Virginia Water Resources Research Center Bulletin 84

Water Quality at Five Proposed Industrial Sites on the Roanoke and New Rivers

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Bulletin 84
November 1977

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This research was supported in part by a traineeship from the Environmental Protection Agency, Training Grant WP-166. The publication was partially supported by the Virginia Water Resources Research Center.

VPI-VWRRC-BULL 84

A Publication of
Virginia Water Resources Research Center
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24060

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ABSTRACT

Aquatic ecological surveys were conducted at five potential industrial development sites in Virginia, four on the New River and one site on the South Fork of the Roanoke River. Eighteen physical-chemical parameters were analyzed and biological information was collected in order to determine the physical, chemical, and biological water quality. This study was designed to generate baseline information essential in assessing the environmental impacts of future development in the watershed. The results indicate that the New River and the South Fork of the Roanoke River support diverse populations of macrobenthic invertebrates and that physical and chemical water quality is high, except for increased levels of nitrate in the New River. Although both rivers have water quality that is considered good by biological and chemical standards, they both are vulnerable. If the assimilative capacity of these two rivers is to be preserved as a valuable resource, they must be used intelligently. Future industrial development should be managed carefully in these watersheds to maintain the high quality of the aquatic environment in the New River and the South Fork of the Roanoke River.

Key Words: Water Quality, New River, Biological Assessment, Baseline Ecological Surveys, Roanoke River.

ACKNOWLEDGMENTS

Special acknowledgment is accorded the following who generously gave their time to a critical review of the manuscript: David S. Bailey, Director, Division of Ecological Studies, Virginia State Water Control Board; and Langley Wood, Coordinator, Environmental Studies Program, Sweet Briar College. Acknowledgment also is made to Anne Trice T. Akers, who did the typesetting, and Patricia Anne Nickinson for lay-out composition.

INTRODUCTION

The purpose of this research was to document selected physico-chemical and biological parameters at sites on the New and Roanoke Rivers in Virginia that the New River Planning Commission has designated for the location of new industry. The objective was to provide baseline information to planners, industrialists, and regulatory agencies involved in determining the maximum beneficial uses to be derived from an aquatic resource with the minimum amount of perturbation to the aquatic system. These data will help in determining the types of wastes that are compatible with the assimilative capacity of the river, and also will serve as a baseline to assess possible changes in water quality, should development occur.

The determination of various physical and chemical parameters has become routine in aquatic studies of this type—and rightfully so, since this information is valuable in helping to describe what is happening in the river. Patrick [1949] points out, however, that even though chemical data produce useful information on stream conditions, it should be used only as supportive evidence for biological data. Therefore, one wanting to know the biological condition of a river would study the organisms in the river, for at best the chemical data could only give weak, indirect evidence about the aquatic organisms.

Various groups of organisms such as fish, algae, bacteria, or insects could be utilized in a study such as this. However, the invertebrate community inhabiting the benthic portion of the river was chosen for a number of reasons:

1. Invertebrates are relatively easy to collect and identify.

2. They are a rather stable group of organisms.

3. Their life cycles are rather well known.

4. Diversity indices can be applied quite easily to these organisms.

5. Unlike measurements of chemical and physical factors, which are instantaneous reflections of current conditions, studies of bottom organisms provide a record of past water quality.

One helpful method for examining biological data of the type generated in this study is the diversity index [Brillouin, 1960; Margalef, 1969; Mathis, 1968; Mathis and Dorris, 1968] which produces numerical analyses of mixed species populations. The Wilhm and Dorris [1968] diversity index ($\overline{d}$) is particularly well suited to this purpose because it reflects delicate changes in community structure and allows qualitative comparisons between stations.

DESCRIPTION OF STUDY AREA

The three stations on the New River corresponding to four prospective industrial sites selected by the New River Planning Commission are located in Giles County, Virginia *(Figure 1)*. In this region, the New River flows over geological formations dominated by various dolomites and limestones interspersed with some shale and sandstone. The calcareous parts of the area are honeycombed with caves of various sizes formed by water percolating through the strata and gradually dissolving it away. The chief agricultural pursuits of the area include animal husbandry, small farms, and orchards. The only major industries currently in the area are Radford Army Arsenal at Radford, Virginia; Celanese Fibers Company at Bluff City; and the Appalachian Power Company plant at Glen Lyn. However, domestic sewage that has undergone various stages of waste treatment eventually finds its way into the New River from municipalities bordering both banks.

