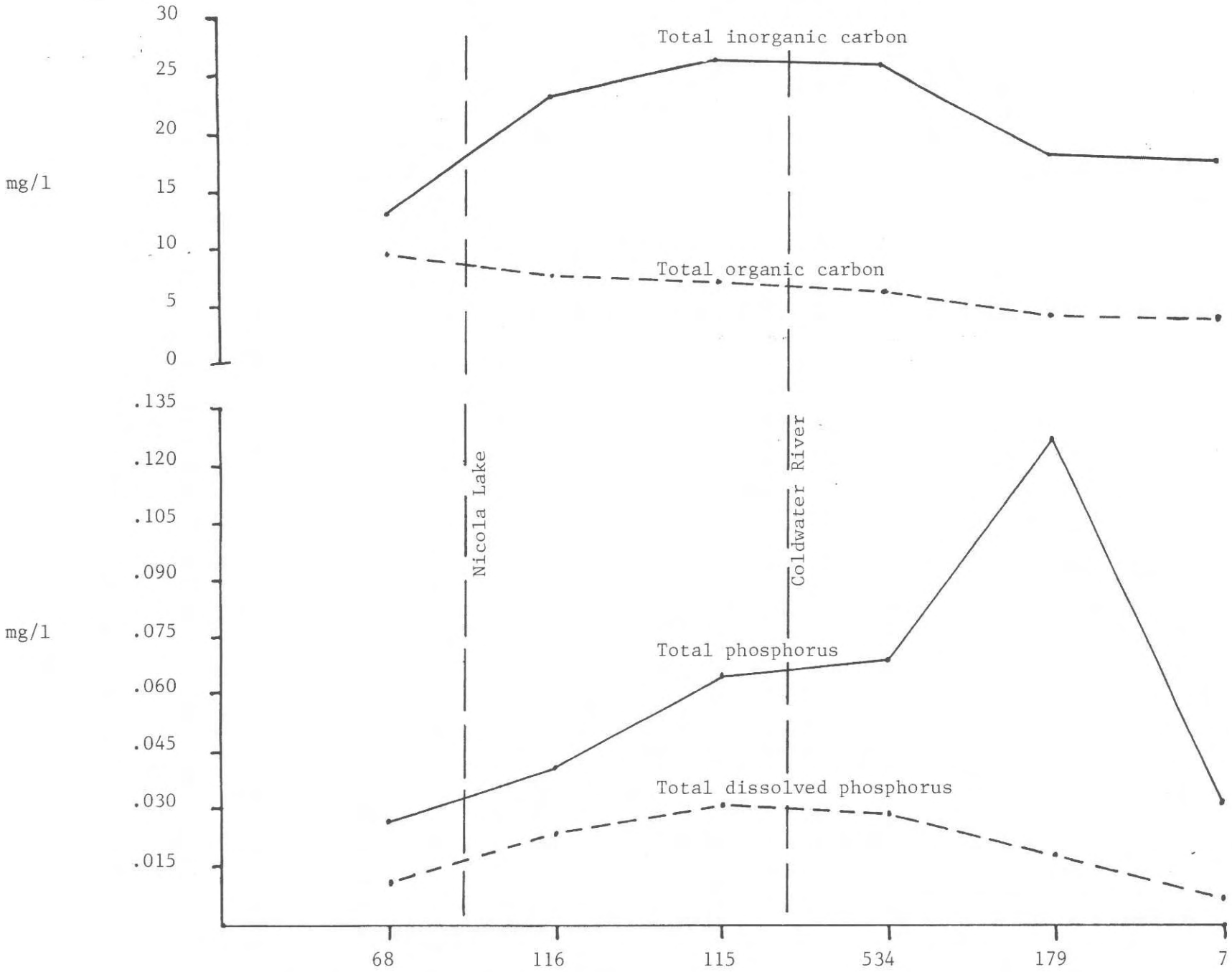

FIG. 2 - Composition of phosphorus and carbon in Nicola River during freshet (1978/79)

TABLE 1 - Percent increase in selected chemical parameters between stations on the Nicola River during freshet (1978/79).

STATION	PHOSPHORUS			
	TOTAL		DISSOLVED	
	Conc.	Loading	Conc.	Loading
68-116	+48.0	+ 58	+118	+230
116-115	+62.5	+ 84	+ 29	+ 35
115-534	+ 5.0	+209	- 7	+108
534-179	+88.0	+186	- 41	-106
179-7	-75	- 49	- 59	0

STATION	NITROGEN							
	TOTAL		ORGANIC		AMMONIA		NO_2-NO_3	
	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
68-116	+15	+ 21	+19	+ 23	0	+ 12	No Change	+ 22
116-115	- 5	+ 2	- 7	+0.4	+ 7	- 6		0
115-534	+ 5	+168	+ 5	+170	+13	+129		+160
534-179	-19	+ 2	+19	+0.9	-12	+ 70		0
179- 7	-28	- 27	-27	- 26	-47	+ 11		--

STATION	CARBON			
	ORGANIC		INORGANIC	
	Conc.	Load	Conc.	Load
68-116	-21	- 15	+75	+123
116-115	- 7	- 3	+13	+ 5
115-534	-14	+125	- 2	+179
534-179	-38	- 3	-30	- 42
179- 7	0	- 20	- 4	+ 12

volume of water at this time of year. This extremely large increase between stations 534 and 179 remains somewhat of a mystery. The river passes through an Indian Reserve between these stations and agricultural activities are not extensive. The decrease in concentration and load between 179 and 7 is probably the result of an ameliorating effect of Spius Creek with its better water quality and nutrient stripping in the river.

The total dissolved phosphorous concentrations showed the opposite patte from total P (fig. 2). After increases at the first two stations, the concentration began to decrease at 534 below the confluence and continued to decrease to the mouth.

The load of dissolved phosphorous increased from 11.57 kg/day at the background station (68) to 63.82 kg/day at the mouth (table 1). Large increases (G200%) were noted between the background station (68) and the outlet of Nicola Lake (116). The next largest increase of 108% was between the two stations above and below the Coldwater confluence. From this point to the mouth the loading rate dropped by approximately 100%. The large increase at station 116 was the result of the conversion of particulate to dissolved phosphorous in Nicola Lake.

The lower concentration at station 534 was cuased by the influence of the better qulaity Coldwater River. The continued drop in concentration and load between 534 and 179 indicates the phosphorous that entered between these stations was in a particulate form. This could indicate the source of phosphorous may be organic wastes.

b) Nitrogen

Total nitrogen concentraiton stayed relatively static throughout the mid-reach of the river length but then diminished toward the mouth (fig. 3). Organic and ammonia followed the same pattern while NO_2-NO_3 remained the same throughout the system.

Total nitrogen loading increased from the background station (68) to the mouth (7). The major increase (170%) occurred just below the Coldwater confluence at 534 (table 2). From this station to the mouth the load reduced by 27%. The load increase at 534 was noticeable in all components of the total nitrogen.

The large increase in load at station 534 was the result of increased water volumes due to the addition of Coldwater River water. The decrease in nitrogen downstream was mainly the result of the influence of Spius Creek and nutrient stripping.

c) Carbon

Organic carbon concentration was highest at the background station, 68 and lowest at the mouth, 7 (fig. 2). There was a gradual decrease at all stations in the system. A large increase in the organic load was evident below the confluence with the Coldwater due to the large volume of water entering the system (table 1).

Inorganic carbon concentration on the other hand showed a strikingly different pattern. A large increase (75%) occurred between the background station, 68 and 116, below Nicola Lake. A large increase (~~7100%~~ 123%) in the inorganic load was also noted at this station. This increase was the result of the conversion of organic to inorganic carbon in Nicola Lake both from the upper Nicola River and other lake tributaries. The increase in the inorganic load at 534 was the result of the addition of

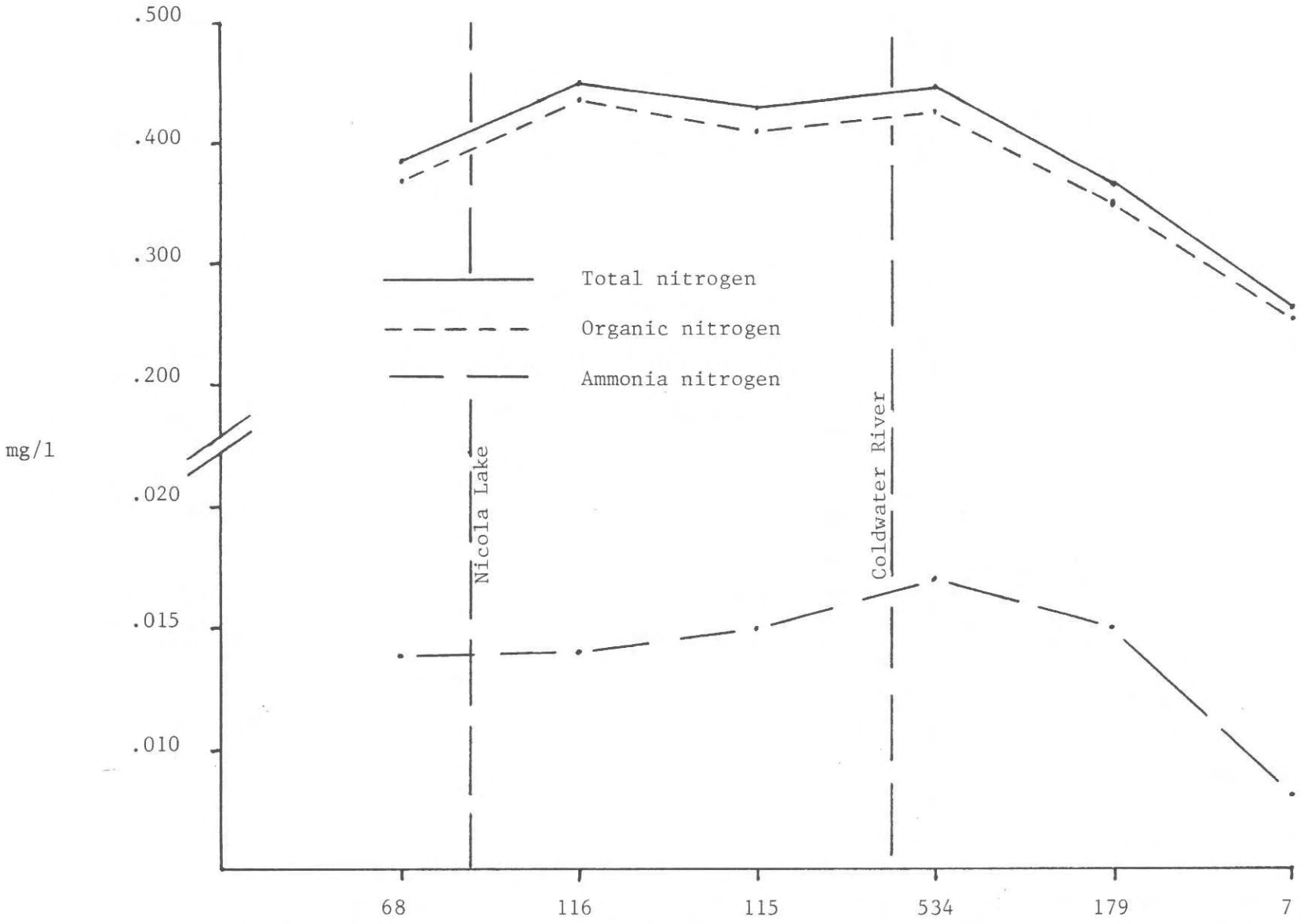

FIG. 3 - Nitrogen composition at six stations in Nicola River during freshet period (mean of all samples during this period--1978/79).

TABLE 2 - Percent increase in selected chemical parameters between stations on the Nicola River during non-freshet (1978/79).

