Environmental Protection Branch
Environmental Protection Service
Pacific Region

WATER QUALITY AND PERIPHYTIC ALGAL STANDING CROP OF LYNN CREEK, NORTH VANCOUVER: A COASTAL STREAM ADJACENT TO A SANITARY LANDFILL

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ABSTRACT

Significant increases in total ammonia, nitrate and total organic carbon were found in Lynn Creek downstream of the Premier Street landfill in North Vancouver. The higher levels of total ammonia downstream of the landfill were not restricted to any particular season of the year.

The standing crop of attached algae, measured as ug chlorophyll-a/cm^2, at the sample site downstream of the landfill was generally higher than that of the control stations. Levels at the control stations were similar to those reported for two other Northshore Vancouver streams.

RESUME

On a relevé une augmentation sensible des taux de concentration en ammoniaque, nitrate et carbone organique dans la rivière Lynn, en aval du dépôt d'ordures de la Premier Street, à North Vancouver. L'augmentation du taux d'ammonique relevé en aval du dépôt d'ordures n'est pas propre à une saison particulière.

La production des algues fixées mesurée en ug de chlorophylle par cm^2 au point d'échantillonnage situé en aval du dépôt d'ordures était généralement supérieure à celle des stations de contrôle. Les taux relevés par ces dernières étaient proches de ceux qui on été trouvés pour deux autres cours d'eau du North Shore.

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SUMMARY

The water quality of Lynn Creek downstream of the Premier Street landfill in North Vancouver was found to differ from that upstream. Significant increases in total ammonia, nitrate and total organic carbon were found downstream of the landfill. The increased total ammonia levels downstream of the landfill were significant irrespective of the season of the year. Calculated un-ionized ammonia concentrations were below recommended levels for continuous exposure to salmonids. The increased levels of nitrate downstream of the landfill could be due to the nitrification of ammonia. The phosphate content, dissolved oxygen content, pH and temperature of Lynn Creek did not appear to be influenced by the landfill. The high detection limit of .01 mg/l for total and total dissolved phosphate may not have been adequate to monitor the influence of the landfill on that component.

The standing crop of attached algae, as measured by ug chlorophyll-a/cm^2, was found to be greater downstream of the landfill and this could be related to the elevated nitrogen concentrations. The yearly mean standing crop for 1975 at the upstream control stations L1 and L2 was 0.24 ug chlorophyll-a/cm^2 and 0.77 ug chlorophyll-a/cm^2, respectively, compared to 1.36 ug chlorophyll-a/cm^2 downstream of the landfill at station L3. The precipitation of iron hydroxides on attached algae may be a factor controlling the level of primary production and the distribution of algae downstream of the landfill.

The diversity of diatoms present in Lynn Creek in June 1975 and September 1975 were comparable between the control stations and downstream of the landfill station. The relative abundance of the diatoms _Achnanthes_, _Navicula_ and _Nitzschia_ were appreciably greater downstream of the landfill in June 1975. In September 1975 the dominant diatoms downstream of the landfill were _Achnanthes_ and _Navicula_ while upstream _Cymbella_, in addition to the former two genera, was dominant. _Ulothrix_ was the dominant green alga recorded in Lynn Creek during June 1975 and September 1975. The green alga _Zygnema_ was identified in a sample at the upstream control station L1 in September 1975. Blue-green algae were not identified in either the June 1975 or September 1975 samples.

1.0 INTRODUCTION

Sanitary landfills are recognized to have a potential to pollute groundwater and surface waters through the generation of leachate (Culham & McHugh, 1969; Rovers et al., 1974). This problem is particularly evident at landfills where the application of sound engineering principles in site selection and design are not met. Leachates are formed when rainfall, surface run-off or groundwater come in contact with the solid waste and extract dissolved and suspended materials in it.

The City of North Vancouver, Premier Street landfill, started operations in 1956 and has been identified as a source of leachate contamination to Lynn Creek (Kelly, 1971). During 1974 and 1975 the Environmental Protection Service conducted a monitoring program to characterize the water quality of Lynn Creek above and below the influence of the sanitary landfill. Water quality measurements were made weekly over the period May 1974 to October 1975 and algal standing crop was determined once a month over the period October to November, 1974, and March to October, 1975.

2.0 DESCRIPTION OF THE STUDY AREA AND SAMPLE SITES

Lynn Creek drains a 36 km^2 area of the Coast Mountain Range, north of the City of Vancouver, British Columbia (Figure 1). The average annual rainfall for the Second Narrows area near Lynn Creek is in the order of 1 731 mm. The total monthly precipitation for the area over the study period is shown in Figure 2. It is likely that the rainfall would be somewhat greater nearer the Northshore mountains.

Flows on Lynn Creek are not monitored, but Water Survey of Canada (1977) historical stream flow data for 1915 to 1919 gives some indication of the seasonal discharge pattern (Table 1). Lowest flows are generally recorded over the months of August and September. The City of North Vancouver has a water license to use water from Lynn Creek for domestic purposes but they must maintain a 0.06 m^3/s minimum flow requirement. On average, the City of North Vancouver uses 0.18 m^3/s of Lynn Creek water and up to 0.58 m^3/s during peak periods (Scott, personal communication). The creek is obstructed with a cement dam at the City of North Vancouver intake approximately 6.4 km upstream of Burrard Inlet. There is a natural barrier to fish migration approximately 4.8 km upstream of Burrard Inlet.

For purposes of collecting water samples for water chemistry and determining algal standing crop, three stations were established on the creek. Control station L1 was located immediately downstream of the City of North Vancouver intake, control station L2 was established immediately upstream of the northwest border of the landfill, but downstream of Hastings Creek and Station L3 was located opposite Bridgeman Park approximately 0.75 km downstream of the southern boundary of the landfill. Point source discharges of leachate contaminated water into Lynn Creek are located at the northwest and southwest boundaries of the landfill site (Figure 3). Leachate also permeates through the dyke on the west boundary of the landfill. Samples to determine leachate quality were collected from the north perimeter outfall during the course of the study.

