

The benthic macroinvertebrates of the Musselshell River, Montana
by Mark William Gorges

A thesis submitted in partial fulfillment of the requirements for the. degree of MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University
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Abstract:
The benthic macroinvertebrates and water quality of the Musselshell River were studied from June 1974 through June 1975 prior to anticipated alteration of flows in the river. Ephemeroptera, Trichoptera and Diptera combined accounted for over 98% of the organisms taken from modified Hester-Dendy plates recovered from riffles at six stations. ChoroterPes, Baetis, Simuliidae and Hydropsyche together comprised about 80% of the organisms collected. The ranges of dissolved oxygen, pH and temperature were similar, at all stations. Conductivity, turbidity, alkalinity, calcium and total hardness, chloride, and sulfate levels increased progressively downstream.

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by

MARK WILLIAM GORGES

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Fish and Wildlife Management

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ABSTRACT

The benthic macroinvertebrates and water quality of the Musselshell River were studied from June 1974 through June 1975 prior to anticipated alteration of flows in the river. Ephemeroptera, Trichoptera and Diptera combined accounted for over 98% of the organisms taken from modified Hester-Dendy plates recovered from riffles at six stations. *Choroterpes*, *Baetis*, Simuliidae and *Hydropsyche* together comprised about 80% of the organisms collected. The ranges of dissolved oxygen, pH and temperature were similar at all stations. Conductivity, turbidity, alkalinity, calcium and total hardness, chloride, and sulfate levels increased progressively downstream.

INTRODUCTION

The Musselshell River flows through the Bull Mountains Coal Field which contains some of the most important coal deposits in Montana. The increasing development of coal reserves in Montana makes it likely coal production from this area will be expanded. Additional development of the Bull Mountains Coal Field could cause an increased demand for water resulting in alteration of the river's flow and water quality.

Little information on the biota and water chemistry of the Musselshell River is presently available. I conducted field research from 12 June 1974 through 30 June 1975 to obtain baseline information on the benthic macroinvertebrates and the water quality of the Musselshell River prior to increased coal development. The data collected should facilitate the monitering of these parameters.

DESCRIPTION OF THE STUDY AREA

The Musselshell River is located in Central Montana (Figure 1). It rises from the junction of the North and South Forks of the Musselshell River in Wheatland County, flows easterly through Wheatland, Golden Valley and Musselshell Counties, northward along the east side of Petroleum County and empties into Fort Peck Reservoir on the Missouri River.

Most of the Musselshell Valley was not glaciated during the Pleistocene (Perry, 1933). It is a relatively narrow valley filled, in places, to depths of over 50 feet with interbedded silt, clay, sand and gravel typical of deposits formed by ordinary stream action (Perry, 1933).

Flows of the Musselshell River have been monitored by the U.S.G.S. at four stations in the study area for over 27 consecutive years. A summary of the flows at these stations during the period of record and the study period is presented in Table 1. Subsurface flows in the riverbed gravel are usually maintained even when surface waters dry up (Perry, 1933).

Six collecting sites were established over the approximately 300 km of the river flowing in an easterly direction (Figure 1). The locations of stations and distances between stations are given in Table 2. Stations 1, 2 and 3 lie in a portion of the river supporting

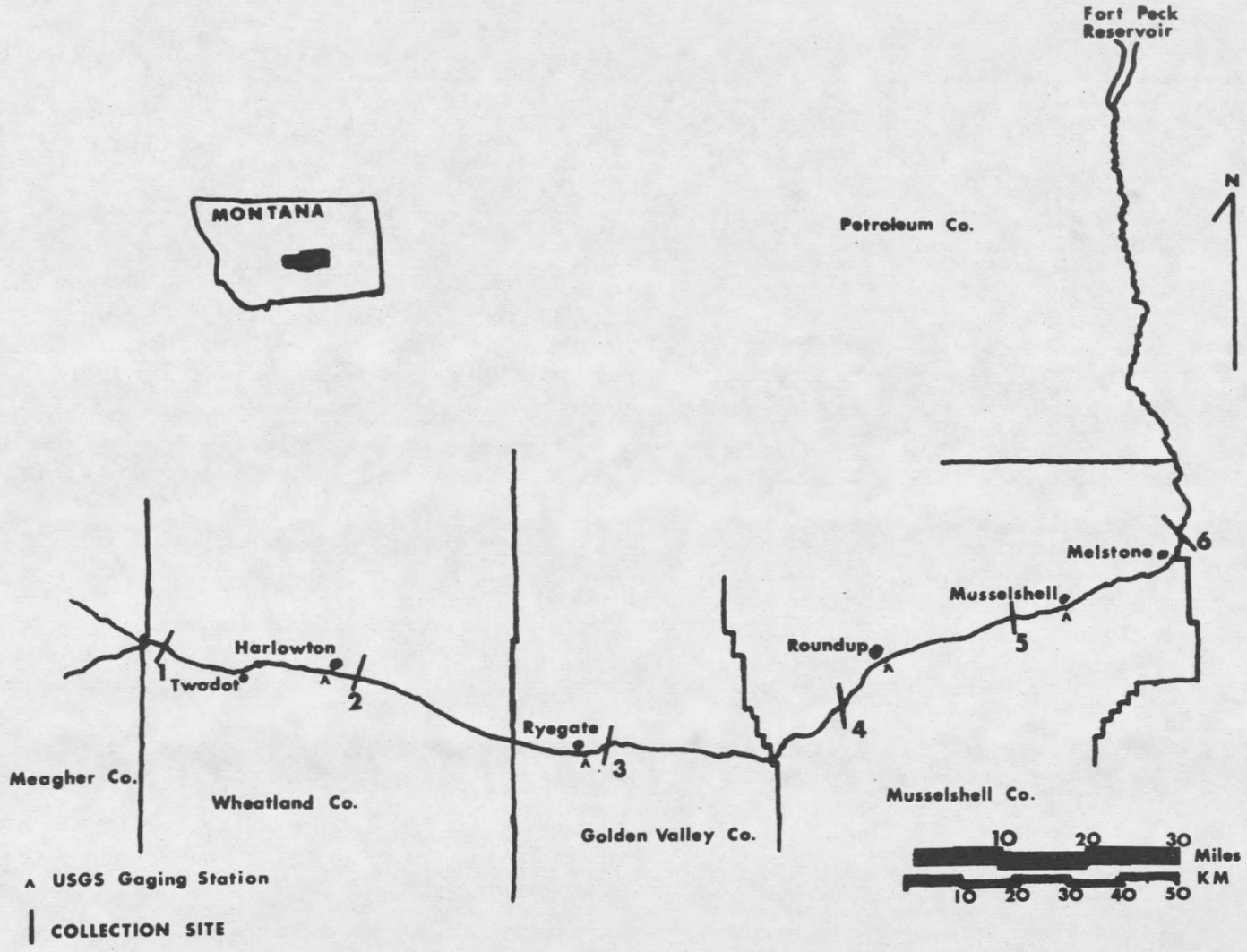


FIGURE 1. Map of the study area showing location of collection sites.