STATION	PHOSPHORUS			
	TOTAL		DISSOLVED	
	Conc.	Load	Conc.	Load
68-116	108	379	107	453
116-115	32	33	23	25
115-534	35	163	16	142
534-179	-30	-30	-16	-15
179-7	-76	-66	-81	-77

STATION	NITROGEN							
	TOTAL		ORGANIC		AMMONIA		NO_2-NO_3	
	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
68-116	55	261	65	268	44	462	-35	79
116-115	6	-2	0	-10	33	18	72	43
115-534	2	96	-11	65	187	483	-2	129
534-179	-33	-31	-30	-27	-51	-49	21	13
179-7	-48	-31	-36	-16	-89	-87	--	--

STATION	CARBON			
	ORGANIC		INORGANIC	
	Conc.	Load	Conc.	Load
68-116	-10	159	44	249
116-115	-5	-31	32	20
115-534	-16	57	-11	69
534-179	-25	-25	-8	-6
179-7	-30	-12	2	29

Coldwater River water.

d) N/P ratio

This ratio was based on ammonia nitrite and nitrate nitrogen versus total dissolved phosphorous.

The N/P ratio during runoff varied from 1.19 at station 68, below Douglas Lake, to 1.61 at the mouth, station 7 (fig. 4). A low ratio of 0.38 occurred at station 115, above Coldwater confluence and stayed below 1.0 at the rest of the stations (Table 3). The ratio indicates an extremely N-limited system during freshet. The changes that occurred over the system were relatively small. The decrease from stations 68 to 116 and 115 were caused by the large influx of dissolved phosphorous into the system as mentioned earlier. The change from 115 to the downstream stations resulted from the increase in ammonia and organic nitrogen to the river.

2. Non-freshet

a) Phosphorous

There was a large increase of 108% in total phosphorous from the background station (68) below Douglas Lake to 116, the outlet of Nicola Lake (fig. 5). Increases of 30+% were also noted between the next two stations to below the confluence (534). From here on, the concentration decreased to the mouth. The dissolved phosphorous concentration followed exactly the same pattern as the total phosphorous, (fig. 5). Large decreases were noted at the mouth station (7) for both parameters.

The increase between stations 68 and 116 were probably the result of numerous activities. Since the largest increase occurred during the winter months, some the phosphorous may have come from Nicola Lake. After

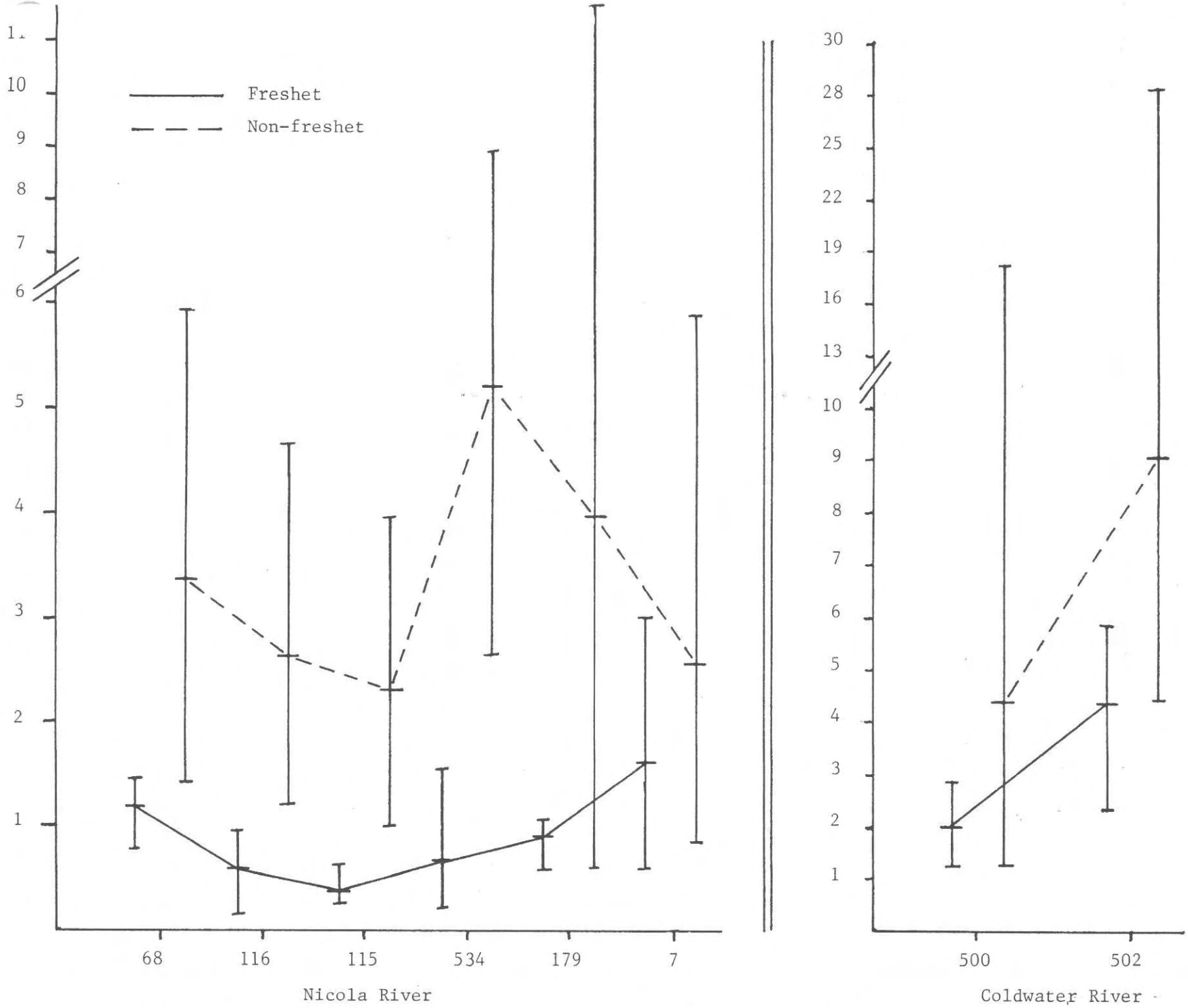

FIG. 4 - N:P ratios at various stations in the Nicola and Coldwater Rivers showing means + ranges during freshet and non-freshet (1978/79)

TABLE 3 - N:P ratios at various stations in Nicola and Coldwater Rivers (NH_3 + NO_3/Total Dissolved Phosphorus).

	NICOLA RIVER						COLDWATER RIVER	
DATE	068	116	115	534	179	007	500	502
Mar. 1, 1978	--	--	6.18	8.88	11.53	5.88	1.03	7.81
Mar. 20	--	--	2.16	4.44	5.34	--	3.79	4.42
June 5	1.50	0.60	0.28	0.22	1.05	1.22	2.82	2.30
June 20	0.80	0.18	0.26	0.24	0.60	--	2.00	4.20
July 10	1.00	0.95	0.61	0.70	1.00	0.60	1.25	5.16
July 17	1.45	--	--	1.52	0.77	3.00	1.67	5.86
July 31	3.40	4.63	2.71	6.67	9.17	2.50	1.67	5.6
Aug. 14-15	2.13	1.92	1.10	5.09	1.92	3.33	3.00	5.29
Aug. 28-29	2.13	3.38	1.23	2.64	0.62	2.67	1.67	5.72
Sept. 11-12	1.42	--	1.57	5.81	0.68	1.40	1.67	10.1
Sept. 25-26	1.86	1.77	1.29	4.50	1.47	0.83	1.25	9.5
Oct. 10-11	--	--	1.00	4.54	2.17	1.33	1.67	28.5
Oct. 23-24	4.83	1.19	1.00	4.89	1.48	--	--	7.1
Dec. 6	--	--	2.23	4.90	4.81	--	11.50	8.5
Jan. 1979	5.93	2.60	3.24	5.33	4.38	--	18.00	7.2
Feb. 1979	5.44	2.79	3.95	4.75	3.85	--	2.76	8.8

fall overturn nutrients are recycled from the hypolimnion throughout the lake water column. In fact, phosphorous at station 116 was mainly dissolved during winter and particulate during summer. This indicates a release of phosphorous from biomass in Nicola Lake during the non-growth season. Also, during the winter months, cattle are brought down from summer range and fed on the winter ranges which are ususally next to the river. A considerable amount of phosphorous probably results from cattle activites during this time period.

The increase between stations 116 and 115 followed a different pattern than between 68 and 116. The largest increases appeared to be related more to water run-off rather than lake effects. Again, it appears as though land use activities add phosphorous to the system in this stretch of the river. Agriculture appears to be the main contributor with some domestic addition just prior to station 115. The large concentration increase that occurred between 115 and 534 was from the Coldwater River. The largest increases occurred during December and January with an anomalously large increase in early August . The August increase was due to a large phosphorous input from the Merritt STP.

Between stations 534 and 179, phosphorous concentrations generally decreased during summer with less fluctuations. The decrease probably indicated a utilization of phosphorous by river biota.

Very large decreases occurred between 179 and 7 due to the addition of Spius Creek water which diluted the concentration plus further biological utilization.

The lading rate followed essentially the same pattern as concentration however the effect was magnified at the stations below Nicola Lake (116)

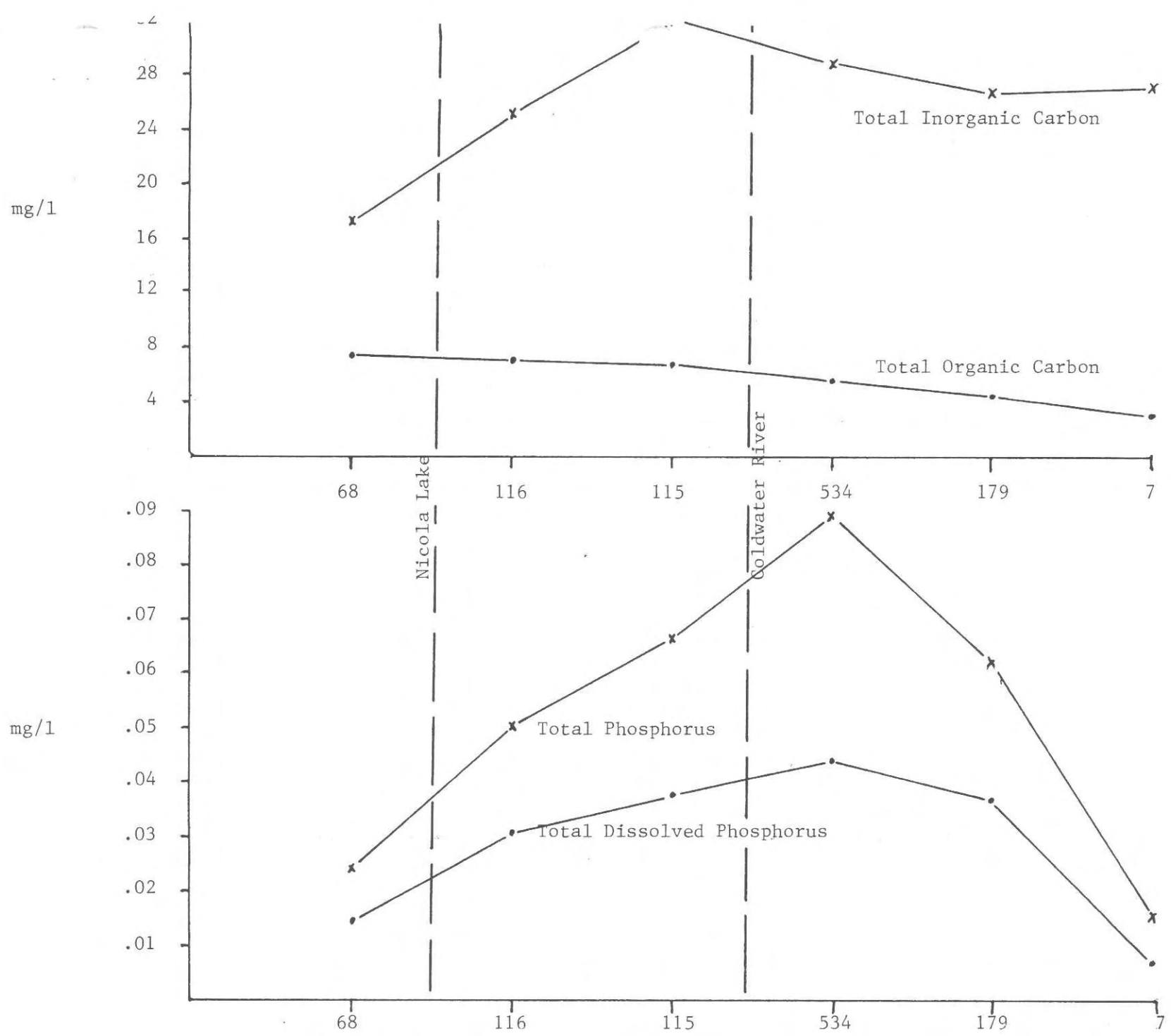

FIG. 5 - Total and total dissolved phosphorus and total organic and inorganic carbon at six stations on the Nicola River during the non-freshet period (1978/79).

and below the confluence (534). These increases ranged up to 400%. As with the concentration, the loading rate diminished at the lower two stations. The increases at 116 and 534 were due to the larger flow than the upstream stations plus the previously mentioned concentration increase.

b) Nitrogen

Total nitrogen concentrations followed the same pattern as phosphorous with large increases below Douglas Lake and the confluence and decreases at the bottom two stations (fig. 6). The organic portion followed the total nitrogen pattern; however, ammonia differed somewhat in that an extremely large increase (187%) was noted below the confluence. The NO_2-NO_3 did not follow a predictable pattern.