A fourth station was located on the South Fork of the Roanoke River in the vicinity of another proposed industrial site. The South Fork of the Roanoke River flows through geological formations composed of limestone, dolomite, shale, and sandstone. Chief agricultural pursuits include small farming, orchards, and livestock raising. No large industries exist in the area, but domestic sewage that has undergone various stages of waste treatment enter the river along its length from small municipalities on both banks.

I. Station 1

Station 1 *(Figure 2)* was located at the Castle Rock site, Pembroke, Virginia in the vicinity of State Route 623 bridge over the New River (latitude 37° I8′ 52″ N, longitude 80° 38′ 39″ W). This station was about 44 kilometers below Claytor Lake. At the Route 623 bridge, the river is 130 meters wide and about 5 meters deep in the middle portions. The bottom is composed of large boulders and bedrock outcroppings, with rubble and gravel in some places. The riffles on either side of the island 200 meters below the bridge are composed of smaller boulders and rubble interspersed with gravel on the lee sides. Beds of *Justicia americana* are found at the head of the island, while *Juncus sp.* and *Scirpus vallidus* are rooted in the soil of the right bank. Other aquatic vascular plants present include *Elodea canadensis, Podostemum ceratophyllum, Eleocharis obtusa, Potamogeton crispus*, and *Carex sp.* The macroscopic green alga, *Chara sp.*, is rooted in shallow water near the right shore. Both banks are lined with box elder, *Acer negundo;* sycamore, *Platanus occidentalis,* and black willow, *Salix nigra.* The left bank lies at the foot of a 110-meter cliff and is heavily shaded and rocky. The right bank is mostly sloping, with a good deal of exposed soil at the water's edge. Several meters back from the forested right bank lie pastures and cultivated fields of the river bottom land.

II. Station 2

Station 2 *(Figure 3)* was located at the Lees-McVitty site, Bluff City, Virginia in the vicinity of the U.S. Highway 460 bridge over the New River (latitude 37° 20′ 26″ N, longitude 80° 45′ 27″ W). This station was about 61 kilometers below Claytor Lake. The river is 160 meters wide at the U.S. Highway 460 bridge and about 4 meters deep in the main channel. The bottom is composed of bedrock outcroppings and boulders mixed with sand. The riffles between the two islands 300 meters upstream are composed of rubble interspersed with some gravel. Both banks are rocky, with much sand along the shores and bordered with box elder, *Acer negundo;* sycamore, *Platanus occidentalis;* and black willow, *Salix nigra.* The riffle areas between the two islands are bordered by beds of *Justicia americana,* and *Scirpus vallidus* is rooted in exposed areas of the left bank. Other aquatic vascular plants present include *Potamogeton crispus* and *Podostemum ceratophyllum.* Celanese Fibers Company is located just downstream and on the opposite bank of the river from this proposed site.

III. Station 3

Station 3 *(Figure 4)* was located at the Boxley White and Ould sites in the vicinity of the U.S. Highway 460 bridge over the New River at Glen Lyn, Virginia (latitude 37° 22′ 18″ N, longitude 80° 51′ 41″ W). This station was about 44 kilometers above the dam of the Bluestone Reservoir and 75 kilometers below Claytor Lake. It is across the river from Appalachian Power Company's Glen Lyn electric generating plant and adjacent to the Glen Lyn Recreation Area. The river is 220 meters wide at this point and has a bottom composed of bedrock outcroppings and boulders interbedded with rubble. The riffle area under the bridge is composed of small boulders and rubble interspersed with a little gravel and sand. Both banks are artificial, built of rock rip-rap, and bordered with sycamore, *Platanus occidentalis;* box elder, *Acer negundo;* and black willow, *Salix nigra.* Aquatic vascular plants at this station are submerged attached forms including *Elodea canadensis*, *Podostemum ceratophyllum*, and *Potamogeton crispus.* The macroscopic green algae *Chara sp.* also is present at this station in sandy substrate near the right shore.