TABLE 1. AVERAGE, MAXIMUM AND MINIMUM FLOWS (in cfs) OVER THE PERIOD OF RECORD AND THE STUDY PERIOD AT FOUR STATIONS ON THE MUSSELSHELL RIVER (USGS, 1975 and 1976*).

Station	Period of Record			Period of Study		
	Avg.	Max.	Min.	Avg.	Max.	Min.
Harlowton	158	6,200	0	372	6,200	40
Ryegate	163	9,500	0	445	7,550	25
Roundup	196	9,610	0.6	479	6,600	25
Musselshell	185	9,850	0	485	6,800	30

*Preliminary data subject to revision.

TABLE 2. LOCATIONS OF COLLECTING SITES AND DISTANCE (in river km) BETWEEN STATIONS.

Station #	Township	Range	Section	Distance from Last Upstream Station
1	T8N	R12E	5	--
2	T8N	R16E	34	54
3	T6N	R20E	2	55
4	T7N	R25E	8	69
5	T9N	R28E	28	56
6	T10N	R31E	21	61

trout while Stations 4, 5 and 6 lie in a section containing warmwater fish.

The bottom types varied at sampling sites. The substrate at Station 1 was gravel. At Station 2 the gravel bottom was interspaced with silt. The substrate at Station 3 was silty mud over broken sandstone slabs. The bottom at Stations 4, 5 and 6 was gravel embedded in a layer of silty mud.

METHODS

Benthic macroinvertebrates were sampled with artificial substrates similar to Hester-Dendy samplers (APHA, 1971) but with 11 x 11 cm plates giving a total surface area of 0.2 m^2 per sampler. Four samplers were used at each station. All plates were anchored in areas of visually similar current and positioned just above the substrate with plates lying parallel to the bottom. Macroinvertebrates were collected after a colonization period of approximately four weeks. In August 1974, four additional samplers were installed at both Stations 1 and 6; two of these samplers were collected from each station after two and six weeks of colonization.

The material on each recovered sampler was scraped into a separate jar and preserved in 10% formalin. Samples were taken to Montana State University where they were individually washed on a US Series Number 30 screen. The aquatic macroinvertebrates from each sample were hand picked from the material retained by the screen and preserved in 50% isopropyl alcohol. These organisms were identified to the lowest practical taxon using Ward and Wipple (1959) and counted.

The individual diversity based on Brillouin's interpretation of the information theory and the redundancy of the collection for each site on each collecting date were calculated using the formulae of Pielou (1969). Data were calculated at the Montana State University

Computer Center utilizing a computer program written by personnel of the Department of Mathematics, Montana State University.

Conductivity, turbidity, pH, alkalinity, calcium hardness, total hardness, chloride, sulfate and dissolved oxygen were measured with a Hach DR/EL2 with Conductivity kit. Measurements were made monthly from July 1974 through June 1975, conditions permitting, at streamside on dates scheduled for collecting macroinvertebrates. The range of water temperatures at each station during each colonization period was recorded with a Taylor Max-Min thermometer. The water temperature at the time of each collection was taken with a pocket thermometer.

RESULTS

Biotic

4 Week Sampling

Ordinal Composition.-- During the monthly sampling, 192 samplers were installed. Ice, floods and shifting substrates prevented the recovery of 60 samplers. The numbers and kinds of benthic macroinvertebrates collected from each sampler retrieved are presented in Appendix Tables 6 to 11. During the study, 25,088 organisms belonging to nine orders were taken. Ephemeroptera comprised 43% of the number collected and contained representatives of 11 genera. Trichoptera accounted for 37% of the total number and contained 5 genera. Diptera made up 18% of the collection and consisted of three families. Odonata, Plecoptera, Hemiptera, Neuroptera, Pulmonata and Coleoptera each made up 1% or less of the total number. These orders contained 4, 3, 1, 1, 1 genera and 1 family, respectively.

The average number and ordinal composition of organisms collected at each station is presented in Table 3. Over six times as many organisms per sampler were taken from Station 6 as from Station 5. Mayflies and caddisflies combined accounted for 80% or more of the macroinvertebrates collected at each station except Station 1 where they made up 59%. In bottom samples taken by the Montana State Board of Health (1960), caddisflies and dipterans at a site near Station 2

TABLE 3. AVERAGE NUMBERS[+] PER SAMPLER AND PERCENT[+] COMPOSITION (in parentheses) OF BENTHIC MACROINVERTEBRATES BY ORDER FROM MONTHLY COLLECTIONS. Hyphens indicate zero counts.

Station # of Samplers	1 28	2 21	3 17	4 23	5 17	6 26
Order						
Ephemeroptera	43 (25)	65 (32)	51 (53)	93 (71)	38 (64)	155 (41)
Diptera	62 (36)	39 (19)	11 (11)	7 (5)	2 (3)	71 (19)
Trichoptera	57 (34)	101 (49)	31 (32)	30 (23)	17 (30)	152 (40)
Plecoptera	3 (2)	>1 (>1)	1 (1)	>1 (>1)	>1 (>1)	>1 (>1)
Odonata	-	-	>1 (>1)	>1 (>1)	>1 (>1)	>1 (>1)
Coleoptera	1 (1)	1 (>1)	1 (1)	1 (1)	1 (2)	3 (1)
Hemiptera	-	>1 (>1)	1 (1)	-	-	-
Neuroptera	-	-	-	>1 (>1)	-	-
Pulmonata	4 (2)	>1 (>1)	1 (1)	>1 (>1)	-	-
Totals	170 (100)	206 (100)	97 (100)	131 (100)	59 (99)*	381 (101)*

[+]Rounded to the nearest whole number.