The reasons given for the phosphorous increases can also apply for the nitrogen increases. The ammonia increase at station 534 was wholly related to the vast amount of ammonia received from the Coldwater River. The largest percent increase came during the lowest flows. The total, organic and ammonia nitrogen loads followed similar patterns to the concentration curves (table 2). The percent load increase in these patterns was considerable reaching as high as 483% at station 534. The largest increase again occurred in ammonia. The NO_2-NO_3 load also increased which was not indicated by the concentration. The lading rate increases were magnified by the increased flows from tributaries.

c) Carbon

Organic carbon showed a general uniform decrease in ambient concentration throughout the watercourse (fig. 5) Inorganic carbon however, show an initial increase with a subsequent very samll decrease.

Large load increases occurred below Nicola Lake for both inorganic and

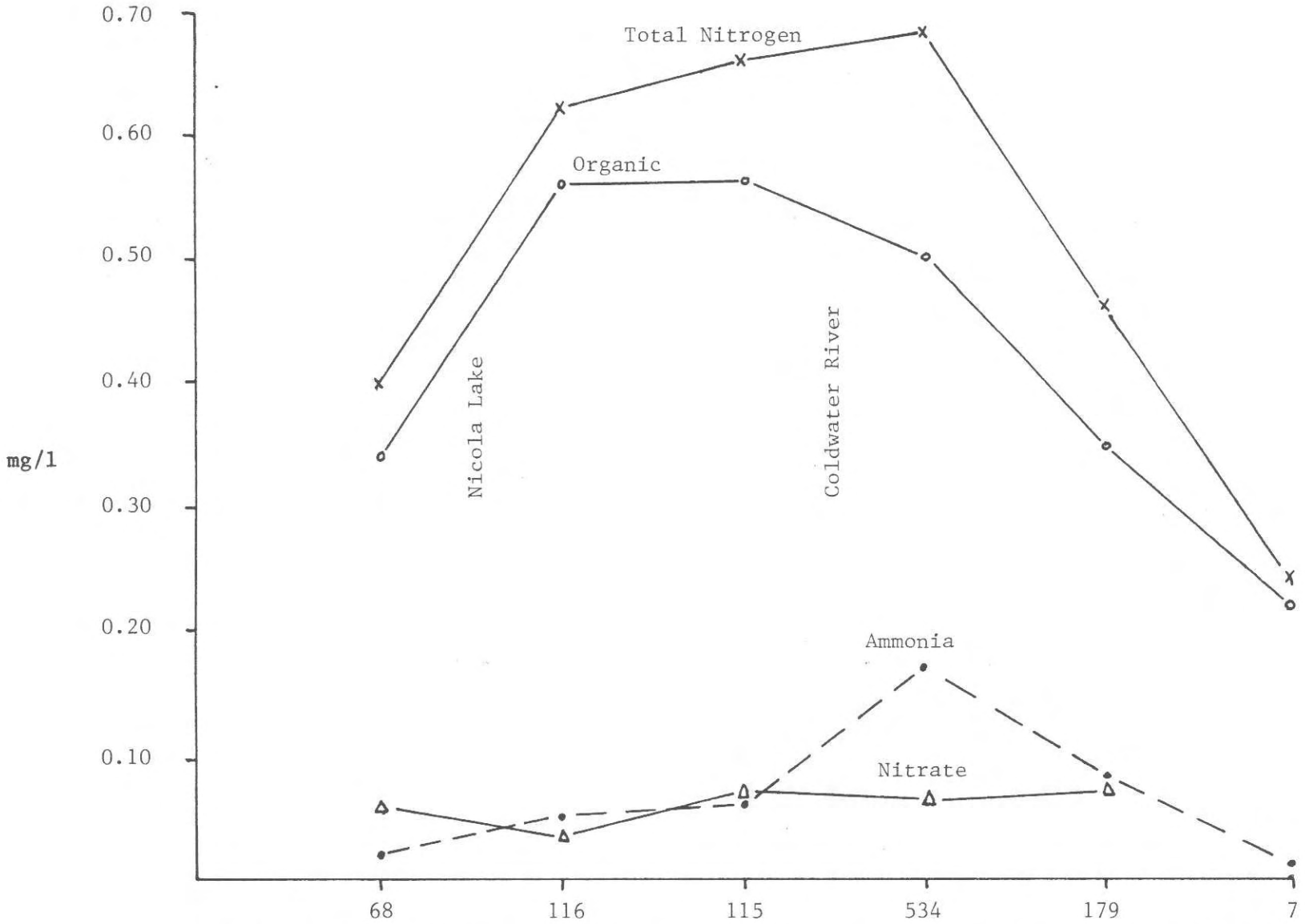

FIG. 6 - Nitrogen composition at six stations in Nicola River during non-freshet period (mean of all samples during this period)(1978/79).

organic carbon (table 2). Following this station, the load rate varied over the remaining stations with little uniformity.
The carbon change from station 68 to 116 was due to biological activity in Nicola Lake. The load increases were due to addition of water to the system. There was little change in the pattern over the length of the non-freshet period.

d) N:P ratio

The ratio varied greatly at the various stations during the non-freshet period (fig. 4). The mean ratio at each station varied from 2.31 to 5.20. The larger ratio occurred below the confluence of the Coldwater River station 534 and then dropped to 2.56 at the mouth.
Prior to the confluence with the Coldwater, the N:P ratios generally were lower and had less variance, however, the overall patterns were similar (table 3).
The addition of ammonia nitrogen from the Coldwater system increased the ratio at station 534, however, the system remained nitrogen limited.

B. Coldwater River

The results of the sampling indicate that of the 2 stations below the STP discharge (502 - north shore and 543 - south shore), only 502 was affected by the effluent. Lack of mixing prevented any effluent from being detected at 543, therefore results from 543 will not generally be discussed in the chemistry section, however will be discussed in the periphyton section.

1. Freshet

a) Phosphorous

During freshet, there was an icnrease in concentration of 44% in total phosphorous between the background station 500 and the

downstream station 502 (table 4). Total dissolved phosphorous, however, increased by 713%. The loading rate for total phosphorous decreased by 8% but the load for dissolved phosphorous increased by 365%.

The increases were caused by the Merritt STP but the results show the effluent remained on the north side of the river and did not mix with the whole river. The majority of phosphorous from the STP was in the dissolved form.

b) Nitrogen

A large increase (135%) in total nitrogen concentration was evident during this period which translated into a load increase of 27% (table 4). There was no change in NO_2-NO_3 and a small change in organic, 36% in concentration and 5% in load. The increase in nitrogen was attributable to the ammonia portion where the concentration increased by 3,588% and the load by 1,304%. This increase in ammonia is indicative of sewage effluents.

c) Carbon

Extremely large increases occured below the STP in organic carbon - 214% in concentration and 49,500% in load (table 4). Inorganic carbon decreased below the discharge by 8% in concentration and - 39% in load. It appears that the carbon addition from the STP was in the organic form.

d) N:P ratio

During this period, the ratio was larger below the STP than above it; however, the system remained nitrogen limited at both stations (fig. 4). At the upstream station, 500, the ratio varied from 1.25 - 2.8 at the downstream station 502, it varied from 2.3 - 5.86 (table 3). The increase in ratio was due to the large addition of ammonia nitrogen

TABLE 4 - Percent increase/decrease in selected chemical parameters between stations on the Coldwater River during non-freshet (1978/79).

P H O S P H O R U S

	TOTAL		DISSOLVED	
Stations	Conc.	Load	Conc.	Load
500-502	3,294	2,257	1,900	1,418

N I T R O G E N

STATIONS	TOTAL		ORGANIC		AMMONIA		NITRITE/NITRATE	
	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
500-502	1,900	1,639	2,044	1,562	23,171	19,415	315	187

C A R B O N

	ORGANIC		INORGANIC	
Stations	Conc.	Load	Conc.	Load
500-502	646	21,508	29	26

from the STP.

2. Non-freshet

a) Phosphorous

Increases in total and dissolved phosphorous below the discharge were extremely large (table 5). In concentration, total phosphorous increased by 3,294% while dissolved phosphorous increased 1,900%. In loading rate, total phosphorous increased by 2,257% and dissolved by 1,418%.

b) Nitrogen

Total nitrogen concentration increased by 1,900% below the discharge (table 5). Smaller increases were noted in NO_2-NO_3 concentration and load while increases in the organic portion were similar to total nitrogen. Extremely large increases were evident in the ammonia portion witha 23,171% increase in concentration and a 19,415% increase in load.

c) Carbon

Organic carbon increased greatly in concentration and load - 646% and 21,508% respectively (table 5). Inorganic carbon increases were very moderate, with 29% in concentration and 26% in load. All of the increases were a result of the STP discharge however, since full mixing had not occurred at station 502, the results are somewhat misleading. The impact of the discharge was generally limited to the north shore however, during low water conditions, the whole river was also limited to the north shore.

TABLE 5 - Percent increase/decrease in selected chemical parameters between stations on the Coldwater River during freshet (1978/79).

	P H O S P H O R U S			
STATIONS	TOTAL		DISSOLVED	
	Conc.	Load	Conc.	Load
500-502	44	-8	713	365

	N I T R O G E N							
STATIONS	TOTAL		ORGANIC		AMMONIA		NITRITE/NITRATE	
	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load
500-502	135	27	36	5	3,588	1,304	N. C.	N.C.

	C A R B O N			
	ORGANIC		INORGANIC	
Stations	Conc.	Load	Conc.	Load
500-502	214	49,500	-8	-39

d) N:P ratios

During the non-freshet period, the ratio at station 502 was almost double that of station 500 owing to the large addition of ammonia and organic nitrogen from the STP (fig. 4).

The majority of the time, the river was nitrogen limited however, the upstream river was phosphorous limited during December and January (table 3). The addition of phosphorous from the STP however changed the river to N-limited in those months. The opposite occured during September and October when additions of nitrogen changed the system from N-limited to P-limited.

II. RIVER PERIPHYTON

A. 1. Chlorophyll "a"

There were eight 2 week periods sampled in 1978. Only one period, March 2 - 20, was sampled prior to spring runoff (table 6). Some growth was evident in both river systems. Periphyton accumulations were similar at the Nicola River above confluence (115) and Nicola River above Guichon Creek (179), however no growth was present at the Nicola River below the confluence. On the Coldwater, some growth was evident on the south shore below the STP (543), but none was present on the north shore (502). No data were collected above the STP.

