

A BIOLOGICAL SURVEY OF WATER QUALITY IN THE SPEED RIVER

by

The students* of
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* Appendix 1

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INTRODUCTION

One purpose of the dam, built by the Grand River Conservation Authority (G.R.C.A.) on the upper Speed River, is to provide water storage for low flow augmentation (Mackie, 1976). The G.R.C.A. (1966) states that by impounding flood waters from the normally high spring runoff, and gradually releasing them during the dry summer season, a minimum flow rate can be maintained all year long. This should provide dilution of polluted waters discharged from industrial and municipal sewer outfalls and sewage treatment plants.

The G.R.C.A. assumed operation responsibilities for the dam on March 17, 1976 (G.R.C.A., 1976a) and the Guelph Dam was officially functional June 16, 1976 (G.R.C.A., 1976b). If low flow augmentation is successful, then one would expect to see an overall increase in the water quality of the lower Speed River. Because persistent environmental changes cause changes in the distribution and abundance of particular species and the composition of communities (Warren, 1971), this enhancement should be reflected by an increase in the number of sensitive species and the diversity of the benthic fauna in the river bed.

This biological survey was conducted in order to detect any improvements in the water quality of the Speed River through space and time.

Three stations were chosen for sampling on the basis of their accessibility, location and previous data base. Samples of benthic fauna were taken from these stations and the data obtained was statistically analysed. The results were compared to those from last year's study (Biological Survey, 1976) and will be added to the present data base to allow for future comparisons.

METHODS

Three stations were chosen for sampling (Figure 1): Victoria Road Station, Hanlon Road Station and Puslinch Lake Road Station. All sampling sites were assumed to be submerged year round and free from disturbances (the reasons for selecting these stations are given in Appendix 2).

Eight samples were taken from riffle areas at each station using a standardized Surber sampling method (Appendix 3). Riffle areas were chosen so that the habitat type would not add to the variability between stations or samples. All substrate materials from a one foot square area to a depth of 8 cm. (3 in.), were washed into the surber sieve, transferred to buckets, and taken to the University laboratory. These samples were hand sorted and then identified using the following references: crustaceans were identified using Ward and Whipple (1959) and Pennak (1953); aquatic insects were identified using Mason (1968), Ross (1972), Burks (1975), Frison (1975), Usinger (1963), and Ward and Whipple (1959). A reference collection, compiled over the years from the area, was also used in order to standardize identifications.

The Trent biotic index and Shannon-Weiner diversity index were calculated for each sample, as were the mean values for each station. Stations were compared using Cluster Analysis (Biological Survey, 1976) and ANOVA (Steel and Torrie, 1960). To detect similarities and significantly different changes, the results from this year's survey were compared to last year's results for the same stations (Biological Survey, 1976) using Cluster Analysis and ANOVA.

RESULTS

The number of individuals of each species, from the eight samples taken at each of the three stations, are listed in Table 1. This table is the data base for the following analytical procedures.

The Shannon-Weiner diversity index (Table 3) is significantly different for each station, as demonstrated by the ANOVA and DNMRT (Appendix 4). The Victoria station has an index of 2.89, the Hanlon Rd. station's index is 2.30 and the Puslinch Lake Rd. station's index is 1.72. The statistical comparison of the Shannon-Weiner indices for this and last years study (Biological Survey, 1976) shows no significant change with time (Appendix 5). The mean Victoria Rd. indices for both studies are significantly higher than all other mean indices.

The statistical analysis of the Trent biotic index (Table 3) for this study, shows that Victoria Rd. station is significantly different than the other two stations (Appendix 6). The 1976, 1977 mean Trent Biotic indices for Victoria Rd. station are significantly higher than the indices of the other stations (Appendix 7). However, the Trent Biotic indices for the two surveys are not different when statistically tested (Appendix 7).

Figure 2 is a graphical representation of the mean values of the Trent Biotic and Shannon-Weiner diversity indices, for both years for the three stations tested, on the Speed River.

Figure 3 depicts the changes in the number of individuals and the number of species at the three stations for the two surveys.

The number of facultative and sensitive species for 1976 and 1977 at each station is listed in Table 2. The differentiation between the two groups is made using

Beak's (1965) classification. Victoria Rd. station has a higher number of sensitive species than the other stations. It also has the highest number of facultative species. Figure 4 shows graphically the number of sensitive species found in the river's bed as it flows in a southerly direction.

The stations examined during both surveys are "clustered" using the applied Cluster Analysis method outlined in the Biological Survey (1976). This type of analysis groups (clusters) those stations which are similar, according to the calculated Jaccard Coefficients. Those stations which have the highest coefficient are clustered first and therefore are the most similar. Figure 5 is a dendrogram of the Cluster Analysis for both surveys, which was developed after a common species list for the two years was tabulated (Appendix 8). An arbitrary cut-off coefficient of 0.4 was chosen because it yielded three functionally different community types.

The results of this study (1977) are also clustered, but because only three stations were sampled the analysis is inconclusive. The dendrogram has been included for completeness (Appendix 9).