*Rounding gave numbers unequal to 100%.

and caddisflies and gastropods at a location near Station 4 made up 80% or more of the organisms collected.

Not all stations were sampled during the same months. However, all stations were sampled during the months of July, August, October and November. During these months, the relationships between numbers and ordinal composition were similar to those presented in Table 3.

Generic Composition.-- The composition of the taxa within each order is presented in Table 4. The mayfly *Choroterpes*, the dipteran Simuliidae and the caddisfly *Hydropsyche* were the dominant taxa, with each contributing over twice as many organisms per sampler as any other taxon. Each form accounted for over 50% of the numbers within its order and was most abundant at Station 6.

Twenty-six of the thirty-two taxa collected during this study have been reported from either the Yellowstone River (Newell, 1975) or the Tongue River (Gore, 1975) in Montana. Of the organisms I collected, the mayfly *Caenis*, the caddisflies *Mystacides* and *Helicopsyche*, the damselflies *Ishnura* and *Calopteryx* and the neuropteran *Sialis* were not found in their studies.

Distribution.-- The distribution of the taxa taken in monthly collections throughout the study area is graphically displayed in Figure 2. The mayflies *Heptagenia*, *Choroterpes*, *Tricorythodes* and *Baetis*, the dipterans Simuliidae and Tendipedidae, the caddisflies *Hydropsyche*, *Mystacides* and *Brachycentrus* and the beetle Elmidae were

TABLE 4. AVERAGE NUMBERS[+] PER SAMPLER AND PERCENT[+] COMPOSITION (in parentheses) OF EACH TAXA WITHIN EACH ORDER FROM MONTHLY COLLECTIONS. Hyphens indicate zero counts.

Station	1	2	3	4	5	6	Average
TAXA							
Ephemeroptera							
Ephemeridae							
Ephoron	-	<1 (<1)	<1 (1)	<1 (<1)	2 (5)	1 (1)	1 (1)
Heptagenidae							
Heptagenia	7 (14)	5 (7)	11 (22)	6 (6)	2 (4)	6 (4)	6 (8)
Baetidae							
Isonychia	-	<1 (<1)	7 (14)	8 (7)	4 (9)	6 (4)	4 (5)
Choroterpes	2 (5)	7 (11)	16 (30)	71 (76)	29 (72)	131 (84)	43 (56)
Traverella	-	-	2 (3)	3 (3)	2 (5)	2 (1)	2 (3)
Paraleptophlebia	4 (8)	<1 (<1)	-	-	-	-	1 (1)
Ephemerella	5 (12)	<1 (<1)	-	-	-	-	1 (1)
Tricorythodes	6 (14)	13 (20)	6 (12)	4 (4)	1 (2)	1 (1)	5 (6)
Caenis	-	<1 (<1)	-	-	-	-	<1 (<1)
Brachycercus	-	-	<1 (<1)	<1 (<1)	<1 (1)	-	<1 (<1)
Baetis	22 (48)	39 (60)	9 (17)	1 (1)	1 (3)	9 (5)	14 (18)
Diptera							
Simuliidae	51 (83)	31 (78)	7 (67)	4 (61)	1 (62)	81 (96)	29 (85)
Tendipedidae	10 (14)	8 (21)	4 (33)	3 (37)	1 (38)	3 (4)	5 (15)

TABLE 4. Continued.

Station	1	2	3	4	5	6	Average
TAXA							
Diptera (continued)							
Tipulidae	<1 (<1)	<1 (<1)	-	<1 (<1)	-	<1 (<1)	<1 (<1)
Trichoptera							
Hydropsychidae							
Hydropsyche	20 (36)	98 (96)	30 (97)	31 (99)	17 (98)	151 (100)	58 (91)
Leptoceridae							
Oecetis	1 (2)	<1 (<1)	-	<1 (<1)	-	-	<1 (<1)
Mystacides	<1 (<1)	<1 (<1)	<1 (<1)	<1 (<1)	<1 (1)	<1 (<1)	<1 (<1)
Brachycentridae							
Brachycentrus	28 (52)	2 (2)	<1 (3)	<1 (1)	<1 (1)	<1 (<1)	5 (8)
Helicopsychidae							
Helicopsyche	5 (10)	1 (1)	-	-	-	-	1 (2)
Plecoptera							
Pteronarcidae							
Pteronarcella	<1 (12)	-	-	-	-	-	<1 (9)
Perlodidae							
Isoperla	3 (81)	<1 (100)	-	<1 (25)	-	-	1 (68)
Perlidae							
Acroneuria	<1 (7)	-	1 (100)	<1 (75)	<1 (100)	<1 (100)	<1 (23)
Odonata							
Gomphidae							
Gomphus	-	-	<1 (13)	-	-	-	<1 (5)
Coenagrionidae							
Argia	-	-	<1 (75)	<1 (44)	<1 (100)	<1 (33)	<1 (57)

TABLE 4. Continued.

Station	1	2	3	4	5	6	Average
TAXA							
Odonata							
Coenagrionidae (continued)							
Ishnura	-	-	-	-	-	<1 (67)	<1 (10)
Calopterygidae							
Calopteryx	-	-	<1 (12)	<1 (56)	-	-	<1 (29)
Coleoptera							
Elmidae	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	3 (100)	1 (100)
Hemiptera							
Naucoridae							
Ambrysus	-	<1 (100)	1 (100)	-	-	-	<1 (100)
Neuroptera							
Sialidae							
Sialis	-	-	-	<1 (100)	-	-	<1 (100)
Pulmonata							
Physidae							
Physa	4 (100)	<1 (100)	1 (100)	<1 (100)	-	-	1 (100)

+Rounded to the nearest whole number.

