ATHABASCA RIVER
MONITORING PROGRAM
1980

G. Byrtus
Pesticide - Chemicals Branch
Pollution Control Division
Alberta Environment
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Abstract

The use of methoxychlor in the Athabasca River to control black fly (Diptera: Simuliidae) larvae was monitored in 1980 by Alberta Environment. Effective control of black fly larvae was observed for a distance of 60 km. The effect of the methoxychlor on non-target invertebrate organisms was considerable at sites located 60 km and closer to the treatment points, however, complete recovery was observed over the summer. Methoxychlor residues in the silt bedload dissipated fairly rapidly after treatment. Adult black fly activity data indicated that adults were more abundant in August than in June, suggesting that methoxychlor treatment of the river in late May had an effect on reducing adult numbers in the farming area during June.

Acknowledgements

I would like to express thanks and appreciation to all of the people that assisted in this program, especially: R. Jackson, N. Wandler, G. Sawchuk, D. Pledger, L.K. Peterson, B.W. Taylor, B. Murray, K. Wegner, G. Bodie, Dr. Y. Kumar, H. Coli and A. Furnell. I would also like to thank Aquatic Environments Ltd. for kindly providing the drift sample for my use.

Table of Contents

List of Figures

List of Tables

List of Appendices

Introduction

In 1980, as in 1978 (Pledger and Byrtus, 1980) and 1979 (Byrtus, 1981) the Pesticide Chemicals Branch conducted a biomonitoring program along the Athabasca river. The program was set up to determine any deleterious impact on the aquatic environment due to methoxychlor treatment of the river for larval black fly (*Simulium arcticum* Malloch) control. The control program was conducted by Treval Environmental Applications Ltd., who had been contracted by the County of Athabasca No. 12 to conduct the treatment. Methoxychlor treatment of the Athabasca River is at present the most economical and effective method of reducing adult black fly populations in the farming area near Grassland and Wandering River (Depner *et al*. 1980a) in northeastern Alberta (Figure 1).

The objectives of the biomonitoring program involved:

(1) Monitoring larval black fly populations and assessing the impact of the treatment on larval populations,

(2) monitoring nontarget invertebrate organism populations and assessing the impact of treatment on these organisms,

(3) monitoring methoxychlor residues in the silt bedload of the river over the summer of 1980,

(4) monitoring methoxychlor residues in water samples taken at Fort McMurray,

(5) monitoring adult black fly population levels and activity along the river surface,

and (6) monitoring adult activity in the farming area affected by black flies.

Sampling Sites

There were seven sampling sites located along the Athabasca River that were used in 1980. Control sites were located 20 km upstream (-20) and 40 km downstream of the Town of Athabasca. Treated sites were located at 80, 120, 180, 200 and 240 km downstream of the Town of Athabasca (Figure 1). During 1979 a site was located at 160 km but sampling at this site was discontinued for the 1980 program due to difficulty in obtaining samples there.

River Characteristics

The features of the Athabasca River in the study area has been described by Kellerhals et al (1972), Haufe and Croome (1980) and Byrtus (1981). River discharge during 1980 is illustrated in Figure 2 and shows that extremely high water levels were

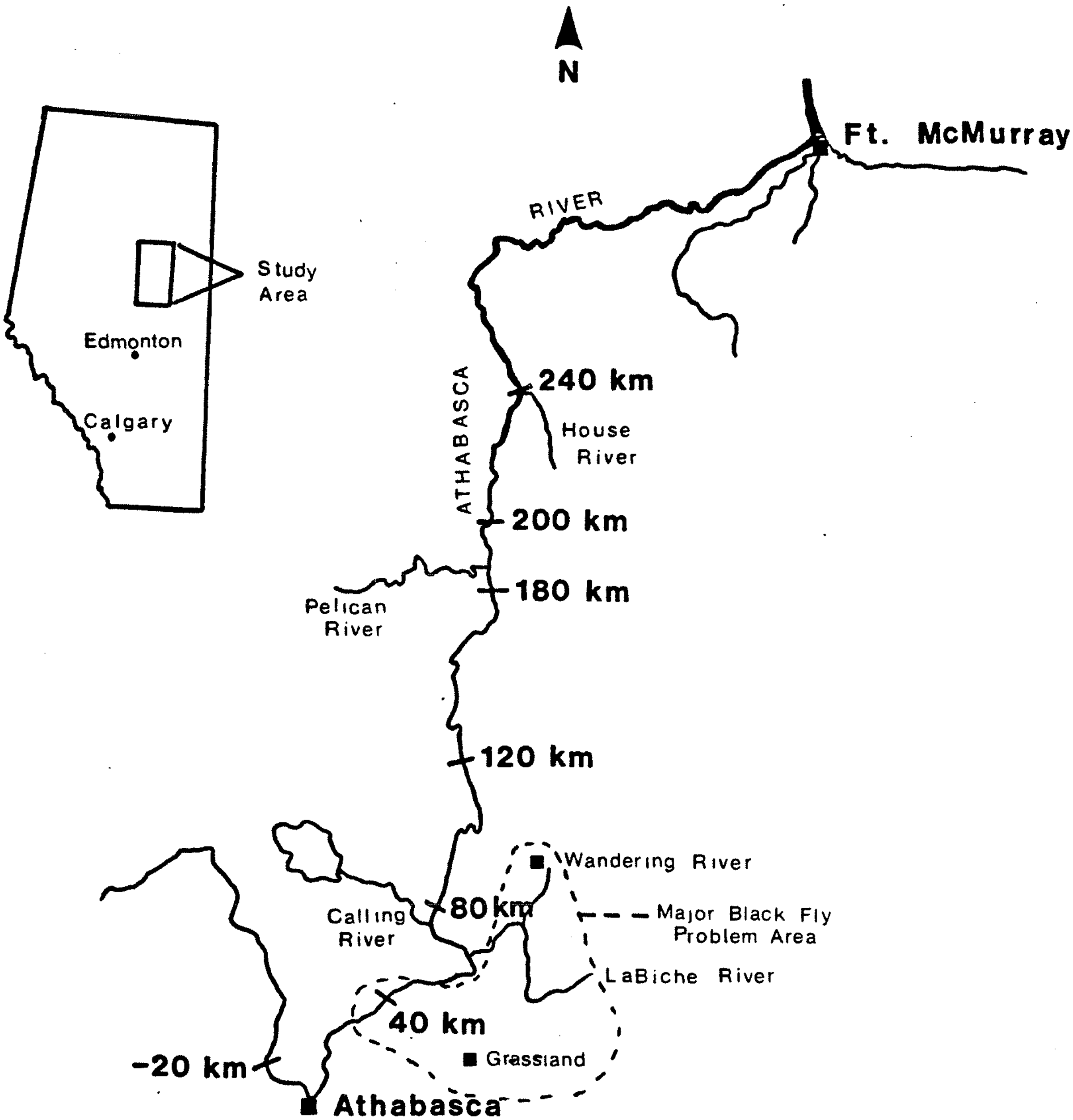

FIGURE 1 - Study Area and Sampling Sites

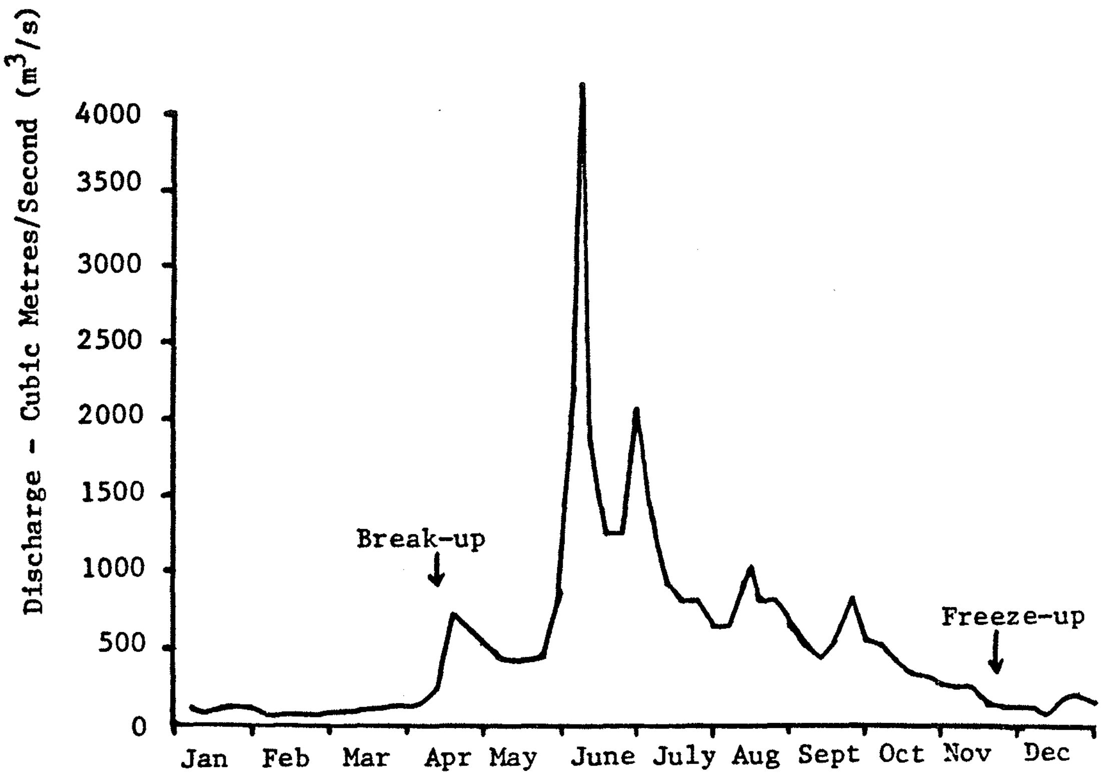

Figure 2 - Discharge of Athabasca River at Athabasca, 1980 (Water Survey of Canada Station No. 07BE001)

encountered in early June due to heavy rain in the Rocky Mountain foothills, the headwaters of many tributaries that feed into the upper Athabasca River (Graham, 1980). River levels were approximately 3 metres above normal for that time of year and caused considerable havoc with sampling apparatus maintained in the river and with sampling schedules.

Treatment

Monitoring of black fly larval development indicated that a two part treatment would be required on or about May 20. The first injection took place at 203 km on May 20 at 1445 hrs. River discharge at the site was calculated to be 487 m^3/sec. and 273 litres of methoxychlor (24% emulsifiable concentrate) was injected over 7.5 minutes to achieve a 299 parts per billion (ppb) concentration. The second injection took place at 59.5 km on May 21 at 1840 hrs. River discharge at the site was calculated to be 444 m^3/s and 250 litres of methoxychlor was injected over 7.5 minutes to achieve a 300 ppb concentration. The procedure and materials used in treating the river is described by Depner _et al_ (1980a).

Sampling Methods

Larval Sampling

Black fly larvae were collected at each of the seven sites, on a weekly basis, using the artificial substrate (plastic cone) method described by Depner et al (1980a) and Pledger and Byrtus (1980). Collected larvae were placed into 1 oz. Universal sampling vials filled with 95% ethanol and taken back to the laboratory. Sorting and aging (according to Fredeen, 1976) of the larvae was then conducted under dissecting microscopes.

Non-target Organism Sampling

Non-target invertebrate organisms were collected over the summer at each of the seven sites using the rock tumble method described by Depner et al (1980b) and Pledger and Byrtus (1980). Sample sites were established in riffle areas near to shore and adjacent to the black fly larval sampling sites. The samples obtained were preserved in 95% ethanol and taken back to the laboratory for sorting and identification. Specimens were taken to the generic level where possible using the keys in Ward and Whipple (1959), Usinger (1973), Pennak (1953), Merrit and Cummings (1978), Wiggins (1977) and Baumann et al (1977).

Sample sites were analyzed individually and not pooled as in 1979 (Byrtus, 1981) as it appeared that the methoxychlor caused varying effects at the various sites during the field sampling. Percent reduction was calculated using unadjusted percent changes in pre and post-treatment populations as well as using the modified Abbott's formula to adjust for changes at control sites

(Flannagan *et al* 1980). Diversity indices for each sample was calculated using the Shannon-Weiner formula ($D = -\Sigma\rho i \log_2 \rho i$) as presented by Smith (1974). Diversity indices are used as an indication of apportionment of individuals among a population and indicate changes in a community due to pollution or natural causes (Wilhm 1972).

Adult Sweeps

Adult black fly sweeps were conducted in 1980 in much the same fashion as described by Pledger and Byrtus (1980) and Byrtus (1981) for 1978 and 1979 respectively. A 30 cm diameter net was held just above the surface of the water while travelling at a speed of 40-50 km/hr in a boat for a 2 km distance at 10 km intervals. Black flies collected were preserved in 95% ethanol and taken back to the laboratory for counting and identification.

Barrel Traps

Barrel traps (Byrtus, 1981) were again set out in 1980 in the farming area to monitor adult activity. Three traps were set up at various locations in the pasture of G. Lantz (SE1/4, Sec 29, Twp 68, Rge 19, W 4th), one trap was located at a landing along the Athabasca River nearby (48 km downstream of the Town of Athabasca), and one trap was located adjacent to a stream 5.6 km NW of the Lantz pasture. The Tanglefoot ® covered plastic was changed on a weekly basis and the samples were taken back to the laboratory for counting.