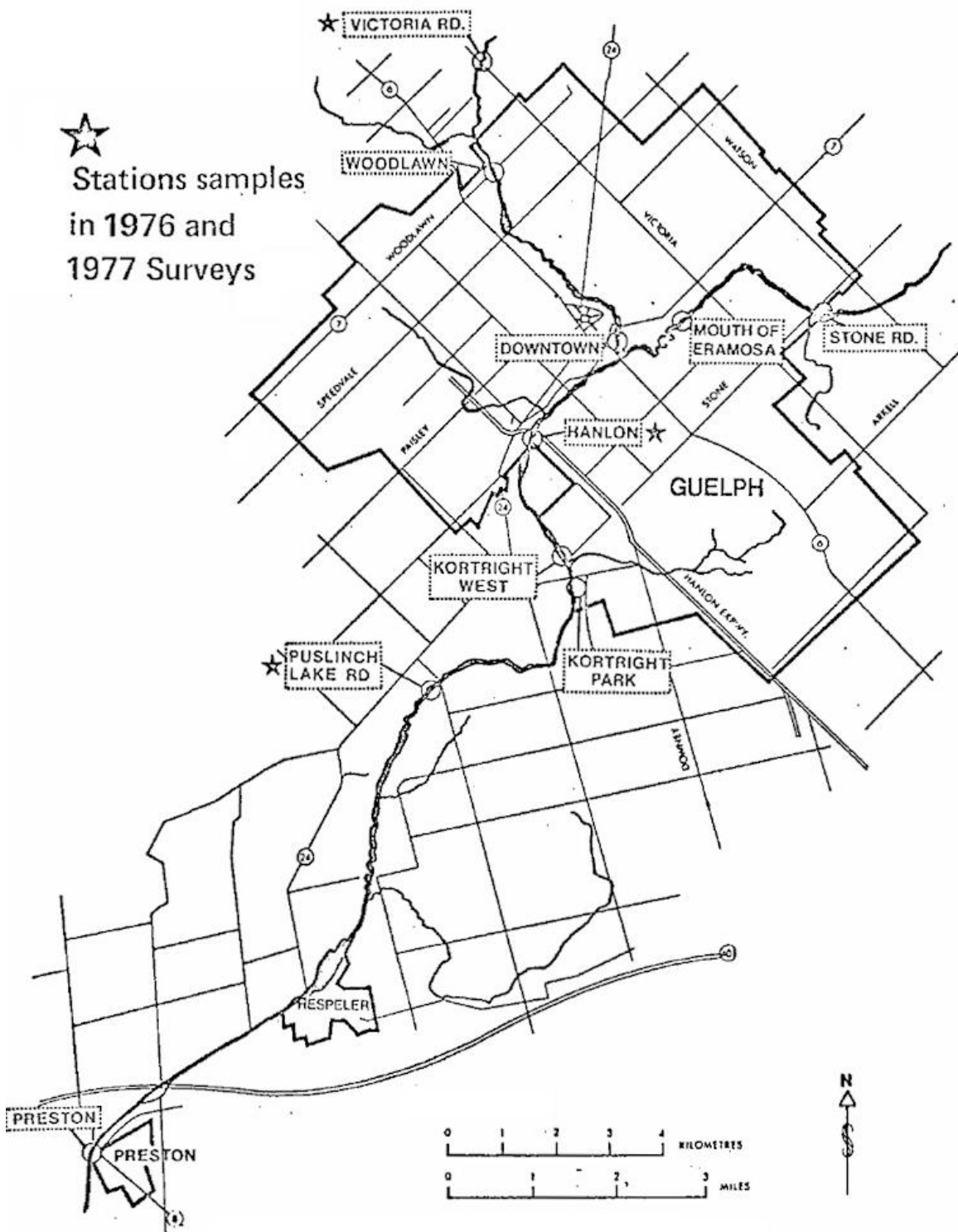


Figure 1: Map of Survey Area

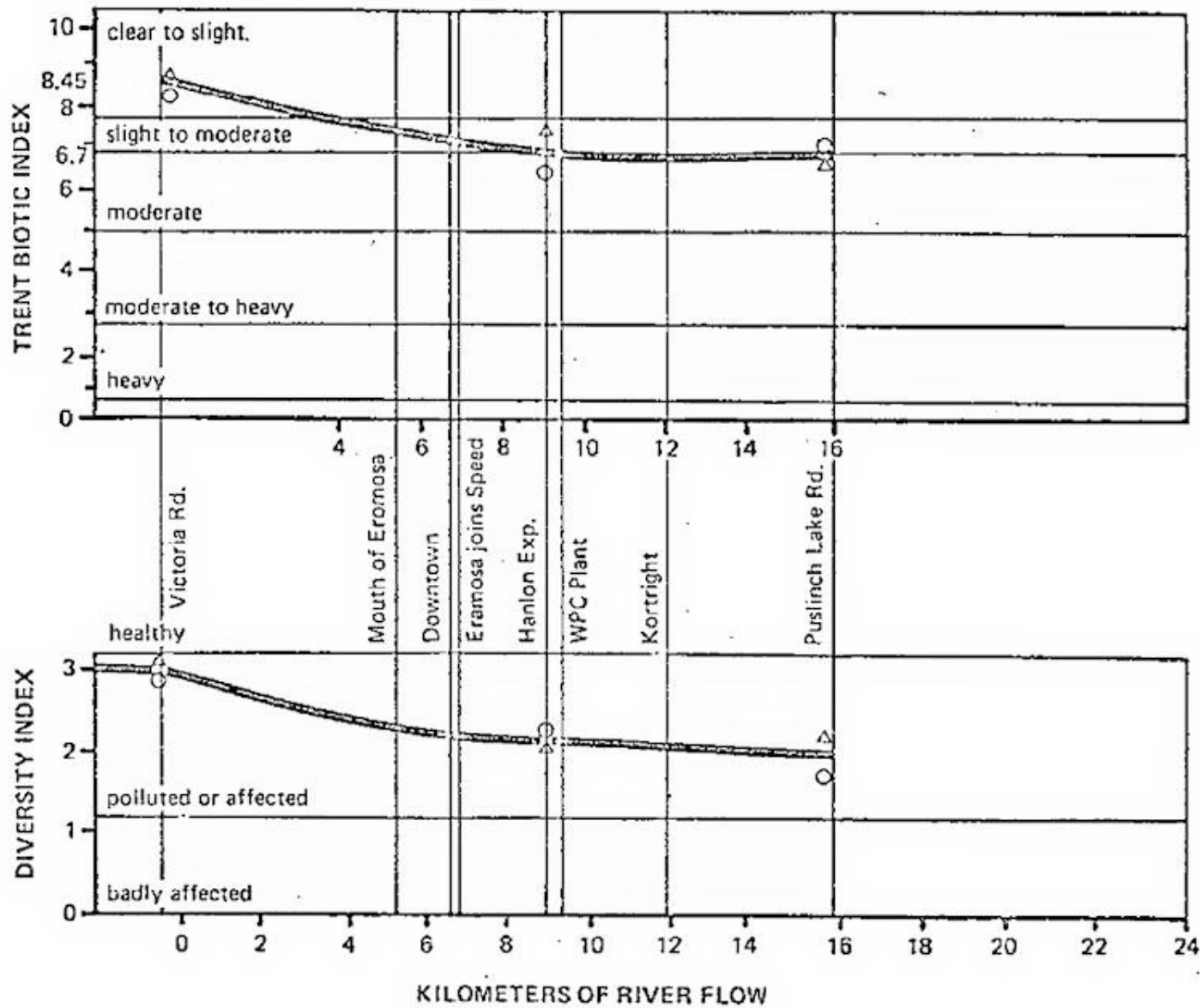


Figure 2: Mean Biological and Diversity Indices Obtained in the Speed River.