It appears that toxic conditions may have been present probably caused by the STP. This is evidenced by the lack of growth at stations 502 and 534. Conditions similar to station 115 appeared at station 179.

The first sampling period after freshet was July 17-31. On the Nicola, growth was heaviest just below the confluence (534) and lightest above the confluence (115). The only station on the Coldwater with

TABLE 6 - List of chlorophyll "a" concentrations (ug/cm^2) at stations on Coldwater and Nicola Rivers during 1978.

DATES	STATIONS					
	500	502	543	115	534	179
March 2-20	---	L0.03	0.06	0.34	L0.03	0.03
	---	L0.03	0.04	0.28	L0.03	0.04
July 17-31	---	0.47	---	0.09	0.20	0.14
	---	0.35	---	0.05	0.24	0.28
	---	0.79	---	---	0.70	0.11
	---	1.80	---	---	---	0.26
July 31 - Aug. 14	---	4.9	---	7.7	8.1	13.2
	---	7.1	---	9.4	8.5	9.6
	---	---	---	10.1	8.5	8.7
	---	---	---	6.4	2.9	2.8
August 14-29	0.47	0.14	1.6	6.0	5.3	0.45
	0.39	0.10	1.9	3.4	4.4	1.8
	0.45	L0.03	1.0	4.9	2.5	7.6
	0.41	---	3.4	1.8	5.8	3.4
Aug. 29 - Sept. 12	0.18	L0.03	0.10	4.0	---	3.4
	0.20	L0.03	0.29	---	---	4.4
	0.64	0.03	0.26	---	---	14.7
	0.19	L0.03	0.08	---	---	---
Sept. 12-26	L0.03	L0.03	L0.03	0.81	---	5.7
	0.04	L0.03	L0.03	0.57	---	8.0
	0.05	L0.03	0.03	1.1	---	3.2
	0.05	L0.03	---	1.8	---	7.2
Sept. 26 - Oct. 11	---	0.08	L0.03	1.7	0.27	---
	---	0.03	L0.03	5.0	0.26	---
	---	0.03	L0.03	6.8	0.21	---
	---	L0.03	L0.03	17.3	0.30	---
October 11-26	0.31	L0.03	0.06	2.9	0.26	1.1
	0.03	L0.03	L0.03	4.5	0.22	1.3
	0.03	L0.03	L0.03	3.9	0.31	0.66
	0.04	L0.03	L0.03	3.0	1.10	3.0

data was below the STP on the north shore (502) where growth was heavier than the Nicola system. It is evident that the addition of Coldwater River water enhanced growth in the Nicola. Although growth data are lacking for station 500, it is evident from the water chemistry data that the cause of the heavy growth is a result of the STP addition of dissolved phosphorous and organic and ammonia nitrogen.

Extremely heavy growth occurred during the July 31 - August 14 period on both rivers although only one station on the Coldwater had data (502). Chlorophyll "a" was highest during this time period for the whole year. The growth during this period followed the same reasoning as the previous 2 weeks. This time, however, the growth at 115 was also extremely heavy so Coldwater River water did not have as great an influence. Water levels were beginning to drop at this time resulting in clearer, warmer temperatures and resultant heavier growth. Periphyton growth during the August 14-29 period on the Coldwater was heaviest at station 543, below the STP - south shore and lightest at 502, below the STP - north shore. Growth was heavy at all three stations on the Nicola River. Possible toxicity occurred during this period at station 502 only this time it did not extend into the Nicola system. During the August 29 - September 12 period, on the Coldwater, growth was heaviest at the background station 500, above the STP and lightest at 502, below the STP, North shore. The two stations with data on the Nicola River had heavier growths than the Coldwater. Definite toxicity occourred at station 502 due to the STP, The poor data from the

indicated little effect from the Coldwater, however station 534 data were lacking so no knowledge of toxic effects was obtained. Almost no growth was evident in the Coldwater during the September 12-26 period. Heavy growth occurred at station 179, Nicola River above Guichon Creek with lighter growth at station 115, Nicola River above confluence. Data from 534 were missing. The heavy growth at station 179 had to be the result of heavy nutrient loads from the STP. Dissolved phosphorous went from approximately 9 kg/day at station 115 to 28 kg/day at 534 and 16 kg/day at 179.

There was almost no periphyton growth at the Coldwater stations during the September 26 - October 11 period. Growth at station 115, Nicola River above confluence was extremely heavy, but very light at 534, below the confluence. Data from this time period indicate toxic conditions existed due to the STP. Ample nutrients were made available to stations 502 and 543 on the Coldwater, however, little growth occurred. Dissolved phosphorous at 543 approximated .004 mg/L while at 502 it was approximately .050 mg/L. The decrease in productivity from station 115 to 534 on the Nicola could only have been caused by toxic conditions since dissolved phosphorous remained static while usable ammonia nitrogen increased.

During the October 11 - 26 period, some growth occurred at station 500, Coldwater above the STP, while little growth was evident at the downstream Coldwater stations. On the Nicola system a large amount of periphyton was present at the upstream station 115, with lesser growth at 179, above Guichon Creek and the least at 534 below the confluence. Extreme toxicity was evident at station 502 during October. This toxicity was carried

to station 534 on the Nicola where productivities decreased by almost 90%. A slight improvement in growth occurred at 179.

B 7. Species Identification

During the July 17 to July 31 period, all sites were dominated by diatoms of the order Penales (table 7). The dominant species were similar for the Nicola stations with slight changes for the Coldwater River. One blue-green Oscillatoria sp. was present at station 534, Nicola River below the confluence.

The July 31 - August 14 period was also dominated by the Penales diatoms. Blue-greens were present at stations 534 and 179 on the Nicola River with Oscillatoria ameona being dominant at 179.

The August 14-29 period followed the same general pattern as the previous two periods. Oscillatoria sp. was present at stations 115 on the Nicola and 502 on the Coldwater. No sampling data was available at 179 and 534 for this period.

The switch from the diatoms to the blue-greens at stations below the influence of the STP corroborates the eutrophication acceleration at these stations. This appears to be a direct result of the nutrient addition from the STP.

III. RIVER INVERTEBRATES

A 1. August 28 - September 26

Six families from 4 Orders with 83 individuals were collected from the two multiple plate samples from station 500, Coldwater River above the STP (table 8). Of the 83 invertebrates collected, 64 were Tricopterans (fig. 7). The major Tricopterans in the sample were detritiuores - herbivores, living mainly on algal cells or other plant and animal cells. The Ephemeropterans present had similar

TABLE 7 - List of Periphyton species found in the Nicola and Coldwater Rivers during study (1978/79).

NAME	SITE NO. 0600115			SITE NO. 0600534			SITE NO. 0600179			SITE NO. 0600500			SITE NO. 0600502		
	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978
Order Penales															
Achnanthes sp.		X	X					X							
lanceolata												X			
Amphipleura pellucida															X
Ceratoneis sp.				X											
Cocconeis sp.							X					X	X		
placentula	+D	D	X	+D	D		+D	D							
Cymatopleura sp.					X										
Cymbella sp.	X	X	X	X	X		D	X				X	X		
sinuata												D			
Diatoma vuligare	X	D	+D	X	X		X	X							
Epithemia sp.	X	X	X		X			X				X			X
sorex				D			X						X		
Fragilaria sp.	X														
leptostauron			X												
vaucheriae	X	X	X					X							
Gamphonema sp.	X	X		X	X		X	X				X			
angustatum													+D		
olivaceum	X		X	X			X						D		
parvulum			X											+D	+D
Meridion circulare	X	X			X		X								
Navicula sp.		X	X		X			X				X	X		X
cryptocephala	D	X	+D	D	D		D	D				X			
radiosa	D			D			X								
Nitzschia sp.			X	X			X								X
dissipata	D	D			D			X							
Rhoicosphenia sp.	X														

. . . /2

NAME	SITE NO. 0600115			SITE NO. 0600534			SITE NO. 0600179			SITE NO. 0600500			SITE NO. 0600502		
	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978
Order Penales															
Rhopalodia sp.	X														
gibba												X			
*Gomphoneis sp.			X		X			X							X
herculeonia		D										X			
Surirella sp.					X			X							
Synedra sp.	X													X	
ulna		D	+D	X	X		X	D				+D	X		X
Order Centrales															
Cyclotella sp.				X											
bodanica	X														
meneghiniana			X		X							X			
Melosira sp.		X													
Stephanodiscus sp.							X	X							
niagarae					X										
Order Chlorococcales															
Pediastrum sp.		X	X		X			X							
Selenastrum sp.												X			
Stigeoclonium sp.			X												+D
Order Dismidiales															
Closterium sp.					X			X				X			
Cosmarium sp.			X					X				X			

. . . /3

NAME	SITE NO. 0600115			SITE NO. 0600534			SITE NO. 0600179			SITE NO. 0600500			SITE NO. 0600502		
	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978	July 17-31, 1978	August 14, 1978	August 29, 1978
Order Oscillatoriales															
Aphanizomeron sp.															X
Oscillatoria sp.			X	X	X										X
ameona								D							
Order Oedogoniales															
Oedogonium sp.															X
Order Zygnematales															
Spirogyra sp.												X			
*Order Chaetophorales															
Stigeoclonium sp.					X										
flagelliferum								D							

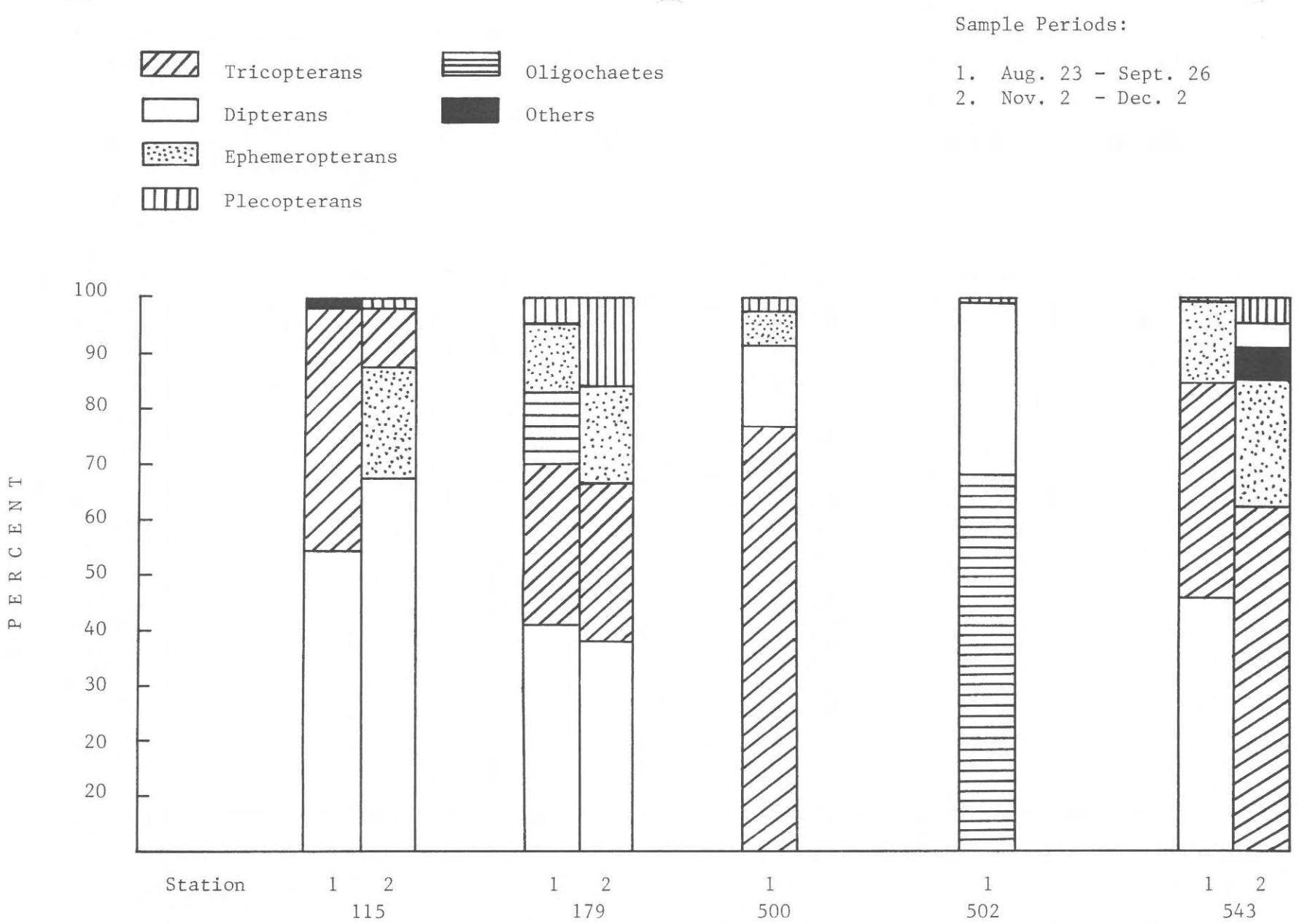

FIG. 7 - Comparison of invertebrates collected on multiple plate samples during two sample periods on Nicola and Coldwater Rivers (1978/79).

feeding habits to the Tricopterans while the Plecopterans present were probably predators. The small number of individuals and their composition were indicative of a relatively non-productive system.