Methoxychlor Residues - Silt and Water

Silt from the river bottom was collected for methoxychlor residue analysis. Collection was carried out by placing three modified Bogardi samplers (Charnetski and Depner 1980) at each sampling site on the downstream trip and picking them up on the return trip the next day. The collected samples were mixed and placed into clean polyethylene bags, taken back to the laboratory, frozen and sent to the Pollution Control Laboratory in Vegreville for analysis.

Water samples were collected for methoxychlor residue analysis at Fort McMurray (395 km downstream of the Town of Athabasca) after the 203 km injection. Samples were taken from the river, the water treatment plant, and the Suncor and Syncrude water storage ponds prior to and during the calculated passage of the methoxychlor. The samples were analyzed by the Pollution Control Laboratory.

Results

Larval Sampling

Samples of black fly larvae were collected from the Athabasca River over a four week period, initiating when the consultant in charge of the control program indicated that early samples were over the treatment threshold level of 500 larvae/cone (Murray 1980). Sampling was discontinued after June 3 due to extremely high water levels that continued for the remainder of June. The mean number of larvae/cone collected during 1980 is presented in Table 1.

Sample Date	-20		40		80		120		180		200		240		Overall
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$
May 13/14	24	15	36	22	195	104	744	238	1145	432	4135	1296	877	204	1022
May 20/21 (pre-treatment)	68	17	76	70	224	64	1086	344	259	169	1642	568	194	85	507
May 23/24 (post-treatment)	11 (4)	9.9	75	52	14	6.4	42	18	120	92	642	370	3	1.8	130
May 27/28	28	10.6	21	13	60	36	43	17	3	2.1	149	85	3	2.2	44
June 3/4	9 (4)	7.8	11	8.0	16 (4)	14	4	4.2	– (0)	–	6	4.7	7	2.4	9

Table 1 - Mean number of larvae/cone ($\bar{x}$) and standard deviation (S.D.) (Number in brackets indicates number of cones collected if less than six were obtained.)

Larval numbers during 1980 were highest in mid-May with an overall mean number of 1022 larvae/cone. Numbers decreased the next week to a mean of 507 larvae/cone and decreased again significantly just after the treatments (to 130 larvae/cone).

Numbers of larvae continued to decrease until the sampling was terminated on June 3.

	May 13/14	May(Pre) 20/21	May(Post) 23/24	May 27/28	June 3/4
1	3.92	4.20	3.43	18.3	31.7
2	14.3	22.2	4.05	22.1	43.4
3	11.4	13.8	2.03	2.83	9.06
4	12.5	12.1	1.62	3.21	5.28
5	20.4	14.1	4.17	2.39	3.77
6	36.4	14.9	19.6	15.1	3.77
7	1.03	15.0	40.6	21.9	2.26
Pupae	0	3.58	24.4	14.1	0.75
Total Larvae and Pupae	42 922	21 294	5422	1840	265

Table 2 - Percent distribution of black fly larval instars (Seven sites)

Development of the larvae and pupae in the river is expressed in Table 2. When the first samples were obtained on May 13, the majority (almost 57%) of the larvae were in the fifth and sixth instars. On May 20, just prior to treatment, the development pattern had changed, with almost 15% of the larvae being fully mature (seventh instar) and over 3.5% attaining the pupal stage. The post treatment samples indicate that the majority of immature black flies collected (83.6%) were mature larvae (sixth or seventh instar) or pupae. The May 27 sampling period showed that a second hatch occurred at the time of treatment, as 40.4% of the larvae collected were first and second instar larvae, while the percentage of mature larvae declined. The following week (June 3) showed that most of the mature larvae had emerged and that the majority of larvae collected were from the first and second instars.

A more complete description of the larval instar development data prior to treatment (Appendix 1 & 2) shows that in general, immature larvae were more predominant at sites in the upper reaches of the study area (-20, 40, 80 and 120 km) while mature larvae and pupae were predominant at the sites in the lower reaches of the study area (180, 200 and 240 km). This difference in development is the main reason that the first injection of methoxychlor was at the 203 km location while the second injection was further upstream. This procedure was also conducted for the first 1979 treatment (Byrtus, 1981) and for the 1976 treatment (Depner et al. 1980a) for the same reasons.

Table 3 lists the percent reduction of larval populations at the treated sites. The numbers were adjusted to allow for changes in the control sites populations by using the modified Abbott's formula. The data show that at 80 and 120 km, considerable reductions in overall larval populations was observed. However, at 180 and 200 km, reduction of larval numbers was poor, ranging from 22.4 to 34.5%. At 240 km, larval populations were severely affected (97.4% reduction) by the methoxychlor.

Instar	80	120	180	200	240
	Site Locations				
1	61.3	87.6	88.9	79.5	73.6
2	97.3	99.7	100	100	100
3	98.6	99.8	98.3	98.5	100
4	97.8	99.7	92.0	98.1	98.9
5	100	100	57.7	86.1	100
6	97.1	82.4	2.23	41.9	97.3
7	100	97.8	17.4	72.3	99.6
Pupae*	+100	+558	+2937	+32.5	50.0
Overall Reduction (Larvae only)	89.5	93.5	22.4	34.5	97.4

Table 3 - Percent reduction of each instar of black fly larvae (adjusted by modified Abbott's formula). May 20/21 and May 23/24 samples.

* unadjusted figures

In examining percent reductions of specific instars (Table 3), it is apparent that considerable reductions of early instar larvae (first, second, third and fourth) occurred at all sites. Reduction of fifth, sixth and seventh instar larvae at 80, 120 and 240 km was considerable but at 180 and 200 km, reduction was very low (2.23%) to moderate (86.1%). The unadjusted results for the pupae (unadjusted as no pupae were collected at the control sites prior to treatment) showed considerable increases at all sites except 240 km, which showed a 50% decrease.

Non-target Invertebrate Organism Sampling

Non-target organism (NTO) sampling commenced on April 22/23 and continued on a weekly basis until May 27/28, after which samples were collected on July 22/23 and August 12/13. Results from the samples collected are presented in Appendices 6 - 14.

Table 4 presents the percent change in numbers of non-target organisms from pre-treatment (May 20/21) and post-treatment (May 23/24) samples taken at the different sites. Figures from the control column (control being the mean of sites -20 and 40 km) indicate an increase in numbers between pre and post-treatment samples of all taxa sampled. The figures for 80, 120 and 180 km show variable reductions in most of the taxa (Ephemeroptera, Plecoptera, Trichoptera) with increases in numbers of certain taxa occurrring occasionally. The figures from 200 km show a slight increase in unadjusted total numbers and a slight decrease in adjusted total numbers, with most of the reduction limited to the Trichopterans. The figures from 240 km show considerable reduction of all taxa with the exception of an increase in unadjusted Trichopteran numbers.

	Site Location										
	Control	80		120		180		200		240	
TAXA	Unadjusted	Unadj	Adj	Unadj	Adj	Unadj	Adj	Unadj	Adj	Unadj	Adj
EPHEMEROPTERA	+45.4	-11.4	-39.1	-47.8	-64.1	-43.5	-39.8	+30.9	-9.9	-70.8	-79.9
PLECOPTERA	+208	-84.7	-90.1	-82.2	-88.5	-61.2	-74.9	+10.7	-28.0	-94.0	-96.1
TRICHOPTERA	+550	-61.2	-94.0	-35.3	-90.0	-56.5	-93.3	-57.0	-93.4	+97.8	-69.6
DIPTERA	+83.8	+ 7.6	-41.4	+90.0	+ 3.4	+10.0	-40.2	+180	+52.1	-100	-100
OTHER	+150	+10.3	-55.9	+ 5.0	+ 5.0	-21.4	-68.6	+20	-52	-100	-100
TOTALS	+67.1	-41.7	-65.1	-47.4	-68.5	-41.5	-65.0	+17.8	-29.5	-53.5	-72.2

Table 4 - Percent change between pre and post
- treatment samples among major invertebrate taxa
(Adjusted figures obtained by using modified Abbott's formula)

Figure 3 illustrates the percent proportions of the 4 major taxa at the seven sites before and after treatment. It is apparent from the graphs that Ephemeroptera and Diptera showed reductions only at 240 km. Plecoptera showed considerable reductions at 80, 120 and 240 km and a slight reduction at 180 km. Trichoptera showed a massive increase in percent proportion at 240 km.

A more detailed look at the impact of the methoxychlor treatment on the same "sensitive" non-target genera as used in 1979 (Byrtus, 1981) is given in Figures 4 - 12. Figure 4 shows the fluctuations in Ephemerella populations over the summer. Populations of Ephemerella remained stable at 180, 200, and 240 km and even increased at 80 and 120 km just after treatment. Figure 5 shows the fluctuations in Rhithrogena populations over the summer. This genus showed considerable reductions in numbers after treatment at only 80, 120 and 240 km. Figure 6 shows the population fluctuations of Heptagenia over the summer. The control sites both showed an increase in numbers between pre and post-treatment samples. Sites at 80, 120 and 240 km all showed a considerable reduction in populations. The site at 180 km showed a slight reduction in populations, but the following week populations increased. The site at 200 km showed an increase similar to that at the control sites but experienced a considerable decline in numbers the week following treatment. Figure 7 shows the fluctuations in Baetis populations over the summer. This genus showed considerable populations reductions at

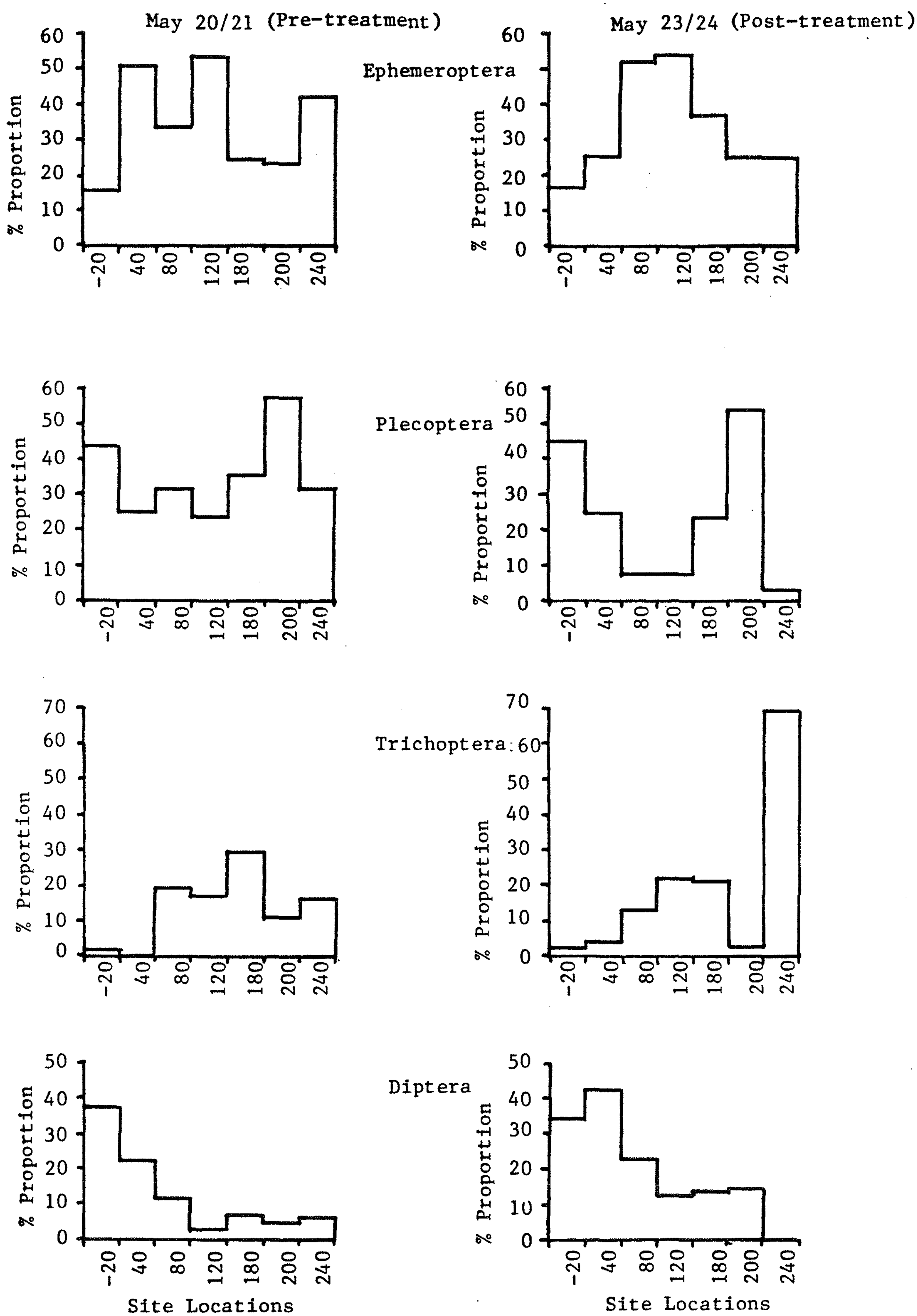

Figure 3 - Percent proportions of four major taxa - pre and post-treatment samples