Δ — January 1976 values ○ — January 1977 values

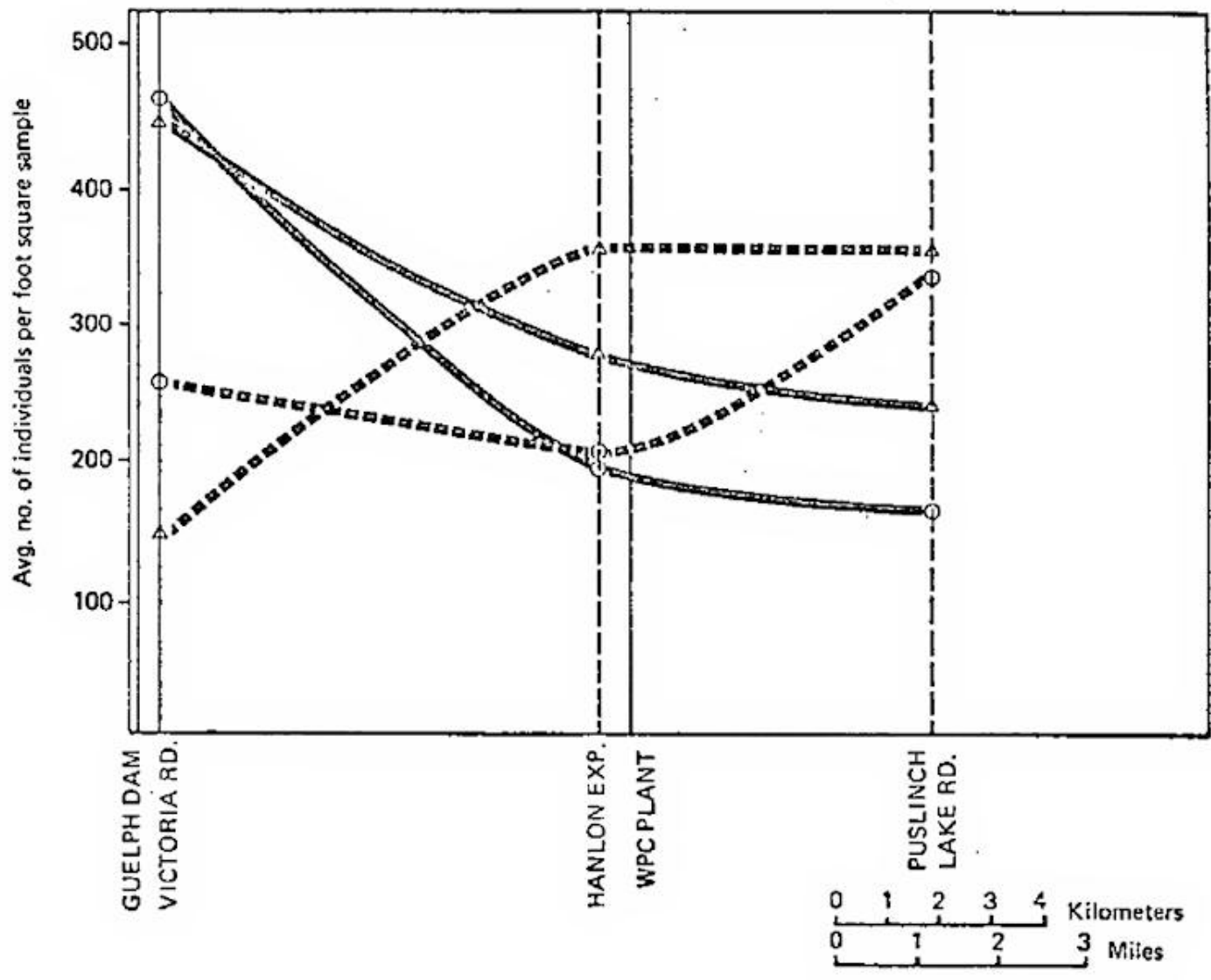


Figure 3: The Number of Individuals per Sample and the Number of Species per Station.

- - - individuals ○ — January 1977 values
 _____ species Δ — January 1976 values

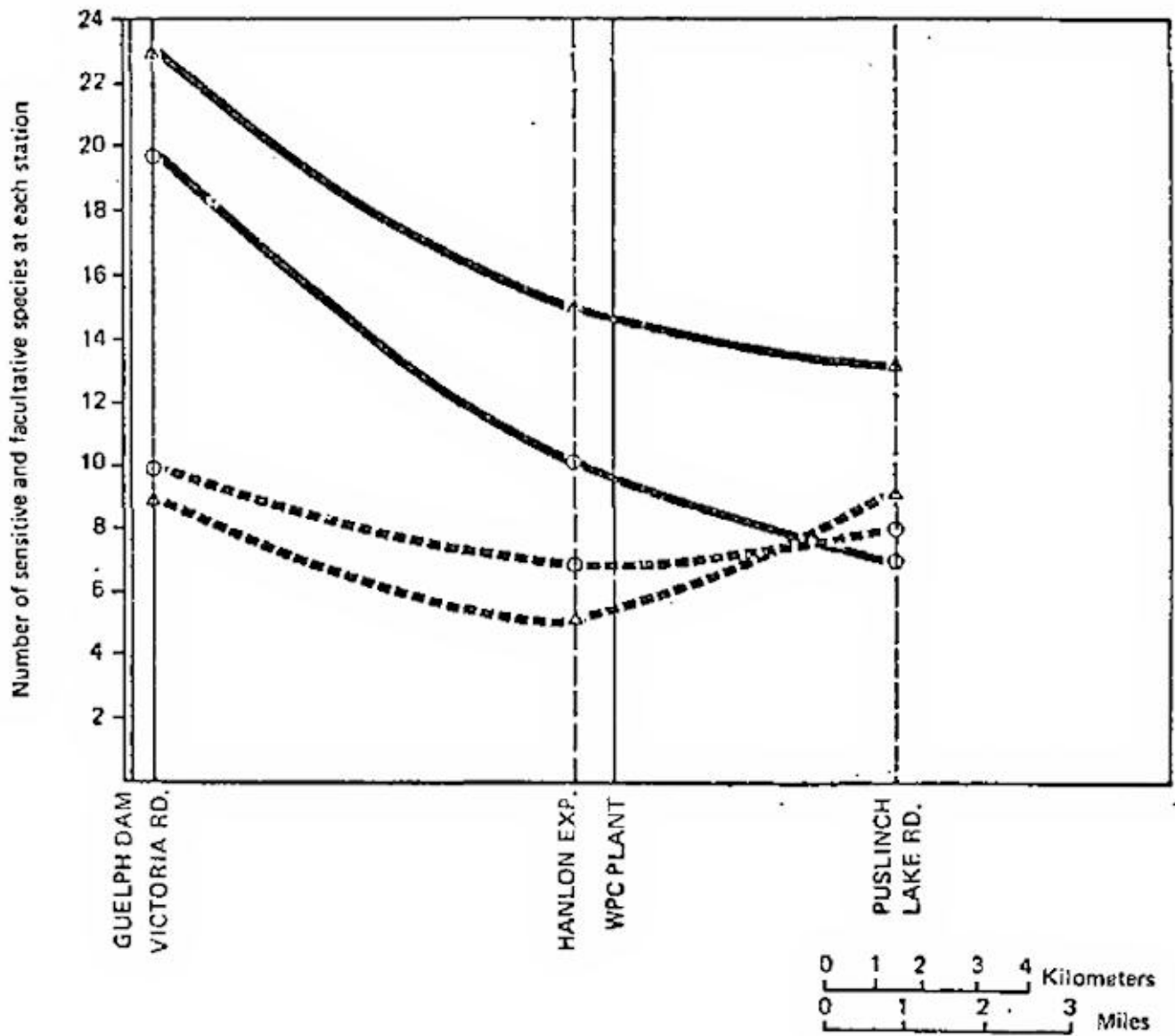


Figure 4: The Number of Sensitive and Facultative Species at Each Station for the Years 1976 and 1977.