IV. Station 4

Station 4 *(Figures 5 and 6)* was located at the Lafayette site on the South Fork of the Roanoke River, 9.5 kilometers above its confluence with the North Fork, (latitude 37° 10′ 51″ N, longitude 80° 14′ 45″ W). U.S. Route 460 runs along the river at this point for several miles, crossing the river about 0.4 kilometers above Station 4. The river is about 10 meters wide at this point and perhaps 1 meter deep in the pool areas. The bottom consists of rubble interspersed with some gravel and sand, with some leaf debris in the pools. The banks are forested to the water's edge with alder, *Alnus serrulata;* sycamore, *Platanus occidentalis;* black willow, *Salix nigra;* and box elder, *Acer negundo.* Aquatic vascular plants include *Bidens trondosa, Polygonum pennsylvanicum, Justicea americana,* and *Cyperus strigosus.* The left bank lies at the bottom of a steep, rocky hillside and is heavily shaded. The right bank is more gently sloping, with flat cultivated farmland and pastures separated from the river by a border of trees 10 to 50 meters wide. During periods of extremely high flow, the river often overflows its banks, covering the bottomland and spreading to a width of nearly half a kilometer.

4 ... is located at the Lafayette site on the So... Kankakee River, ... kilometers above its confluence ... (latitude 37° 10' 5... N, longitude 10... 14' 40" W). ... the river at this point ... wide ... 4 kilometers above Station 4. ... about ... this point and perhaps 1 meter deep in the pool areas. The bo... of rubble interspersed with some gravel and sand, ... some... the ... The banks are forested to the water's edge with al... sycamore, Platanus occidentalis, ... Salix ... elder, Acer negundo. Aquatic vascular plants include ... The left bank lies at the bottom of a steep ... hillside ... shaded. The right bank is more gently sloping, with flat ... land and pastures separated from the river by a border of ... meters wide. During periods of extremely high flow, the ... overflows its banks, covering the bottomland and spreading ... nearly half a kilometer.

MATERIALS AND PROCEDURES

I. Sampling of Macrobenthic Organisms

A. Kick Samples

In order to assess the structure of the benthic community and monitor the relative abundance of each taxon during seasonal population changes, monthly samples were taken at each station over a 13-month period (January 1972 through January 1973). A D-frame aquatic dip net (Turtox) was used to sample riffle areas that were ecologically similar as to bottom type and flow characteristics. Water 0.50–0.75 meters deep, flowing an estimated 50 to 100 cm/sec over rock and rubble, met the criteria set up in the selection of locations for kick samples. A total of three one-minute kick samples was taken at random in a given riffle area at every station each month. Frost, Huni, and Kershaw [1971] have shown this to be an effective method for collecting bottom fauna. In order to minimize backwash of animals from the net, as well as eddy currents which would prevent organisms from entering the net, timing of each one-minute kick sample was interrupted and the net was emptied when the mesh became clogged. When the net was again in position and sampling continued, timing was resumed. The contents of the net were preserved in 70 percent ethanol, placed in one-quart Mason jars, and brought back to the laboratory to be processed. Organisms were handpicked from among the gravel and detritus in a white enamel pan. With the use of a Nikon binocular dissecting microscope, specimens were identified to genus (except for Chironomidae and Elmidae, which were identified to the family level), utilizing Usinger's [1956] key. Each taxon was placed with labels bearing location data, date, and taxonomic determination in four-dram, screw-top vials filled with 70 percent ethanol. The Wilhm and Dorris [1968] diversity index ($\bar{d}$) was selected for use in evaluating the species diversity at each station.

B. Artificial Substrates

In addition to the monthly kick samples taken in the riffle areas, an effort was made to sample the deeper three to four-meter sections of the river at each station, using artificial substrates. Simmons and Winfield [1971] and Dickson and Cairns [1972] demonstrated the value of artificial substrates in their studies. Chicken Bar-B-Que baskets (Androck Corp.) containing four squares of 15.8 × 15.8 cm (approximately 0.1 square meter) conservation webbing (3-M Company) were attached to six cinder blocks by a seven-meter length of 6.4 mm (¼") braided nylon cable. The cinder blocks were wired together with 4.8 mm (3/16") steel aircraft cable and a large, dense styrofoam float (RadVa Plastics) was attached to the blocks by another seven-meter piece of steel cable as a marker buoy. Three basket samplers were laid out on a transect at each station and were designated left bank, midchannel, and right bank (looking downstream). The squares of conservation webbing were collected every six weeks and replaced with new ones to allow adequate colonization of the substrates. In order to work the deep reaches of the river, a flat-bottomed aluminum boat equipped with a motor was used in artificial substrate sampling. The baskets containing substrates were retrieved when possible by dragging the bottom for the substrate line attached to the cinder blocks with a five-meter "shepherd's crook" commonly used as rescue equipment in swimming pools. The conservation webbing was placed in wide-mouth gallon jars and 10 percent formalin solution was added as a perservative. In the laboratory, organisms and debris were washed from the webbing onto a standard number 30 mesh sieve, and the contents placed in a white enamel pan where animals were handpicked from among the gravel and detritus. Specimens were identified to genus and placed with labels bearing location data, date, and taxonomic determination in four-dram, screw-top vials filled with 70 percent ethanol. The Wilhm and Dorris diversity index ($\bar{d}$) was used to determine the diversity on each sample and on composites for each station. Composites were prepared by pooling organisms taken from all samples present at each sampling period.