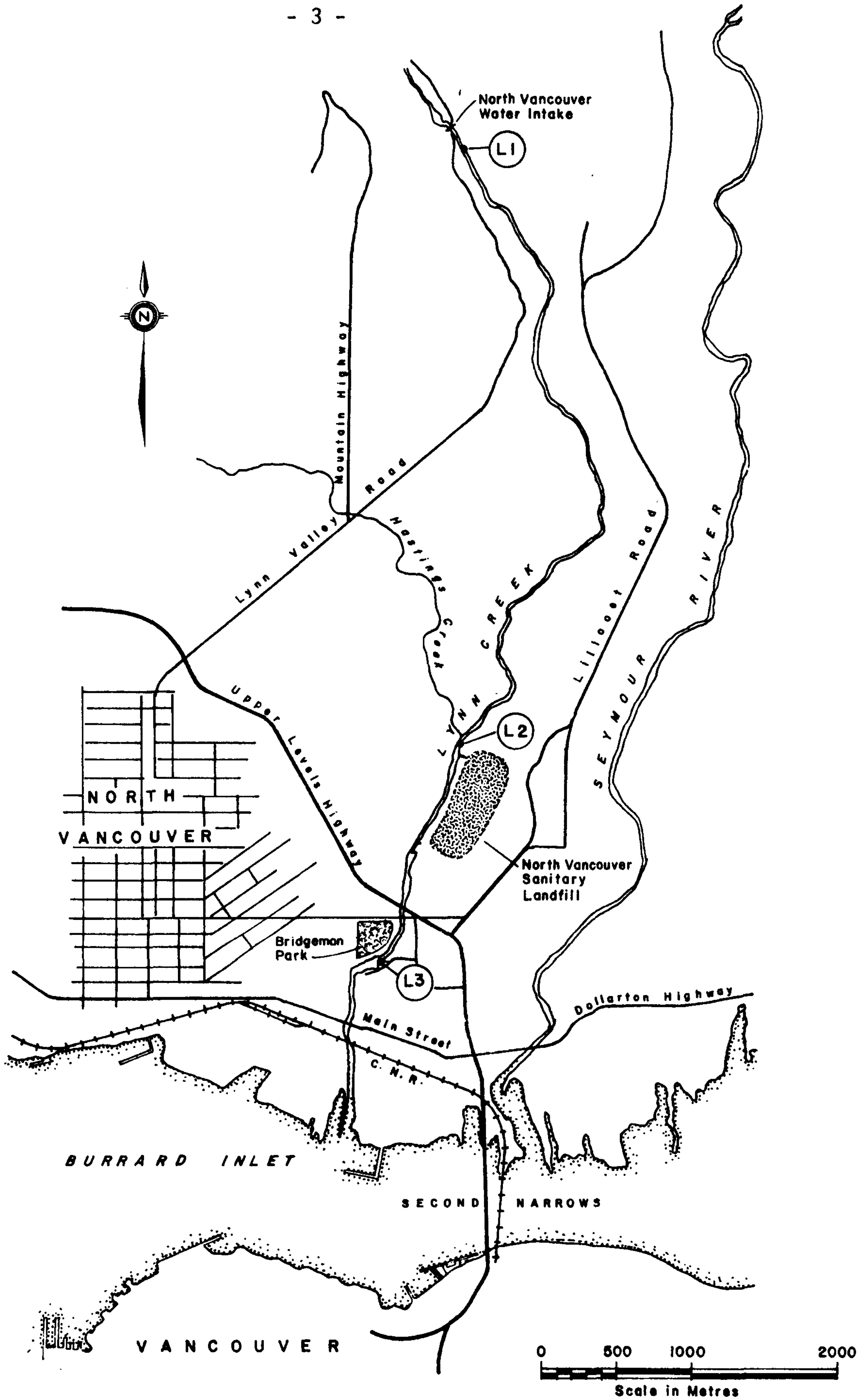

FIGURE I LOCATION OF LYNN CREEK IN NORTH VANCOUVER AND SAMPLE STATION LOCATIONS

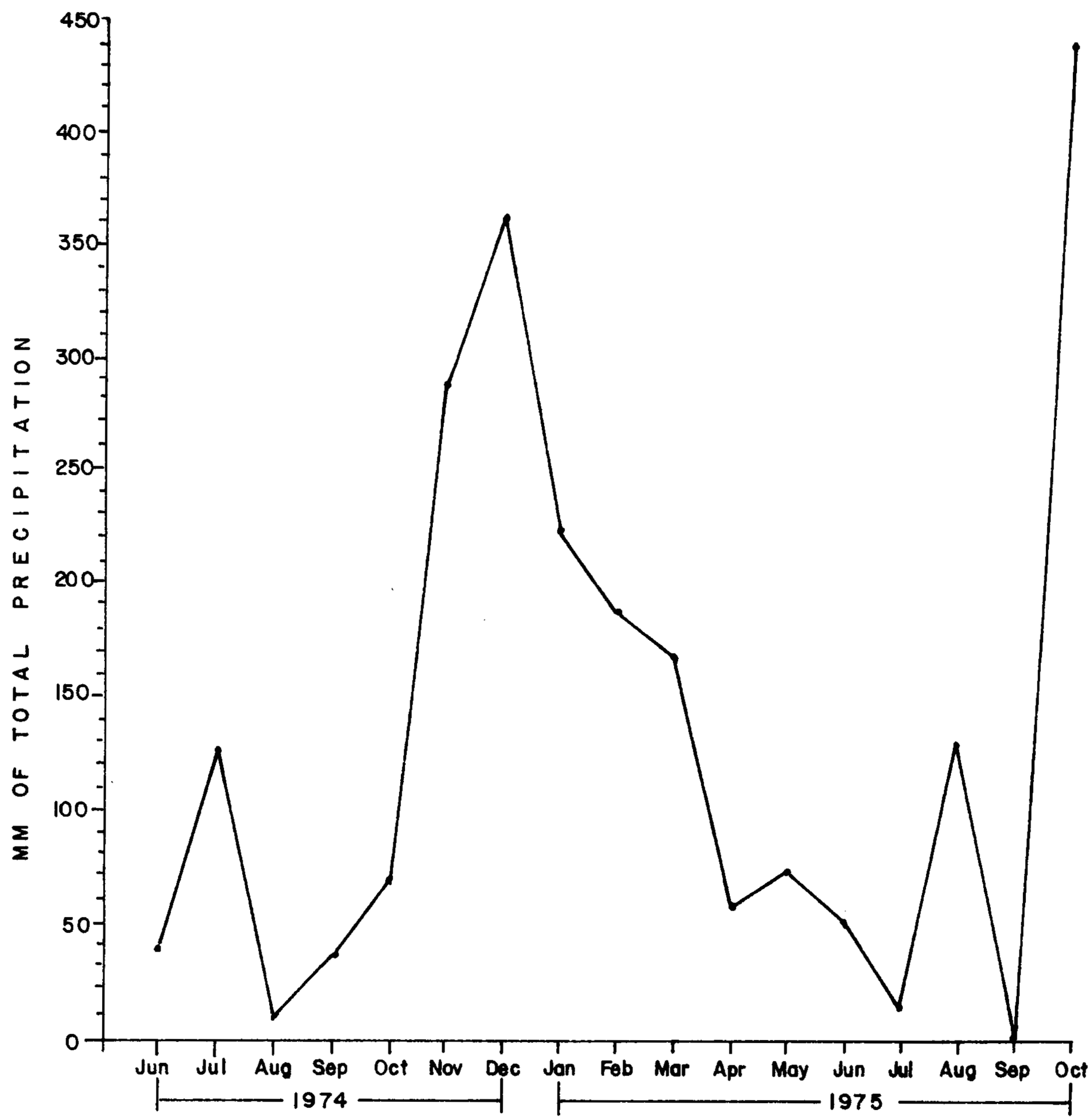

FIGURE 2 TOTAL PRECIPITATION AT ATMOSPHERIC ENVIRONMENT SERVICE - NORTH VANCOUVER, SECOND NARROWS STATION

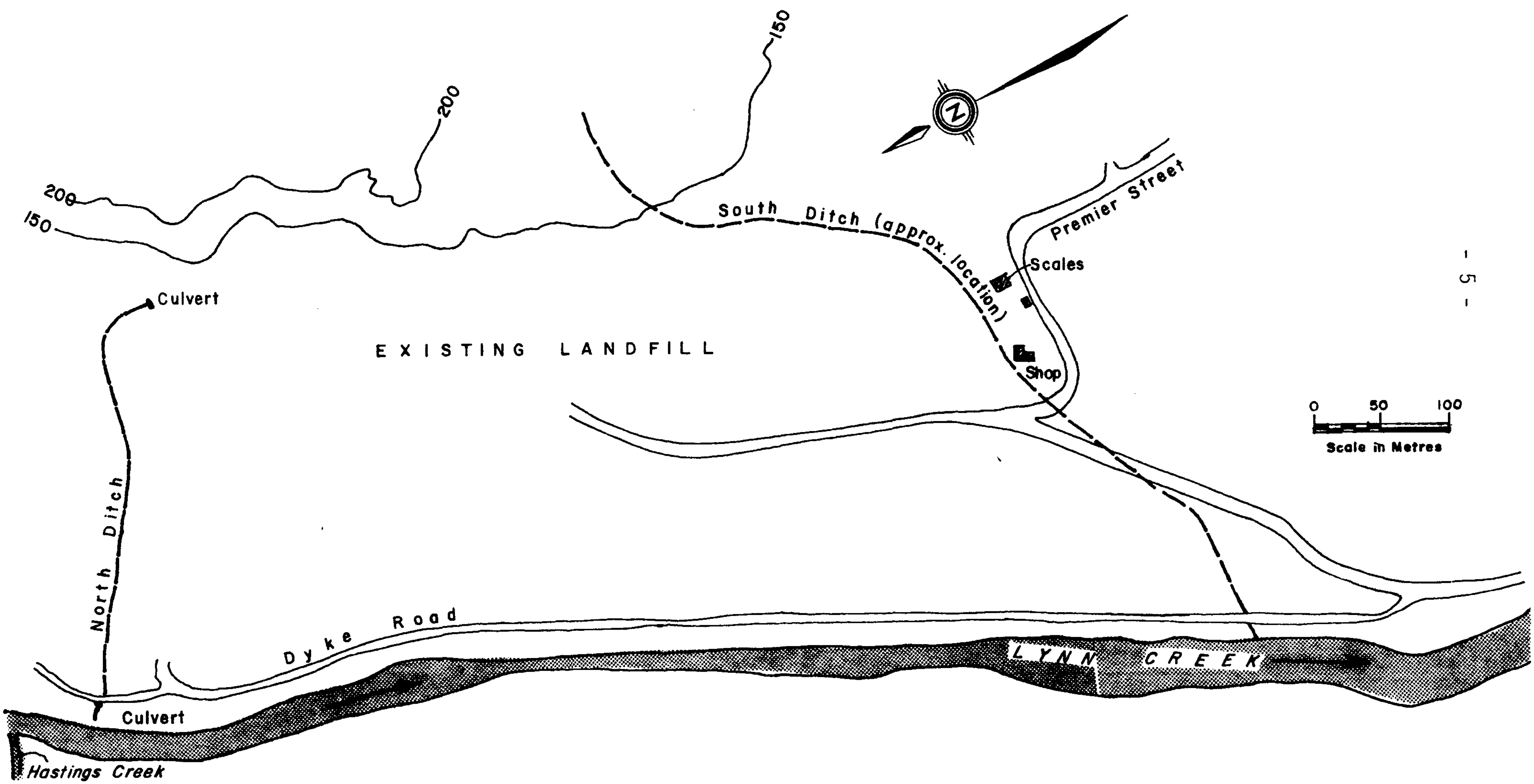

FIGURE 3 SITE MAP OF PREMIER STREET LANDFILL - NORTH VANCOUVER

TABLE 1 HISTORIC STREAMFLOW SUMMARY FOR LYNN CREEK, 1915 TO 1919

	MEAN MONTHLY FLOW (m^3/s)											
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1914	-	-	-	-	-	-	1.34	0.08	4.11	4.64	8.92	2.43
1915	3.29	4.93	4.39	6.20	6.32	1.55	0.38	0.08	0.06	8.38	7.05	9.32
1916	3.06	6.60	15.78	10.20	8.27	9.72	9.94	4.53	0.57	2.34	5.41	1.54
1917	6.17	5.61	1.62	5.89	7.79	13.74	9.46	2.83	3.51	2.38	5.72	16.57
1918	14.05	2.77	5.72	2.62	4.79	1.88	0.54	13.82	0.39	11.16	9.40	10.39
1919	5.01	2.81	3.99	10.96	4.96	5.83	5.01	1.05	0.57	-	-	-

All sample sites are characterized by fast-flowing water and a boulder type substrate. Generally, the rocks were typically rounded river rocks, but at station L1 the rocks were much larger and in some cases consisted of bedrock outcrops. The forest canopy at station L1 was moderate and there was no canopy at stations L2 and L3.

3.0 MATERIALS AND METHODS

3.1 Physical and Chemical Water Quality

All water samples were grab samples collected in a polyethylene sample container. Samples for dissolved oxygen were put in 300 ml BOD bottles, preserved with manganous sulphate and alkali-iodideazide reagents and titrated against a 0.025 N sodium thiosulphate solution within 4 hours. Samples for total organic carbon (T.O.C.) were stored in a 100 ml polyethylene sample bottle. Samples for total ammonia (NH_3+NH_4^+), nitrate (NO_3-N), total phosphate (TP), orthophosphate (OP) and pH were stored in a 500 ml polyethylene sample bottle. Dissolved phosphate (TDP) samples were filtered immediately through a distilled water washed 0.45 u cellulose acetate membrane filter and were kept in a 100 ml polyethylene sample bottle. Analytical methods used are those outlined in the Pollution Sampling Handbook of the Environmental Protection Service of Environment Canada (Anon., 1976).

Ammonia was analyzed with an Orion ammonia probe up to December 1974, a manual Berthelot method between December 1974 and July 1975 and thereafter by an automated Berthelot procedure. Nitrate was analyzed by an automated Diazotization method with copper-cadmium reduction.

For orthophosphate, the procedure consisted of a molybdenum blue method run on a Technicon automated system. The total phosphate and total dissolved phosphate analysis consisted of a potassium persulphate and HNO_3-H_2SO_4 autoclave digestion and then the sample was run on the orthophosphorous manifold of the Technicon.

Total organic carbon was measured on a carbon analyzer. Water temperature was determined with a hand-held thermometer and pH samples were run on a model 29 Radiometer pH meter either in the field or in the laboratory.

All samples were returned within 3 hours of collection to the Environment Canada, Cypress Creek, Laboratory in West Vancouver for analysis.

3.2 Periphytic Algal Standing Crop

Initially, plexiglass plates raised above the upper surface of a 10 kg cement block were staked at each sample station to colonize for a 4 week period. This method proved to be unsatisfactory due to the extreme variation in flows over short periods of time. The plates quite often were destroyed due to substrate movement during high flows, not recoverable due to high flows or left exposed during unpredicted low flows. In addition, the substrates were frequently vandalized.

An alternative method was selected based on a "toothbrush" sampler described by Stockner and Armstrong (1971) and had a 5.3 cm^2 sampling area. Six periphyton samples were collected at each station from areas which appeared to be representative of that stretch of the river.