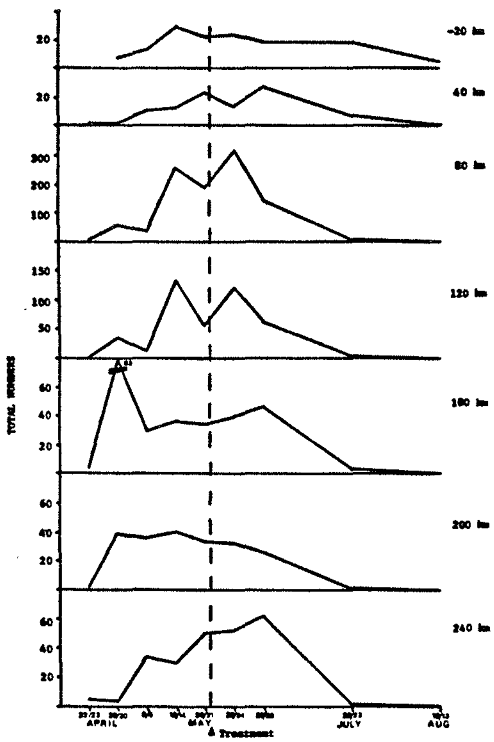

Figure 4 - Population fluctuations of *Ephemerella* at seven sites along the Athabasca River, 1980

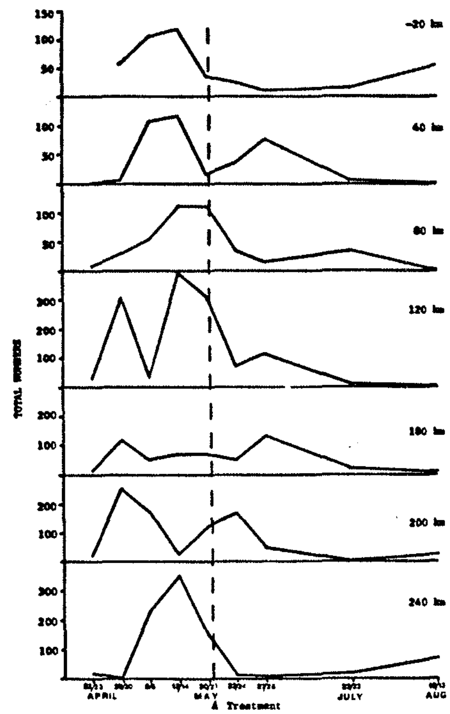

Figure 5 - Population fluctuations of *Rhithrogena* at seven sites along the Athabasca River, 1980

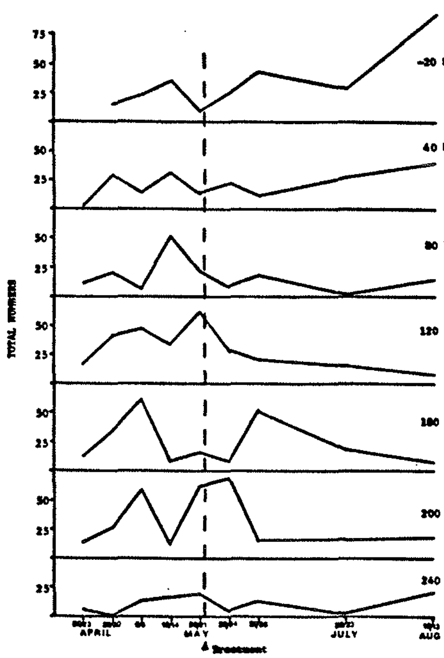

Figure 6 - Population fluctuations of *Heptagenia* at seven sites along the Athabasca River, 1980

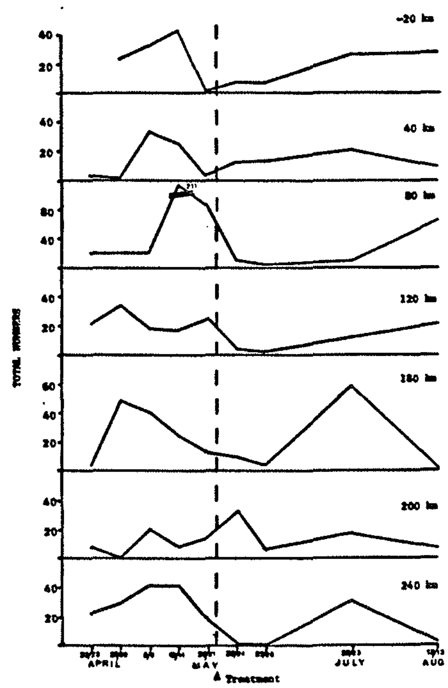

Figure 7 - Population fluctuations of *Baetis* at seven sites along the Athabasca River, 1980

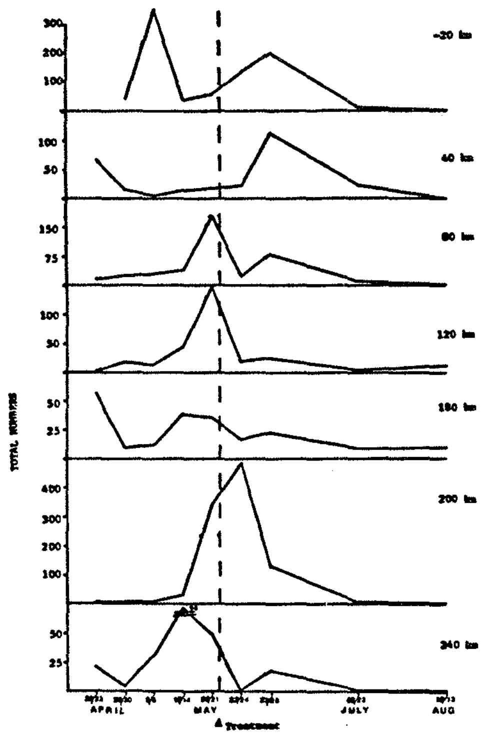

Figure 8 - Population fluctuations of *Isoperla* at seven sites along the Athabasca River, 1980

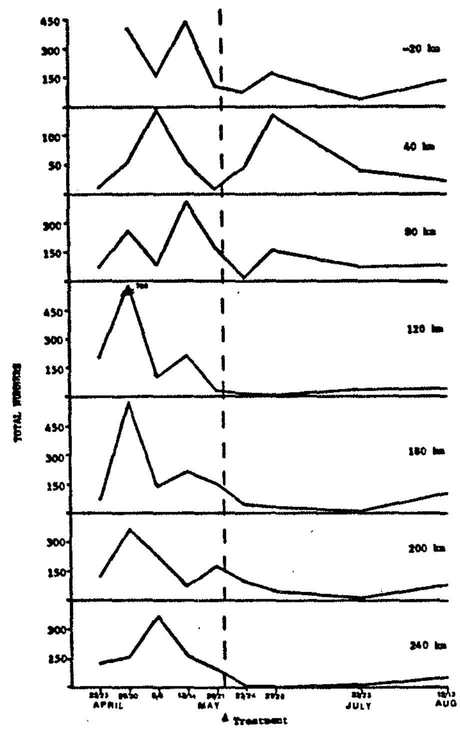

Figure 9 - Population fluctuations of *Isogenus* at seven sites along the Athabasca River, 1980

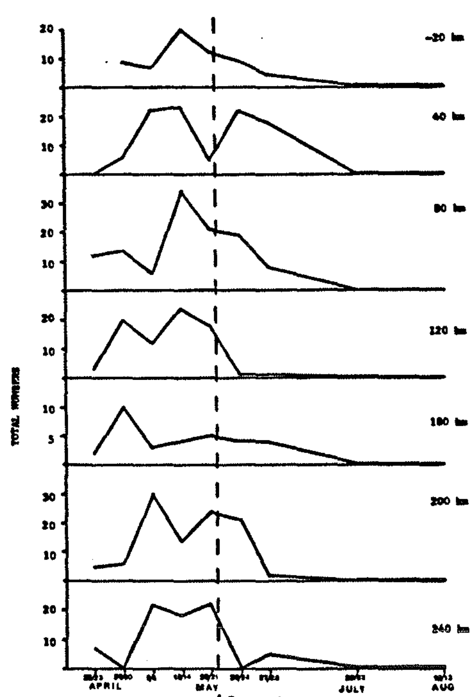

Figure 10 - Population fluctuations of *Hastaperla* at seven sites along the Athabasca River, 1980

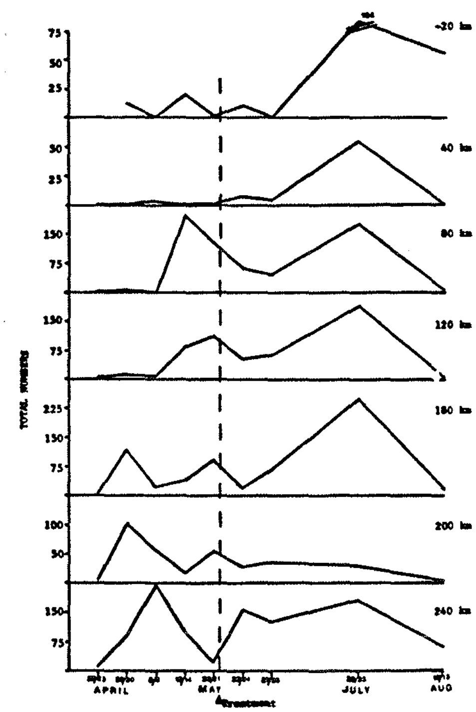

Figure 11 - Population fluctuations of *Hydropsyche* at seven sites along the Athabasca River, 1980

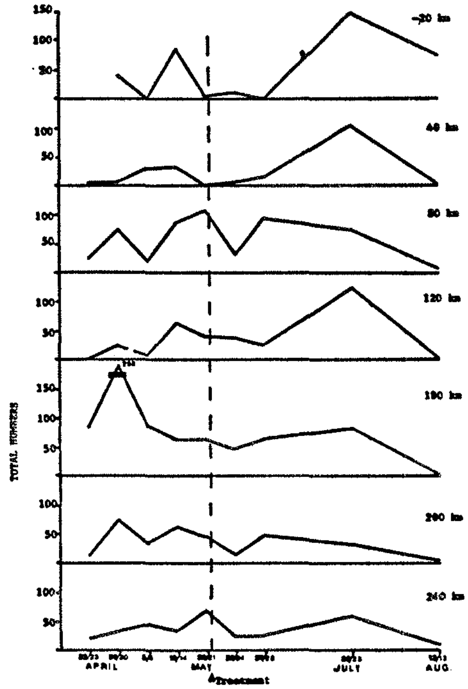

Figure 12 - Population fluctuations of *Cheumatopsyche* at seven sites along the Athabasca River, 1980

sites 80, 120 and 240 km while at 180 km populations dropped only slightly and at 200 km populations actually increased after treatment. Figure 8 shows that the Isoperla genus also showed reductions in populations mainly at 80, 120 and 240 km. Reductions in numbers at 180 km was evident as well but at 200 km populations increased, although they returned to more normal levels the week following treatment. Figure 9 shows that Isogenus populations show reductions at sites 80, 180, 200 and 240 km. Populations of Isogenus were large and variable during the summer and it is difficult to assess whether it is natural fluctuations or chemical impact that is influencing the populations.

Figure 10 shows that major population reductions of the Hastaperla genus is evident only at sites 120 and 240 km. Slight reductions at 80, 180 and 200 km correlate to the slight reduction in Hastaperla populations at control site - 20. Figure 11 shows that reductions in Hydropsyche populations occurred at all treated sites except 240 km, where a considerable increase in numbers was observed. Figure 12 shows that considerable reductions in Cheumatopsyche populations occurred at 80 and 240 km. Reductions were slight to moderate at the other treated sites.

Table 5 lists the diversity indices and number of taxa collected at the seven sampling sites over the summer. The diversity at the control sites appears to be fairly constant over the summer, with the exception of the sample taken at 40 km on April 22/23 (D.I. = 0.47) where there was 93.6% of one taxa (Hemiptera: Corixidae) present (Appendix 6), dominating the sample and lowering the diversity index. The diversity indices from 80 km indicate a reduction immediately after treatment, but recovery to control site levels appears the following week.