II. Chemical Techniques

A sampling schedule was set up to monitor seasonal changes in water quality. Monthly samples of river water were collected and brought to the laboratory to determine the values of l8 physicochemical parameters. The sampling periods extended through the 14 months between January, 1972 and February, 1973. All samples were taken on a Monday in the first half of each month. Sampling was conducted in the morning and the stations were always sampled in the same order, starting at the same hour. Water samples were collected in clean, white, opaque, one-gallon milk jugs with screw-on caps and gaskets, and returned to the laboratory for immediate analysis each month after completion of field work.

Dissolved Oxygen Concentration—The Azide Modification of the Winkler or iodimetric method outlined in Standard Methods [1971, p. 477] was used to analyze two samples collected in standard 300 milliliter B.O.D. bottles from each station.

Water Temperature and Air Temperature—A mercury thermometer (Fisher Scientific Co.) was used to measure water temperature and air temperature to the nearest 0.25° centigrade at each station.

pH—The glass electrode (electrometric) method was used to measure the pH of water samples collected at each station using a Fisher Accument Model 310 pH meter (Fisher Scientific Co.).

Alkalinity—Two 100 milliliter samples were analyzed for total alkalinity using the procedure outlined in Standard Methods [1971, p. 54], using methyl purple as an indicator.

The procedure outlined in Standard Methods [1971, p. 54] was used to analyze two 100 milliliter samples from each station for phenolphthalein alkalinity.

Chloride—An argentometric method was used to analyze two 100 milliliter samples from each station using the procedure outlined in Standard Methods [1971, p. 96].

Nitrates—The phenoldisulfonic acid method outlined in Standard Methods [1971, p. 234] was used to analyze two 100 milliliter samples from each station. Absorbance was read on a Bausch and Lomb Spectronic 20 Spectrophotometer (Bausch and Lomb, Inc.) at 410 mμ.

Phosphates—Water samples were analyzed for four forms of phosphate using the following procedures. First, two filtered 50 milliliter samples from each station were analyzed for orthophosphates using the ascorbic acid method B [Murphy and Riley, 1962]. Absorbance was read on a Bausch and Lomb Spectronic 20 Spectrophotometer (Bausch and Lomb, Inc.) at 880 mμ. Second, to determine condensed (acid hydrolyzable) phosphate, acid hydrolysis was carried out on two filtered 50 milliliter samples from each station following the procedure outlined in Standard Methods [1971, p. 523], using an autoclave. The resulting orthophosphate solutions were analyzed as described above. Third, persulfate digestion procedures described in Standard Methods [1971, p. 524] were performed on two, 50 milliliter unfiltered samples in an autoclave to determine total phosphates. The resulting orthophosphate solutions were analyzed as described for orthophosphates. Fourth, values for organic phosphate were calculated by subtracting the total of condensed phosphates plus orthophosphate from total phosphates.

Conductivity—This was measured using a Barnstead Conductivity Bridge, Model PM–70 CB (Barnstead Still and Sterilizer Co.).

Biochemical Oxygen Demand—Undiluted water samples were allowed to equilibrate to incubation temperature, oxygenated, and read on a YSI 51 Oxygen Meter (Yellow Springs Instrument Co., Inc.). Samples were incubated for five days at 20° centigrade in darkness and the drawdown in oxygen concentration measured, again using the YSI 51 Oxygen Meter.

Hardness—Two samples of water from each station were analyzed to determine calcium hardness, using the EDTA method with reagents sold by the Hach Chemical Company. Two samples of water from each station also were analyzed to determine total hardness, using the EDTA method with reagents sold by the Hach Chemical Company. Magnesium hardness was calculated by subtracting calcium hardness from total hardness.

Sulfates—The tubidimetric method described in Standard Methods (1971, p. 334) was used to analyze two 100 milliliter samples from each station. Absorbance was read on a Klett-Somerson Photoelectric Colorimeter (Klett Mfg. Co., Inc.) using a violet filter (No. 42).