Dotted lines (— — —) represent facultative species

Solid lines (_____) represent sensitive species

Open circles (O) represent 1977 results; (Δ) represent 1976 results

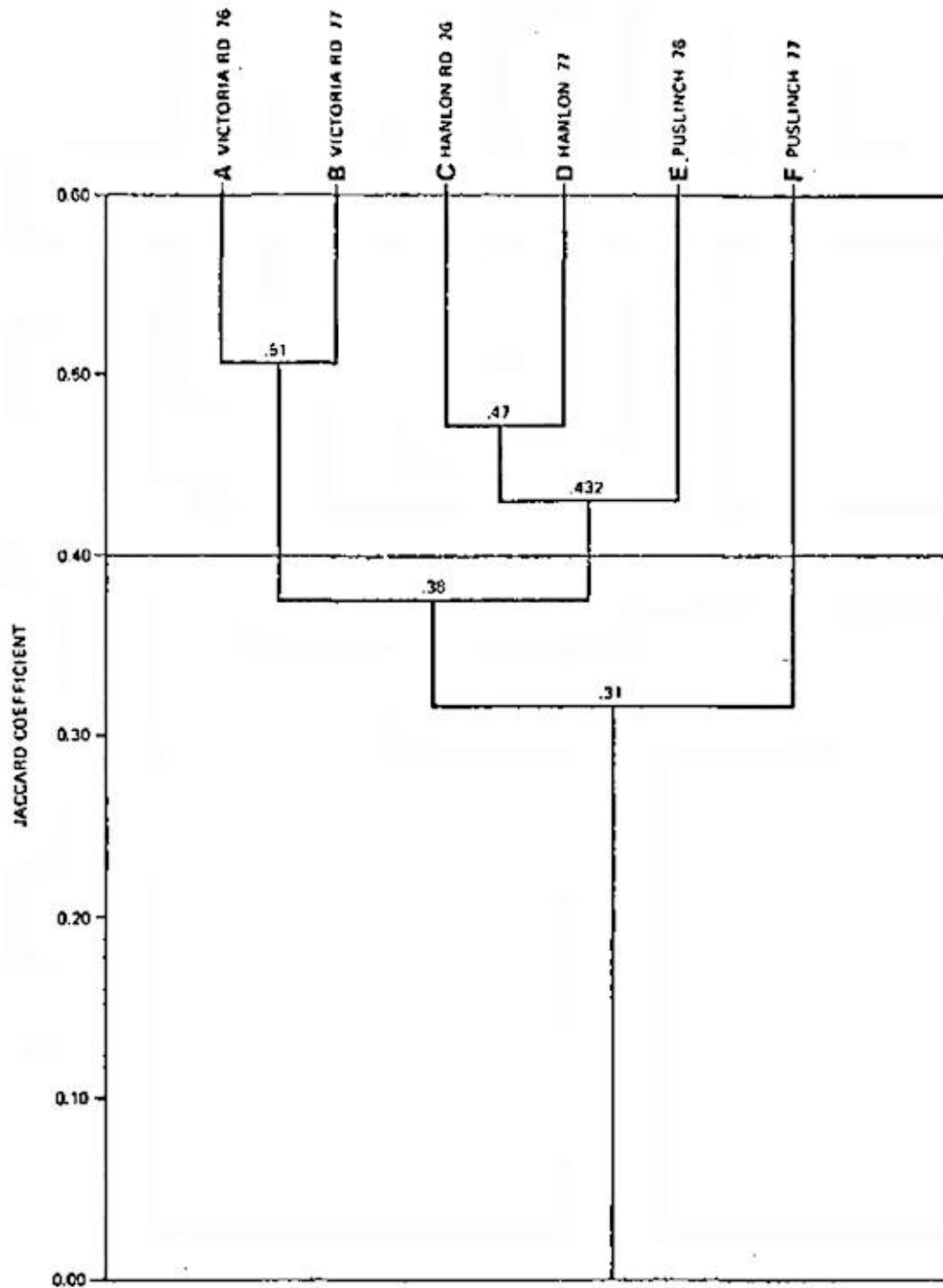


Figure 5: Dendrogram of cluster Analysis for 1976-1977 Survey.

Note: At coefficient 0.40 there are three functionally different communities (A—B, C—D—E, F)

SPECIES LIST (TABLE 1)

GROUP	SPECIES	VICTORIA RD. STATION								SUM
PLECOPTERA	Paragnetina media									
	Taeniopteryx sp.									
EPHEMEROPTERA	Ephemera guttulata	7	1	4	4	2	1	3	15	37
	E. varia	8		2	3	2		8		23
	Heptagenia sp.	5								5
	Stenonema tripunctatum	1								1
	S. canadense									0
	S. heterotarsale									0
	S. bipunctatum							1		1
	Caenis sp.					8	1	12	3	29
	Ephemerella eutope		2							2
	E. unident. sp.							2		2
	Baetis levitans	1								1
TRICHOPTERA	Hydropsyche bifida gp.		7			3	4	2	14	30
	H. sp. B.						2			2
	H. sp. C		2				1			3
	H. simulans									
	Mystacides sepulchralis									
	Limnephilus sp.									
	Cheumatopsyche sp.	38	84	31	39	77	57	93	307	726
	Ochotrichia sp.					1				1
	Chimarra sp.	1								1
	Polycentropus sp.	1								1
	Heliopsyche borealis							8	1	9
	Limnephilus sp.	2								2
MEGALOPTERA	Sialis sp.							1		1
COLEOPTERA	Dubitraphia sp.			3				1		4
	Optioserus sp.		12	10		8		25	35	90
	Stenelmis cranata					68		53		121
	S. sp.	12	10	91	9		3		68	193
	Psephenus sp.							2	1	3
	Ectoparia sp.		6	2		3	1	7	8	27
	Berosus sp.				1					1
DIPTERA	Hexatoma sp.	6			3	3		5	3	20
	Antoeha sp.						1			1
	Limaria sp.									0
	Pedicia	1								1
	Atherix variegata			1	1			2	3	7
	Empididae unident.								1	1
	Dicranota sp.								1	1
	Palpomyia sp.				1					1
	Chironominae		4	10	4	6		27	22	73
	Tanytarsinae	4	49	3		8		20	1	85
	Tanypodinae			7		28		30	27	92
	Orthocladinae	3	1			3	121			128
	Simuliidae unident.	5	24	16			10	21	40	116
	Helius mainensus			2		1				3
	Similium vittatum				3					3
	Cryptochironomus									0
	Tipula sp.	1	1					1	1	4

SPECIES LIST (TABLE 1 CONTINUED)

GROUP	SPECIES	VICTORIA RD. STATION					SUM	
LEPIDOPTERA	Parargyractis sp.					2	2	
CRUSTACEA	Asellus sp.						0	
	Hyalella azteca	4		4	3	1	0	12
	Gammarus sp..							0
	Oronectes propinquus			1				1
HYDRACARINA	Hydracarina sp. A				1			1
	H. sp. B					3		3
	H. sp. C							0
	H. sp. D					6		6
	Hydrobaticeae unident.			3				3
	Hydracarina unident.							0
MOLLUSCA	Physa sp.	8	2		1	3	2	16
	Lymnaea sp.	1						1
	Helisoma sp.	1						1
	Valvata tricarinata							0
	Sphaeium striatinum	4	1	2		27	10	44
	Pisidium casertanum	3						3
ANNELIDA	Tubificidae unident. or Lumbriculidae unident.		3					3
	Ag. Earthworms unident.							0
NEMATODA	Nematoda unident.			1				1
PLATYHELMINTHES	Dugesia sp.			1				1
	Phagocata gracilis					1		1
COELENTERATA	Hydra sp.		42	20	41	32		135

Station Total = 2086

SPECIES LIST (TABLE 1 CONTINUED)

GROUP	SPECIES	HANLON STATION								SUM
PLECOPTERA	Paragnetina media									2
	Tacniopteryx sp.							1		2
EPHEMEROPTERA	Ephemora guttulata									0
	E. varia									0
	Heptagenia sp.				1					1
	Stenonema tripunctatum	3								3
	S. canadense									0
	S. heterotarsale							1		1
	S. bipunctatum									0
	Caenis sp.									0
	Ephemerella eutope									0
	E. unident. sp.									0
	Bactis levitans									0
TRICHOPTERA	Hydropsyche bifida gp.	10	13	13	106	12	18	16	18	206
	H. sp. B				21				4	25
	H. sp. C	1	3	6	39	6	8	7	10	80
	H. simulans									0
	Mystacides sepulchralis									0
	Limnephilus sp.									0
	Cheumatopsyche sp.	100	93	76	308	63	65	71	86	862
	Ochotrichia sp.									a
	Chimarra sp.									0
	Polycentropus sp.				2					2
	Heliopsyche borealis									0
	Limnephilus sp.									0
MEGALOPTERA	Sialis sp.									0
COLEOPTERA	Dubitrphia sp.	1								1
	Optioserus sp.				3				4	9
	Stenelmis cranata									0
	S. sp.	18	4	35	28	13	6	50	62	196
	Psephenus sp.				1					1
	Ectoparia sp.					1	1			2
	Berosus									0
DIPTERA	Hexatoma sp.									0
	Antocha sp.									0
	Limaria sp.									0
	Pedicia									0
	Atherix variegata							1		1
	Empidae unident.						4			4
	Dicranota up.									0
	Palpomyia sp.									0
	Chironominae									0
	Tanytarsinae	1	2							3
	Tanypodinae	8	6	2	25	13	4		17	75
	Orthocladinae	18	26	22	32	12	32	24	47	213
	Simuliidae unident.	3								3
	Helius mainensus									0
	Similium vittatun									0
	Cryptochironomus									0
	Tipula sp.									0