The 4,620 invertebrates collected at station 502, below the STP, represented only 4 orders. The Oligochaetes comprised 68% of the individuals and the Dipterans comprised 31%. There were few Plecopterans and Tricopterans. The Oligochaetes are ingesters and are found in great numbers in algal accumulations. The Dipterans Plecopterans were generally predators and/or collectors and the Tricopterans were collectors. The extremely large number of individuals represented by only four orders is indicative of an unbalanced population. The large number of Oligochaetes combined with their food habits indicates an extremely enriched system. The "clean water" indicators, Plecopterans and Ephemeropterans, were not present in any numbers at this station.

At station 543, below the STP, south shore, there were 7 families and 674 individuals collected. Dipterans comprised 46%, Tricopterans 38% and Ephemeropterans, 13.5%. The Dipterans were collectors or predators, and the Tricopterans and Ephemeropterans were collectors or shredders. These data indicated that the STP did not affect this south shore of the river and corroborates the periphyton data. The population of invertebrates here can be considered relatively diverse and well balanced.

Few invertebrates (3 families, 59 individuals) were collected from the Nicola River above the confluence (station 115). Both the Tricopterans and the Dipterans present were collectors. The scarcity of invertebrates at this station is surprising since the

TABLE 8 - List of invertebrates collected in Nicola and Coldwater Rivers during study (1978/79)[1].

NAME	August 28 - September 26, 1978 STATIONS								November 2 - December 2, 1978 STATIONS									
	115	179		500		502		543		115		179		500[2]		502[2]		543	
	(1)[3]	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
Diptera																			
Chironomidae	32		228	278	4	8	400	1,040	172	140	75	82	72	26				23	
Orthocladius																			
Simulidae											9								
Empididae											3								
Tipulidae			4	6														2	
Ephemeroptera																			
Ephemerellidae			93	45	4	1			68		8	15	17	21				68	52
Ephemerella																			
Heptogeniidae											6	7	3	3					
Rhithrogena																			
Baetidae			3							24	4	9							
Baetis																			
Leptophlebiidae									10				1						
Paraleptophebi																			
Trichoptera																			
Hydropsychidae	26		252	104	17	7			22	20	11	9	10	26					
Arctopsyche																		5	3
Hydropsyche																		61	34
Glossosomatidae													3					12	33
Glossoma											3								
Agapetus											2								
Lepidostometidae			2		15	24			128	88			18	12				71	86
Brachycentridae			3	5		1					1			3				11	7
Brachycentrus																			
Leptoceridae													1						
Psychomyiidae							16												
Plecoptera																			
Pteronarcidae			19	6	2								17	15				3	3
Perlidae			7	6									1						
Perlodidae			14	9			12		1		4		6	1				13	4
Lepidoptera																			
Pyralidae	1										1							1	
Mollusca																			
Physidae																		1	2
Lymnaeidae																		9	16
Oligochaeta																			
Enchytraeidae							1,808												
Naididae			60	95				1,344											
Coleoptera																			
Elmidadae			2	1															
Anthicidae									1										

[1]Size of sample is 0.09 m^2.

[2]Plates at stations 500 and 502 were lost; consequently no data were available for November 2 - December 2 period.

[3]Numbers in brackets refer to sample plates 1 and 2.

periphyton productivity was very high. Other factors, possible the silt load, may have accounted for the low numbers and diversity.

The greatest number of families (12) were collected at station 179, Nicola River above Guichon Creek. There were 1242 individuals comprising these families. Depterans comprised 41.6% of the organisms with Tricopterans at 29,5% and Ephemeropterans and Plecopterans at 11.4 and 4.9 respectively. Oligochaetes made up 12.5% of the total. The vast majority of the invertebrates in the 12 families were collectors, shredders and detritivoves. A few predator Plecopterans were also present in the sample. The invertebrate structure at this station is due to the periphyton growth present in the river. The diversity indicates that some stability is present although it is surprising more predators were not present.

2. September 26 - November 2

In thisperiod, the samplers were lost at stations 500 and 502, so data are lacking for these stations.

Eleven families containing 541 individuals were collected at station 543 during this sample period. The Tricopterans comprised 60.6% of the total, Ephemeropterans 26.4, and Molluscans and Depterans, 5.2 and 4,6% respectively.

The good deversity present during this period corresponded with that found during the previous sampling and confirms that the STP effluent does not mix on this side of the river.

There were also 11 families collected at station 115 on the Nicola River, with a total of 249 individuals. The Depterans comprised 68% of the total, Ephemeropterans 20% and Tricopterans 11%. The majority of

families from this sample were collectors or gatherers in their food habits. This sample better approximates what was expected at this station as poopsed to the results of the previous sample period. The productivity of the system is shown in the number of families and their food habits. Twelve families with 256 individuals were collected from station 179 on the Nicola River. The Dipterans comprised 38% of the total, Tricopterans 28.5%, Ephemeropterans 17.6%, and Plecopterans 15.6%. The Ephemeropterans and Dipterans at this station were collectors or gatherers. Most of the Plecopterans collected were shredders while the remainder were predators. The majority of Tricopterans were collectors-filterers while a few were scrapers and shredders. Although there was little chnage in composition between this sampling period and the previous one, number of invertebrates were less for this period. The diversity indicated some stability was evident at this station.

IV. RIVER BACTERIOLOGY

A. Freshet

Mean total coliform concentrations in the Nicola River at three stations above the Coldwater River confluence (68, 115 115) and one Coldwater River background station above STP (500) were very similar (68 - 100 MPN) during this flow period (table 9). Under the influence of the Merritt STP discharge the concentration increased by 1500% to 1513 MPN at the Nicola River station below the Coldwater River (station 534). The excessively high level of 792,500 at station 502, Coldwater River below the STP, was attributed to this station's location in the discharge zone of influence, an incompletely mixed area just below the STP. The concentrations remained high in the Nicola above Guichon Creek, station 179, (1183 MPN) and then decreased at

TABLE 9 - Mean number of total and fecal coliforms during freshet and non-freshet periods (1978/79).

TOTAL COLIFORMS

	STATIONS								
	NICOLA RIVER						COLDWATER RIVER		
	68	116	115	534	179	7	500	502	543
FRESHET									
$\bar{x}$	68	95	101	1,513	1,183	244	69	92,500	240
R	4-130	22-240	33-140	540- 2,400	350- 1,600	33-350	49-110	62,400 - 6,240,000	---
S.D.	63	126	59	933	721	183	35	128,800	---
N	3	3	3	3	3	3	3	3	1
NON-FRESHET									
$\bar{x}$	77	51	150	2,776	977	36	152	51,700	504
R	8-220	L2-350	8-540	920- 3,500	130- 2,400	8-79	L2-540	62,400 - 240,000	2-1,600
S.D.	74	106	203	2,460	875	29	306	84,000	630
N	10	10	11	10	11	8	10	10	10

FECAL COLIFORMS

	68	116	115	534	179	7	500	502	543
FRESHET									
$\bar{x}$	9	85	33	1,209	370	42	47	31,500	49
R	2-13	8-240	13-70	49-3,500	79-920	23-79	13-110	5,400 - 54,000	---
S.D.	6	134	32	1,984	477	32	55	24,500	---
N	3	3	3	3	3	3	3	3	1
NON-FRESHET									
$\bar{x}$	11	6	27	981	425	15	68	4,161	177
R	2-31	L2-17	L2-79	33-62,400	17-62,400	L2-33	2-540	L2-17,000	2-920
S.D.	9	5	25	917	801	14	159	5,913	307
N	10	10	11	10	11	8	11	11	10

the mouth, station 7. This decrease was the result of probably dilution by Spius Creek, which enters the Nicola approximately ¼ the distance between stations 179 and 7. Although fecal coliform data during this period folowed the same general pattern as total coliforms, individual sampling results for both followed a more erratic pattern (table 10). Stations influenced by the STP showed a more variable pattern assumedly dependent on the daily STP coliform content. The influence of the STP on the Coldwater River is readily apparent as evidenced by the difference in Coldwater River stations (x = 47 to 31,500 MPN) (Table 9).

B. Non-freshet

The general pattern for this flow period is similar to the freshet flow period at all stations. However, the influence of the STP discharge had a greater impact on the rivers. The subsequent dilution by Spius Creek reducing the concentrations near the mouth of the Nicola River is still evident in the sampling results.

Both mean total and fecal coliforms decreased slightly between the sampling station above the Nicola Lake inlet (68) and outlet (116) and increased by 300%, to 150 MPN from 50 MPN for total coliform in the Nicola River at Merritt above the Coldwater River (station 115). Below the junction of the two rivers, at station 534, the increase in total and fecal coliorm was 170% and 300% respectively due to the influence of the Merritt STP discharge. Both total and fecal coliform concentration decreased in concentration further downstream to eventually attain near background levels at station 7, Nicola River near Spences Bridge.

TABLE 10 - Total and fecal coliforms obtained on all sampling dates during study, 1978/79.

FAECAL

	NICOLA RIVER						COLDWATER RIVER		
DATES	68	116	115	534	179	7	500	502	543
March 1	5	L2	L2	70	240	L2	7	L2	2
20	---	---	5	920	33	---	5	920	---
June 20*	2	240	13	49	79	23	17	5,400	---
July 10*	13	8	17	79	920	79	13	35,000	---
17*	13	8	70	3,500	110	23	110	54,000	49
31	17	13	33	1,600	17	L2	14	3,300	20
August 14	31	8	49	G 2,400	50	22	33	17,000	140
28	11	2	33	700	L20	5	2	8,000	33
September 11	17	25	20	1,300	31	23	2	13,000	11
25	13	7	11	---	130	33	94	500	50
October 10	7	5	13	33	G 2,400	33	23	L2	31
23	2	L2	79	220	33	2	540	630	920
December 6	2	L2	L2	G 2,400	130	---	2	G 2,400	540
Febuary 15	5	17	49	170	1,600	---	27	20	26

TOTAL

March 1	13	L2	23	920	1,600	8	---	2	2
20	---	---	31	G 2,400	350	---	33	G 2,400	---
June 20	4	4	33	540	350	350	49	G 2,400	---
July 10*	130	23	130	1,600	1,600	350	49	35,000	---
17*	70	22	140	G 2,400	1,600	33	110	G 240,000	240
31	170	13	33	1,600	350	33	49	160,000	70
August 14	220	33	79	G 2,400	330	33	33	G 240,000	790
28	79	13	540	9,200	130	13	33	79,000	49
September 11	49	13	80	3,500	540	79	13	24,000	49
25	70	49	49	---	130	79	540	1,700	170
October 10	130	23	23	920	G 2,400	33	23	2	170
23	8	5	240	3,500	1,600	9	920	9,200	1,600
December 6	14	5	8	G 2,400	920	---	L2	G 2,400	1,600
February 15	14	350	540	920	2,400	---	170	230	540

*Freshet Period

V. NICOLA LAKE

A. Physical

On June 7 there was a 4°C. difference in temperature in the upper water column of Nicola Lake (fig. 8). This had increased to over 7°C by July 6 and by July 19, a thermocline was formed between 12 and 13 metres. Therefore, at this date, the ipilimnion comprised 12 metres and the hypolimnion approximately 35 - 38 metres. A weak thermocline existed at the 12 metre depth throughout August and disappeared in September. On August 30, there was approximately a 5°C. temperature difference in the top 15 metres but by September 13, this had dropped to an approximately 1°C. difference, essentially isothermal conditions.