III. Diurnal Studies

Diurnal temperature and oxygen curves were determined for the months of June, July, and August, 1972. Once a month on a clear sunny day, every three hours for a period of 24 hours, air temperature and water temperature were measured to the nearest 0.25° centigrade, using a mercury therometer (Fisher Scientific Co.). Also every three hours, two water samples were taken in standard 300 milliliter B.O.D. bottles and analyzed for dissolved oxygen. Curves were drawn showing changes in oxygen concentration over each 24-hour period.

RESULTS AND DISCUSSION

The organisms collected at each station are listed by month in *Tables 1-4, Appendix A.* From these data it is apparent that a great many organisms are present in both the New River and the South Fork of the Roanoke River which are considered to be intolerant of stress. Cairns and Dickson [1971] and Mason et al. [1971] list Plecoptera (stoneflies), Trichoptera (caddisflies), Ephemeroptera (mayflies), Elmidae (riffle beetles), and Megaloptera (helgrammites) as pollution-sensitive or intolerant organisms. These insects taxa are well-represented among the bottom fauna at all stations; the Ephemeroptera in particular are present in great numbers. Other dominant forms in these two rivers include Diptera (true flies, particularly Chironomidae) and Trichoptera. The trichopteran family Hydropsychidae decreased in abundance in the New River from Station 1 to Station 3, a pattern similar to that exhibited by other filter feeders in rivers below reservoirs. As the phytoplankton density decreased after initially high levels immediately below an impoundment, the animals which strain them from the water and utilize them as a food source also decreased in abundance [Welch, 1948; Hynes, 1970; Spence and Hynes, 1971].

The lists of organisms for the stations also give an indication of seasonal variations and population changes. The mayfly *Ephemerella* appeared in great abundance in the spring, emerged, and was rare by June. During the early summer months it was infrequently collected as the eggs incubated, hatched, and the nymphs went through several early instars. By late summer and autumn, the nymphs were large enough to be retained in the mesh of a collecting net, and as winter progressed and spring approached, *Ephemerella* was present in larger and larger numbers. Other insects showed similar patterns of abundance, but at different seasons of the year. Mayflies such as *Baetis, Caenis, Pseudocloeon* and *Tricorythodes* reached their greatest numbers later in the summer and early in the fall [Needham, Traver, and Hsu, 1935]. The stoneflies *Allocapnia, Brachyptera,* and *Taeniopteryx* are often called winter stoneflies because they emerge during the winter [Frison, 1929]. They are collected very rarely, if at all, between March and late August or September. Other taxa of aquatic insects appear at all seasons. The Megaloptera and some of the larger Plecoptera have life cycles of longer than one year, and thus would not be expected to disappear after emergence peaks. Late instar nymphs of the mayflies *Stenonema* and *Isonychia* can be found throughout the year, indicating that they do not all emerge at one time, perhaps because several species are present.

Differences in the types of organisms collected in the kick samples and the basket samplers appeared because two different habitats were sampled and the conservation webbing itself was somewhat selective. The turbellarian *Dugesia* was found much more frequently in the artificial substrates which were located in deep, slower water than in the kick samples taken in the riffle areas. The gastropod *Physa* also was abundant at times in the basket samplers, evidently being washed in more readily than other snails such as *Nitocris.* In contrast, *Nitocris* was often present in kick samples and *Physa* absent, perhaps because the latter with its lighter, thinner shell is less well-adapted to life in the presence of a current, and thus was absent from the riffles [Hynes, 1970]. Greater numbers of odonates (dragonflies) were also collected in the basket samplers, as might be expected from organisms which prefer slower water. In contrast, members of the order Megaloptera (hellgrammites), organisms typical of swifter waters, were present in kick samples much more frequently than in the artificial substrates.

Tables 1-4 summarize the results of analysis for species diversity in the kick samples, using the Wilhm and Dorris [1968] diversity index. Each of the four stations shows a stable level of diversity throughout the year. On the New River, the diversity decreased slightly in the downstream direction from Station 1 to 3, but still indicated a relatively clean condition, since the organisms apparently responsible for the redundancy were pollution-intolerant mayflies. The Roanoke River also appeared to be unencumbered by stress, since the diversity never dropped to three, the value above which Wilhm and Dorris [1968] feel indicates clean water conditions.

The results obtained from diversity analysis of the basket samplers were much more variable *(Tables 5-7).* The New River is a large, swift river with a great deal of drifting detritus which buries the artificial substrates or collects in masses on the marker buoy lines, increasing the water resistance until the lines are torn loose and washed downstream. So not only was it difficult to control the positioning of the baskets so that they were on the river bed and not buried in it, but the recovery rate of samplers was very low during periods of high water flow. During April, runoff after heavy rains resulted in a flow of 26,000 cfs at Glen Lyn, while in June the worst floods in a quarter of a century resulted in a flow of 72,400 cfs.