SPECIES LIST (TABLE 1 CONTINUED)

GROUP	SPECIES	HANLON. STATION						SUM
LEPIDOPTERA	Parargyractis sp.							0
CRUSTACEA	Asellus sp.							0
	Hyalella azteca							0
	Gammarus sp.							0
	Oronectes propinquus							0
HYDRACARINA	Hydracarina sp. A	6		1				7
	H. sp. B		4		4			8
	H. sp. C							0
	H. sp. D	1		3				4
	Hydrobatidae unident.							0
	Hydracarina unident.							0
MOLLUSCA	Physa sp.							0
	Lymnaea sp.				1			0
	Helisoma sp.		1					1
	Valvata tricarinata		1					1
	Sphaeium striatinum	1	1		1	1		4
	Pisidium casertanum							0
ANNELIDA	Tubificidae unident. or Lumbriculidae unident.							0
NEMATODA	Nematoda unident.	1	2	3	1	2	1	20
PLATYHELMINTHES	Dugesia sp.							0
	Phagocatagracilis							0
COELENTERATA	Hydra sp.							0
	Ag. Earthworms unident. **	1	3	7			8	19

Station Total = 1747

SPECIES LIST (TABLE 1 CONTINUED)

GROUP	SPECIES	PUSLINCH STATION								SUM	
PLECOPTERA	Paragnetina media									0	
	Taeniopteryx sp.									0	
EPHEMEROPTERA	Ephemera guttulata									0	
	E. varia									0	
	Heptagenia sp.									0	
	Stenonema tripunctatum	1		1						2	
	S. canadense	6	4		10	13	22	1		56	
	S. heterotarsale	1		1		6	1	1		10	
	S. bipunctatum									0	
	Caenis sp.		1	3	2	7	2			15	
	Ephemerella eutope									0	
	E. unident. sp.									0	
	Baetis levitans									0	
TRICHOPTERA	Hydropsyche bifida gp.				4					4	
	H. sp. B										
	H. sp. C										
	H. simulans										
	Mystacides sepulchralis										
	Limnephilus sp.										
	Cheumatopsyche sp.	141		133	130	213	176	127	283	52	1255
	Ochotrichia sp.									0	
	Chimarra sp.									0	
	Polycentropus sp.									0	
	Heliopsyche borealis									0	
MEGALOPTERA	Sialis sp.	2		1	1		6	1		11	
COLEOPTERA	Dubitraphia sp.									0	
	Optioserus sp.									0	
	Stenelmis cranata				2			4		6	
	S. sp.			4	2	3	5	4	7	4	29
	Psephenus sp.									0	
	Ectoparia sp.			2	1	3		1	1	8	
	Berosus sp.			2	1	2	1	6		12	
DIPTERA	Hexatoma sp.									0	
	Antocha sp.									0	
	Limaria sp.				1					1	
	Pedicia									0	
	Atherix variegata									0	
	Empididae unident.									0	
	Dicranota sp.									0	
	Palpomyia sp.									0	
	Chironominae	1	6		7		8	1		23	
	Tanytarsinae		2		11	6	34		7	4	64
	Tanypodinae	8	6		1	2	2	22		17	58
	Orthocladinae		21		17	5		1		44	
	Simulidae unident.	12	164		278	219	205	59	46	136	1119
	Helius mainensus									0	
	Similium vittatun									0	
	Cryptochironomus				1					1	
	Tipula sp.									0	

SPECIES LIST (TABLE 1 CONTINUED)

GROUP	SPECIES	PUSLINCH STATION					SUM
LEPIDOPTERA	Parargyractis sp.						0
CRUSTACEA	Asellus sp.	1	1				2
	Hyalella azteca	4	1	1			6
	Gammarus sp.			1	1	1	3
	Oronectes propinquus				1		1
HYDRACARINA	Hydracarina sp. A					1	1
	Hydracarina sp. H	5		1	1	1	8
	Hydracarina sp. C						0
	Hydracarina sp. D						0
	Hydrobatidae unident.						0
	Hydracarina unident.					4	4
MOLLUSCA	Physa op.		1	1	1	1	4
	Lymnaea sp.						0
	Helisoma sp.						0
	Valvata tricarinata						0
	Sphaeium striatinum						0
	Pisidium casertanum						0
ANNELIDA	Tubificidae unident. or						
	Lumbriculidae unident.						0
	Ag. Earthworms unident.						0
NEMATODA	Nematoda unident.	3		3			6
PLATYHELMINTHES	Dugesia sp.						0
	Phagocata gracilis						0
COELENTERATA	Hydra sp.						0

Station Total, =2753

Table 2. No. of facultative and sensitive species per station; 1977, 1976; using Beak's classification.

Sensitive groups	Stations and Years					
	Victoria Rd.		Hanlon Rd.		Puslinch Lake Rd.	
	1977	1976	1977	1976	1977	1976
Odonata	0	1	0	1	0	1
Trichoptera	9	6	5	5	2	6
Megaloptera	1	1	0	0	1	1
Ephemeroptera	10	14	3	8	4	4
Plecoptera	0	1	2	1	0	1
Total	20	23	10	15	7	13
Facultative groups						
Tentipedidae	4	4	3	3	4	4
Amphipoda	1	0	0	1	2	1
Isopoda	0	0	0	0	1	0
Gastropoda	3	3	3	1	0	3
Pelecypoda	2	2	1	0	1	1
Total	10	9	7	5	8	9

Table 3. Trent Index, Diversity Index, No. of individuals and No. of species per station; 1976, 1977.

Station Name	Trent Index		Diversity Index		No. of individuals		No. of species	
	1977	1976	1977	1976	1977	1976	1977	1976
Victoria Rd.	9	9	3.69	2.40	117	328		
	9	9	3.60	3.55	205	181		
	8	10	3.02	3.86	232	95		
	8	9	2.86	2.53	81	132		
	9	7	2.58	1.62	246	52		
	7	9	2.55	3.23	252	68		
	8	8	2.56	3.76	388	121		
	7	9	2.23	2.90	565	163		
mean	8.1	8.8	2.89	3.04	261	142	59	57
Hanlon Rd.	7	7	2.78	2.55	163	310		
	7	7	2.67	1.72	147	323		
	7	6	2.36	2.17	160	217		
	6	7	2.29	1.09	577	327		
	7	8	2.26	1.67	140	386		
	6	7	2.19	2.56	143	533		
	6	7	1.95	1.87	157	382		
	5	8	1.92	1.53	260	369		
mean	6.3	7.1	2.30	1.89	218	356	30	38
Puslinch Lake Rd	6	5	1.30	1.83	172	143		
	8	5	2.09	2.26	350	556		
	8	7	2.06	2.18	466	249		
	7	7	1.92	1.53	473	226		
	7	7	1.89	2.65	460	356		
	6	7	1.74	1.90	236	810		
	8	8	1.69	2.09	373	299		
	6	6	1.08	1.84	223	160		
mean	7.0	6.5	1.72	2.16	344	350	27	35

DISCUSSION

The Speed River above Guelph has a diversified benthic community, which reflects little pollution and good water quality. As it passes through the Guelph region it picks up industrial effluent as well as urban and agricultural runoff which decrease the water quality as reflected by the lower Shannon-Weiner diversity and Trent Biotic indices.