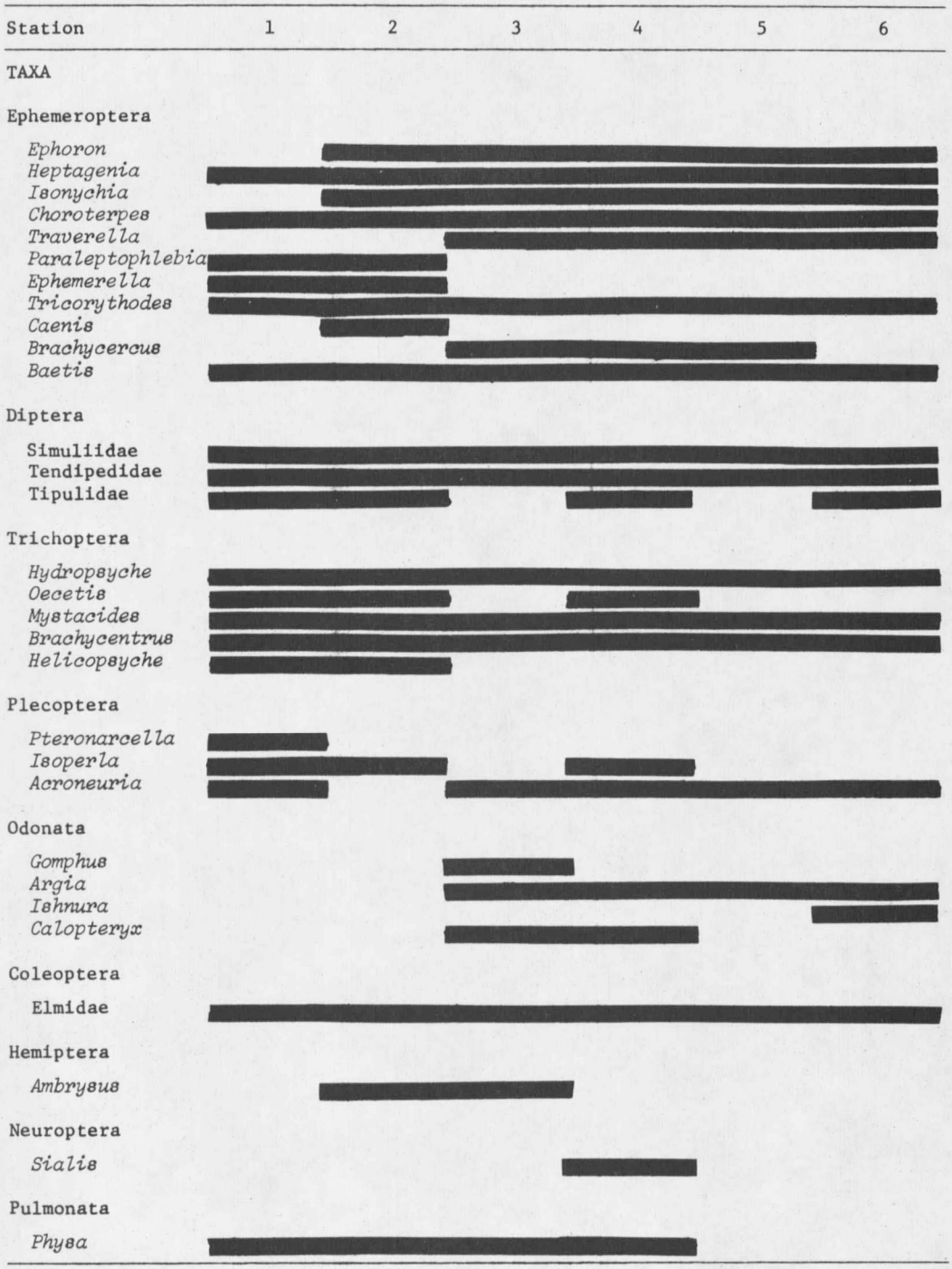


Figure 2. Distribution of each taxon from monthly collections.

found at all stations. The distribution of the remaining taxa suggests the presence of different communities in the upper, middle and lower sections of the stream. As in this study, Dr. George Roemhild (personal communication) has found *Ambrysus* only in waters intermediate between clear mountain streams and turbid prairie rivers. Possibly, even those genera found throughout the study area were represented by various species in different sections of the river.

The distribution of some forms may have been more extensive than is indicated in Figure 2. Tipulidae, *Oecetis*, *Isoperla* and *Acroneuria* each had a discontinuous distribution; each was collected at rates of less than one individual per sampler at the stations above and below the station at which none were found. This suggests they may also have been present at the intermediate stations but were not collected because of their small numbers.

A more complete pattern of distribution was probably gotten for organisms present throughout much of the year. The distribution of *Isonychia*, *Traverella*, *Brachycercus*, *Gomphus*, *Ishnura* and *Ambrysus* may have been underestimated because each was collected in July and/or August only.

Diversity Index.-- Maximum diversity exists when each species in a community is represented by one individual, and minimum diversity exists when all individuals belong to the same species. The redundancy parameter measures the equality of the distribution of

individuals into the taxa present and can theoretically range from zero to one, with equal distribution of individuals among the taxa being represented by the value of zero (Pielou, 1969). A stable community would typically have a large number of taxa with relatively even distribution (EPA, 1972). Recently, Goodman (1975) suggested that diversity does not accurately measure stability in biological communities, and Hurlbert (1971) has questioned the basic validity of present diversity indices.

The individual diversity and redundancy of the families present at each station on each sampling date are given in Table 5. Families were used because all organisms were identified, at least, to that taxonomic level. Diversities were generally higher and redundancies lower at upstream sites than at downstream stations. However, Station 6 had higher diversity and lower redundancy 50 and 60% of the time than Stations 4 and 5, respectively.

2 & 6 Week Sampling

Plates were colonized for 2 and 6 weeks at both Stations 1 and 6. The numbers and kinds of macroinvertebrates collected and the diversity of the families are presented in Appendix Table 12. The 2 and 6 week collections were compared with the monthly collections made on the same dates.

In August, samplers colonized for 2 weeks had about 50% fewer organisms per plate at Station 1 and 25% more per plate at Station 6

TABLE 5. NUMBERS OF SAMPLES (S), ORGANISMS (N) AND FAMILIES (F) WITH THE DIVERSITY (D) AND REDUNDANCY (R) OF THE FAMILIES AT EACH STATION ON EACH SAMPLING DATE.