Two attached algal samples were taken from three separate rocks located in close proximity to each other and the samples were combined, thoroughly mixed and the resulting composite was split in half. Ennis, 1975, found that combining two individual samples from a single substrate reduced the variability of biomass from a single substrate by about half. During extreme high flow and reduced flow conditions sample sites were relocated on the river bank as required.

One half of the composite sample was preserved with Lugol's solution for identification purposes. For analysis the sample was shaken and a 5 ml aliquot was taken and allowed to settle for 24 hours. Using an inverted microscope, the counts of two fields were averaged and extrapolated to number of cells/cm^2.

The remaining half of the composite sample was filtered, within 3 hours, through a 0.45 u cellulose nitrate membrane filter at 254 mm of mercury, treated with $MgCO_3$, frozen and returned to the Cypress Creek Laboratory for analysis (Anon., 1976).

4.0 RESULTS AND DISCUSSION

4.1 Premier Street Landfill Leachate Characteristics

The concentrations of various chemical constituents of leachate entering Lynn Creek are reported in Table 2. The leachate is characterized by high levels of ammonia, total organic carbon and low dissolved oxygen. The highest un-ionized ammonia concentration calculated from the limited sampling data was 0.110 mg/l.

4.2 Lynn Creek Physical and Chemical Water Quality

All analytical results for Lynn Creek over the period May 1974 to October 1975 are reported in Appendix I.

Temperature, dissolved oxygen and pH showed no appreciable differences between the control stations L1 and L2 and the downstream station L3. The pH in Lynn Creek ranged between 6.2-7.2 and is similar to the range of 6.3-7.2 reported by Derksen (in print) for the Capilano and Seymour Rivers which also drain the Vancouver northshore. Seasonally, water temperatures ranged between lows of 1.5-2.0°C in February to highs of 14-15°C in August. The percent saturation of dissolved oxygen remained near 100% saturation at all stations over the course of the study (Appendix I).

Total phosphate, total dissolved phosphate and orthophosphate did not indicate a documentable influence on the water quality of Lynn Creek downstream of the landfill. The high detection limit of 0.01 mg/l for total and total dissolved phosphate may not have been adequate to monitor the possible influence of the landfill on Lynn Creek water quality. Values of total and total dissolved phosphate were generally below detection (0.01 mg/l) as was orthophosphorous (0.005 mg/l).

Elevated concentrations of total ammonia, nitrate and total organic carbon were found at station L3, downstream of the landfill, compared to control stations L1 and L2 and indicate a deterioration in water quality. To test for levels of significance the data were arbitrarily grouped into four periods representing the seasons of the

TABLE 2 NORTH VANCOUVER PREMIER STREET LANDFILL, NORTH PERIMETER DITCH LEACHATE QUALITY

Sample Date (1975)	Nitrate (mg/l)	Total Ammonia (mg/l)	Un-ionized** Ammonia (mg/l)	Total Phosphorous (mg/l)	Total Dissolved Phosphorous (mg/l)	Temperature (°C)	Dissolved Oxygen (mg/l)	pH	Total Organic Carbon (mg/l)
May 29	8.0	14.2	-	.01*	.01*	11.0	0.0	-	46
June 05	0.22	7.2	.004	.091	.01*	11.0	2.0	6.5	70
18	.01	57.0	.110	.076	.01	13.5	1.6	6.9	46
26	0.20	11.0	.009	.01*	.01	11.5	1.1	6.6	50
July 10	0.40	2.0	.002	.070	.01*	10.0	5.5	6.8	4
Aug. 28	0.28	8.5	.008	.030	-	14.0	2.4	6.6	44
Oct. 09	0.10	11.0	-	-	-	11.0	0.30	-	53
24	0.85	7.0	.004	.090	.070	10.0	0.6	6.5	-

* less than detection limit
** calculated from formula from Emerson et al 1975.