According to Nutall and Purves (1974), the Shannon-Weiner diversity index is an expression which reflects the number of component groups and the numerical balance of these groups, while ignoring the requirements of different species. The index increases as the number of groups increase and their representation becomes equal. In polluted streams the diversity index ranges from 0.4 to 1.5. In unaffected streams the range is from 3.2 to 3.6. In light of this classification, the Victoria Rd. station (mean diversity index 2.89-3.04) can be termed slightly polluted, while Hanlon Rd. station (1.89-2.30) and the Puslinch Lake Rd. station (1.72-2.16) can be termed moderately polluted.

The Trent Biotic index sorts invertebrates into groups which consist of species, genus, or family units. Six of these groups are given key status according to their sensitivity to pollution. The number of groups in a sample, together with the dominant key groups, are used to calculate the biotic Index. Clean streams score an index of ten and this number is reduced with increased pollution to zero, representing septic conditions (Nutall and Purves, 1974). Comparison of the Trent Biotic indices (Table 3) with the foregoing distribution yields similar conclusions to those using the Shannon-Weiner Diversity index. That is, Victoria Rd. station is slightly polluted while Hanlon Rd. and Puslinch Lake Rd. stations are moderately polluted.

The dendrogram of the Cluster Analysis (figure 5) appears to divide the river catchment into three functionally different community types. With respect to the Trent Biotic and Shannon-Weiner diversity indices, these communities can be classified as slightly polluted (Victoria Rd. 1976,1977), moderately polluted (Hanlon Rd. 1976, 1977, Puslinch Lake Rd. 1976), and polluted (Puslinch Lake Rd. 1977). The differences between Puslinch Lake Rd. 1977 and the moderately polluted stations is not statistically supported and is probably attributable to extensive ice cover which made sampling at Puslinch Lake Rd. station (1977) very difficult.

The analysis of the Trent Biotic and Shannon-Weiner indices (Appendices 7 and 5 respectively) indicate that the water quality of the lower Speed River has not improved since the previous study (Biological Survey, 1976). Therefore, the water quality enhancement objective of the Guelph Dam has not been realized, to date.

The Speed River receives a number of pollutants from various sources. Above Victoria Rd. small tributaries drain into the river carrying agricultural runoff. As the river passes through Guelph it picks up sewage, industrial, and urban runoff. Below Hanlon Rd. the Guelph Pollution and Control Plant dumps treated sewage effluents into the lower Speed River. However, since the summer of 1976 the plant has been running below capacity with an effluent discharge of 8 ½ million gallons per day as opposed to a 10 m.g.d. capacity.

The Guelph Dam, as proposed in 1966, has been used to maintain a minimum flow rate through the summer months. In 1975, (before the dam was in operation) the average mean monthly flow rates for July, August and September were 8.5, 11.5, and 19.0 cu. ft. per sec., respectively with daily minima of 4.7, 2.5 and 8.7 c.f.s., respectively. During the same months of 1976, 80% of the maximum holding capacity was released, maintaining a constant flow rate of 20 c.f.s. (Dr. Stevens, personal

communication).

The number of variables affecting the pollution status of the Speed River are numerous and therefore, the reasons why the Guelph Dam has not been effective to date, will need further research.

SUMMARY

1. The water quality of the Speed River was high as it entered Guelph at the Victoria Rd. station but showed a substantial decrease at the Hanlon Rd. station and the Puslinch Lake Rd. station.
2. The water quality of the lower Speed River can be classified as moderately polluted.
3. The water quality of the lower Speed River as it flows through Guelph, is not significantly different than the water quality as determined last year (Biological Survey, 1976).
4. The Guelph Dam appears to have had no influence on the quality of the water in the lower Speed River. The expected "pollution dilution" effect is not evidenced by the data from this study.

RECOMMENDATIONS

1. Further biological surveys should be carried out over the next few years (at the previously studied stations, with comparable techniques) to determine if the proposed beneficial effects of the dam will be realized. This will be valuable information when considering other low flow augmentation proposals in the future.
2. Physical parameters, such as flow rate, depth, and substrate characteristics, should be measured in future studies.
3. Research is needed to determine why the Guelph Dam has not been effective to date.

GLOSSARY

ANOVA - analysis of variance, a statistical method used to determine if treatments (stations) are significantly different from one another.

BENTHIC FAUNA - the assemblage of animals living on or in the aquatic substrate.

CLUSTER ANALYSIS - a statistical procedure that uses the Jaccard Coefficient to group sampling stations together on the basis of the amount of similarity between species.

DUNCAN'S NEW MULTIPLE RANGE TEST (DNMRT) - a multiple comparison test to compare each treatment (station) mean with every other treatment mean to determine which are significantly different.

FACULTATIVE SPECIES - a somewhat subjective term that implicates certain species as being able to live and reproduce in clean as well as slightly to moderately polluted waters.

JACCARD COEFFICIENT - a numerical expression of species overlap.

RIFFLE AREA - a shallow in a stream, producing a stretch of rapidly flowing waters, and considered to be a relatively homogeneous habitat area.

SENSITIVE SPECIES - a somewhat subjective term that implicates certain species as ones which cannot tolerate polluted waters.

SHANNON-WEINER DIVERSITY INDEX - an index used to summarize large amounts of information about the numbers and kinds of organisms in an area. Numbers between 3.2 - 3.6, or higher represent a relatively undisturbed (healthy) community while those between 0.4 - 1.5 represent an adversely affected community.

SURBER SAMPLER - a device, designed for systematic bottom sampling, in which a metal frame marks off a one foot square area and which is hinged to a fine mesh net.

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APPENDIX 1

The Names of the Students and the Faculty Participating in the
January, 1977 Biological Survey.

Students	Instructors
Beckerton, Pat	Sprague, J.B.
Brisco, Brian	Dixon, George D.
Browning, Mark	MacGregor, R.
Cunjak, Rick	
Daub, Brian	
Dunlop, Greg	
Fernandez, Ephraim	
Fry, Donald	
Gallant, Jim	
Halahil, Tarik	
Hill, Barry	
Holmes, Lexie	
Hurlbut, Tom	
Hutchinson; Neil	
Kooi, Bert	
Maclennan, Tom	
Marshal, Steve	
O'Reilly, Laurie	
Rodrigues, Cajetan	
Saunders, Karen	
Savoie, Paul	
Scholfield, Bill	
Sutherland, Bob	
Walker, Valeri	
Wiley, Kent	

APPENDIX 2

The Stations Chosen:

It was decided that eight replicates at each station was statistically desirable. Therefore, the number of stations was limited by the number of students available. Three stations were chosen for the following reasons:

Victoria Rd. Station

This station is located 50 yards upstream of where Victoria Rd. crosses the Speed River. It was chosen because:

- a) it was easily accessible.
- b) it gives a measure of the water quality of the Speed River before entering Guelph.
- c) it had been sampled in January 1976.

Hanlon Rd. Station

This station was chosen because:

- a) it had been sampled in 1975 and 1976, giving a good data base with which the effects of the dam could be ascertained.
- b) it is above the Guelph sewage plant and thus the water quality is only affected by runoff, drainage and industrial wastes from within the city of Guelph and not by sewage effluent. This station should show the effect of low flow augmentation within the city.

Puslinch Lake Rd. Station

This station was chosen because:

- a) it was sampled in 1975 and 1976 and therefore provided a good data base for comparison.
- b) it is below the Guelph sewage plant and therefore the water quality will be affected by the addition of partially treated sewage effluent as well as the sources mentioned for Hanlon Rd. Station. Studies done here should show

how low flow augmentation from the dam have increased the capacity of the Speed River to recover from both types of effluent at a distance downstream from the source of the pollution.