Dissolved oxygen remained relatively high throughout the summer months. Teh eprcent saturation remained above 50% and the concentration above 5 mg/L in the epilimnion (figure 9). On June 7, the saturation varied between 70 and 75% in the upper 15 metres. By July 6, the percent range had dropped to 50 - 70%. The epilimnion range on July 19 was from 60 - 95% and the hypolimnion range was 35 - 50%. On August 1, the range showed its greatest variation, from 45 - 120% in the epilimnion and 18 - 45% in the hypolimnion. The large range in the epilimnion was die to the heavy phytoplankton bloom resulting in supersaturation near the surface. Late August lake water showed a similar trend of great variation while the mid-August results had a much smaller range. The phytoplankton blooms had diminished during August resulting in less oxygen produced and lower saturation percentages.

By September 13th, the range had narrowed, but the percent saturation increased (85 - 112%). This was d e to an increase in the plankton bloom and consequently supersaturation.

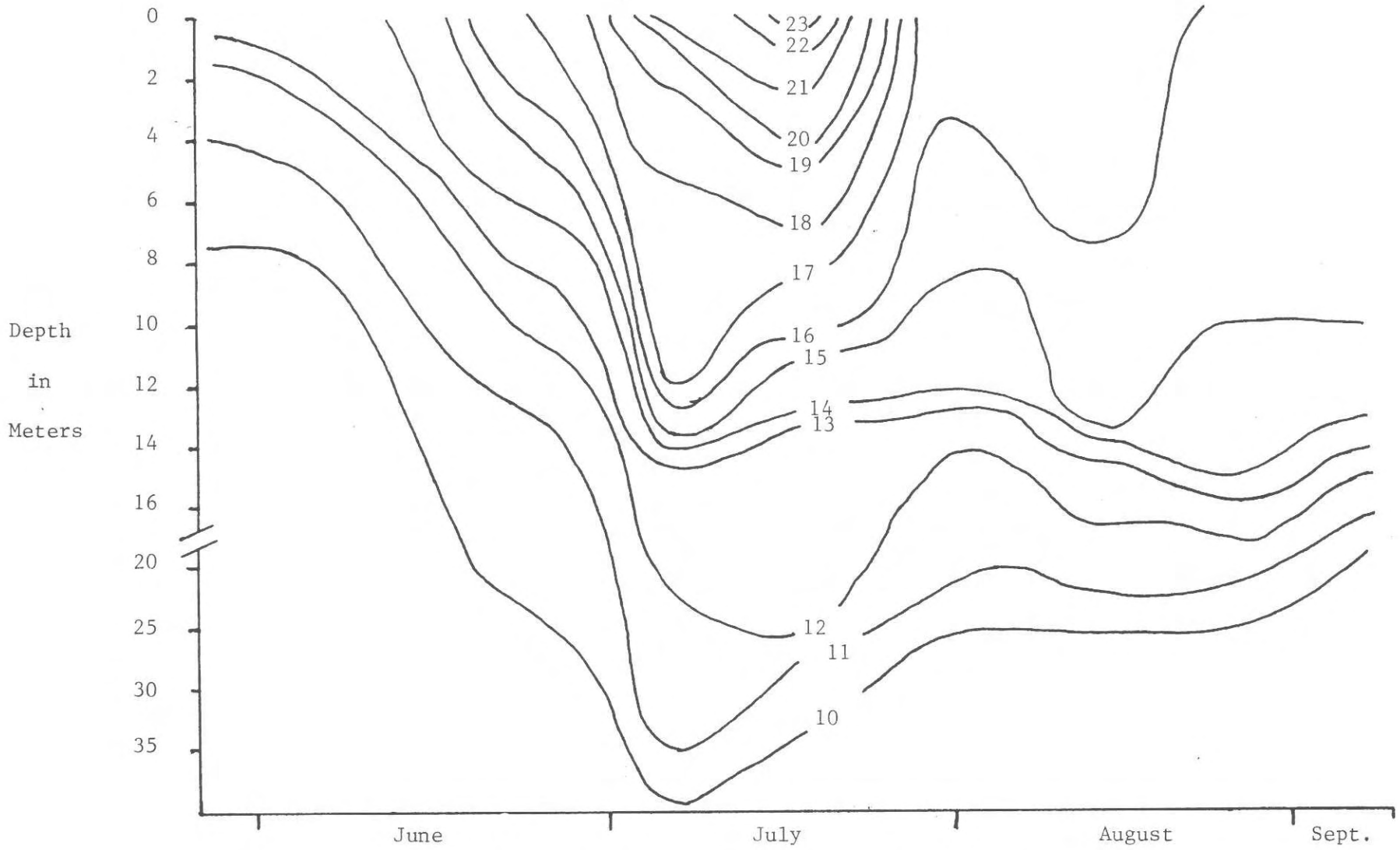

FIG. 8 - Temperature profile (^{o}C) in Nicola Lake during summer months of 1978.

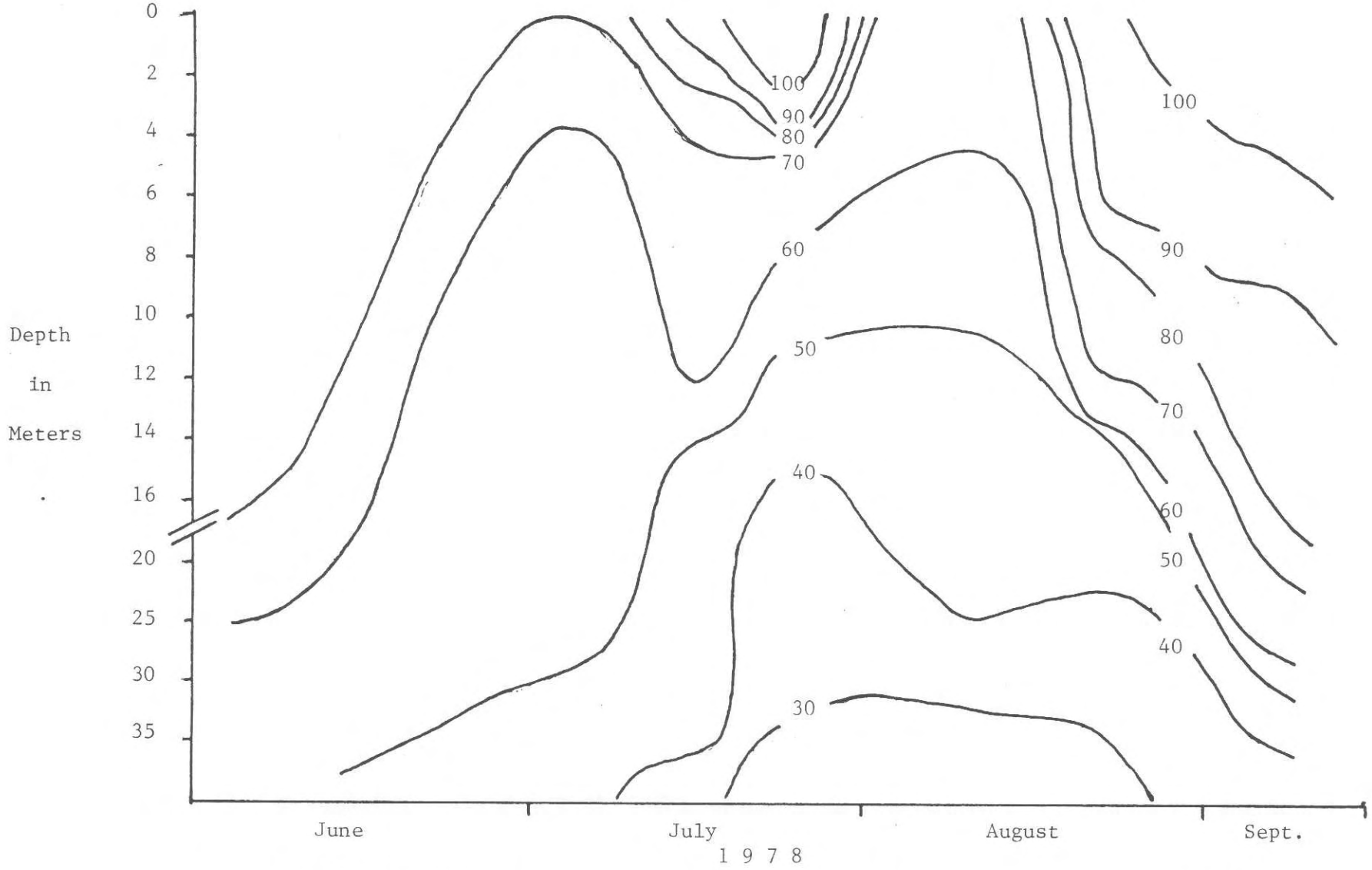

FIG. 9 - Percent dissolved oxygen regime in Nicola Lake during summer months of 1978.

B. Chemical

1. Phosphorous

Total and dissolved phosphorous concentrations showed a slight increase from the north end of the lake (inlet) to the south end of the lake (outlet) (figure 10). The inlet station (3004) had slightly higher mean phosphorous concentrations than station 3005 (opposite Nicola River). A slight increase then occurred from 3005 to 3006 (deepest point). From 3006 to the outlet, 3007, there was no increase in total phosphorous but a small increase in dissolved phosphorous.

The slight increase in phosphorous from inlet to outlet was mainly due to the influx of nutrient rich Nicola River water which was first evident at station 3006. The decrease between 3004 and 3005 was the result of phosphorous utilization by plankton and eventual loss to the hpyolimnion.