Date	Station 1					Station 2					Station 3					Station 4					Station 5					Station 6				
	S	N	F	D	R	S	N	F	D	R	S	N	F	D	R	S	N	F	D	R	S	N	F	D	R	S	N	F	D	R
15/16 July	4	1845	11	2.159	.383	3	581	8	1.995	.350	4	657	10	2.219	.348	3	673	8	1.892	.384	4	580	11	1.815	.502	4	1572	11	1.386	.613
12/13 Aug.	4	640	8	1.833	.405	4	955	9	1.691	.481	3	436	9	1.618	.520	4	543	9	1.103	.685	1	68	5	.989	.708	4	3269	8	1.192	.609
12/13 Sept.	4	285	12	2.505	.337	4	1638	13	1.734	.544	3	271	10	1.768	.517	4	489	7	.653	.804	0	--	--	--	--	4	2923	8	1.493	.508
12/13 Oct.	4	302	11	2.579	.280	4	562	10	2.130	.378	3	92	9	1.709	.588	4	682	6	1.142	.576	4	314	4	.310	.886	4	1302	5	.697	.711
9/10 Nov.	4	175	10	2.942	.132	4	186	8	1.912	.408	4	176	8	1.574	.542	4	426	8	.683	.818	4	51	5	.651	.945	4	620	5	1.403	.408
8 Dec.	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--	4	31	3	1.173	.349	4	464	6	1.071	.612
2 May	4	1124	9	1.583	.514	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--	0	--	--	--	--
1/2 June	4	396	9	2.166	.338	2	418	8	1.479	.537	0	--	--	--	--	4	255	9	2.107	.369	0	--	--	--	--	2	87	4	.884	.646

than plates colonized for 4 weeks. In September, samplers colonized for 6 weeks had about 25% fewer organisms per plate at Station 1 and about 50% more per plate at Station 6 than plates colonized for 4 weeks. After 6 weeks of colonization at Station 6, samplers had collected the mayfly *Ephemerella*. In the monthly collections this genus was not taken at any station downstream from Station 2. There were no other additions to the distribution of organisms. Diversity for both the 2 and 6 week samples was higher than the 4 week samples at Station 1 but lower at Station 6. Despite the small sample size, the 2 and 6 week data indicate that different areas may require different colonization periods to obtain maximum numbers of organisms, maximum species representation or highest diversity.

Chemical

The chemical and physical parameters measured on each sampling date are presented in Appendix Table 13. The ranges of dissolved oxygen, temperature and pH were similar at all stations. Conductivity, turbidity, alkalinity, calcium hardness, total hardness, chloride and sulfate levels increased progressively downstream. The highest ionic concentrations and lowest turbidity at each station were found in December and January when flows were lowest.

The levels of pH and temperature measured by the Montana State Board of Health (1960) near Station 2 on 22 August 1958 were similar

to the levels present on 12 August 1974. Total hardness and alkalinity were lower and turbidity was higher in my samples than in theirs; this was probably due to the differences in flows at the time of the two collections. During their collection, the stream flow was 53 cfs while during mine it was about 212 cfs (USGS, 1975). The measurements made by the Montana State Board of Health on 26 June 1959 near Station 4 were comparable to my measurements at Station 4 on both 16 July 1974 and 30 June 1975.

Oxygen levels probably were not a limiting factor at my collecting sites; measurements were all above 8.0 ppm. Surber and Bessey (1974) demonstrated stream invertebrates survived oxygen levels far below levels found in my study.

DISCUSSION

The development of coal resources in Montana has increased rapidly in recent years as industry has increased its use of low sulfur coal. Development is anticipated to intensify in the future. Coal in east central Montana, near the town of Circle, is being considered as a source of fertilizer. A number of electric generating and gassification plants are projected to be built. All of these activities require the use of substantial supplies of water.

The rich deposits in the Bull Mountains Coal Field make the area attractive for potential development. Under present flow conditions, the Musselshell River could not provide the year round quantities of water demanded by industries converting coal into other products. However, the availability of water could be increased by storing spring runoff of the Musselshell River and releasing it during times of lower flows, or, as has been proposed, water from other drainages could be brought in to augment the natural flow of the river.

Modifying the natural flow of the Musselshell River would change its present flow pattern, temperature regime, sedimentation pattern, bottom features, and water chemistry which, in turn, would cause changes in the stream communities. The data collected during this study and the detailed water quality information being gathered by the Montana Department of Health and Environmental Sciences

should be useful in determining the extent of changes in the Musselshell River if flows are altered.

APPENDIX

TABLE 6. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES COLLECTED FROM EACH SAMPLER RECOVERED ON 15/16 JULY 1974. Hyphens indicate zero counts.

Station	1				2			3				4			5				6			
Sampler	1	2	3	4	1	2	3	1	2	3	4	1	2	3	1	2	3	4	1	2	3	4
TAXA																						
Ephemeroptera																						
Ephoron	-	-	-	-	-	-	-	-	3	1	-	-	9	-	2	-	27	2	5	6	14	7
Heptagenia	12	19	15	16	2	-	2	7	14	20	17	9	10	17	1	3	4	3	8	16	19	10
Isonychia	-	-	-	-	-	-	-	29	5	13	40	25	63	98	12	6	19	20	31	49	40	29
Choroterpes	-	-	-	-	-	-	-	-	-	-	-	-	3	4	16	46	37	24	33	36	39	41
Traverella	-	-	-	-	-	-	-	3	1	1	1	8	6	17	1	-	7	1	-	9	8	2
Paraleptophlebia	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerella	5	4	6	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes	11	35	20	36	4	7	6	2	3	2	6	7	1	-	2	3	1	5	3	4	4	1
Caenis	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brachycercus	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	2	-	-	-	-	-
Baetis	99	55	114	76	44	55	85	35	14	33	52	12	5	2	1	1	4	1	3	25	23	24
Diptera																						
Simuliidae	154	222	180	166	29	85	69	36	4	5	74	83	1	8	1	1	1	2	-	-	-	1
Tendipedidae	49	13	46	68	7	10	10	3	3	2	8	3	2	-	1	3	3	3	5	1	7	6
Tipulidae	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
Trichoptera																						
Hydropsyche	-	3	7	6	44	61	38	50	54	24	67	88	82	102	60	37	62	123	264	234	217	321
Mystacides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	-
Brachycentrus	121	85	102	65	3	7	6	4	2	4	-	1	1	1	-	-	1	1	-	1	-	1
Plecoptera																						
Pteronarcella	1	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla	4	2	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acroneuria	-	1	-	4	-	-	-	1	7	3	1	-	-	-	-	-	1	-	-	-	-	-
Odonata																						
Argia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Gomphus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera																						
Elmidae	-	-	-	1	1	-	1	-	2	-	-	-	2	2	3	6	9	5	4	6	3	7
Pulmonata																						
Physa	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	456	439	499	451	136	226	219	170	112	109	266	236	186	251	104	107	179	190	356	389	375	452

TABLE 7. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES COLLECTED FROM EACH SAMPLER RECOVERED ON 12/13 AUGUST 1974. Hyphens indicate zero counts.