TABLE 3 SEASONAL DIFFERENCES IN MEAN TOTAL AMMONIA LEVELS OF LYNN CREEK, 1974 TO 1975

Station	June to August, 1974 (mg/l)	September to November, 1974 (mg/l)	December 1974 to February 1975 (mg/l)	March to May, 1975 (mg/l)	June to August, 1975 (mg/l)	September to October, 1975 (mg/l)
L3	.059	.210	.313	.194	.123	.212
L2	.034	.007	.011	.012	.008	.006
L1	.034	.008	.011	.012	.006	.005
L3/L2	*	**	**	**	**	**
L3/L1	*	**	**	**	**	**
L2/L1	NS	NS	NS	NS	NS	NS

* significantly different at α = .05, 1 tailed
** significantly different at α = .01, 1 tailed
NS = not significant

year. Namely: Winter (December to February), Spring (March to May), Summer (June to August), and Autumn (September to November). The Wilcoxon two-sample test was used to test for the differences between two stations in a particular season (Walpole, 1968). The detection limit was used as the actual concentration in determining the mean.

Total ammonia levels upstream of the landfill were generally at or near the detection limit while levels downstream were much greater (Appendix I). As noted in section 3.1, two methods of ammonia analysis were used in this study. In addition, two levels of minimum detection were used and varied for different periods of the study. The mean total ammonia levels for the control stations generally reflect the detection limit (0.01 mg/l or 0.005 mg/l). Based on a mean total ammonia concentration calculated for each season, the differences between the control stations (L1 and L2) and the downstream station (L3) were significant for all seasons (Table 3).

The highest value of total ammonia (0.75 mg/l) recorded in Lynn Creek downstream of the landfill was on February 6, 1975. Using formula from Emerson et al., 1975, to determine the percent un-ionized ammonia, for station L3, the levels were less than 0.001 mg/l. This level is below the 0.005 mg/l concentration reported by Wedemeyer and Yasutake, 1977, as the safer continuous exposure level for salmonids. It is conceivable that concentrations in the immediate area of the leachate discharges may reach unacceptable levels. Burkhalter and Kaya, 1977, demonstrated that the growth and development of rainbow trout sac fry are inhibited by long-term exposure to concentrations of un-ionized ammonia as low as 0.05 mg/l.

Nitrate concentrations were often higher at station L3 downstream of the landfill (Appendix I). The seasonal mean nitrate concentration at control station L2 was often greater than that at station L1 (Table 4). Nitrate concentrations were significantly greater at station L3 compared to control stations L1 and L2 in the fall of 1974 and 1975 (Table 4). For the period December 1974 to February 1975, the

TABLE 4 SEASONAL DIFFERENCES IN MEAN NITRATE LEVELS OF LYNN CREEK, 1974 TO 1975

Station	June to August, 1974 (mg/l)	September to November, 1974 (mg/l)	December, 1974 to February, 1975 (mg/l)	March to May, 1975 (mg/l)	June to August, 1975 (mg/l)	September to October, 1975 (mg/l)
L3	.070	.220	.261	.205	.163	.242
L2	.070	.174	.227	.193	.125	.195
L1	.072	.161	.188	.184	.127	.163
L3/L2	NS	*	NS	NS	NS	**
L3/L1	NS	*	**	NS	NS	*
L2/L1	NS	NS	*	NS	NS	NS

* significantly different at = .05, 1 tailed
** significantly different at = .01, 1 tailed
NS = not significant

mean nitrate concentration was significantly greater at station L3 compared to station L1. However, station L2 was also significantly greater than station L1.

Total organic carbon levels were also noted to be greater downstream than upstream of the landfill (Appendix I). The differences were significant between stations L3 and L2 for all but the summer 1975 period and between stations L3 and L1 for the winter and spring period only (Table 5).

4.3 Periphytic Algal Standing Crop

4.3.1 Standing Crop. The standing crop of periphytic algae as measured by ug chorophyll-a/cm^2, is reported in Table 6 and shown schematically in Figure 4. The standing crop of attached algae was notably greater at station L3 downstream of the landfill compared to the control stations L1 and L2. There were considerable differences in the standing crop recorded between the control stations and this is likely directly related to differences in the degree of forest canopy and substrate. Station L1 had a considerable canopy whereas station L2 was in the open and the substrate at station L1 was composed of large rocks and bedrock outcrops which were difficult to sample while the substrate at station L2 was more typical of the creek.

Much of the chlorophyll-a measured at station L1 is likely attributable to the abundant growths of moss on the substrate as there only appeared to be a visible growth of attached algae in June 1975 and again in September 1975 during very low flows. For comparative purposes, station L2 most accurately reflected the forest canopy and substrate type at downstream station L3.

The highest standing crop values were recorded during late summer and early fall, coinciding with low flows, maximum water temperatures and long periods of daylight. Precipitation increases dramatically in the fall (Figure 2) and with increased creek flows, the attached algae are reduced to low levels. Based on samples collected in

TABLE 5 SEASONAL DIFFERENCES IN MEAN TOC LEVELS OF LYNN CREEK, 1974 TO 1975

Station	June to August, 1974	September to November, 1974	December, 1974 to February, 1975 (mg/l)	March to May, 1975 (mg/l)	June to August, 1975 (mg/l)	September to October, 1975 (mg/l)
L3			4.0	2.7	2.5	2.6
L2			2.0	1.8	1.5	1.6
L1			1.6	2.0	1.5	2.0
L3/L2			**	*	NS	*
L3/L1			**	*	NS	NS
L2/L1			NS	NS	NS	NS

* significantly different at $\alpha = .05$, 1 tailed
** significantly different at $\alpha = .01$, 1 tailed
NS = not significant

TABLE 6 PERIPHYTIC ALGAL STANDING CROP OF LYNN CREEK AND COMPARABLE STATIONS ON THE CAPILANO AND SEYMOUR RIVERS, NORTH VANCOUVER (ug CHLOROPHYLL-A per cm2)

	SAMPLE STATION					
	Lynn Creek			Seymour River*		Capilano River*
Date	L1	L2	L3	S1	S2	C1 (control)
1974						
Oct. 18	.05 (.02)	1.29 (.69)	2.62 (.87)	5.01 (1.88)	4.29 (7.39)	1.94 (.64)
Nov. 28	.46	BDL	.26	.22	.42 (.74)	.01
1975						
Mar. 06	.12	.01	.04	.10	.53 (.09)	BDL
Apr. 08	.21 (.04)	-	1.12 (.38)	.23 (.07)	.22 (.14)	BDL
May 08	.02	.46	1.19	.03	.42	.05
June 18	.55	.05	1.65	.25	.22 (.39)	.04
July 24	.15	.32	.63	.11	.93	.27
Aug. 25	.63 (.55)	3.03 (.25)	2.25 (.11)	1.13 (.07)	1.47 (.55)	.40 (.06)
Sep. 18	-	1.52	3.95 (1.97)	.03	2.05	.61
Oct. 23	BDL	BDL	.02	.01	.03	BDL

BDL = Below Detection Limit.
* = from Derksen (in print).
() = Pheopigment as ug/cm^2, reported only if sample above detectable limit.