Other Possible Stations:

Downtown Guelph. This area was not chosen because it had only been sampled once before (Sept., 1975).

Kortright West and Park side. These stations were not sampled because past data had been inconclusive.

Preston Station. This station is located where the Speed River meets the Grand River, just below the town of Preston. The presence of the towns of Hespler and Preston above this station increase the variability making it impossible to attribute changes in the water quality to the Guelph Dam. Previous sampling was done immediately below an overflow dam giving results which would not be comparable to ours because of the high level of disturbance.

Woodlawn Rd. Station. This station had been previously sampled but was rejected because of the presence of a drainage ditch and the lack of good riffle areas.

APPENDIX 3

The Sampling Method

Last years survey team (Biological Survey, 1976) used two methods of obtaining samples at each station (a kitchen sieve and a Surber sampler). Because an analysis of variance on the Trent Biotic and Shannon-Weiner Diversity indices for the two sampling methods showed no significant difference (at $\alpha=0.5$) it was possible for them to group the data for comparison between stations.

It was decided this year that a standardised method of sampling would reduce the sampling methods variance in the ANOVA, and allow for a more valid statistical analysis. The Surber sampler was chosen because it was the easier method to be standardized. Choosing one method as opposed to two does not reduce the effectiveness of the data comparison between years because it was statistically verified that both methods were similar.

APPENDIX 4

Shannon-Weiner Diversity Index - for three stations - 1977.

ANOVA

Source	df	SS	MS	F	F _α 0.05
Station A	2	5.4289	2.7144	16.389*	3.47
error	21	3.4782	0.1656		
Total	23	8.9071			

Standard error 0.14389

at $\alpha = 0.05$ stations are significantly different

Duncans multiple range test
means

Victoria Rd.	2.886
Hanlon Rd.	2.303
Puslinch L. Rd.	1.721

Ranked means

1	2	3
Puslinch L. Rd.	Hanlon Rd.	Victoria Rd.
1.721	0.303	2.886

All stations are significantly different.

APPENDIX 5

Shannon-Weiner Diversity Index - for three stations - 1976, 1977.

ANOVA					
Source	df	SS	MS	F	F _α 0.05
Station A	2	9.1121	4.5561	18.9002*	3.23
Years B	1	0.0213	0.0213	0.0882	4.08
Interaction AB	2	1.4491	0.7245	3.0056	
error	42	10.1245	0.2411		
Total	47	20.7070			

at $\alpha=0.05$ stations are significantly different; years are not

Duncans multiple range test
means

Victoria Rd. 77	2.89
Victoria Rd. 76	3.04
Hanlon Rd. 77	2.30
Hanlon Rd. 76	1.90
Puslinch L. Rd.77	1.72
Puslinch L. Rd.76	2.16

Ranked means

1	2	3	4	5	6
Puslinch 77	Hanlon 76	Puslinch 76	Hanlon 77	Victoria 77	Victoria 76
1.72	1.90	2.16	2.30	2.89	3.04

Victoria Rd. station (76, 77) is significantly different than all other stations.

Hanlon Rd. station (77) is significantly different than Puslinch L. Rd. station (77).

APPENDIX 6

Trent Biotic Index - for three stations - 1977

ANOVA

Source	df	SS	MS	P	$F_{\alpha} 0.05$
Station A	2	22.5833	6.2917	8.958*	3.47
error	21	14.7500	0.7024		
Total	23	27.3333			

Standard error 0.29631

at $\alpha = 0.05$ stations are significantly different

Duncans multiple range test

means

Victoria Rd.	8.125
Hanlon Rd.	6.375
Puslinch L. Rd.	7.000

Ranked means

1	2	3
Hanlon Rd.	Puslinch L. Rd.	Victoria Rd.
6.375	7.000	8.125

Victoria Rd. station is significantly different.

APPENDIX 7

Trent Biotic Index - for three stations - 1976, 1977.

ANOVA

Source	df	SS	MS	F	Fa.05
Station A	2	30.3750	15.1875	20.4940*	3.23
Years B	1	1.0208	1.0206	1.3775	4.08
Interaction AB	2	3.7917	1.8958		
error	42	31.1250	0.7411		
Total	47	66.3125			

at $\alpha = 0.05$ stations are significantly different; years are not

Duncans multiple range test
means

Victoria Rd. 77	8.100
Victoria Rd. 76	8.800
Hanlon Rd. 77	6.300
Hanlon Rd. 76	7.100
Puslinch L. Rd.77	7.000
Puslinch L. Rd.76	6.500

Ranked means

1	2	3	4	5	6
Hanlon 77	Puslinch 76	Puslinch 77	Hanlon 76	Victoria 77	Victoria 76
6.3	6.5	7.0	7.1	8.1	8.8

Victoria Rd. station (77, 76) is significantly different than all other stations.

APPENDIX 8

Combined Species List for Cluster Analysis. Serber Samples for Winter 76 and Winter 77.

Group	Genus and Species	Victoria 76	Victoria 77	Hanlon 76	Hanlon 77	Puslinch 76	Puslinch 77
PLECOPTERA (Stoneflies)	Paragnetina media	✓					
	Acroneuria ruralis	✓					
	A. sp.						
	Neophasganophora sp.						
	Chloroporla sp.	✓					
	Hastaperla sp.						
	Kathoperla sp.						
	Alloeapnia sp.	✓					
	Nemoura sp.						
	Taeniopteryx sp.			✓			
	Strophopteryx sp.	✓					
Unidentified stonefly							
EPHEMPTERA (Mayflies)	Ephemera gluttulata	✓					
	E. varia						
	Hexagenia sp.						
	Brachycerus sp.			✓			
	Heptagenia sp.						
	Stenonera tripunctatum	✓					
	S. canadense	✓		✓			✓
	S. heterotarsale	✓		✓			
	S. fuscum	✓					✓
	S. frontale	✓					
	S. rioulicotum						
	S. femoralum			✓			✓
	S. biunetatum	✓					
	S. vicarium	✓					
	S. ares	✓					
	S. pudicom						
	Unident. Heptageniidae	✓		✓			✓
	Caenis sp.	✓		✓			
	Paraleptophlibia sp.	✓					
	Ephemerella spa.	✓		✓			
	E. walkeri group	✓		✓			
	E. eutope						
	E. unident.	✓					
Isonychia bicolor							
Centroptilum							
Pseudocloen sp.							

APPENDIX 8 (Cont'd)

Croup	Gents and Species	Victoria 76	Victoria 77	Hanlon 76	Hanlon 77	Puslinch 76	Puslinch 77
EPHEMPTERA (Mayflies) cont'd.	Ameletus sp. Unidentified mayflies						
TRICHOPTERA (Caddisflies)	Hydropsyche bifida sp. H. sp. E. H. sp. C. Hydropsyche simulans Cheumatopsyche sp. Diplectrona sp. Ochotrichia sp. Chimarra sp. Polycentropus sp. Unident. Psychomyiidae Helicopsyche borealis Hydroptida sp. Rhyacophila sp. Lepidostoma sp.	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓		✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓		✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	
Megaloptera (Alderflies)	Sialis sp. Ohauliodes sp. Nisronia sp.	✓ ✓ ✓				✓ ✓ ✓	
ODONATA (Damsel & Dragonflies)	Ischnura sp. Enallagma sp. Amphiagrion sp. Agria sp. Calopteryx sp. Unident. Coenagrionidae	✓ ✓ ✓ ✓ ✓ ✓		✓ ✓ ✓ ✓ ✓ ✓		✓ ✓ ✓ ✓ ✓ ✓	
COLEOPTERA (Beetles)	Paragyraea sp. Dubitraphia sp. Optioserus sp. Stenelmis cranata S. decorata S. sp. Ordobrevia Unident. Elmidae sp. A Unident. Elmidae sp. B	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓		✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓		✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	