Total and disoolved phosphorous generally decreased at each station over the summer (figure ~~10 &~~ 11). More uniform changes were noticed at 3005, 3006, 3007 as opposed to 3004. Station 3004 may have been directly affected by a tributary, Moore Creek, however, chemical data are lacking from this stream so absolute proof is not available. The uniform decrease at the other three stations can be attributed to two major items. Firstly, tributary water containing large phosphorous loads in early summer runoff decreased in flow and impact as summer progressed. Secondly, phosphorous was transported to the hypolimnion when the algal cells died and were removed to the bottom. The dissolved phosphorous portion of the total phosphorous varied from 18 - 98%. The overall mean for all stations for the summer period was very similar ranging from 44% at station 3005 to 54.8%

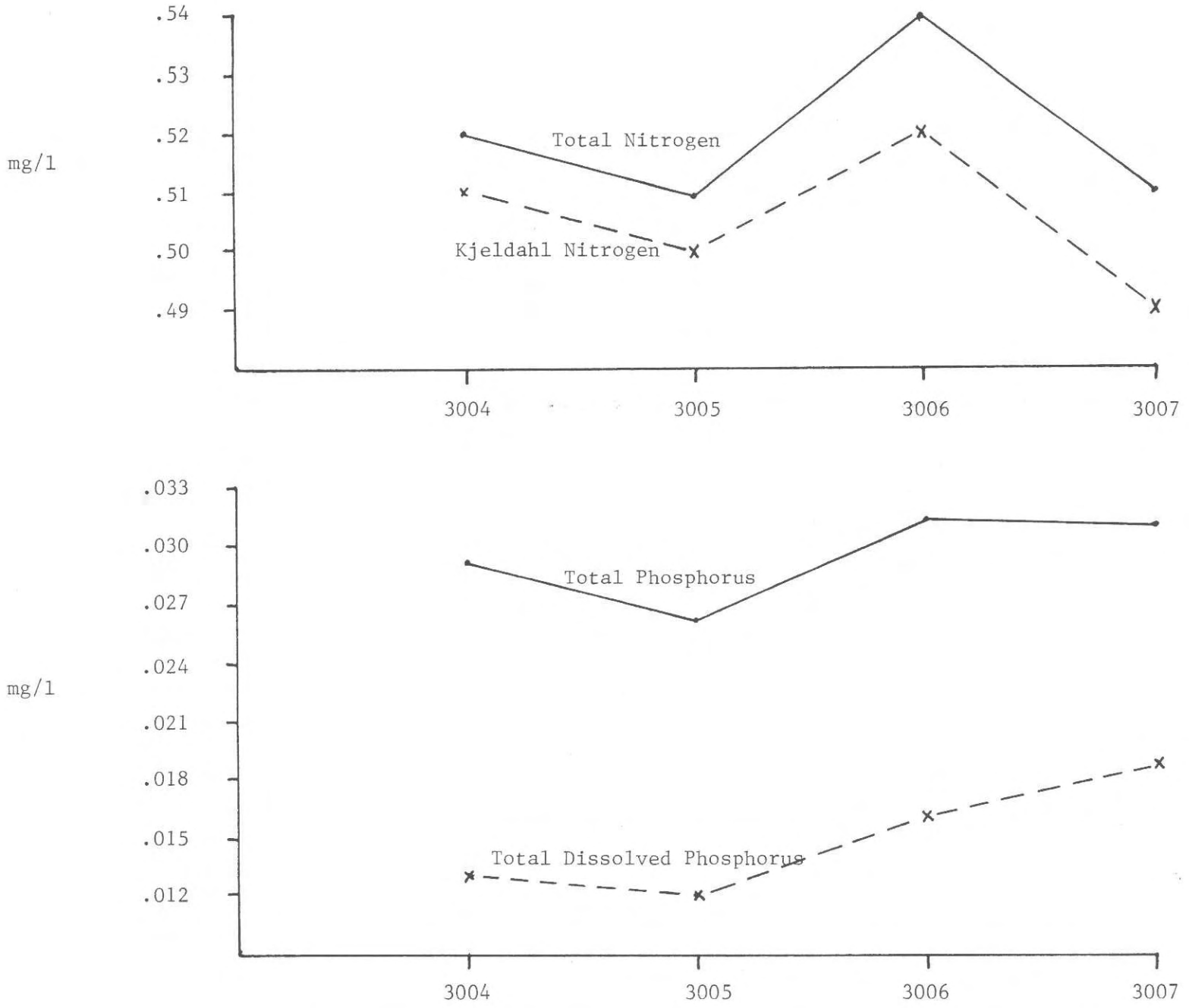

FIG. 10 - Nitrogen and phosphorus composition at four stations in Nicola Lake (1978/79).

at station 3007. Some of this variation was due to the amount of algae present during sampling. Algal blooms are not evenly distributed and single samples, although vertical composites can still miss or hit algal clumps.

The percent variation at stations from June to September was much greater. This variation was directly related again to plankton production.

2. Nitrogen

Mean nitrogen concentrations for the summer remained relatively similar from the inlet end of Nicola Lake (3004) to the outlet (3007) (fig. 10). A perceptible increase was noted at 3006 but then concentration dropped at 3007 to similar values at 3004 and 3005. The overall difference between the mean minimum and maximum concentrations was only about 6%.

Although concentrations varied considerably at each station over the summer period, the only discernable pattern was a gradual increase up to a maximum in September. This gradual build-up over time could have been caused by N-fixation by the blue-green algae present. No descernable pattern between stations was evident.

Kjedahl nitrogen comprised 100% of the total nitrogen in 22 of 30 samples. Nitrate nitrogen and nitrite nitrogen were detectable in 6 of 30 samples. The nitrate and nitrite occurred on two sample dates in August just after large plankton blooms had been present in the lake. When the blooms crashed, ammonia released by the lysed cells was attacked by nitrifying bacteria releasing nitrite which was then oxidized to nitrate. For the majority of the summer period, the nitrogen was tied up in algal biomass as evidenced by the large amount in the kjedahl form.

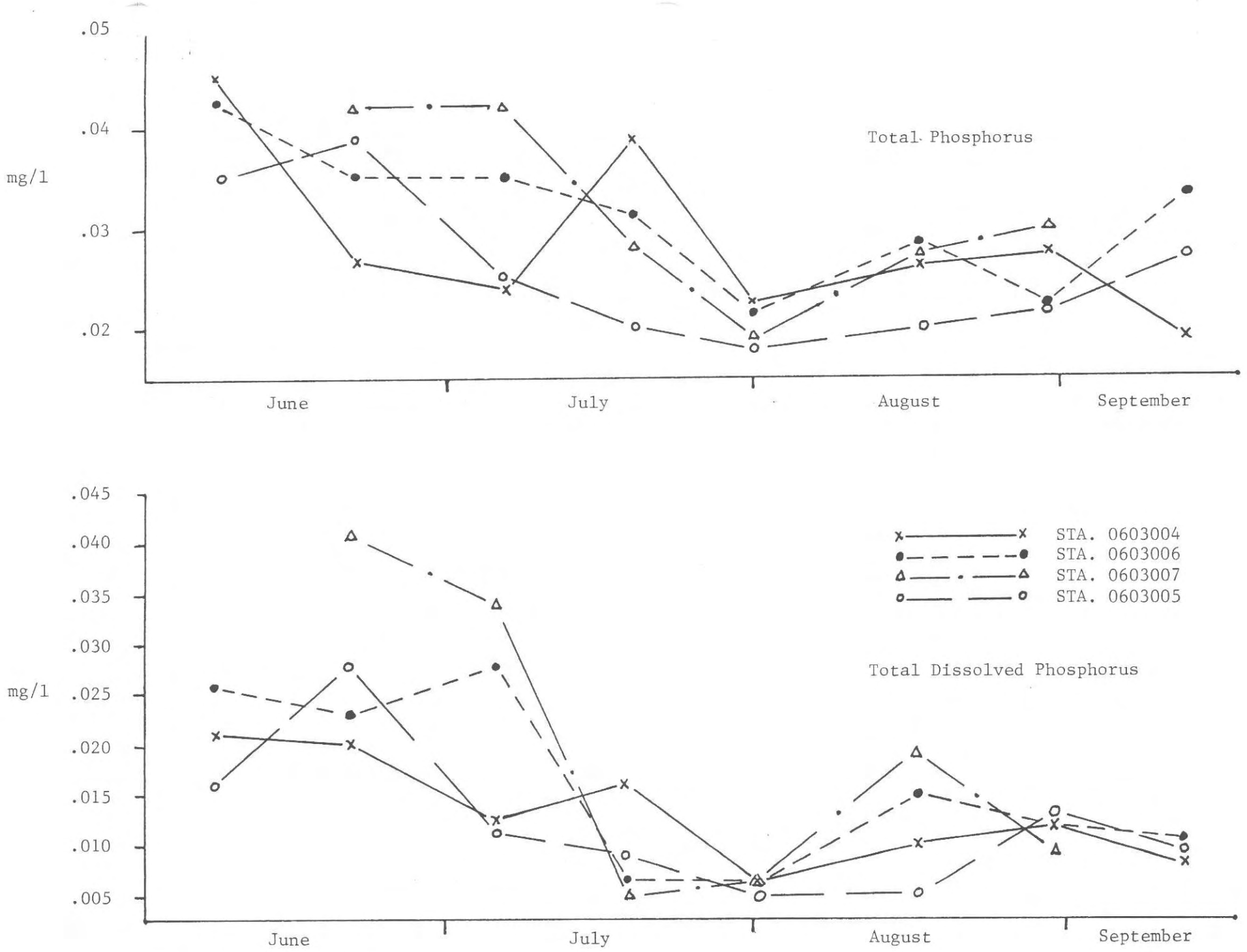

FIG. 11 - Total phosphorus and total dissolved phosphorus concentrations at various stations in Nicola Lake (1978/79).

3. Carbon

Very few changes occurred in organic and inorganic carbon over the sampling period. The only pattern noted was one of consistency especially in inorganic carbon. Higher organic carbon readings were noted on August 17 and June 7 however, the June 7th increase was slight. The August 17 increase was 3 mg/L higher than the average for allssampling dates. This increase corresponded to the previously mentioned crash in the phytoplankton bloom in early August.

C. BIOLOGICAL

1. Chlorophyll "a"

Chlorophyll "a" concentrations were low on the June 21 sampling date but then increased rapidly to a peak reading of 43 mg/L at station 3006 on July 19 (table 9). Concentrations dropped on August 17 but then rose slightly on August 30 and September 13. The high values recorded classify Nicola Lake as eutrophic and are in direct relationship to the high -nutrient levels previously discussed.

2. Species Identification

The number of species present varied from 5 on June 21 to 15 on September 13. No single species was present on all 6 sampling dates, however, 2 diatoms were present on 4 of the dates.

There were 18 diatoms species, 12 blue-greens, 6 greens, 1 rotifer, 1 dinoflagellate and 1 yellow-brown algae present through the summer. Diatoms were dominant on June 21 and July 6. On July 19 the blue-greens Aphanizominon flos-aquae and Oscillatoria amphibia were the most dominant with the diatom Cyclotellia Bodanica of lesser dominance. Although no sample was taken on August 1, a large bloom of Aphanizomenon sp. was present. The blue-green Oscillatoria tenuis

TABLE II Chlorophyll "a" concentrations (ug/L) at stations on Nicola Lake (1978).

Date	Station				Mean
	004	005	006	007	
June 21, 1978	3.1	2.5	2.7	-	2.77
July 6, 1978	9.4	6.9	2.9	1.4	5.15
July 19, 1978	17.6	16.9	43.0	24.0	29.78
August 1, 1978	24.0	-	-	19.0	20.5
August 17, 1978	8.7	9.7	3.8	3.5	6.43
August 30, 1978	7.9	12.4	-	11.1	10.47
September 13, 1978	13.3	14.8	14.4	-	14.17
Mean chlorophyll "a" concentration for all dates					12.8

was most dominant on August 17 with the diatoms Cyclotella bodanica, Stephanodiscus niagare and Melosire granulata of lesser dominance. The blue-greens Oscillatoria limnetica, Gomphosphaeria aponina and Chroococcu limneticus were dominant on August 30. On September 13, the diatoms Melosira granulata and Cyclotella bodanica and the blue-green Oscillatoria amphibia dominated.

The overall data indicated that diatoms remained numerous throughout the sampling period especially the order Centrales. Blue green algae became more important in the latter part of the summer while green algae remained a minor component. The presence of the blue-greens, especially Aphanizomenon sp. and Oscillatoria sp. is evidence of the eutrophication of Nicola Lake.

NICOLA / COLDWATER RIVERS AFTER UPGRADING THE MERRITT STP

I. Water Chemistry

A. Freshet:

a) Phosphorus

Phosphorus concentrations shifted from a steady increase at all stations until confluence with the Nicola River, as was the condition prior to the STP upgrading, to a steady increase in the Coldwater River reaching a peak after confluence with the Nicola. The Nicola River, however, dropped abruptly in phosphorus concentration after confluence, and once again reached a low at 0600179, above Guichon Creek.

Total phosphorus loadings differed again from those recorded before the upgrading of the STP. The patterns noted earlier were similar to the total concentration of phosphorus. Recent data, however, demonstrate the loadings to follow much the same pattern in the Coldwater River, but the Nicola River, instead of rising continuously until confluence with the Thompson, drops slightly at station 179.

-total dissolved phosphorus:

The total dissolved phosphorus concentrations followed the same pattern in the Nicola River as prior to the 1979 upgrading, but differed slightly in the Coldwater. That is, like the previously recorded pattern, the total dissolved phosphorus concentration increased from station 500 to 502 (above and below the STP, respectively), but instead of decreasing after confluence with the Nicola, it increased.