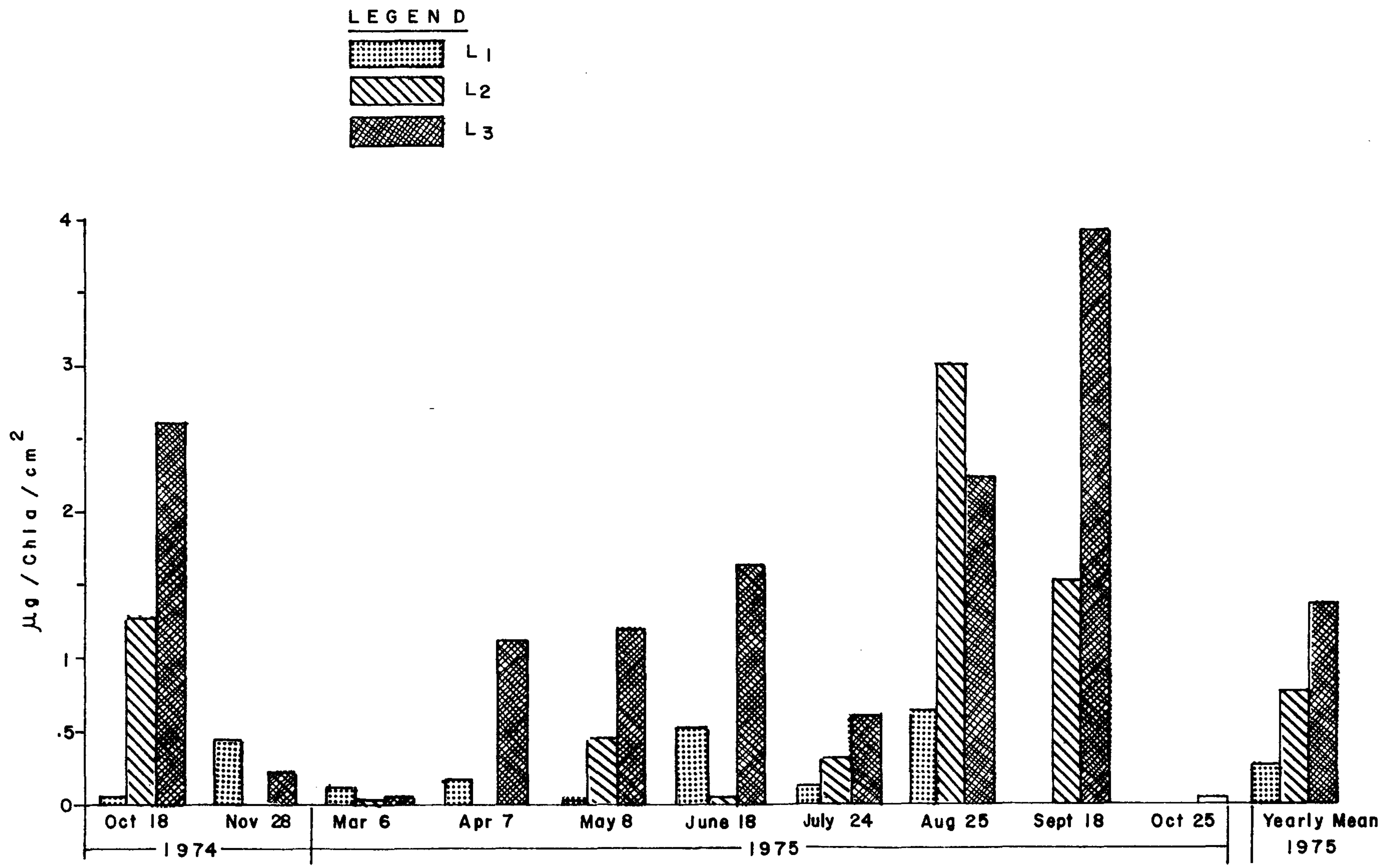

FIGURE 4 LYNN CREEK - MONTHLY RECORD OF PERIPHYTIC ALGAL STANDING CROP

1975 alone, control stations L1 and L2 had annual mean standing crops of 0.24 ug chlorophyll-a/cm^2 and 0.77 ug chlorophyll-a/cm^2 respectively compared to a value of 1.36 ug chlorophyll-a/cm^2 for station L3. Derksen (in print) reported for comparable stations, sampled on identical dates and with identical methods, an annual mean of 0.21 ug chlorophyll-a /cm^2 for the Capilano River and 0.77 ug chlorophyll-a/cm^2 and 0.27 ug chlorophyll-a/cm^2 for two stations on the Seymour River (Table 3).

The high standing crop value of 2.62 ug chlorophyll-a/cm^2 in October 1974 at station L3 was only about half of that reported by Derksen (in print) on the Seymour River for that month (Table 6). Standing crop levels at station L3 for the period April to June 1975 were higher than that reported on the Seymour River and the Capilano River (Table 6). The standing crop reported in September 1975, prior to autumn rains and increased river flows, were higher at station L3 (3.95 ug chlorophyll-a/cm^2) compared to station L2 (1.52 ug chlorophyll-a/cm^2) but in August 1975 a higher value was reported for station L2 (3.03 ug chlorophyll-a/cm^2) compared to that at station L3 (2.25 ug chlorophyll-a/cm^2).

4.3.2 Algal Identification. Identifications were made on the periphyton samples collected June 18, 1975, and September 18, 1975, (Table 7 and 8 respectively).

The composition of the attached algae in June 1975 was similar for all three stations. Bacillariophyceae (diatoms) represented the largest variety of algae. With the exception of *Achnanthes*, *Navicula*, *Nitzschia* and *Synedra* which were in increased abundance downstream of the landfill the number of cells per cm^2 for each genus of diatom present were similar. In a composite rating of algae tolerating organic pollution, *Nitzschia* and *Navicula* were among the top 8 genera (Palmer, 1969).

The Chlorophyta (green algae) were dominated by *Ulothrix* at all stations and were recorded in highest numbers at control station L1. Cyanophyta (blue-green algae) were not identified in any of the samples collected in June 1975. Bryophytes (mosses) were identified in the

TABLE 7 IDENTIFICATION OF ALGAE FROM LYNN CREEK FOR JUNE 18, 1975
ACTUAL COUNT EQUALS AMOUNT REPORTED TIMES 100 CELLS PER CM^2

	STATION/DATE (1975)		
	L1	L2	L3
Identification	June 18	June 18	June 18
CHLOROPHYTA			
Bulbochaete	-	-	-
Cladophora	-	-	-
Mougeotia	-	-	P
Oedogonium	-	-	-
Spirogyra	-	-	-
Ulothrix	2700.00	260.00	1300.00
Zygnema	-	-	-
CHRYSOPHYTA			
BACILLARIOPHYCAE			
(Pennales)			
Achnanthes	2.00	17.00	100.00
Amphora	-	-	-
Cymbella	14.00	8.50	19.00
Diatoma	2.00	P	1.50
Eunotia	0.60	-	1.50
Fragilaria	14.00	0.50	6.00
Hannaea arcus	2.50	P	2.00
Gomphonema	-	0.90	0.75
Navicula	8.60	15.00	140.00
Nitzschia	1.80	3.00	510.00
Synedra	1.20	3.50	76.00
Surirella	1.20	-	P
Tabellaria	15.00	1.80	5.90
(Centric)			
Melosira	29.00	1.00	7.40
BRYOPHYTA (moss)	P	-	-

P = Present

TABLE 8 IDENTIFICATION OF ALGAE FROM LYNN CREEK FOR SEPTEMBER 18, 1975
ACTUAL COUNT EQUALS AMOUNT REPORTED TIMES 100 CELLS PER CM^2

	STATION/DATE (1975)		
	Lynn Creek		
	L1*	L2	L3
Identification	September 18	September 18	September 18
CHLOROPHYTA			
Bulbochaete	1.25	-	-
Cladophora	-	-	-
Mougeotia	-	0.50	3.00
Oedogonium	P	-	-
Spirogyra	-	-	7.50
Ulothrix	P	310.00	12.00
Zygnema	470.00	-	-
CHRYSOPHYTA			
BACILLARIOPHYCAE			
(Pennales)			
Achnanthes	.30	8400.00	300.00
Amphora	P	-	14.00
Cymbella	.30	400.00	1.00
Diatoma	-	P	15.00
Eunotia	P	-	-
Fragilaria	2.00	1.50	1.50
Hannaea arcus	P	P	P
Gomphonema	-	45.00	P
Navicula	1.90	1600.00	3000.00
Nitzschia	P	10.00	35.00
Synedra	1.90	35.00	38.00
Surirella	-	-	0.50
Tabellaria	0.60	P	3.90
(Centric)			
Melosira	-	-	7.00
BRYOPHYTA (moss)	-	-	-

P = Present
* not representative of general creek condition, sample collected from a small visible patch of algae colonizing an area only accessible due to the low creek flow.

June 1975 station L1 sample and are thought to have contributed to the high chloryphyll-a value for that station.