Distance from Athabasca (km)

Sampling Period	-20		40		80		120		180		200		240	
	D.I.	N	D.I.	N	D.I.	N	D.I.	N	D.I.	N	D.I.	N	D.I.	N
April 22/23	-	-	0.47	13	3.01	20	2.34	18	3.26	22	2.78	16	3.07	18
April 29/30	2.27	19	2.99	17	3.05	19	2.25	19	2.63	19	2.43	15	2.36	12
May 5/6	2.24	16	2.69	14	3.02	15	2.87	15	3.01	17	2.98	17	2.75	18
May 13/14	2.56	16	3.17	14	3.17	17	2.91	20	2.77	15	3.32	16	2.78	16
May 20 (Pre-treatment)	2.48	14	2.87	10	3.44	19	3.02	20	3.05	16	2.98	16	2.95	15
May 23/24 (Post-treatment)	2.70	15	2.99	17	2.73	16	3.23	18	3.38	16	2.73	15	1.76	8
May 27/28	2.31	12	3.17	17	3.17	19	1.94	19	3.22	17	3.13	18	2.66	11
July 22/23	2.71	13	2.95	14	2.46	13	2.36	14	2.39	14	2.86	15	2.34	13
August 12/13	2.88	14	2.20	10	2.23	12	2.57	9	2.23	10	2.31	11	2.41	10

Table 5 - Diversity Index (D.I.) and **Number of Taxa** (N) from Non-target Invertebrate Samples

Results from 120 and 180 km indicate a slight increase in diversity, with diversity stabilizing the following week, with the exception of 120 km which experienced a considerable decrease due to a large number of Brachycentrus (Trichoptera: Brachycentridae) that occurred in the sample (Appendix 12). As they were of a very small size (<2 mm) it is conjectured that a hatch had just recently occurrred and an area was sampled where the eggs had originally been laid and little migration from this area had occurred. The diversity for the 200 km site showed a slight decrease after treatment but had stabilized by the following week. The diversity for the 240 km site showed a significant reduction after treatment, related to the reduction in numbers of taxa collected. Diversity was still depressed one week after treatment compared to other sites, but by nine weeks after treatment (July 22/23), diversity and numbers of taxa were comparable to the other sites.

Methoxychlor Residues - Silt

A total of thirty silt bedload samples were collected at sampling site locations along the Athabasca River during 1980. The results of the analysis are presented in Table 6.

	Site Locations					
	40	80	120	180	200	240
May 20 (pre-treatment)	nil	nil	nil	nil	nil	-
May 24 (post-treatment)	nil	trace	46	52	40	79
May 28	nil	nil	12	trace	trace	-
June 4	nil	nil	nil	nil	trace	trace
July 23	nil	nil	nil	-	nil	-
August 13	nil	-	nil	nil	nil	-

Table 6 - Residues of methoxychlor (ppb) in Athabasca River silt bedload - 1980

From the table it appears that some methoxychlor was attached to silt in the bedload immediately after the treatment, however it moved downriver with time and either decomposed or dissipated as the concentrations decreased considerably. No evidence of methoxychlor residue was found during the July and August sampling trips.

Methoxychlor Residues - Water

A total of nine water samples were collected at Fort McMurray to determine whether methoxychlor would be present in river water and water storage facilities there. The results are presented in Table 7.

Date	Time	Concentration (ppb)	Sample Location
May 21		< 0.1	Athabasca River
May 21		< 0.1	Town-Storage Pond
May 22		< 0.1	Athabasca River
May 22		< 0.1	Town-Storage Pond
May 22		< 0.1	Suncor-Storage Pond
May 22		< 0.1	Syncrude-Water Intake
May 22		< 0.1	Athabasca River
May 22		< 0.1	Town-Storage Pond
May 22		< 0.1	Town-Tap Water

Table 7 - Methoxychlor residues from water samples collected in the Fort McMurray area - 1980.

It is apparent from the Table that no detectable methoxychlor was present in any of the water samples collected.

High Speed Adult Sweep Samples

Sampling for adult black flies using high speed adult sweeps was conducted along the Athabasca River for four sampling periods during 1980. The mean number of flies/sweep collected during each of these periods is graphically described in Figure 13. This graph illustrates that adult numbers were stable during the sampling periods in June and July and increased during the sampling period in August. Sampling was not conducted later and it is uncertain when the adult activity peaked along the river.

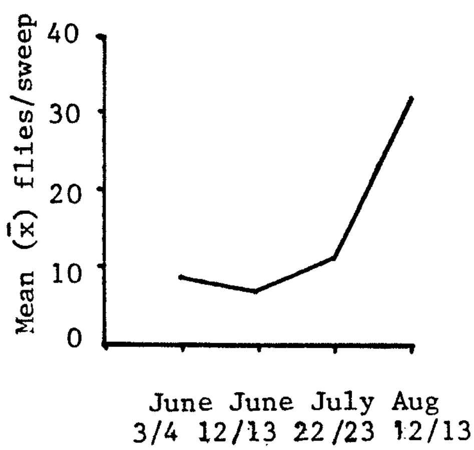

Figure 13- Mean numbers of adult flies collected (HSAS) over four sampling periods

Adult activity as a function of distance along the river is illustrated in Figure 14. This graph shows a major peak in activity around 80 km and a secondary peak near 180 km. Very low adult activity was observed from the Town of Athabasca downstream to 30 km and from 210 km to 240 km.

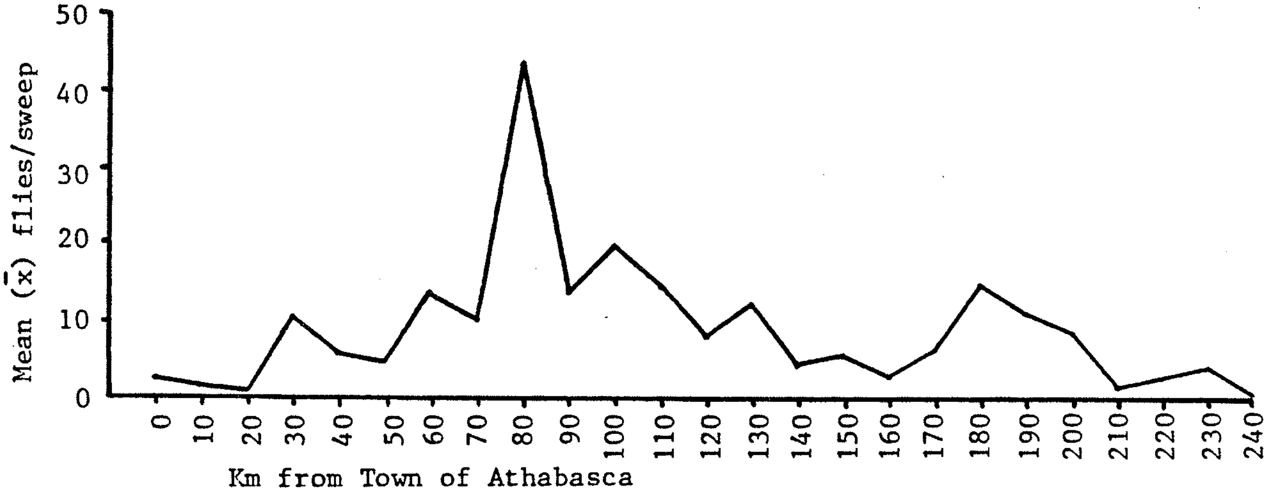

Figure 14- Mean numbers of adult black flies collected (HSAS) as a function of distance along Athabasca River

Adult black fly activity as a function of time of day is illustrated in Figure 15. Little activity was observed prior to 1000 hours. Activity then increased and peaked at 1200 - 1300 hours. Activity was then very low from 1500 to 1900 hours and subsequently increased to very high levels by 2100 hours.

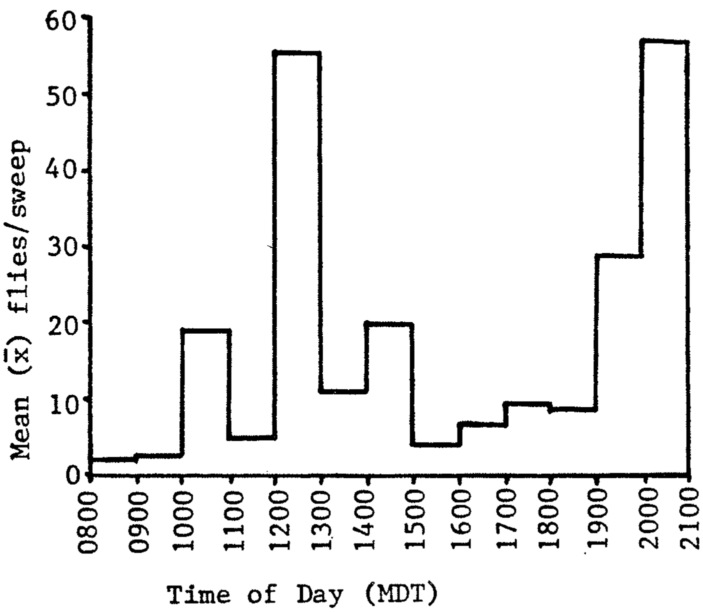

Figure 15- Mean numbers of adult flies collected (HSAS) as a function of time of day

Figure 16 - Photograph of black flies resting on rocks at 200 km.
May 27, 1980.

Figure 17 - Photograph of black flies resting on rocks at 200 km.
May 27, 1980.

One interesting observation made in 1980 was at 200 km on May 27, where numerous black fly adults were found on shoreline rocks at the sampling site (Figure 16 & 17). The air temperature at the time (1600 hrs) was about 10° C, and the relative humidity was 100%, as it was heavily overcast and had been raining for most of the day. Water temperature of the river that day was 11° C. It appeared that numerous black flies were emerging from the river in this area, and due to the inclement weather were forced to retire to the river beach to await more favorable weather for flying.

Barrel Trap Samples

Very few flies were collected from barrel traps located at the river landing and the stream near the G. Lantz pasture (Table 8) and the results will not be discussed to any extent. Many flies were collected however, on the barrel traps located in the pasture area. In comparing the different trap locations in the pasture, it is apparent that the trap located in the open area and supported 1.5 m above the ground collected the most flies (Table 8). Traps located in the wooded area and in the open area but supported 2.5 m above the ground collected considerably fewer flies.

Figure 18 graphically illustrates the mean number of flies collected over the summer on the barrel traps located in the pasture. Very high numbers were collected on the June 5 and August 14 sampling periods. Relatively low numbers were collected during the first three weeks of July and near the middle of

			Lantz Pasture				
	River Landing	Stream	Wooded area	Open area-1.5m above ground	Open area-2.5m above ground	$\bar{x}$	S.D.
June 5	0	0	52	2706	-	1379	1876.7
June 12	0	0	253	33	-	143	155.6
June 19	2	0	45	610	47	234	325.6
June 26	0	0	75	1013	126	404.7	527.4
July 3	1	0	9	85	13	35.7	42.8
July 10	0	1	11	107	10	42.7	55.7
July 17	0	0	4	137	2	47.7	77.4
July 24	0	-	5	606	75	228.7	328.6
July 31	0	-	13	404	46	154.3	216.8
Aug. 14	3	0	1024	3623	143	1596.7	1809.3
Aug. 21	0	0	223	1515	149	629	768.2
Aug. 29	1	-	134	1287	22	481	700.2
Sept. 4	2	-	38	730	16	261.3	406.0
Sept. 11	2	1	7	253	9	89.7	141.4
Sept. 18	4	0	15	2	196	71	108.5
$\bar{x}$	1	0.18	127.2	874.1	65.7		

Table 8 - Barrel Trap Sample Data - No. of flies per trap.

September. Numbers collected were generally high during the months of June and August.

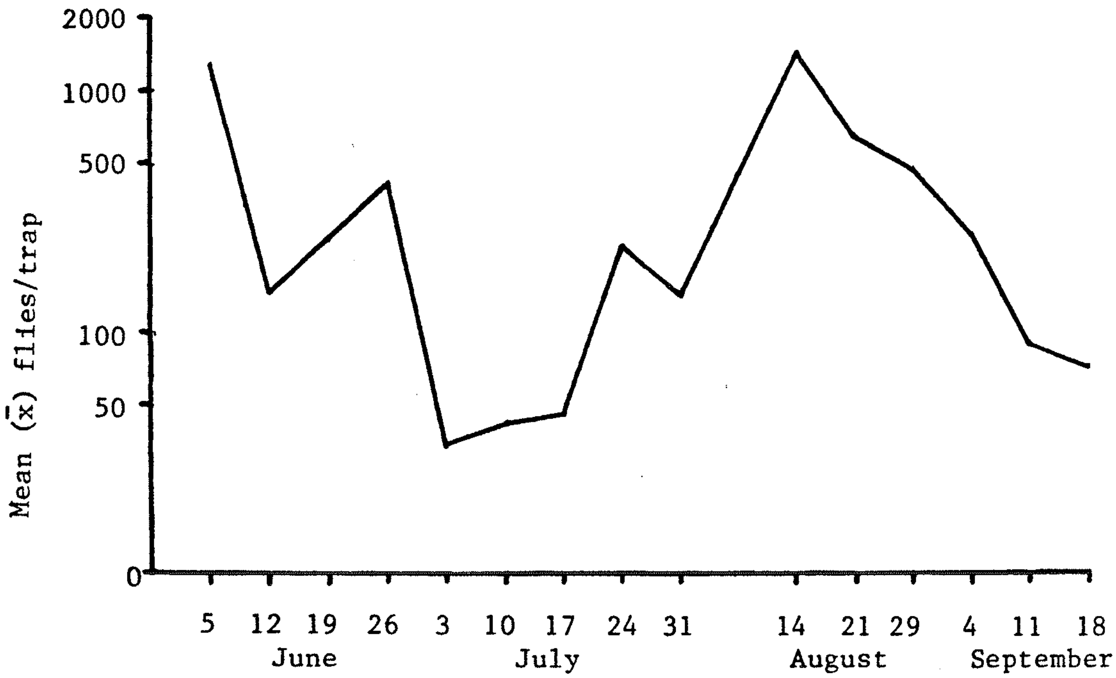

Figure 18 - Mean ($\bar{x}$) numbers of adult black flies collected on barrel traps - Lantz pasture

Discussion

Larval Sampling

Although larval sampling was conducted for only a four week period in 1980, several observations were noted. Data from Table 2 indicates that a second hatch may have occurred about the time of treatment and this would correlate with data from 1979 (Byrtus 1981) where it appeared that populations of black fly larvae were hatching in succession. Fredeen *et al*. (1951) also observed early instar larvae shortly after larvicidal treatment of the Saskatchewan River, but this was attributed to re-infestation from untreated areas upstream and delayed hatching of some eggs. Upon examining Table 2 closer, it is observed that although the percentage proportion of first and second instar larvae increased by June 3/4, total numbers of larvae had decreased considerably, which leads to the conclusion that after the initial hatch in late April (Murray, 1980), a small continual hatch of larvae occurred over the sampling period. A second major hatch after the treatment of the Athabasca River was therefore not observed over the 1980 sampling period.