Station	1				2				3			4				5	6			
Sampler	1	2	3	4	1	2	3	4	1	2	3	1	2	3	4	1	1	2	3	4
TAXA																				
Ephemeroptera																				
Ephoron	-	-	-	-	-	-	-	-	1	-	2	-	-	1	-	-	-	-	-	-
Heptagenia	5	10	13	6	1	6	3	5	-	1	6	-	-	3	-	2	27	25	17	22
Isonychia	-	-	-	-	3	1	1	-	2	-	33	-	-	1	-	3	1	1	2	2
Choroterpes	14	17	7	10	17	27	59	36	61	24	35	150	68	64	39	16	388	520	465	248
Traverella	-	-	-	-	-	-	-	-	2	-	19	5	-	3	22	23	10	6	1	4
Paraleptophlebia	15	17	5	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes	4	12	7	7	15	5	17	49	15	7	40	10	1	20	14	4	-	2	2	-
Brachycercus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Baetis	12	9	8	10	13	40	49	36	-	-	5	2	-	9	-	10	19	40	9	29
Diptera																				
Simuliidae	1	-	-	-	4	1	3	11	-	-	1	-	-	-	-	-	-	1	-	-
Tendipedidae	3	1	5	1	30	13	21	29	4	-	26	7	2	10	9	2	6	8	11	4
Trichoptera																				
Hydropsyche	24	-	10	56	144	16	85	201	14	3	121	4	1	4	90	6	503	422	211	249
Mystacides	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-
Brachycentrus	107	66	69	88	2	2	2	3	-	1	1	-	-	-	-	-	1	1	1	2
Plecoptera																				
Isoperla	2	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acroneuria	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1
Odonata																				
Argia	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Ishnura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Coleoptera																				
Elmidae	-	-	-	-	1	-	1	-	1	4	2	-	-	-	1	2	-	2	2	-
Hemiptera																				
Ambrysus	-	-	-	-	2	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
Pulmonata																				
Physa	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	187	134	127	192	232	111	242	370	100	44	292	180	73	115	175	68	957	1030	721	561

TABLE 8. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES COLLECTED FROM EACH SAMPLER RECOVERED ON 12/13 SEPTEMBER 1974. Hyphens indicate zero counts.

Station	1				2				3			4				6			
Sampler	1	2	3	4	1	2	3	4	1	2	3	1	2	3	4	1	2	3	4
TAXA																			
Ephemeroptera																			
Ephoron	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Heptagenia	6	1	2	2	7	6	2	1	1	9	3	-	-	-	-	2	1	-	1
Choroterpes	4	7	1	-	1	11	1	2	1	23	19	114	178	34	76	307	347	212	331
Paraleptophlebia	19	9	16	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes	2	1	-	6	10	17	14	14	1	6	7	5	4	4	19	2	1	1	1
Caenis	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Baetis	-	-	-	1	92	84	66	82	2	3	3	-	-	-	1	10	1	6	6
Diptera																			
Simuliidae	-	-	-	-	69	51	133	41	3	-	-	-	-	-	-	168	18	62	3
Tendipedidae	5	4	1	1	6	2	1	8	1	3	4	2	1	-	1	4	5	2	3
Tipulidae	4	2	3	-	-	-	5	-	-	-	-	-	2	-	-	-	-	-	-
Trichoptera																			
Hydropsyche	13	1	-	88	251	196	270	164	5	89	69	-	-	3	37	371	363	431	216
Oecetis	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mystacides	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-
Brachycentrus	1	-	-	39	2	-	5	1	-	-	-	-	-	-	-	-	-	-	-
Helicopsyche	-	2	-	2	6	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Plecoptera																			
Isoperla	-	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acroneuria	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Odonata																			
Argia	-	-	-	-	-	-	-	-	-	-	3	1	-	-	1	-	-	-	-
Coleoptera																			
Elmidae	-	-	3	-	2	-	5	-	-	5	-	-	2	2	1	3	12	15	14
Hemiptera																			
Ambrysus	-	-	-	-	2	-	2	-	3	4	2	-	-	-	-	-	-	-	-
Neuroptera																			
Sialis	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Pulmonata																			
Physa	11	8	-	7	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
TOTALS	65	38	28	154	448	370	507	313	18	142	111	122	187	44	136	867	749	729	578

TABLE 9. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES COLLECTED FROM EACH SAMPLER RECOVERED ON 12/13 OCTOBER 1974.
Hyphens indicate zero counts.

Station	1				2				3			4				5				6			
Sampler	1	2	3	4	1	2	3	4	1	2	3	1	2	3	4	1	2	3	4	1	2	3	4
TAXA																							
Ephemeroptera																							
Heptagenia	4	2	1	4	2	2	2	4	17	30	12	4	3	7	5	1	5	2	5	-	2	2	3
Choroterpes	-	-	-	-	-	-	1	-	3	4	8	94	123	121	114	81	87	73	57	21	26	6	13
Paraleptophlebia	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerella	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes	2	1	2	-	21	5	14	3	-	-	-	-	-	3	-	-	-	-	1	-	2	-	1
Baetis	-	-	1	-	44	21	37	18	2	-	-	1	-	-	-	-	-	-	-	2	9	6	5
Diptera																							
Simuliidae	-	-	-	-	28	31	34	17	-	-	-	-	-	-	-	-	-	-	-	357	385	279	120
Tendipedidae	-	-	1	1	5	8	5	2	-	-	2	-	-	-	4	-	-	-	-	-	-	2	-
Trichoptera																							
Hydropsyche	2	4	17	-	81	72	55	15	-	-	1	50	29	112	8	-	1	-	-	19	-	20	22
Oecetis	-	12	4	4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mystacides	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Brachycentrus	23	24	13	4	-	3	3	1	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-
Helicopsyche	-	87	28	1	14	2	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plecoptera																							
Pteronarcella	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla	4	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata																							
Argia	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
Calopteryx	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-
Coleoptera																							
Elmidae	1	-	1	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pulmonata																							
Physa	-	13	11	17	-	-	1	-	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	37	153	81	31	197	146	158	61	27	39	36	150	155	245	132	82	94	75	63	399	424	315	164

TABLE 10. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES COLLECTED FROM EACH SAMPLER RECOVERED ON 9/10 NOVEMBER 1974. Hyphens indicate zero counts.