APPENDIX 8 (Cont'd)

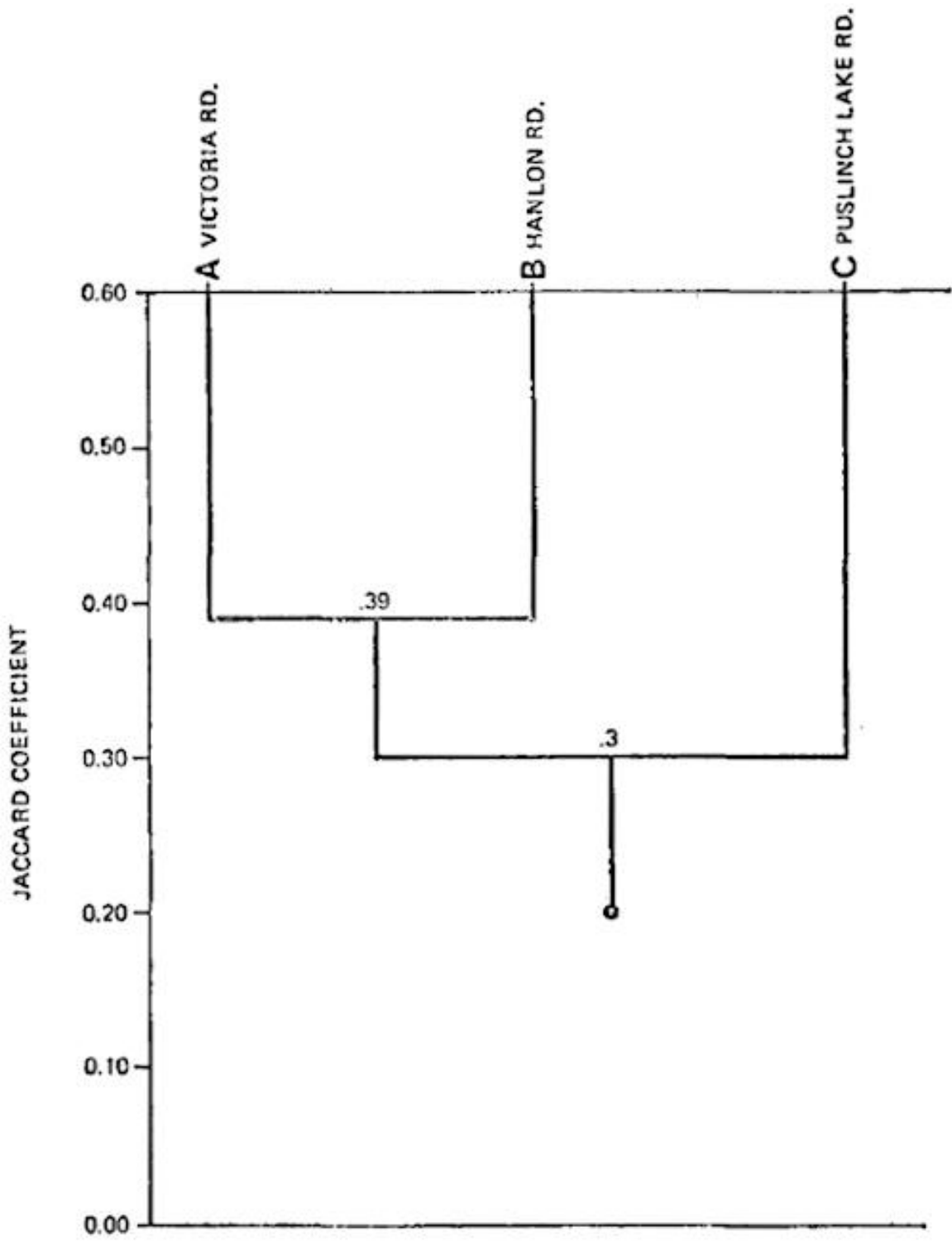
Group	Genus and Species	Victoria 76	Victoria 77	Hanlon 76	Hanlon 77	Puslinch 76	Puslinch 77
COLEOPTERA (Beetles) cont'd.	Unident. Elmidae sp. C						
	Psephenus sp.	✓		✓			
	Eetoparia sp.	✓		✓		✓	
	Brychius sp.			✓			
	Berosus sp.			✓		✓	
	Unident. Dryopidae						
DIPTERA (Flies and midgits)	Hexatoma sp.	✓					
	Antocha sp.	✓					
	Limaia sp.					✓	
	Pedicia sp.	✓					
	Holorusia sp.						
	Limnophora quifrons						
	Atherix variegata	✓		✓		✓	
	Pilorus sp.	✓		✓			
	Unident. Phytopteridae						
	Unident. Empidae	✓		✓			
	Evalatia sp.						
	Dicranota sp.	✓					
	Delpomyia sp.	✓					
	Daspelae sp.						
Unident. Chironomidae sp. A	✓		✓		✓		
Unident. Chironomidae sp. B	✓		✓		✓		
Unident. Chironomidae sp. C	✓		✓		✓		
Unident. Chironomidae sp. D	✓		✓		✓		
Unident. Simuliidae	✓		✓		✓		
HEMIPTERA (Bugs)	Unident. Corixidae					✓	
	Rhagiovelic sp.						
LEPIDOPTERA (Butterfly)	Dararguractis sp.						
CRUSTACEA	Aseilus sp.						
	Hyallega azteca			✓		✓	
	Gammarus sp.					✓	
	Oroneates propinquas	✓		✓			
	O. limosus	✓					
	O. rusticus			✓			

APPENDIX 8 (Cont'd)

Croup	Genus and Species	Victoria 76	Victoria 77	Hanlon 76	Hanlon 77	Puslinch 76	Puslinch 77
CRUSTACEA cont'd.	Unident. Cambarinae Cyclops sp.						
HYDROCARINA (Water mites)	Hydrocarina sp. A Hydrocarina sp. B Hydrocarina sp. C Hydrocarina sp. D Hydrocarina sp. E Unident. Hydrobatidae Unident. Hydrocarina	✓ ✓ ✓ ✓		✓ ✓ ✓			
MOLLUSCA (Snails and clams)	Physa sp. Goniobasis sp. Lymnae sp. Helisoma sp. Ferrissia sp. Valuata sincera V. triarinata Campeloma sp. Unident. bastropods Sphaeium striatinum Museulium sp. Disidoiem cesertanum Eliptio complanatus Unident. Pelecypoda	✓ ✓ ✓ ✓ ✓ ✓ ✓		✓		✓ ✓ ✓ ✓ ✓ ✓	
ANNELIDA (Sludge worms and leaches)	Unident. Tubificidae Branchiura sowerby Unident. Ag. Earthworms Glossiphonia sp. G. complanata Erpobdella punctata Unident. Hirudinoa	✓			✓	✓ ✓ ✓	✓
NEMATODA (Roundworms)	Unidentified Nematode			✓		✓	

APPENDIX 8 (Cont'd)

Group	Genus and Species	Victoria 76	Victoria 77	Hanlon 76	Hanlon 77	Puslinch 76	Puslinch 77
PLATYHELMINTHES (Matworms)	Dugesia sp.			✓			
	Unident.grey sp.						
	Unident. Planariidae						
	Phagoeatagracilis						
GELENERATA	Hydra sp.						



APPENDIX 9. Dendrogram of Cluster Analysis for 1977 Survey.