The load of dissolved phosphorus demonstrated a trend opposite to what was previously noted. Instead of a steady decrease after station 115 in the Nicola River and 502 in the Coldwater, a gradual increase was observed

in both systems, with a peak of 49.5 kgs/day at station 0600179.

b) Nitrogen:

Prior to the 1979 upgrading of the Merritt STP, total nitrogen, organic nitrogen and ammonia concentrations remained quite static throughout the Nicola river system, diminishing only a slight amount at station 179, but with a huge increase of 135% at station 502. Recent data, however, indicate a slight change. As before, $NO_2 + NO_3$ concentrations remained constant along the whole sampling system, but ammonia concentrations remained at a level as well. Organic and total nitrogen concentration patterns, like those previously noted, reached a peak at station 502, below the STP, and then leveled off at stations 534 and 179.

Organic and Total nitrogen loading patterns demonstrated the same trends that were visible in all nitrogen forms before the upgrading project. That is, all concentrations gradually increased to a peak at station 534 for the Nicola river, and a larger peak at station 502 for the Coldwater, and then a small decrease at station 179. Ammonia also showed this same pattern and $NO_2 + NO_3$ showed a steady increase to 179, above Guichon Creek.

c) Carbon:

Both Inorganic and organic Carbon concentrations and loads varied somewhat after the upgrading of the STP, in comparison with patterns observed before. Organic carbon remained the same with a large peak at 502, below the effluent discharge site and exhibited a steady decrease to 179. Previously recorded loads demonstrated a peak at station 502, however after 1979, this changed to a constantly increasing pattern, with station 179 at the high. Inorganic carbon concentrations, which previously decreased, currently reached a high after the confluence of the two rivers, and the load both before and after upgrading did so as well. It appears that before upgrading, carbon addition from the STP was in the organic form.

d) N/P Ratio:

This ratio was based on ammonia, nitrate and nitrite nitrogen versus total dissolved phosphorus. The ratios which were recorded before the 1979 upgrading project indicate an extremely N-limited system during freshet. A low concentration of 0.38 mg/l occurred at station 115, and did not rise above 1.0 at all other Nicola stations. The ratios were somewhat higher than this in the Coldwater system, but even so, both were still N-limited. The concentrations, however, soared after upgrading. The Coldwater river experienced a peak of 29.7 mg/l at station 502, below the sewage treatment plant, and the low, still at station 115, was only 1.63 mg/l.

B. Non-Freshet

a) Phosphorus:

Like the results which were evident before 1979 during the freshet period, increases in total and total dissolved phosphorus were extremely large below the discharge. Data recorded before and after the STP upgrading indicate that in both cases the phosphorus loading rates presented a trend similar to that of the concentration, but with a much more definite peak. That is, the peak which occurred at station 502, before upgrading began, was a 2257% increase over station 500, whereas the peak at station 502, after upgrading was a 160% increase from loading rates at 500.

b) Nitrogen:

The non-freshet total nitrogen concentrations varied from station to station in the same manner as the total phosphorus, with a small peak occurring below the confluence, and a larger one at 502, the station just below the STP, both before and after the upgrading. The organic nitrogen followed the total nitrogen closely, and the ammonia, save for a slight decrease in concentration at station 115 noted in later data, did as well. In both cases, the $NO_2 + NO_3$ remained quite constant at all stations, so

it was difficult to interpret any particular pattern. The total, organic and ammonia nitrogen loads followed similar patterns of concentration curves. The percent load increase in these patterns was considerable, reaching as high as 19415% in NH_3 at station 502 before the upgrading to 1723% in total nitrogen at station 502 after. The NO_2 + NO_3 load also increased, and this was not indicated by the concentration. The loading rate increases were magnified by the increased flows from tributaries.

c) Carbon:

Trends in inorganic and organic carbon concentration have changed considerably since the upgrading of the Merritt STP, in both the Nicola and Coldwater Rivers. Prior to this, both concentrations increased sharply between 500 and 502, but decreased in all Nicola stations to a low at 179. Later data demonstrate an initial decrease in Nicola stations, which increases slightly at 179, and as before, a general increase in the Coldwater stations. The loading patterns followed the concentrations closely during both time periods.

d) N/P Ratios:

During the non-freshet period before the upgrading of the Merritt STP, the ratio at station 502 was almost double that of station 500 owing to the large addition of ammonia and organic nitrogen from the STP. In the Nicola River, concentrations increased to a peak at 534, after confluence, and decreased again at 179. Recent results show a very similar pattern, except for a much more dramatic increase of eight times between stations 500 and 502.

II. River Periphyton:

1. Chlorophyll "a"

Prior to the 1979 upgrading of the STP, there were eight - two week periods sampled in 1978. Only one period, March 2-20, was sampled before the spring runoff. During 1980, sampling dates ranged from stretches of one week between sampling, to stretches of four weeks. Thus, the plexiglass samplers were checked between intervals of 1, 2, 3, and 4 weeks at each station. The 1978 recordings indicated that some growth was evident in both river systems during the period of March 2-20, but that very little was present below the confluence and none at the STP. Also, the periphyton accumulations were similar at the Nicola River above confluence, and above Guichon Creek. Due to the lack of growth at stations 502 and 534, it is possible that toxic conditions may have been present. Since no samples were taken above the STP, it is difficult to be entirely certain of this possibility. There was no 1980 data collected during this time period for which to draw any comparison. The first 1978 sampling period after freshet was June 17-31, and corresponding with that is the July 9-29 in 1980. The previous data indicate that growth was heaviest on the Nicola, just below the confluence, and lightest above. However, 1980 recordings show the complete opposite. Furthermore, where once growth was much heavier in the Coldwater system, recent data indicate a reversal of this observation. Thus, in 1978 it was evident that the addition of the Coldwater enhanced growth in the Nicola, whereas this was not so in 1980. However, since growth in the latter year at station 500, above the STP, was very minute, the lesser growth in the Coldwater and below the confluence could not be attributed to any toxicity caused by the Merritt STP.

July 31 to August 14, 1978 had the highest chlorophyll "a" reading at station 502, for the whole year. The growth at 115, however, was also extremely heavy, so the Coldwater River water did not have as great an influence. This pattern was followed with very little variance during the

1980 period, except that values recorded at station 502 were not the highs for the year.

The following two weeks, August 14-29, 1978 demonstrated an extremely high periphyton growth at station 543, South shore below the STP, but a very minimum growth at 502. This indicates possible toxicity occurred during this period at station 502, but since growth at all other stations was fairly heavy it did not extend into the Nicola River system. 1980 data does not have any indication of toxicity. Station 502 shows a tremendous periphyton growth, which increases even more following confluence with the Nicola River.

During the August 29/78 to September 12/78 period on the Coldwater growth was heaviest at the background station 500, above the STP, and lightest at 502, below the STP, North Shore. The two stations with data on the Nicola River had heavier growths than the Coldwater, and thus definite toxicity occurred at station 502 due to the STP. 1980 data for this time period indicate very similar results. Chlorophyll "a" was the highest at 115, but dropped below the confluence. Station 502 was extremely low, but since no data were recorded for 500, it was impossible to claim that any toxicity occurred due to the STP.

The September 12-26 period differed very greatly in 1980 as compared to 1978. Earlier recordings indicated that almost no growth was evident in the Coldwater system, whereas later data indicate a very heavy growth at station 502, below the STP. Once again, 1980 growth at 179 was extremely large, with lighter growths at the two preceeding Nicola Stations. The heavy growth at station 179 during 1978 was attributed to heavy nutrient loads from the STP, since dissolved phosphorus went from approximately 9 kgs/day at station 115 to 28 kgs/day at 534 and 16 kgs/day at 179. Similarly, in 1980 load increased from 6 kgs/day at 115, to 12 at 534 and then dropped to 8 kgs/day at 179. Hence, the trends in 1980 can probably be attributed

to the same factors as those which set the 1978 patterns.

As in 1978, there was almost no periphyton growth at the Coldwater stations during the September 26 - October 11 period. Growth at station 115, Nicola River above confluence was extremely heavy, but whereas a light growth was found during 1978 at 534, the heavy growth continued throughout the Nicola system during 1980. Thus, the earlier results indicate a toxicity due to the STP, which is absent in later data.

During the 1978 October 11-26 period, some growth occurred at station 500, Coldwater above the STP, while little growth was evident at the downstream Coldwater stations. On the Nicola system a large amount of periphyton was present at the upstream station 115, with lesser growth at 179, above Guichon Creek and the least at 534 below the confluence. Extreme toxicity was evident at station 502 during October. This toxicity was carried to station 534 on the Nicola where productivities decreased by almost 90%. A slight improvement in growth occurred at 179.

The exact opposite occurred during 1980. Growth was evident at 500, but increased by about 80% at station 502. Growth at 115 was even heavier than at 502, and the whole system peaked at 534. Thus, in no way was the STP responsible for toxic conditions during this time.

2. Species Identification:

During the July 17, 1978 to July 31, 1978 period, all sites were dominated by diatoms of the order Penales. This was true for 1980 as well, with all Nicola stations exhibiting a similar array of species. As was noted two years before, 1980 data as well show stations on the Coldwater, 500 and 502, to differ in their diatom types, and a blue-green Oscillatoria sp. was present at 502, whereas before it dominated below the confluence. One green algae, Cosmarium sp. was present at 500, during 1980.

The July 31 to August 14 period of both 1978 and 1980 was also dominated by the Penales diatoms. However, whereas 1978 data show blue-greens

to be present at stations 534 and 179 on the Nicola, with Oscillatoria ameona being dominant at 179, 1980 recordings find blue-greens dominant only at stations above confluence, 502 and 115. The dominant blue-greens were Lygbya sp. and Oscillatoria sp. No data were available for 534, and thus no comparisons could be made at this station.

The 1978 period from August 14 to August 29 followed the same general pattern as the previous two periods. Oscillatoria sp. was present at stations 115 on the Nicola and 502 on the Coldwater, but no sampling data were available at 179 and 534 for this period. 1980 data for this time period show diatoms of the order Pennales to dominate at all stations, however, blue-greens were not dominant at any stations. The green algae, Pediastrum sp. was a dominant at 115, whereas Stigeoclonium sp., also a green, dominated at 534.

The switch from the diatoms to the blue-greens at stations below the influence of the STP, during 1978, corroborates the eutrophication acceleration at these stations. This appears to be a direct result of the nutrient addition from the STP.

III. River Bacteriology:

A. Freshet:

Mean total coliform concentrations in the Nicola River above confluence and in the Coldwater river above the STP, were similar and quite low during the 1978 freshet period. There was an excessively high concentration at station 502, below the STP, of 792500 MPN/100 mls. This was attributed to the station's location in the discharge zone of influence, an incompletely mixed area just below the STP, and led to increased concentrations of 1500% at 534 in the Nicola.

Mean total coliform concentrations during 1980 followed much the same pattern as was noted in 1978, however the differences of concentration from

station to station are not nearly as dramatic. That is, the increase at station 502 is only to a concentration of 10400 MPN, causing Nicola station 534 to rise to 2900. However concentrations of total coliform at stations 115 and 179 in the Nicola, and 500 in the Coldwater are much the same.

Fecal coliform concentrations during the freshet in both 1978 and 1980 followed the same general pattern as total coliforms, however individual sampling results for both followed a more erratic pattern. This variability between stations is assumedly dependent on the daily STP coliform content. Thus, in 1978 and in 1980 the influence of the STP on the Nicola and Coldwater Rivers is readily apparent as evidenced by the large differences in concentrations of both fecal and total coliforms.

B. Non-Freshet:

The general pattern for this flow period in both 1978 and 1980 is similar to the freshet flow period at all stations. However, whereas 1980 indicates no marked differences, 1978 demonstrates the influence of the STP discharge had a greater impact on the two rivers. Both mean total and fecal coliforms increased immensely at station 502, below the STP, resulting in high readings at 534 and 179, the two Nicola stations below the confluence.