Station	1				2				3				4				5				6			
Sampler	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
TAXA																								
Ephemeroptera																								
Heptagenia	1	2	3	2	2	1	-	1	10	15	18	14	2	5	3	1	-	1	1	-	2	-	-	2
Choroterpes	-	-	2	-	-	1	-	-	12	21	21	32	119	71	123	63	8	1	7	30	37	24	112	25
Paraleptophlebia	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerella	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes	3	4	2	1	3	1	1	3	1	11	2	2	-	3	1	-	-	-	-	-	1	-	3	-
Baetis	1	2	1	-	22	3	10	14	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1
Diptera																								
Simuliidae	-	-	-	-	4	6	6	20	-	-	1	-	3	-	-	-	-	1	-	-	148	44	65	95
Tendipedidae	3	1	-	1	1	-	1	-	1	2	1	-	1	2	-	-	-	-	1	-	4	-	-	2
Trichoptera																								
Hydropsyche	-	13	2	4	28	13	7	27	-	2	2	2	1	5	15	2	-	-	1	-	10	7	13	22
Oecetis	-	2	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brachycentrus	3	5	4	12	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Helicopsyche	6	4	2	19	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plecoptera																								
Pteronarcella	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla	2	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata																								
Argia	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calopteryx	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Coleoptera																								
Elmidae	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pulmonata																								
Physa	10	11	12	13	2	-	-	1	1	1	-	1	-	-	-	1	-	-	-	-	-	-	-	-
TOTALS	30	48	32	65	65	28	25	68	26	54	45	51	127	89	142	68	8	3	10	30	202	76	195	147

TABLE 11. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES COLLECTED FROM EACH SAMPLER RECOVERED IN DECEMBER 1974 AND IN MAY AND JUNE 1975. Hyphens indicate zero counts.

Date	8 December 1974								2 May 1975				31 May/1 June 1975											
Station	5				6				1				1				2		4				6	
Sampler	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	1	2	3	4	1	2
TAXA																								
Ephemeroptera																								
Heptagenia	-	-	-	1	-	-	-	-	-	-	-	-	10	5	11	4	20	28	11	15	9	23	-	-
Choroterpes	3	1	3	6	2	21	47	25	-	-	-	-	-	-	-	-	-	-	22	16	13	24	31	39
Paraleptophlebia	-	-	-	-	-	-	-	-	1	1	-	-	2	1	2	-	-	-	-	-	-	-	-	-
Ephemerella	-	-	-	-	-	-	-	-	31	12	12	16	10	10	21	11	2	2	-	-	-	-	-	-
Tricorythodes	1	-	-	-	-	1	2	1	2	-	1	-	5	8	2	1	38	18	-	-	2	-	1	-
Baetis	-	-	-	1	-	-	-	-	31	23	50	49	-	1	4	-	5	4	-	-	-	-	-	-
Diptera																								
Simuliidae	3	-	3	9	80	57	82	128	96	227	201	185	-	-	-	-	-	-	-	-	-	-	-	-
Tendipedidae	-	-	-	-	-	2	3	2	12	6	8	6	18	12	16	10	8	3	8	1	2	3	2	-
Tipulidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Trichoptera																								
Hydropsyche	-	-	-	-	1	2	4	3	46	28	22	25	82	27	47	40	162	118	14	31	24	20	10	2
Oecetis	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	2	-	-	-	-	1	-	-	-
Brachycentrus	-	-	-	-	-	-	-	1	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Plecoptera																								
Pteronarcella	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla	-	-	-	-	-	-	-	-	1	5	2	4	5	-	1	2	3	3	1	-	-	-	-	-
Acroneuria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-
Coleoptera																								
Elmidae	-	-	-	-	-	-	-	-	4	3	3	4	12	1	2	3	1	1	-	2	5	5	1	1
Neuroptera																								
Sialis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Pulmonata																								
Physa	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	3	1	-	-	-	-	-	-	-
TOTALS	7	1	6	17	83	83	138	160	225	309	300	290	145	65	110	76	241	177	57	65	57	76	45	42

TABLE 12. NUMBERS AND TAXA OF BENTHIC MACROINVERTEBRATES OBTAINED FROM SAMPLERS COLONIZED FOR 2 WEEK (AUGUST) AND 6 WEEK (SEPTEMBER) PERIODS WITH THE DIVERSITY AND REDUNDANCY OF THE FAMILIES AT EACH STATION. Hyphens indicate zero counts.

Date	12/13 August				12/13 September			
Station	1		6		1		6	
Sampler	1	2	1	2	1	2	1	2
TAXA								
Ephemeroptera								
Heptagenia	9	10	13	15	1	-	-	-
Isonychia	-	-	3	3	-	-	-	-
Choroterpes	32	13	618	658	3	-	376	440
Traverella	-	-	5	12	-	-	-	-
Paraleptophlebia	3	2	-	-	9	2	-	-
Ephemerella	-	-	-	-	-	-	6	4
Tricorythodes	5	6	3	3	-	-	-	-
Baetis	7	6	4	17	-	-	-	-
Diptera								
Simuliidae	-	1	9	-	-	-	76	50
Tendipedidae	5	1	8	4	1	2	-	5
Tipulidae	-	-	-	-	2	2	-	-
Trichoptera								
Hydropsyche	-	-	427	372	3	-	736	1200
Oecetis	-	1	-	-	1	1	-	-
Brachycentrus	32	24	-	-	1	2	-	10
Plecoptera								
Isoperla	1	1	-	-	1	-	-	-
Acroneuria	-	-	-	-	-	-	-	2
Coleoptera								
Elmidae	-	-	-	-	-	1	20	41
Pulmonata								
Physa	1	1	-	-	1	-	-	-
Totals	95	66	1090	1084	23	10	1214	1752
Diversity	1.834		1.286		2.694		1.274	
Redundancy	.445		.549		.384		.551	

TABLE 13. HIGH (H) AND LOW (L) TEMPERATURES OVER THE PAST MONTH AND TEMPERATURE (P), CONDUCTIVITY (CD), TURBIDITY (T), pH, DISSOLVED OXYGEN (DO), ALKALINITY (A), CALCIUM HARDNESS (CH), TOTAL HARDNESS (TH), SULFATE (SO4), AND CHLORIDE (Cl) ON EACH COLLECTING DATE. Hyphens indicate no data collected.