Another observation made in 1980 was that larval populations were highest in samples collected one week prior to treatment and not in the immediate pre-treatment samples. This was also observed in 1979 (Byrtus 1981) and it was suggested that emergence from natural substrates, natural mortality and drift may be factors in reducing the number of larvae prior to treatment. As well, pretreatment samples collected in 1980 at site 200 km showed an extensive number of pupae already present (Appendix 2) on the artificial substrates.

The impact of the methoxychlor treatment upon larval populations was quite variable in 1980. Only at site 240 was excellent reduction of black fly larvae attained (97.4%) due likely to the fact that two pulses of chemical passed this sampling site. Good reduction of larvae was attained at 80 and 120 km (89.5 and 93.5%), but poor reduction was observed at 180 and 200 km (22.4 and 34.5%). This is likely due to the correlation between river discharge and treatment effectiveness. Fredeen et al. (1953), Depner et al. (1980a) and Byrtus (1981) have observed that high river discharges and correspondingly high river turbidity result in greater treatment effectiveness and a greater distance of control. The treatment at 59.5 km on May 21 with a discharge of 444 m^3/s resulted in effective control extending for between 60 and 120 km while in 1979 effective control was observed for up to 250 km when river discharge was 1356 m^3/s (Byrtus 1981).

The methoxychlor also appeared to have a greater impact on the immature larvae (second, third and fourth instar) than on mature larvae (fifth, sixth and seventh instar) (Table 2). Fredeen (1975) also observed this in his work along the Saskatchewan River and Wallace et al. (1976) also made note of this difference in susceptibility. It is also apparent that the methoxychlor had little if any effect on the pupae, as numbers of pupae increased considerably at most of the sites following treatment. It would have been expected that the methoxychlor would have affected many of the seventh instar larvae, thereby affecting the increase of pupal numbers. However, it appears that either the methoxychlor did not affect the seventh instar larvae to any extent or that pupation occurred in the time interval between pre-treatment cone pick-up and treatment. This is quite possible as a large number of pupae were already present on pre-treatment cones collected at 200 km.

Non-target Invertebrate Organism Sampling

The results obtained from the 1980 non-target invertebrate samples indicate that the methoxychlor had overall effects on invertebrates mainly at those sites immediately downstream of the two treatment points (ie 80, 120 and 240 km). The sites that were further from the treatment point (180 and 200 km) did not appear to be affected to the same extent. This is the same pattern as was observed with the larval black fly data (Table 3). It would appear that the impact of the methoxychlor was intensified at sites close to the treatment points due to methoxychlor depositing out of the flow. The inability of the river to maintain the methoxychlor in suspension after 120 km was thought to be because of the relatively low river discharge and corresponding low velocity and low silt load. Depner et al. (1980b) indicated that low river discharges would result in a reduction of effective control distances and would have a greater adverse effect on non-target organisms.

The taxa that appeared to have been affected the most by the methoxychlor was the Plecoptera. This was also observed in 1979 (Byrtus 1981) and Wallace and Hynes (1975) observed this in work on streams in Quebec. Considerable population reductions in all three of the "sensitive" Plecoptera genera were observed at 80, 120 and 240 km sites, and of the three genera, Isoperla appeared to be affected the most. This was also observed by Fredeen (1974) in methoxychlor larviciding tests along the Saskatchewan River.

The only genus that did not appear to be affected by the methoxychlor was Ephemerella (Figure 4) and this was also observed in 1979 (Byrtus 1981). However Fredeen (1974) and Haufe et al. (1980) observed mortality or reductions in populations of Ephemerella due to methoxychlor treatments.

One curious aspect of the non-target sample data is the increase in Hydropsyche in the post-treatment sample collected at 240 km. Wallace and Hynes (1975) showed that Trichoptera were affected considerably by methoxychlor treatments. Some impact on Trichopteran populations was also observed in 1979 (Byrtus 1981). It is postulated that the increase in Hydropsyche at 240 km is due to organisms drifting from upstream, possibly due to the second treatment at 59.5 km. The other consideration is the reliability of the sample data due to the sampling regime employed. Although it appears that fairly representative samples were collected using this sampling technique, there is no indication of variability in the sample populations.

Diversity indices are often used to describe the extent of pollution in streams (Wilhm 1972). In 1980, diversity indices were calculated for invertebrate samples collected over the summer, and the results showed that the impact of methoxychlor on invertebrates, as measured at the community level, was most noticeable at sites 80 and 240 km. These sites were nearest to the treatment points and were obviously affected to the largest extent. Recovery at 80 km appeared to be complete one week after treatment, however recovery at 240 km was not apparent one week after treatment. By nine weeks after treatment (the next sampling date) recovery at 240 km appeared to be complete. Flannagan et al. (1979) observed no significant recovery in invertebrate populations at four weeks after a methoxychlor treatment of the Athabasca River. Fredeen (1975) observed populations of most taxa of non-target invertebrates recovered and surpassed pre-treatment population levels within one to three weeks after treatment.

From the data collected in 1980, it appears that river discharge has an important influence on the distance of effective black fly larval control and on the degree of impact on non-target invertebrates. Results from 1979 showed that high river discharges resulted in long distances of control and only slight impact on non-target invertebrates (Byrtus 1981). In 1980, relatively low river discharges resulted in short effective control distance and a marked increase in effect on non-target invertebrates.

In regards to the drift sample that was kindly provided to us by Aquatic Environments Ltd. (Appendix 19), some interesting observations can be made, even though it is recognized that only one sample does not give a reliable indication of the effects of the methoxychlor. The most interesting observation is that Simuliidae made up by far the largest proportion of the sample (66.6%). This is in direct contrast to results obtained by Wallace and Hynes (1975), who found that Simuliidae comprised the smallest portion of the drift. Although they used a similar type of samples, they were working with a small stream, where it was likely that less suspended silt in the water may have influenced the efficiency and selectivity of methoxychlor. Another interesting observation is that Ephemerella, which was selected by Haufe et al. (1980) as being a "sensitive" genera, comprised only 0.02% of the drift sample. This result would be suspect as other authors (Fredeen 1974, Haufe et al. 1980) have observed impacts on Ephemerella populations due to methoxychlor, however results obtained in 1980 (Figure 4) also showed that Ephemerella was not affected by the methoxychlor to any noticeable extent. Other genera that showed reductions at site 240 km were also present in the drift sample, except for Cheumatopsyche.

Methoxychlor residues - Silt

Charnetski and Depner (1980) found that methoxychlor levels in the Athabasca River bedload material dissipated fairly rapidly after river treatments. This was also observed with the data collected in 1980 as residue levels dropped off to detection limits within one week after treatment. As well, it appeared that the methoxychlor laden silt was subject to movement downstream as detectable residues were collected at only 200 and 240 km sites two weeks after treatment. It is suspected that no methoxychlor was detected in the July and August samples due to the extremely high water which came through Athabasca on June 8 and stirred up the river bottom considerably, resulting in a displacement of the remaining residues.

Methoxychlor residues - Water

Although the residue results obtained from water samples collected in 1980 did not show any detectable levels of methoxychlor, these results become invalid when a recalculation of the time of arrival of the methoxychlor at Fort McMurray was done using the values described by Beltaos and Charnetski (1980). It appears that an error occurred in the initial calculations and the water sampling was terminated prior to the arrival of the chemical. Further evidence is given by the drift sample collected by Aquatic Environments Ltd. after the water sampling had been terminated, and which showed a marked increase in sample size due to the effects of the methoxychlor (D. McCart, 1980).

Adult Sampling

Adult black fly activity along the river in 1980 was not measured in the same detail as it was measured in 1979, however it did appear that adult black fly activity was greater during August that during June or July of 1980 (Figure 13). This is reinforced by data obtained from barrel trap samples on the farm (Figure 16) where a major peak in activity is also observed in mid-August, although a second peak in activity occurred in early June on the farm.

In 1979 it was observed that adult activity was greatest in the area from 80 - 88 km and that activity was quite low in the 0 - 30 km reach of the river (Byrtus 1981). This is also apparent from the results obtained in 1980 (Figure 14). As the area around 88 km is adjacent to the northern fringe of the black fly problem area (Figure 1) and 30 km approximates the southern fringe, it appears that dispersal of upstream migrating black flies occurrs in this reach of river. This leads to the observation that if the farming area extends northward considerably in the future, this may be reflected in a downstream shift of peak adult activity. In other words, as adult black flies migrate upstream and accumulate in numbers, they will begin dispersing into adjacent farming areas at a point further downstream than has been observed in 1979 and 1980.

The time of day of peak adult activity measured in 1980 is very similar to that observed in 1979. In 1979 adult activity on the river surface peaked between 1100 and 1200 hours and again between 2000 and 2100 hours (Byrtus 1981). In 1980, it was observed that adult activity peaked between 1200 and 1300 hours and again between 2000 and 2100 hours (Figure 15). As was mentioned in the 1979 report (Byrtus 1981), it is felt by numerous authors that optimum light intensity (between 1 and 25 foot-candles) is a major factor in controlling adult black fly activity, however climatic extremes can overrule the effect of light intensity.

Barrel traps were also placed in potential migration pathways from the river. One trap was located at a river landing where a considerable open area of river shoreland was present, and the other trap was placed in the bottom of a stream valley. Neither trap collected many flies, and it is felt that the color of the trap by itself was not an adequate attractant to black flies. The traps located on the farm collected many more flies due to the proximity of host material attractive to black flies.

Although the barrel trap data indicates two peaks in adult activity at the farm over the summer, apparently only one of these peaks was damaging to cattle. Philip (1981) indicated that large numbers of flies entered the farming area in early June, however unfavorable weather limited their activity to only a few days. The large and continual peak in August was apparently damaging to cattle in the area and is thought to be the result of a second smaller population of black flies that was observed in the river in July. This second population of black fly larvae just approached the treatment threshold and consequently the river was not treated (Murray, 1980).

Conclusions

1. Effective control of black fly larvae in the Athabasca River was observed for at least 60 km after a 300 ppb methoxychlor treatment.
2. The impact of methoxychlor on non-target invertebrate organisms appeared to be more severe than was observed in 1979, however, recovery of populations was observed to occur during the summer.
3. Residues of methoxychlor in the silt bedload of the Athabasca River dissipated rapidly, with only trace amounts detected two weeks after the treatment.
4. Adult activity was greatest during the month of August, and this is thought to be related to a second population of black fly larvae occurring in the Athabasca River in July.