For September 1975, the sample collected at station L1 was not truly representative of the overall creek. The sample was taken from a specific small area where a green growth of Zygnema was spotted and this area was only accessible due to the very low flow conditions. The overall variety of the attached algae assemblage in September 1975 at control station L2 and the downstream station L3 was similar (Table 8).

The dominant diatoms reported at station L2 were Achnanthes, Cymbella and Navicula; and at station L3, Achnanthes and Navicula were dominant. Achnanthes was found in higher densities at station L2 while Navicula was found in higher densities at station L3. The green alga Ulothrix was found in greatest density at control station L2. Blue-green algae were not found in any of the Lynn Creek samples in September 1975.

The substrate of Lynn Creek downstream from the north perimeter ditch outfall past Marine Drive is tinged a rusty color and is aesthetically unsightly. Kelly, 1971, reported that the colour is due to the accumulation of iron sulphide left by slime growths which are present in winter months. During the course of this survey, the substrate at station L3 had a brown discolouration and in the late summer and early fall period long strands of a brown precipitate were evident. As the growth on the substrate at station L3 was rusty and not typical of that observed on other Northshore streams it would seem likely that ferrous iron in the creek is being oxidized and ferric hydroxides are being deposited in association with iron bacteria on the attached algae. The Environmental Protection Service (unpublished data) found the concentration of total iron in Lynn Creek to be higher downstream of the landfill than upstream on two separate occasions. Concentrations of 0.05 mg/l and 0.10 mg/l were detected at station L2 on November 14, 1974, and March 6, 1975, respectively, compared to 0.08 mg/l and 0.67 mg/l at station L3. The long strands of growth are washed out of the system during the initial increase in rainfall and stream flows in the autumn.

Healey (1973) reports that when both nitrate and ammonia are present together, ammonia is usually taken up to exhaustion before the uptake of nitrate begins. As indicated in section 4.2, ammonia levels downstream of the landfill are significantly greater than upstream and available for algal growth. McKee and Wolf, 1963, reported that algae which thrive on high nitrate concentrations appear to be harmed or inhibited when the nitrogen is in the form of ammonia. In addition, they reported that 0.4 to 0.5 mg/l of ammonia nitrogen (as total) caused a complete disappearance of Aphanizomenon, a blue-green alga. Results of this study are not of sufficient detail to determine the influence leachates have on the distribution of attached algae or the level of primary productivity but increased nitrogen levels and iron precipitation must play an important role.

REFERENCES

Anon. Pollution Sampling Handbook of the Environmental Protection Service of Environment Canada (1976).

Burkhalter, D.W., and C.M. Kaya. Effects of Prolonged Exposure to Ammonia on Fertilized Eggs and Sac Fry of Rainbow Trout (Salmo gairdneri). Trans. Am. Fish. Soc., Vol. 106, No. 5 (1977).

Culham, R.S., and R.A. McHugh. Leachates from Landfills May Be New Pollutant. Journal of Environmental Health Vol. 31, No. 5 (1969).

Derksen, G.A. Water Quality and Periphytic Algal Standing Crop of the Capilano River and Seymour River, North Vancouver, British Columbia. Dept. of the Environment, Environmental Protection Service. Pacific Region. In Print.

Emerson, K., R.C. Russo, R.E. Lund and R.V. Thurston. Aqueous Ammonia Equilibrium Calculations: Effect of pH and Temperature. J. Fish. Res. Board Can. 32: 2379-2383 (1975).

Ennis, G.L. Distribution and Abundance of Benthic Algae Along Phosphate Gradients in Kootenay Lake, British Columbia. Verh. Int. Ver. Limnol. 19: 562-570 (1975).

Healey, F.P. Inorganic Nutrient Uptake and Deficiency in Algae. Reprinted from: Critical Review in Microbiology, Vol. 3, No. 1, pp. 69-113, September 1973 (1973).

Kelly, H.G. Pollutants from Refuse Dumps. Major Essay Submitted in Partial Fulfillment of M. Eng. Department of Civil Engineering, U.B.C. (1971).

McKee, J.E., and H.W. Wolf. Water Quality Criteria. The Resources Agency of California, Publication No. 3-A (1963).

Palmer, C.M. A Composite Rating of Algae Tolerating Organic Pollution. J. Phycol. 5, pp. 78-82 (1969).

Rovers, F.A., et al. Landfill Contaminant Flux - Surface and Subsurface Behaviour. Proceedings of 21st Ontario Industrial Waste Conference pg. 98-118 (1974).

Stockner, J.G., and F.A.J. Armstrong. Periphyton of the Experimental Lakes Area, Northwestern Ontario. J. Fish. Res. Board Cdn. 28: 215-229 (1971).

Walpole, R.E. Introduction to Statistics. The MacMillan Company, New York (1968).

Water Survey of Canada. Historical Streamflow Summary for British Columbia to 1976. Inland Waters Directorate, Water Resources Branch, Ottawa. (1977).

Wedemeyer, G.A., and W.T. Yasutake. Clinical Methods for the Assessment of the Effects of Environmental Stress on Fish Health. Technical Papers, U.S. Fish and Wildlife Service, Washington, D.C. (1977).

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APPENDIX I

ANALYTICAL RESULTS FOR LYNN CREEK
- MAY, 1974 TO OCTOBER, 1975

a) Dissolved Oxygen and Percent Saturation
b) Temperature, pH and Total Organic Carbon
c) Nitrate and Ammonia
d) Total Phosphate, Total Dissolved Phosphate and Orthophosphate

APPENDIX I(a) DISSOLVED OXYGEN AND PERCENT SATURATION OF LYNN CREEK, MAY 1974 TO OCTOBER 1975

Sample Date		D.O. (mg/l)			% Saturation		
	Station:	L1	L2	L3	L1	L2	L3
1974							
May	02	12.7	12.4	12.8	97.7	97.1	100.2
	09	12.7	12.8	12.7	97.2	99.4	99.6
	16	12.8	13.0	12.5	97.9	100.7	99.7
	23	12.5	12.7	12.2	96.2	101.3	97.3
	30	12.4	12.2	11.7	95.1	96.3	92.6
June	05	12.6	12.3	12.7	95.3	96.8	99.5
	13	13.0	12.8	10.4	101.0	102.1	82.9
	20	12.8	12.8	12.6	100.8	103.6	103.2
	27	13.3	13.3	12.9	104.7	107.6	106.9
July	04	12.5	12.6	12.7	98.4	104.4	105.3
	12	12.2	12.4	11.8	96.0	100.3	96.6
	19	12.0	12.1	11.7	97.1	100.3	98.2
	26	12.3	11.7	11.7	112.7	108.4	110.8
August	01	10.3	10.7	10.2	97.6	101.4	98.9
	08	10.4	11.4	10.4	97.4	108.0	102.0
	15	9.0	10.8	9.5	77.4	95.3	86.1
	22	-	-	-	-	-	-
	28	10.5	10.4	10.8	97.0	96.1	97.3
September	04	10.0	10.3	10.0	-	-	-
	12	12.8	12.3	12.5	114.8	111.9	114.5
	20	10.6	10.4	10.1	97.1	99.2	96.8
	26	-	-	-	-	-	-
October	03	11.4	11.4	11.8	101.9	104.4	108.1
	10	11.3	11.6	11.4	101.1	106.3	104.4
	18	12.9	11.5	11.6	110.9	102.9	101.1
	24	-	-	-	-	-	-
November	01	11.8	12.0	11.9	100.2	104.6	103.7
	07	11.9	12.1	11.7	99.8	102.8	100.7
	14	12.1	12.1	12.0	100.3	102.8	101.9
	21	12.2	12.1	12.2	98.7	97.9	98.7
	28	12.6	12.7	12.5	99.2	99.9	98.4

continued...