Station	H	L	P	CD	T	pH	DO	A	CH	TH	SO4	Cl
	°C			umho/cm	FTU		ppm	mg/l CaCO3			mg/l	mg/l
15/16 July 1974												
1	23	13	18	-	-	-	12	170	180	300	-	-
2	25	12	18	-	-	-	11.4	190	200	320	-	-
3	-	16	24	-	-	-	10	200	210	400	-	-
4	-	-	19	-	-	-	8.6	210	230	400	-	-
5	-	-	20	-	-	-	9.8	230	240	440	-	-
6	-	-	23	-	-	-	11.4	230	240	490	-	-
12/13 August 1974												
1	25	11	14	-	50	8.6	10	110	200	230	-	-
2	27	14	22	-	65	8.2	10	120	210	240	-	-
3	27	17	21	-	20	8.4	9	200	220	420	-	-
4	28	16	20	-	40	8.8	8	160	210	420	-	-
5	-	-	20	-	50	8.2	9	220	240	410	-	-
6	-	16	18	-	75	8.2	10	260	240	430	-	-
12/13 September 1974												
1	20	8	9	680	8	8.3	9	210	215	380	-	-
2	22	11	12	1000	8	8.3	9	250	230	400	-	-
3	23	10	13	1250	10	8.35	8	240	240	470	-	-
4	28	10	10	1425	25	8.25	8	220	240	480	-	-
5	-	-	17	1300	35	8.75	9	240	240	500	-	-
6	-	10	15	1550	18	8.6	10	230	230	510	-	-
12/13 October 1974												
1	16	2	5	690	12	8.35	9	230	210	350	-	-
2	18	0	8	950	15	8.6	10	240	230	390	-	-
3	18	5	10	1150	10	8.4	9	260	230	410	-	-
4	20	6	10	1550	18	7.9	10	240	250	540	-	-
5	18	12	13	1680	45	7.8	10	250	270	540	-	-
6	-	6	10	1700	30	7.85	10	260	260	600	-	-

TABLE 13. Continued.

Station	H	L	P	CD	T	pH	DO	A	CH	TH	SO4	Cl
	°C			umho/cm	FTU		ppm	mg/l CaCO3			mg/l	mg/l
9/10 November 1974												
1	11	1	1	700	5	7.75	10	200	200	320	145	6.5
2	13	1	3	950	10	8.35	11	230	-	430	260	9.5
3	12	2	4	1350	35	8.4	11	270	-	520	440	13.0
4	20	2	3	1850	30	8.1	12	280	-	650	560	22.5
5	20	2	2	1750	30	8.4	11	270	-	640	560	22.0
6	-	1	2	2000	75	8.2	11	260	290	670	600	23.5
7/8 December 1974												
1	-	-	0	800	10	8.4	-	225	-	310	250	5.5
2	-	-	0	900	10	8.4	-	250	-	380	287.5	6.5
3	-	-	0	1800	30	8.5	-	280	-	460	437.5	10.0
4	-	-	0	1800	30	8.3	-	310	-	580	800	23.0
5	3	0	0	2100	25	8.2	-	330	-	720	750	25.0
6	4	0	0	2200	25	8.3	11	340	-	770	937.5	27.5
4/5 January 1975												
1	-	-	0	725	5	8.0	-	220	-	340	145	5.5
2	-	-	0	950	5	8.0	-	200	-	360	240	6.5
3	-	-	0	1425	20	8.0	-	310	-	550	400	12.0
4	-	-	0	1900	20	8.2	-	350	-	670	688	20.0
5	-	-	0	2100	10	8.15	-	370	-	740	750	24.0
6	-	-	0	2500	10	8.0	-	370	-	740	900	27.5
3 April 1975												
1	-	-	0	700	10	8.1	-	200	-	300	155	6.0
2	-	-	0	850	60	8.1	-	210	-	330	270	7.5
3	-	-	0	875	120	8.3	-	190	-	310	240	8.0
4	-	-	1	1475	150	8.45	-	240	-	510	560	16.5
5	-	-	2	1450	330	8.6	-	280	-	530	630	25.0
6	-	-	4	1700	150	8.55	-	280	-	530	720	22.0
2/3 May 1975												
1	-	-	5	580	5	8.4	-	190	-	260	150	5.0
2	-	-	8	825	65	8.4	-	230	-	330	230	7.0
3	-	-	10	950	95	8.4	-	240	-	340	280	9.5
4	-	-	11	1150	120	8.45	-	260	-	400	400	17.5
5	-	-	12	1100	210	8.53	-	260	220	370	380	16.0
6	-	-	12	1150	260	8.55	-	250	190	330	410	15.5

TABLE 13. Continued.

Station	H	L	P	CD	T	pH	DO	A	CH	TH	SO4	Cl
		°C		umho/cm	FTU		ppm	mg/l CaCO3			mg/l	mg/l
					31 May/1 June 1975							
1	14	2	8	340	25	8.25	-	130	110	160	45	4.0
2	-	-	11	475	30	8.45	-	160	130	200	95	4.5
3	-	-	15	600	60	8.35	-	180	150	240	140	6.0
4	-	-	17	890	110	8.5	-	220	180	330	230	10.5
5	-	-	17	900	110	8.5	-	225	190	340	235	11.0
6	-	-	14	1025	110	8.55	-	240	200	370	290	13.0
					30 June 1975							
1	-	-	18	400	30	8.25	-	140	110	130	55	4.5
2	-	-	20	575	30	8.35	-	180	140	230	100	5.0
3	-	-	20	700	125	8.2	-	200	150	270	160	7.5
4	-	-	20	770	300	8.3	-	-	-	-	185	9.0
5	-	-	20	775	450	8.25	-	-	-	-	190	9.5
6	-	-	22	800	450	8.2	-	-	-	-	195	10.5

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