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Appendix 1 - Distribution of black fly larval instars in Athabasca River
May 13/14, 1980

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
Instar	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	29	20.4	103	48.3	442	37.8	838	18.8	182	2.6	56	0.2	31	0.6	1681	3.9
2	56	39.4	72	33.8	569	48.7	1651	37.0	1403	20.4	1658	6.7	737	14.0	6146	14.3
3	23	16.2	21	9.8	73	6.2	489	11.0	918	13.4	2825	11.4	531	10.1	4880	11.4
4	9	6.3	8	3.7	34	2.9	527	11.8	1261	18.3	3028	12.2	521	9.9	5388	12.6
5	17	12.0	8	3.7	30	2.6	454	10.2	984	14.3	6155	24.8	1110	21.1	8758	20.4
6	7	4.9	1	0.5	12	1.0	412	9.2	2073	30.2	10858	43.8	2264	43.0	15627	36.4
7	1	0.7	0	0.0	8	0.7	90	2.0	48	0.7	228	0.9	67	1.3	442	1.0
Pupae	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	142		213		1168		4461		6869		24808		5261		42922	
No of Cones	6		6		6		6		6		6		6		42	
$\bar{x}$/cone	23.7		35.5		194.7		743.5		1144.8		4134.7		876.8		1021.9	

Appendix 2 - Distribution of black fly larval instars in Athabasca River May 20/21, 1980 (Pre-treatment)

Site locations (km downstream from Town of Athabasca)

	-20		40		80		120		180		200		240		Overall	
Instar	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1	6	1.5	33	7.2	177	13.2	611	9.4	19	1.2	36	0.4	12	1.0	894	4.2
2	108	26.5	251	54.9	645	48.1	2618	40.2	470	30.2	439	4.4	195	16.7	4726	22.2
3	134	32.9	92	20.1	322	24.0	1492	22.9	265	17.0	435	4.4	208	17.8	2948	13.8
4	95	23.3	23	5.0	85	6.3	704	10.8	239	15.4	1271	12.9	169	14.5	2586	12.1
5	44	10.8	30	6.6	48	3.6	338	5.2	175	11.2	2190	22.2	183	15.7	3008	14.1
6	18	4.4	27	5.9	53	3.9	361	5.5	260	16.7	2171	22.0	287	24.6	3177	14.9
7	2	0.5	1	0.2	9	0.7	374	5.7	119	7.6	2591	26.3	96	8.2	3192	15.0
Pupae	0	0.0	0	0.0	2	0.2	17	0.3	8	0.5	720	7.3	16	1.4	763	3.6
Total	407		457		1341		6515		1555		9853		1166		21294	
No of Cones	6		6		6		6		6		6		6		42	
x̄/cone	67.8		76.2		223.5		1085.8		259.2		1642.2		194.3		507	

Appendix 3 - Distribution of black fly larval instars in Athabasca River

May 23/24, 1980 (Post-treatment)

Site locations (km downstream from Town of Athabasca)

Instar	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %	Overall N	Overall %
1	0	0.0	37	8.2	65	78.3	72	28.3	2	0.3	7	0.2	3	16.7	186	3.4
2	21	46.7	184	41.0	10	12.0	5	2.0	0	0.0	0	0.0	0	0.0	220	4.1
3	9	20.0	93	20.7	2	2.4	1	0.4	2	0.3	3	0.1	0	0.0	110	2.0
4	5	11.1	57	12.7	1	1.2	1	0.4	10	1.4	13	0.4	1	5.6	88	1.6
5	2	4.4	35	7.8	0	0.0	0	0.0	37	5.1	152	3.9	0	0.0	226	4.2
6	6	13.3	33	7.3	1	1.2	41	16.1	164	22.8	813	21.1	5	27.8	1063	19.6
7	1	2.2	7	1.5	0	0.0	22	8.7	262	36.4	1911	49.6	1	5.6	2204	40.6
Pupae	1	2.2	3	0.7	4	4.8	112	44.1	243	33.8	954	24.8	8	44.4	1325	24.4
Total	45		449		83		254		720		3853		18		5422	
No of Cones	4		6		6		6		6		6		6		40	
$\bar{x}$/cone	11.3		74.8		13.8		42.3		120		642.2		3		135.6	

Appendix 4 - Distribution of black fly larval instars in Athabasca River
May 27/28, 1980

Site locations (km downstream from Town of Athabasca)

		-20		40		80		120		180		200		240		Overall	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Instar	1	6	3.5	23	18.5	65	78.3	72	28.3	2	0.3	7	0.2	3	16.7	337	18.3
	2	61	35.9	39	31.4	161	44.6	136	52.3	0	0.0	8	0.9	2	11.1	407	22.1
	3	22	12.9	20	16.1	10	2.8	0	0.0	0	0.0	0	0.0	0	0.0	52	2.8
	4	28	16.5	22	17.7	9	2.5	0	0.0	0	0.0	0	0.0	0	0.0	59	3.2
	5	17	10.0	7	5.6	3	0.8	0	0.0	1	6.7	14	1.6	2	11.1	44	2.4
	6	31	18.2	8	6.4	4	1.1	0	0.0	4	26.7	225	25.2	6	33.3	278	15.1
	7	5	2.9	5	4.0	1	0.3	0	0.0	5	33.3	384	43.0	3	16.7	403	21.9
	Pupae	0	0.0	0	0.0	0	0.0	0	0.0	4	26.7	252	28.2	4	22.2	260	14.1
	Total	170		124		361		260		15		892		18		1840	
	No of Cones	6		6		6		6		6		6		6		42	
	$\bar{x}$/cone	28.3		20.7		60.2		43.3		2.5		148.7		3		43.8	

Appendix 5 - Distribution of black fly larval instars in Athabasca River
June 3/4, 1980

Site locations (km downstream from Town of Athabasca)

Instar	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %	Overall N	Overall %
1	4	10.8	19	30.1	30	46.1	2	9.5			12	32.4	17	40.5	84	31.7
2	7	18.9	21	33.3	29	44.6	17	80.9			19	51.3	22	52.4	115	43.4
3	5	13.5	13	20.6	2	3.1	1	4.8			1	2.7	2	4.8	24	9.0
4	7	18.9	6	9.5	0	0.0	1	4.8			0	0.0	0	0.0	14	5.3
5	6	16.2	3	4.8	1	1.5	0	0.0			0	0.0	0	0.0	10	3.8
6	7	18.9	0	0.0	1	1.5	0	0.0			1	2.7	1	2.4	10	3.8
7	1	2.7	0	0.0	1	1.5	0	0.0			4	10.8	0	0.0	6	2.3
Pupae	0	0.0	1	1.6	1	1.5	0	0.0			0	0.0	0	0.0	2	0.7
Total	37		63		65		21				37		42		265	
No of Cones	4		6		4		6		0		6		6		32	
$\bar{x}$/cone	9.3		10.5		16.3		3.5				6.2		7		8.3	

APPENDIX 6 - Benthic Macro-Invertebrates Collected From Athabasca River

April 22/23, 1980

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20*		40		80		120		180		200		240	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus														
Optioservus														
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae			5	0.3	27	4.8	8	1.2	22	6.2	17	6.6	13	4.2
Dolichopus													1	0.3
Hemedromia					6	1.1	1	0.2	2	0.6	3	1.2	2	0.6
Pedicia									1	0.3			1	0.3
Simulium			1	0.0	4	0.7	5	0.8					1	0.3
EPHEMEROPTERA														
Ameletus									2	0.6				
Ametropus					2	0.4	1	0.2	2	0.6	13	5.0		
Baetis			3	0.2	19	3.4	21	3.2	4	1.1	8	3.1	22	7.1
Caenis														
Centroptilum			1	0.0	4	0.7	8	1.2						
Cinygma														
Epeorus														
Ephemerella					5	0.9	1	0.2	5	1.4	2	0.8	5	1.6
Ephoron														
Heptagenia			2	0.1	11	2.0	16	2.4	12	3.4	13	5.0	6	1.9
Hexagenia														
Isonychia														
Leptophlebia					15	2.7	4	0.6	1	0.3	4	1.6	2	0.6
Metropodinae														
Neocleon														
Paraleptophlebia			1	0.0			1	0.2						
Rhithrogena					8	1.4	29	4.4	8	2.3	21	8.1	15	4.8
Siphloplecton														
Stenonema			1	0.0					11	3.1				
Tricorythodes														
PLECOPTERA														
Acroneuria									4	1.1				
Alloperla														
Arcynopteryx														
Brachyptera					1	0.2								
Claassenia														
Hastaperla					12	2.2	3	0.4	2	0.6	5	1.9	7	2.3
Isogenus			10	0.6	74	13.2	209	31.6	75	21.2	129	50.0	125	40.3
Isoperla			66	3.7	15	2.7	2	0.3	57	16.1	3	1.2	21	6.8
Nemoura					160	28.6	82	12.4	32	9.0	10	3.9	39	12.6
Pteronarcella					1	0.2								
Pteronarcys					1	0.2								
TRICHOPTERA														
Brachycentrus									1	0.3				
Cheumatopsyche			4	0.2	23	4.1			84	23.7	13	5.0	21	6.8
Glossosoma														
Hydropsyche							4	0.6	4	1.1	4	1.6	9	2.9
Limnephilus														
Polycentropus														
Rhyacophila														
Theliopsyche														
ODONATA														
Ophiogomphus														
HEMIPTERA														
Corixidae			1651	93.6	159	28.4	266	40.2	22	6.2	12	4.6	14	4.5
LEPIDOPTERA														
GASTROPODA			1	0.0					2	0.6				
OLIGOCHAETA			17	1.0	12	2.1	1	0.1	1	0.3	1	0.4	6	1.9
PELECYPODA														
TOTAL ORGANISMS			1763		559		662		354		258		310	
No. of Taxa			13		20		18		22		16		18	
Diversity Index			0.47		3.01		2.34		3.26		2.78		3.07	

* Not sampled during this week

APPENDIX 7 - Benthic Macro-invertebrates Collected From Athabasca River

April 29/30, 1980

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20		40		80		120		180		200		240	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
COLEOPTERA														
Amphizoa														
Donacia	1	0.1							1	0.1				
Hydrovatus														
Optioservus														
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae	14	2.1	9	5.3	114	16.2	69	4.8	47	3.5	21	2.3	15	4.2
Dolichopus	1	0.1												
Hemedromia	4	0.6			18	2.6	15	1.1	3	0.2			14	3.9
Pedicia					1	0.1								
Simulium														
EPHEMEROPTERA														
Ameletus											4	0.4		
Ametropus			1	0.6	2	0.3								
Baetis	23	3.4	1	0.6	19	2.7	34	2.4	49	3.7			29	8.1
Caenis														
Centroptilum			1	0.6					10	0.7				
Cinygma														
Epeorus														
Ephemerella	7	1.0			59	8.4	34	2.4	85	6.4	38	4.1	4	1.1
Ephoron														
Heptagenia	15	2.2	29	16.9	20	2.8	40	2.8	34	2.6	26	2.8		
Hexagenia														
Isonychia														
Leptophlebia	1	0.1					1	0.1						
Metropodinae														
Neocleon													4	1.1
Paraleptophlebia														
Rhithrogena	56	8.3	4	2.3	30	4.3	303	21.3	117	8.8	253	27.5		
Siphlopleoton					2	0.3								
Stenonema											1	0.1		
Tricorythodes			1	0.6										
PLECOPTERA														
Acroneuria	1	0.1					2	0.1						
Alloperla														
Arcynopteryx														
Brachyptera														
Claassenia														
Hastaperla	9	1.3	6	3.5	14	2.0	20	1.4	10	0.7	6	0.6		
Isogenus	412	61.3	57	33.3	263	37.5	788	55.4	574	43.0	371	40.3	161	45.1
Isoperla	42	6.3	13	7.6	24	3.4	19	1.3	10	0.7	2	0.2	4	1.1
Nemoura	25	3.7	25	14.6	23	3.3	32	2.3	6	0.5	3	0.3		
Pteronarcella							2	0.1						
Pteronarcys	5	0.7	1	0.6			4	0.3	9	0.7	14	1.5	2	0.6
TRICHOPTERA														
Brachycentrus														
Cheumatopsyche	39	5.8	5	2.9	75	10.7	23	1.6	258	19.3	73	7.9	31	8.7
Glossosoma									1	0.1				
Hydropsyche	12	1.8			4	0.6	14	1.0	118	8.8	102	11.1	87	24.4
Limnephilus									1	0.1				
Polycentropus														
Rhyacophila														
Theliopsyche														
ODONATA														
Ophiogomphus			1	0.6	7	1.0	1	0.1	1	0.1				
HEMIPTERA														
Corixidae			2	1.2	8	1.1			1	0.1	1	0.1		
LEPIDOPTERA	3	0.5			1	0.1								
GASTROPODA			1	0.6	7	1.0	1	0.1	1	0.1				
OLIGOCHAETA	2	0.3	14	8.2	18	2.6	18	1.3			6	0.6	5	1.4
PELECYPODA														
TOTAL ORGANISMS	672		171		702		1423		1335		921		357	
No. of Taxa	19		17		19		19		19		15		12	
Diversity Index	2.27		2.99		3.05		2.25		2.63		2.43		2.36	