APPENDIX I(a) (cont'd.) DISSOLVED OXYGEN AND PERCENT SATURATION OF LYNN CREEK, MAY 1974 TO OCTOBER 1975

Sample Date		D.O. (mg/l)			% Saturation		
	Station:	L1	L2	L3	L1	L2	L3
December	04	12.2	12.2	12.4	98.7	98.7	102.8
	12	12.4	12.5	12.1	97.6	98.4	95.3
	19	12.8	12.7	12.7	100.8	102.7	102.7
1975							
January	09	13.5	13.7	12.8	100.7	102.2	98.1
	16	13.4	13.6	12.8	101.3	102.7	98.1
	23	12.7	13.2	12.6	99.9	103.9	99.2
	30	13.3	13.1	12.8	99.2	97.7	95.5
February	06	14.0	14.3	13.6	103.1	105.3	100.1
	13	13.2	13.1	13.0	99.8	100.4	99.7
	20	13.2	13.2	13.2	98.5	98.5	98.5
	27	12.9	13.1	12.8	100.2	102.6	100.8
March	06	13.3	13.4	13.3	99.2	99.9	99.2
	13	12.9	12.9	12.6	99.2	101.6	99.2
	20	13.4	13.2	12.9	102.7	101.2	101.6
April	04	12.8	13.4	12.6	100.8	105.5	99.2
	10	12.6	13.0	12.5	101.9	105.2	103.6
	17	12.9	13.0	12.7	104.4	105.2	102.7
May	01	12.6	12.7	12.7	101.9	102.7	102.7
	08	12.5	12.3	12.3	102.3	103.2	102.4
	15	12.5	12.5	12.4	98.4	101.1	100.3
	22	12.4	12.6	12.5	98.9	101.9	101.1
	29	12.2	12.6	12.4	101.1	104.4	102.8
June	05	12.6	12.5	11.4	101.9	103.6	96.9
	18	11.9	11.8	11.4	99.8	102.8	99.3
	26	12.0	12.0	12.0	99.5	101.9	101.9
July	10	12.4	12.1	11.9	110.9	113.3	111.5
	17	12.2	11.9	11.6	109.1	109.0	107.5
	24	14.3	10.8	10.8	-	-	-
	31	-	-	-	-	-	-

continued...

APPENDIX I(a) (cont'd.) DISSOLVED OXYGEN AND PERCENT SATURATION OF LYNN CREEK, MAY 1974 TO OCTOBER 1975

Sample Date		D.O. (mg/l)			% Saturation		
	Station:	L1	L2	L3	L1	L2	L3
August	07	10.5	10.3	9.6	97.3	101.0	94.2
	14	10.2	10.2	9.8	97.7	104.5	102.5
	21	10.0	10.0	9.9	95.8	99.3	102.5
	28	10.9	10.6	10.6	97.5	94.8	97.1
September	11	10.2	10.3	10.2	93.4	98.7	97.7
	18	10.9	11.0	10.6	97.5	104.2	99.3
October	02	10.5	10.9	10.1	96.2	104.5	96.8
	09	10.9	11.0	10.5	94.9	98.4	95.1
	24	11.8	11.8	11.5	100.2	99.0	96.5

APPENDIX I(b) TEMPERATURE, PH AND TOTAL ORGANIC CARBON CONTENT OF LYNN CREEK, MAY 1974 TO OCTOBER 1975

Sample Date		Temperature (°C)			pH			T.O.C. (mg/l)		
		L1	L2	L3	L1	L2	L3	L1	L2	L3
1974										
May	02	3.0	3.8	3.8	-	-	-	-	-	-
	09	2.8	3.5	3.7	-	-	-	-	-	-
	16	2.9	3.4	4.5	6.7	6.8	6.7	-	-	-
	23	3.0	4.5	4.5	-	-	-	-	-	-
	30	3.0	4.1	4.2	7.1	6.9	6.9	-	-	-
June	05	2.5	4.0	3.8	7.0	6.7	7.0	-	-	-
	13	3.5	4.5	4.5	6.9	6.8	6.7	-	-	-
	20	4.0	5.0	5.5	7.2	7.3	7.3	-	-	-
	27	4.0	5.0	6.0	7.2	7.1	7.1	-	-	-
July	04	4.0	6.0	6.0	6.9	7.3	7.1	-	-	-
	12	4.0	5.0	5.5	7.2	7.1	6.6	-	-	-
	19	5.0	6.0	6.5	6.8	6.9	6.9	-	-	-
	26	10.0	10.5	11.5	6.9	6.9	6.9	-	-	-
August	01	11.5	11.5	12.5	6.8	7.1	6.8	-	-	-
	08	11.0	11.5	13.0	6.8	6.9	6.8	-	-	-
	15	7.5	8.5	9.9	7.1	7.3	7.2	-	-	-
	28	10.4	10.4	10.4	6.9	7.0	-	-	-	-
September	04	-	-	-	7.2	7.2	7.0	-	-	-
	12	9.1	9.7	10.0	-	-	-	-	-	-
	20	10.0	11.8	12.0	-	-	-	-	-	-
	26	-	-	11.4	-	-	-	-	-	-
October	03	9.0	10.0	10.0	-	-	-	-	-	-
	10	9.0	10.0	10.0	-	-	-	-	-	-
	18	7.5	9.0	8.0	-	-	-	-	-	-
	24	-	-	-	-	-	-	-	-	-
November	01	7.0	8.0	8.0	-	-	-	-	-	-
	07	6.5	7.0	7.5	7.1	6.8	6.8	-	-	-
	14	6.0	7.0	7.0	6.7	6.7	6.7	-	-	-
	21	5.0	5.0	5.0	6.7	6.5	6.5	-	-	-
	28	4.0	4.0	4.0	6.9	6.8	6.8	1.0	1.0	2.0

continued...

APPENDIX I(b) (cont'd) TEMPERATURE, PH AND TOTAL ORGANIC CARBON CONTENT OF LYNN CREEK, MAY 1974 TO OCTOBER 1975

Sample Date		Temperature (°C)			pH			T.O.C. (mg/l)		
		L1	L2	L3	L1	L2	L3	L1	L2	L3
December	04	5.0	5.0	6.0	6.5	6.4	6.5	-	-	-
	12	4.0	4.0	4.0	6.6	6.2	6.3	1.0	1.0	1.0
	19	4.0	5.0	5.0	6.6	6.5	6.5	2.0	2.0	5.0
1975										
January	09	2.0	2.0	3.0	6.4	6.4	6.3	2.0	2.0	6.0
	16	2.5	2.5	3.0	6.9	6.7	6.6	2.0	2.0	5.0
	23	4.0	4.0	4.0	6.5	6.4	6.4	2.0	4.0	4.0
	30	2.0	2.0	2.0	6.5	6.4	6.4	-	-	-
February	06	1.5	1.5	1.5	6.4	6.2	6.6	2.0	1.0	3.0
	13	2.5	3.0	3.0	6.5	6.8	6.8	1.0	2.0	4.0
	20	2.0	2.0	2.0	6.6	6.6	6.6	1.0	2.0	4.0
	27	3.5	3.8	4.0	6.5	6.5	6.6	-	-	-
March	06	2.0	2.0	2.0	7.0	6.6	6.8	1.0	1.0	2.0
	13	4.0	4.0	4.0	6.9	6.8	6.9	1.0	1.0	2.0
	20	3.0	3.0	4.0	6.6	6.6	6.5	-	2.0	4.0
April	04	4.0	4.0	4.0	6.8	6.6	6.7	-	-	-
	10	5.0	5.0	6.0	6.5	6.8	6.7	4.0	5.0	6.0
	17	5.0	5.0	5.0	6.7	6.7	6.6	1.5	1.5	2.5
May	01	5.0	5.0	5.0	6.8	6.7	6.7	3.0	2.0	3.0
	08	5.5	6.5	6.5	-	-	-	3.0	2.0	2.0
	15	4.0	5.0	5.0	-	-	-	2.0	2.0	3.0
	22	4.5	5.0	5.0	-	-	-	2.0	1.0	2.0
	29	6.0	6.0	6.0	-	-	-	1.0	1.0	1.0
June	05	5.0	6.0	7.0	6.7	6.8	6.8	2.0	2.0	3.0
	18	6.5	8.0	8.0	6.5	6.6	6.6	1.0	1.0	2.0
	26	6.0	7.0	7.0	6.6	6.6	6.6	1.0	1.0	1.0
July	10	9.0	11.0	11.0	6.9	6.6	6.9	1.0	1.0	2.0
	17	9.0	10.0	10.5	6.4	6.5	6.5	1.0	1.0	2.0
	24	10.5	12.5	13.0	6.6	6.6	6.8	3.0	2.0	1.0
	31	11.0	14.0	14.0	7.0	6.9	6.9	1.0	1.0	1.0

continued..