APPENDIX 8 - Benthic Macro-Invertebrates Collected From Athabasca River

May 5/6, 1980

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus														
Optioservus	1	0.1												
DIPTERA														
Antocha														
Atherix													1	0.1
Ceratopgonidae			1	0.3							1	0.1		
Chironomidae	27	3.7	18	4.5	11	3.8	11	3.9	16	3.3	25	3.5	28	2.6
Dolichopus														
Hemedromia	2	0.3	9	2.3	1	0.4	4	1.4	2	0.4	2	0.3	5	0.5
Pedicia														
Simulium									3	0.6	10	1.4		
EPHEMEROPTERA														
Ameletus													2	0.2
Ametropus									1	0.2				
Baetis	32	4.4	33	8.3	21	7.3	18	6.4	40	8.3	20	2.8	41	3.8
Caenis					1	0.4								
Centroptilum											5	0.7		
Cinygma	1	0.1												
Epeorus														
Ephemerella	13	1.8	10	2.5	34	11.9	11	3.9	29	6.0	36	5.0	34	3.2
Ephoron														
Heptagenia	23	3.2	14	3.5	6	2.1	47	16.7	62	12.8	59	8.3	13	1.2
Hexagenia														
Isonychia														
Leptophlebia														
Metropodinae														
Neocleon														
Paraleptophlebia														
Rhithrogena	101	13.9	107	26.9	54	18.9	36	12.8	51	10.6	170	23.8	226	21.0
Siphloplecton														
Stenonema														
Tricorythodes							1	0.4						
PLECOPTERA														
Acroneuria	1	0.1												
Alloperla														
Arcynopteryx														
Brachyptera	1	0.1												
Claassenia														
Hastaperla	7	1.0	22	5.5	6	2.1	12	4.2	3	0.6	30	4.2	22	2.0
Isogenus	158	21.7	144	36.2	86	30.1	110	39.0	144	29.9	231	32.3	370	34.4
Isoperla	353	48.5	2	0.5	29	10.1	12	4.25	13	2.7	7	1.0	31	2.9
Nemoura					1	0.4			1	0.2				
Pteronarcella														
Pteronarcys	5	0.7					2	0.7	4	0.8	21	2.9	6	0.6
TRICHOPTERA														
Brachycentrus									1	0.2				
Cheumatopsyche			29	7.3	20	7.0	9	3.2	87	18.0	36	5.0	45	4.2
Glossosoma														
Hydropsyche			3	0.8			5	1.8	24	5.0	57	8.0	222	20.6
Limnephilus														
Polycentropus														
Rhyacophila														
Theliopsyche														
ODONATA														
Ophiogomphus	2	0.3			1	0.4					2	0.3	1	0.1
HEMIPTERA														
Corixidae							2	0.7					6	0.6
LEPIDOPTERA														
GASTROPODA	1	0.1	2	0.5	7	2.5							1	0.1
OLIGOCHAETA			4	1.0	8	2.8	2	0.7	1	0.2	2	0.3	21	1.9
PELECYPODA														
TOTAL ORGANISMS	728		398		286		282		482		714		1075	
No. of Taxa	16		14		15		15		17		17		18	
Diversity Index	2.24		2.69		3.02		2.87		3.01		2.98		2.75	

APPENDIX 9 - Benthic Macro-Invertebrates Collected From Athabasca River

May 13/14, 1980

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %
COLEOPTERA														
Amphizoa							2	0.2						
Donacia														
Hydrovatus														
Optioservus	1	0.1												
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae	35	4.0	35	8.5	204	12.2	25	2.3	32	5.9	51	12.9	37	4.0
Dolichopus														
Hemedromia	13	1.5	1	0.2	41	2.5	18	1.6			1	0.3		
Pedicia														
Simulium	1	0.1					2	0.2	1	0.2	48	12.2	3	0.3
EPHEMEROPTERA														
Ameletus							1	0.1						
Ametropus														
Baetis	43	4.9	25	6.1	211	12.6	17	1.5	25	4.6	8	2.0	41	4.5
Caenis														
Centroptilum														
Cinygma														
Epeorus														
Ephemerella	29	3.3	12	2.9	252	15.1	131	11.8	36	6.7	40	10.1	30	3.3
Ephoron														
Heptagenia	35	4.0	31	7.5	52	3.1	39	3.5	8	1.5	13	3.3	16	1.7
Hexagenia														
Isonychia														
Leptophlebia							1	0.1						
Metropodinae														
Neocleon														
Paraleptophlebia														
Rhithrogena	116	0.1	116	28.2	121	7.2	413	37.2	67	12.4	27	6.8	351	38.3
Siphlopleoton														
Stenonema													2	0.2
Tricorythodes					1	0.1	1	0.1						
PLECOPTERA														
Acroneuria											1	0.3	1	0.1
Alloperla														
Arcynopteryx														
Brachyptera														
Claassenia														
Hastaperla	20	2.3	23	5.6	34	2.0	24	2.2	4	0.7	14	3.6	18	2.0
Isogenus	443	50.2	56	13.6	405	24.2	213	19.2	218	34.1	73	18.5	172	18.7
Isoperla	37	4.2	12	2.9	37	2.2	42	3.8	39	7.2	30	7.6	98	10.7
Nemoura														
Pteronarcella														
Pteronarcys	6	0.7			7	0.4	7	0.6	2	0.4	4	1.0		
TRICHOPTERA														
Brachycentrus														
Cheumatopsyche	83	9.4	31	7.5	86	5.2	63	5.7	63	11.7	63	16.0	32	3.5
Glossosoma									1	0.2				
Hydropsyche	19	2.1			197	11.8	83	7.5	42	7.8	19	4.8	100	10.9
Limnephilus														
Polycentropus													1	0.1
Rhyacophila									1	0.2				
Theliopsyche														
ODONATA														
Ophiogomphus	1	0.1	3	0.7	2	0.1	4	0.4	1	0.2	1	0.2		
HEMIPTERA														
Corixidae			1	0.2	1	0.1								
LEPIDOPTERA														
GASTROPODA	1	0.1	12	2.9	1	1.0	2	0.2						
OLIGOCHAETA			54	13.1	18	1.1	22	2.0			1	0.3	14	1.5
PELECYPODA													1	0.1
TOTAL ORGANISMS	883		412		1670		1110		540		394		917	
No. of Taxa	16		14		17		20		15		16		16	
Diversity Index	2.56		3.17		3.17		2.91		2.77		3.32		2.78	

APPENDIX 10 - Benthic Macro-Invertebrates Collected From Athabasca River

May 20/21, 1980 (Pre-treatment)

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20		40		80		120		180		200		240	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus									1	0.2				
Optioservus														
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae	145	37.1	24	22.2	89	7.4	18	2.0	35	6.4	30	3.1	33	6.0
Dolichopus					1	0.1								
Hemedromia	4	1.0			54	4.5	12	1.4	3	0.6	4	0.4	10	1.8
Pedicia														
Simulium									2	0.4	25	2.6	1	0.2
EPHEMEROPTERA														
Ameletus														
Ametropus														
Baetis	1	0.3	3	2.8	86	7.1	26	3.0	13	2.4	14	1.5	18	3.2
Caenis														
Centroptilum														
Cinygma														
Epeorus														
Ephemerella	21	5.4	23	21.3	186	15.4	55	6.3	34	6.2	34	3.6	49	8.9
Ephoron														
Heptagenia	9	2.3	14	12.9	22	1.8	62	7.1	16	2.9	62	6.5	19	3.4
Hexagenia														
Isonychia														
Leptophlebia														
Metropodinae														
Neocleon														
Paraleptophlebia														
Rhithrogena	33	8.4	14	12.9	111	9.2	308	35.2	72	13.2	120	12.6	150	27.1
Siphloplecton														
Stenonema			1	0.9	6	0.5	19	2.2						
Tricorythodes							1	0.1	1	0.2				
PLECOPTERA														
Acroneuria					4	0.3	4	0.5						
Alloperla														
Arcynopteryx														
Brachyptera														
Claassenia														
Hastaperla	12	3.1	5	4.6	21	1.7	18	2.1	5	0.9	24	2.5	22	4.0
Isogenus	103	26.3	8	7.4	172	14.3	40	4.6	155	28.3	178	18.7	97	17.5
Isoperla	56	14.3	15	13.9	179	14.9	149	17.0	36	6.6	342	35.9	49	8.9
Nemoura														
Pteronarcella											2	0.2		
Pteronarcys					4	0.3	3	0.3			3	0.3		
TRICHOPTERA														
Brachycentrus														
Cheumatopsyche	3	0.8			107	8.9	40	4.6	66	12.1	46	4.8	68	12.3
Glossosoma							1	0.1						
Hydropsyche	1	0.3			129	10.7	112	12.8	95	17.4	54	5.7	22	4.0
Limnephilus														
Polycentropus														
Rhyacophila														
Theliopsyche					4	0.3								
ODONATA														
Ophiogomphus	1	0.3			2	0.2	4	0.5	2	0.4	2	0.2	2	0.4
HEMIPTERA														
Corixidae			1	0.9			1	0.1					3	0.5
LEPIDOPTERA														
GASTROPODA	1	0.3			6	0.5	1	0.1						
OLIGOCHAETA					21	1.7	2	0.2	11	2.0	3	0.3	10	1.8
PELECYPODA	1	0.3												
TOTAL ORGANISMS	391		108		1204		876		547		953		553	
No. of Taxa	14		10		19		20		16		16		15	
Diversity Index	2.48		2.87		3.44		3.02		3.05		2.98		2.95	

APPENDIX II - Benthic Macro-Invertebrates Collected From Athabasca River

May 23/24, 1980 (Post-treatment)

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus														
Optioservus					2	0.3								
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae	151	31.4	143	40.5	135	19.2	36	7.8	37	11.6	123	10.9		
Dolichopus														
Hemedromia	16	3.3	8	2.3	20	2.9	21	4.5	7	2.2	9	0.8		
Pedicia														
Simulium											33	2.9		
EPHEMEROPTERA														
Ameletus														
Ametropus														
Baetis	7	1.4	12	3.4	10	1.4	5	1.1	10	3.1	32	2.8	1	0.4
Caenis														
Centroptilum														
Cinygma							2	0.4						
Epeorus														
Ephemerella	23	4.8	13	3.7	310	44.2	139	30.1	39	12.2	33	2.9	52	20.2
Ephoron														
Heptagenia	25	5.2	23	6.5	9	1.3	28	6.1	8	2.5	69	6.2	5	1.9
Hexagenia														
Isonychia														
Leptophlebia														
Metropodinae											2	0.2		
Neocleon														
Paraleptophlebia							1	0.2						
Rhithrogena	25	5.2	37	10.5	35	5.0	69	15.0	50	15.6	165	14.7	11	4.3
Siphloplecton														
Stenonema	1	0.2	5	1.4			2	0.4	12	3.8				
Tricorythodes	1	0.2	1	0.3										
PLECOPTERA														
Acroneuria														
Alloperla			2	0.6										
Arcynopteryx			2	0.6					1	0.3				
Brachyptera														
Claassenia														
Hastaperla	9	1.9	22	6.2	19	2.7	1	0.2	4	1.3	21	1.9		
Isogenus	74	15.4	44	12.5	17	2.4	18	3.9	54	16.9	100	8.9	9	3.5
Isoperla	134	27.9	20	5.7	21	3.0	19	4.1	17	5.3	485	43.2		
Nemoura														
Pteronarcella					1	0.1					2	0.2	1	0.4
Pteronarcys														
TRICHOPTERA														
Brachycentrus					2	0.3	6	1.3						
Cheumatopsyche	10	2.1	7	2.0	31	4.4	39	8.5	48	15.0	15	1.3	24	9.3
Glossosoma														
Hydropsyche	2	0.4	7	2.0	60	8.6	54	11.7	22	6.9	28	2.5	154	59.9
Limnephilus														
Polycentropus														
Rhyacophila														
Theliopsyche														
ODONATA														
Ophiogomphus	2	0.4					4	0.9	2	0.6				
HEMIPTERA														
Corixidae														
LEPIDOPTERA														
GASTROPODA	1	0.2	1	0.3	11	1.6	6	1.3	1	0.3				
OLIGOCHAETA			6	1.7	19	2.7	11	2.4	8	2.5	6	0.5		
PELECYPODA														
TOTAL ORGANISMS	481		353		702		461		320		1123		257	
No. of Taxa	15		17		16		18		16		15		8	
Diversity Index	2.70		2.99		2.73		3.23		3.38		2.73		1.76	

APPENDIX 12- Benthic Macro-Invertebrates Collected From Athabasca River
May 27/28

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20		40		80		120		180		200		240	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus														
Optioservus			1	0.2										
DIPTERA														
Antocha														
Atherix					1	0.1								
Ceratopgonidae	1	0.2							1	0.2				
Chironomidae	107	18.7	49	9.4	81	11.1	49	4.2	46	9.0	51	11.5	51	15.4
Dolichopus														
Hemedromia	4	0.7	26	5.0	60	8.2	16	1.4	8	1.6	6	1.4	8	2.4
Pedicia														
Simulium											1	0.2		
EPHEMEROPTERA														
Ameletus														
Ametropus					4	0.6								
Baetis	7	1.2	13	2.5	4	0.6	2	0.2	5	1.0	6	1.4		
Caenis														
Centroptilum														
Cinygma											1	0.2		
Epeorus														
Ephemerella	18	3.1	27	5.2	138	18.9	61	5.2	46	9.0	26	5.8	62	18.8
Ephoron														
Heptagenia	43	7.5	11	2.1	18	2.5	20	1.7	52	10.2	15	3.4	18	5.5
Hexagenia	1	0.2												
Isonychia														
Leptophlebia														
Metropodinae														
Neocleon														
Paraleptophlebia							1	0.1						
Rhithrogena	10	1.8	75	14.4	16	2.2	114	9.7	131	25.7	47	10.6	5	1.5
Siphloplecton														
Stenonema							3	0.3			7	1.6		
Tricorythodes					2	0.3	1	0.1						
PLECOPTERA														
Acroneuria					3	0.4	2	0.2						
Alloperla														
Arcynopteryx														
Brachyptera														
Claassenia											1	0.2		
Hastaperla	4	0.7	18	3.5	8	1.1	1	0.1	4	0.8	2	0.5	5	1.5
Isogenus	173	30.2	133	25.6	160	21.9	6	0.5	35	6.9	58	13.0		
Isoperla	200	34.9	112	21.5	78	10.7	26	2.2	23	4.5	132	29.7	17	5.1
Nemoura														
Pteronarcella									1	0.2				
Pteronarcys					1	0.1	2	0.2	1	0.2				
TRICHOPTERA														
Brachycentrus	6	1.0	17	3.3			780	66.3	10	2.0	5	1.1		
Cheumatopsyche			15	2.9	94	12.9	27	2.3	66	13.0	49	11.0	26	7.9
Glossosoma														
Hydropsyche			4	0.8	47	6.5	62	5.3	67	13.2	35	7.9	124	37.6
Limnephilus														
Polycentropus														
Rhyacophila														
Theliopsyche					2	0.3					1	0.2		
ODONATA														
Ophiogomphus					10	1.4	1	0.1	1	0.2	2	0.4	1	0.3
HEMIPTERA														
Corixidae			1	0.2										
LEPIDOPTERA														
GASTROPODA			9	1.7										
OLIGOCHAETA			8	1.5	2	0.3	2	0.2	12	2.4			13	3.9
PELECYPODA			1	0.2										
TOTAL ORGANISMS	573		520		729		1176		509		445		330	
No. of Taxa	12		17		19		19		17		18		11	
Diversity Index	2.31		3.17		3.18		1.94		3.22		3.13		2.66	