APPENDIX I(b) (cont'd) TEMPERATURE, PH AND TOTAL ORGANIC CARBON CONTENT OF LYNN CREEK, MAY 1974 TO OCTOBER 1975

Sample Date		Temperature (°C)			pH			T.O.C. (mg/l)		
		L1	L2	L3	L1	L2	L3	L1	L2	L3
August	07	10.5	13.0	13.0	6.8	7.0	6.9	3.0	2.0	9.0
	14	12.0	15.0	16.0	6.7	6.9	6.9	1.0	2.0	1.0
	21	12.0	13.5	15.5	6.7	6.9	6.9	1.0	2.0	4.0
	28	9.0	9.0	10.0	6.5	6.6	6.6	2.0	2.0	2.0
September	11	10.0	12.0	12.0	6.7	6.9	6.9	1.0	1.0	2.0
	18	9.0	11.5	11.0	6.8	7.0	7.1	2.0	1.0	2.0
October	02	10.0	12.0	12.0	6.7	6.9	7.1	3.0	2.0	3.0
	09	8.0	9.0	9.5	-	-	-	1.0	1.0	3.0
	24	7.0	6.5	6.5	6.7	6.8	6.8	3.0	3.0	3.0

APPENDIX I(c) NITRATE AND AMMONIA CONTENT OF LYNN CREEK, JUNE 1974 TO OCTOBER 1975

Sample Date		NO_3 (mg/l)			NH_3 (mg/l)		
	Station:	L1	L2	L3	L1	L2	L3
1974							
June	05	0.100	0.100	0.090	0.02	0.04	0.040
	13	0.090	0.076	0.070	0.10	0.11	0.130
	20	0.060	0.055	0.058	0.09	0.05	0.080
	27				0.09	0.08	0.060
July	04	0.082	0.086	0.078	0.012	0.005	0.018
	12	0.068	0.077	0.090	0.005*	0.005*	0.035
	19	0.089	0.079	0.079	0.005*	0.005*	0.026
	26	0.051	0.038	0.052	0.005*	0.005	0.080
August	01	0.050	0.045	0.056	0.010	0.005*	0.059
	08	0.047	0.052	0.066	0.005*	-	0.013
	15	0.075	0.071	0.076	0.010*	0.010*	0.144
	22	-	-	-	-	-	-
	28	0.076	0.088	0.054	0.061	0.062	0.022
September	04	0.085	0.05	0.102	0.025	0.018	0.076
	12	0.163	0.165	0.179	0.010	0.013	0.136
	20	0.130	0.150	0.178	0.005*	0.005*	0.156
	26	0.138	0.137	0.223	0.005*	0.005*	0.300
October	03	0.179	0.201	0.222	0.006	0.006	0.390
	10	0.157	0.146	0.257	0.005*	0.005*	0.360
	18	0.076	0.080	0.155	0.005	0.005*	0.500
	24	-	-	-	-	-	-
November	01	0.255	0.245	0.280	0.010*	0.010*	0.190
	07	0.290	0.291	0.318	0.005*	0.005*	0.060
	14	0.132	0.208	0.308	0.005*	0.005*	0.095
	21	0.148	0.148	0.152	0.005*	0.005*	0.045
	28	0.184	0.208	0.272	0.005*	0.005*	-

continued...

* less than detection limit

APPENDIX I(c) (cont'd) NITRATE AND AMMONIA CONTENT OF LYNN CREEK, JUNE 1974 TO OCTOBER 1975

Sample Date		NO_3 (mg/l)			NH_3 (mg/l)		
	Station:	L1	L2	L3	L1	L2	L3
December	04	0.133	0.137	0.138	-	-	-
	12	0.168	0.144	0.206	0.01*	0.01*	0.140
	19	0.154	0.194	0.228	0.01*	0.01*	0.150
1975							
January	09	0.179	0.255	0.330	0.01*	0.01*	0.49
	16	0.219	0.260	0.330	0.01*	0.01*	0.41
	23	0.161	0.200	0.218	0.005*	0.005*	0.110
	30	0.188	0.308	0.258	0.01*	0.01*	0.380
February	06	0.185	0.225	0.270	0.01*	0.01*	0.750
	13	0.217	0.250	0.304	0.01	0.02	0.185
	20	0.240	0.275	0.315	0.02	0.01	0.270
	27	0.225	0.250	0.270	0.02	0.02	0.250
March	06	0.210	0.225	0.230	0.03	0.03	0.180
	13	0.190	0.220	0.240	0.01*	0.01*	0.230
	20	0.205	0.225	0.265	0.01*	0.01*	0.210
April	04	0.195	0.215	0.240	0.01*	0.01*	0.340
	10	0.215	0.231	0.250	0.01*	0.01*	0.280
	17	0.225	0.225	0.245	0.01*	0.01*	0.100
May	01	0.200	0.200	0.200	0.01*	0.01*	0.100
	08	0.147	0.148	0.153	0.01*	0.01*	0.550
	15	0.155	0.155	0.155	0.01*	0.01*	0.040
	22	0.173	0.167	0.170	0.01*	0.01*	0.060
	29	0.108	0.108	0.107	0.01*	0.01*	0.050
June	05	0.126	0.132	0.137	0.01*	0.01*	0.020
	18	0.100	0.103	0.105	0.01*	0.01*	0.030
	26	0.080	0.090		0.005*	0.005*	0.060
July	10	0.074	0.074	0.076	0.005*	0.005*	0.040
	17	0.090	0.090	0.100	0.005*	0.005*	0.190
	24	0.080	0.090	0.110	0.005*	0.007	0.110
	31	0.100	0.100	0.120	0.005*	0.010	0.210

continued...

* less than detection limit

APPENDIX I(c) (cont'd) NITRATE AND AMMONIA CONTENT OF LYNN CREEK, JUNE 1974 TO OCTOBER 1975

Sample Date		NO_3 (mg/l)			NH_3 (mg/l)		
	Station:	L1	L2	L3	L1	L2	L3
August	07	0.140	0.140	0.320	0.006	0.011	0.200
	14	0.120	0.150	0.200	0.005	0.015	0.255
	21	0.139	0.158	0.183	0.005*	0.010	0.200
	28	0.220	0.250	0.280	0.005*	0.005	0.035
September	11	0.170	0.180	0.220	0.005*	0.005	0.110
	18	0.225	0.196	0.235	0.005*	0.005*	0.250
October	02	0.090	0.190	0.300	0.005*	0.005*	0.340
	09	0.150	0.200	0.205	0.005	0.010	0.150
	24	0.180	0.210	0.250	0.005*	0.005*	0.210

* below detection limit

APPENDIX I(d) PHOSPHATE CONTENT OF LYNN CREEK, DECEMBER 1974 TO OCTOBER 1975

Sample Date		TP (mg/l)			TDP (mg/l)			OP (mg/l)		
		L1	L2	L3	L1	L2	L3	L1	L2	L3
1974										
December	04	0.01	0.01	(0.016)	0.01	0.01	0.01	0.005	0.005	0.005
	12	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	19	0.01	0.01	(0.19)	0.01	0.01	0.01	0.005	0.005	0.005
1975										
January	09	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	16	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	23	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	30	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
February	06	0.01	0.01	0.01	-	0.01	0.01	0.005	0.005	0.005
	13	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	20	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	27	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
March	06	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	13	0.01	0.01	0.01	0.01	0.01	0.012	0.005	0.005	0.005
	20	0.01	0.01	0.01	-	-	-	(0.008)	0.005	0.005
April	04	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	10	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	17	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
May	01	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	08	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	15	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	22	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	29	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
June	05	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	18	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-
	26	0.01	(0.01)	0.01	0.01	0.01	0.01	-	-	-

continued...

() - values not below detection limit, all other values are below the detection limit listed.

APPENDIX I(d) (cont'd.) PHOSPHATE CONTENT OF LYNN CREEK, DECEMBER 1974 TO OCTOBER 1975

Sample Date		TP (mg/l)			TDP (mg/l)			OP (mg/l)		
		L1	L2	L3	L1	L2	L3	L1	L2	L3
July	10	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	17	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-
	24	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-
	31	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-
August	07	0.01	0.01	(0.05)	0.01	0.01	0.01	0.005	0.005	0.005
	14	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	21	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	28	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
September	11	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.005	0.005
	18	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-
October	02	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-
	09	0.01	0.01	(0.013)	0.01	0.01	0.01	-	-	-
	24	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-

() - values not below detection limit, all other values are below the detection limit listed.