APPENDIX 13- Benthic Macro-Invertebrates Collected From Athabasca River

July 22/23, 1980

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20 N	-20 %	40 N	40 %	80 N	80 %	120 N	120 %	180 N	180 %	200 N	200 %	240 N	240 %
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus														
Optioservus														
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae	36	6.6	10	3.2	7	1.7	16	3.6	8	1.6	15	9.7	18	5.1
Dolichopus														
Hemedromia					1	0.2			1	0.2				
Pedicia														
Simulium											5	3.2	4	1.1
EPHEMEROPTERA														
Ameletus														
Ametropus									1	0.2	1	0.6		
Baetis	27	5.0	22	7.0	10	2.4	12	2.7	59	11.8	17	11.0	32	9.0
Caenis														
Centroptilum														
Cinygma														
Epeorus														
Ephemerella	18	3.3	7	2.2	7	1.7	3	0.7	4	0.8	1	0.6	2	0.6
Ephoron					1	0.2								
Heptagenia	29	5.4	28	8.9	2	0.5	16	3.6	20	4.0	17	11.0	4	1.1
Hexagenia														
Isonychia			5	1.6										
Leptophlebia														
Metropodinae														
Neocleon														
Paraleptophlebia														
Rhithrogena	26	4.8	5	1.6	36	8.6	7	1.6	22	4.4			21	5.9
Siphlopleoton														
Stenonema														
Tricorythodes														
PLECOPTERA														
Acroneuria														
Alloperla														
Arcynopteryx														
Brachyptera														
Claassenia														
Hastaperla														
Isogenus	36	6.6	41	13.0	71	17.0	38	8.6	14	2.8	18	11.7	17	4.8
Isoperla	13	2.4	22	7.0	12	2.9	3	0.7	10	2.0	9	5.8	1	0.3
Nemoura														
Pteronarcella														
Pteronarcys	1	0.2					2	0.4			1	0.6		
TRICHOPTERA														
Brachycentrus	16	3.0					23	5.2	24	4.8	2	1.3	6	1.7
Cheumatopsyche	149	27.5	106	33.6	75	17.9	127	28.9	82	16.4	35	22.7	61	17.2
Glossosoma														
Hydropsyche	188	34.7	54	17.1	179	42.8	189	42.9	252	50.3	31	20.1	182	51.4
Limnephilus														
Polycentropus														
Rhyacophila			1	0.3										
Theliopsyche														
ODONATA														
Ophiogomphus	1	0.2			16	3.8	1	0.2	2	0.4	9	5.8	2	0.6
HEMIPTERA														
Corixidae			2	0.6			1	0.2	2	0.4				
LEPIDOPTERA														
GASTROPODA			3	0.9										
OLIGOCHAETA	1	0.2	9	2.9	1	0.2	2	0.4			2	1.3	4	1.1
PELECYPODA														
TOTAL ORGANISMS	541		315		418		440		501		154		354	
No. of Taxa	13		14		13		14		14		15		13	
Diversity Index	2.71		2.95		2.46		2.36		2.39		2.86		2.34	

APPENDIX 14- Benthic Macro-Invertebrates Collected From Athabasca River

August 12/13, 1980

Site locations / No. of organisms (N) / Percent proportion (%) / IDENTIFIED TAXA	-20		40		80		120		180		200		240	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
COLEOPTERA														
Amphizoa														
Donacia														
Hydrovatus														
Optioservus														
DIPTERA														
Antocha														
Atherix														
Ceratopgonidae														
Chironomidae	11	2.2			3	1.5	4	3.5	9	4.8	5	3.1		
Dolichopus														
Hemedromia					1	0.5								
Pedicia														
Simulium											1	0.6	1	0.4
EPHEMEROPTERA														
Ameletus														
Ametropus														
Baetis	29	5.9	10	11.8	68	33.3	22	19.1	3	1.6	8	4.9	3	1.3
Caenis														
Centroptilum	18	3.7												
Cinygma														
Epeorus			2	2.4										
Ephemerella	5	1.0			2	1.0							1	0.4
Ephoron														
Heptagenia	91	18.5	40	47.1	15	7.4	9	7.8	8	4.3	19	11.6	22	9.2
Hexagenia														
Isonychia														
Leptophlebia														
Metropodinae														
Neocleon					2	1.0								
Paraleptophlebia														
Rhithrogena	54	11.0	2	2.3	5	2.5	6	5.2	15	8.0	27	16.6	72	30.2
Siphlopleoton														
Stenonema														
Tricorythodes	1	0.2							4	2.1				
PLECOPTERA														
Acroneuria														
Alloperla														
Arcynopteryx														
Brachyptera														
Claassenia														
Hastaperla														
Isogenus	140	28.5	22	25.9	87	42.6	47	40.9	108	57.4	84	51.5	55	23.1
Isoperla	1	0.2					13	11.3	10	5.3	4	2.5		
Nemoura														
Pteronarcella	1	0.2												
Pteronarcys											1	0.6		
TRICHOPTERA														
Brachycentrus	3	0.6											2	0.8
Cheumatopsyche	74	15.1	3	3.5	8	3.9	3	2.6	4	2.1	6	3.7	12	5.0
Glossosoma														
Hydropsyche	56	11.4	1	1.2	9	4.4	5	4.4	20	10.6	5	3.1	63	26.5
Limnephilus														
Polycentropus														
Rhyacophila														
Theliopsyche														
ODONATA														
Ophiogomphus	7	1.4	1	1.2	3	1.5			7	3.7	3	1.8	7	2.9
HEMIPTERA														
Corixidae														
LEPIDOPTERA														
GASTROPODA			3	3.5										
OLIGOCHAETA			1	1.2	1	0.5	6	5.2						
PELECYPODA														
TOTAL ORGANISMS	491		85		204		115		188		163		238	
No. of Taxa	14		10		12		9		10		11		10	
Diversity Index	2.88		2.20		2.23		2.57		2.23		2.31		2.41	

Appendix 15 - List of Invertebrate Genera Collected From Athabasca River in 1980

CLASS	ORDER	FAMILY	GENUS
Insecta	Coleoptera	Amphizoidae	*Amphizoa*
		Chrysomelidae	*Donacia*
		Dytiscidae	*Hydrovatus*
		Elmidae	*Optioservus*
	Diptera	Ceratopogonidae	-
		Chironomidae	-
		Dolichopodidae	*Dolichopus*
		Empididae	*Hemedromia*
		Rhagionidae	*Atherix*
		Simuliidae	*Simulium*
		Tipuliidae	*Antocha*
			Pedicia
	Ephemeroptera	Ametropodidae	*Ametropus*
			Metropodinae
		Baetidae	*Baetis*
			Centroptilum
			Neocleon
		Caenidae	*Caenis*
		Ephemerellidae	*Ephemerella*
		Ephemeridae	*Hexagenia*
		Heptageniidae	*Cinygma*
			Epeorus
			Heptagenia
			Rhithrogena
			Stenonema
		Leptophlebiidae	*Leptophlebia*
			Paraleptophlebia
		Metrotopodidae	*Siphloplecton*
		Polymitarcidae	*Ephoron*
		Siphlonuridae	*Ameletus*
			Isonychia
		Tricorythidae	*Tricorythodes*
	Hemiptera	Corixidae	-
	Lepidoptera	-	-
	Odonata	Gomphidae	*Ophiogomphus*
	Plecoptera	Chloroperlidae	*Alloperla*
			Hastaperla
		Nemouridae	*Brachyptera*
			Nemoura

Appendix 15 (continued)

CLASS	ORDER	FAMILY	GENUS
Insecta	Plecoptera	Perlidae	*Acroneuria*
			Classenia
		Perlodidae	*Arcynopteryx*
			Isogenus
			Isoperla
		Pteronarcidae	*Pteronarcella*
			Pteronarcys
	Trichoptera	Brachycentridae	*Brachycentrus*
		Glossosomatidae	*Glossosoma*
		Hydropsychidae	*Cheumatopsyche*
			Hydropsyche
		Lepidostomatidae	*Theliopsyche*
		Limnephilidae	*Limnephilus*
		Polycentropidae	*Polycentropus*
		Rhyacophilidae	*Rhyacophila*
Gastropoda	-	-	-
Oligochaeta	-	Naididae	*Stylaria*
Pelecypoda	-	-	-

Sampling Date	Total Flies	No. of Sweeps	$\bar{x}$/sweep	Standard Deviation
June 3/4	240	28	8.6	17.2
June 12/13	110	17	6.5	10.0
July 22/23	344	32	10.7	16.3
Aug. 12/13	1546	48	32.2	53.3

Appendix 16 - Data summary for adult black flies collected (HSAS) over four sampling periods.

Km	Total Flies	No. of Sweeps	$\bar{x}$/sweep	Standard Deviation
0-2	21	4	5.2	5.4
10-12	18	6	3.0	6.0
20-22	11	6	1.8	3.5
30-32	126	6	21.0	40.6
40-42	60	5	12.0	19.3
50-52	51	5	10.2	14.5
60-62	138	5	27.6	19.5
70-72	122	6	20.3	19.3
80-82	439	5	87.8	140.2
90-92	115	4	28.7	50.9
100-102	159	4	39.7	44.1
110-112	119	4	29.7	43.1
120-122	64	4	16.0	22.9
130-132	100	4	25.0	33.5
140-142	34	4	8.5	5.3
150-152	47	4	11.7	15.7
160-162	24	4	6.0	4.0
170-172	53	4	13.3	14.5
180-182	182	6	30.3	33.5
190-192	136	6	22.7	19.2
200-202	106	6	17.7	21.6
210-212	23	6	3.8	2.3
220-222	36	6	6.0	5.3
230-232	51	6	8.5	11.3
240-242	5	5	1.0	2.2

Appendix 17 - Data summary for adult black flies collected (HSAS) over summer as a function of distance along river.

Time of Day	Total Flies	No. of Sweeps	$\bar{x}$/sweep	Standard Deviation
0800-0900	6	3	2.0	3.5
0900-1000	30	13	2.3	4.7
1000-1100	247	13	19.0	23.4
1100-1200	83	19	4.4	36.5
1200-1300	445	8	55.6	113.2
1300-1400	164	15	10.9	13.7
1400-1500	239	12	19.9	29.0
1500-1600	48	12	4.0	4.4
1600-1700	59	9	6.6	9.0
1700-1800	83	9	9.2	10.0
1800-1900	34	4	8.5	8.7
1900-2000	143	5	28.6	34.1
2000-2100	169	3	56.3	4.7

Appendix 18 - Data summary for adult black flies collected (HSAS) over summer as a function of time of day (MDT).

Appendix 19 - Sub-sample (¼) of 10 minute drift sample, Athabasca River, May 22, 1980, 1500 hrs.

			Number	Percent Proportion
EPHEMEROPTERA			792	15.8
	Baetidae	*Baetis*	64	1.3
	Ephemerellidae	*Ephemerella*	1	0.02
	Heptageniidae	*Heptagenia*	282	5.6
	"	*Rhithrogena*	441	8.8
	"	*Stenonema*	4	0.1
PLECOPTERA			428	8.5
	Chloroperlidae	*Hastaperla*	81	1.6
	Perlidae	*Acroneuria*	1	0.02
	Perlodidae	*Isogenus*	206	4.1
	"	*Isoperla*	138	2.7
	Pteronarcidae	*Pteronarcella*	1	0.02
TRICHOPTERA			230	4.6
	Glossosomatidae		1	0.02
	Hydropsychidae	*Cheumatopsyche*	3	0.06
	"	*Hydropsyche*	226	4.5
DIPTERA			3571	71.1
	Ceratopogonidae		19	0.4
	Chironomidae		205	4.1
	Simuliidae	*Simulium*	3347	66.7
OLIGOCHAETA				
	Gordiidae	*Gordius*	1	0.02
			5021	

Sample Data:

Net size - 30.5 cm square, 600 u mesh
Location - 8 km upstream of Fort McMurray
Water depth - 0.67 m
Volume of water sampled - 28.5 m^3