Both of these values were considerably above the mean flow of about 6,500 cfs for the year. As a result of these catastrophic floods, the samplers that were to be collected in April and July were completely destroyed. This explains the absence of artificial substrate data for these two months.

Cairns and Dickson [1972] report that artificial substrates composed of conservation webbing should not be used to gather quantitative data concerning the macroinvertebrate community. The lack of permanent stability and the presence of high variability of organisms colonizing the substrates indicate that a prohibitively large number of replicate samplers would be needed to gather reliable quantitative data. They do state, however, and their findings agree with those of Simmons and Winfield [1971], that the conservation webbing does seem to accumulate those organisms which are considered good indicators of water quality, and thus would be of value in water quality monitoring to collect qualitative data. The artificial substrates used in this study on the New River were too few to collect reliable qualitative results, as shown by the highly variable diversity ($\bar{d}$) in the replicate samplers at each station. However, these data would be of value to an industry that located at these sites if they were to implement a water-quality monitoring system using this type of artificial substrate.

The results of monthly analysis of water samples for 18 physiochemical parameters are summarized in *Tables 1-4, Appendix B.* (The discharges recorded for the dates of collection of water-quality data are summarized in *Table 5, Appendix B.)* Heavy metal concentrations in the New River at Route 114 near Radford, Virginia (upstream of the three proposed industrial sites) are shown in *Table 6, Appendix B.* Examination of all these data indicated the presence of no significant pollutional stress in either the South Fork of the Roanoke or the New River. Although the dissolved oxygen concentration varied with temperature, it remained near 100 percent saturation throughout the year. The pH was stable at all seasons. Hardness and alkalinity were also fairly constant, but alkalinity on the South Fork of the Roanoke River at Station 4 seemed to be dependent on flow *(Figure 7).* At times of low flow when there was little runoff, the alkalinity was higher, apparently because proportionally more of the flow was the result of groundwater percolating through limestone and dissolving it as calcium bicarbonate, which greatly enhanced the alkalinity. The pH and alkalinity of the New River are much the same as they were 25 years ago. Shoup [1948] measured the pH and alkalinity in the New

River below Pearisburg in late July of 1947 and reported total alkalinity of 52 ppm and pH of 8, values which compare favorably with data collected in the summer of 1972 at approximately the same location.

The nitrate levels in the New River, particularly in the upstream area below Radford, Virginia, seem to be flow-dependent *(Figure 8).* The Radford Arsenal discharges munitions wastes that are rich in nitro-compounds (nitro-glycerin, TNT, nitrocellulose, etc.) in that area [Cairns and Dickson, 1973]. During periods of low flow, nitrate concentrations reach levels much higher than usual (16 ppm in October at Pembroke), probably because the arsenal discharged continuously and there was less water to dilute it. Nitrate levels decreased downstream as tributaries flowed into the New River, more effectively diluting the nitrate level.

Low levels of BOD_5 (below 5 ppm) indicated that the river was not under any significant stress due to organic pollution and represented high water-quality conditions. Apparently the amounts of domestic wastes entering the South Fork of the Roanoke River and the New River were very small compared to the flow in both systems.

Inorganic nitrogen and phosphorus levels in both rivers were above 0.3 and 0.015 ppm, respectively, and thus are capable of supporting large blooms of algae [Sawyer, 1947]. Although bloom conditions are not likely to occur in either river as long as they are flowing continuously, it might pose a problem in any reservoirs that might be constructed downstream.

Statistical analysis of the physical-chemical water-quality data was performed on the values obtained from the four stations for the 12-month period from March, 1972 through February, 1973. Seventeen parameters at each station were compared for significant correlation. Phenolphthalein alkalinity was omitted because it was nearly always zero. Tests were run on the data to determine whether they fit a bivariate normal distribution, a condition necessary for the test of correlation. *Tables 8-11* summarize the results of the correlation test significant at the 95 percent or higher confidence level. There was a high level of negative correlation (that is, the values had a tendency to diverge) between dissolved oxygen and both air temperature and water temperature. This is to be expected, because cold water at saturation contains much more oxygen than warm water at saturation.

Chlorides and BOD also showed a significant correlation with temperature. The seasonal high temperatures coincided with high values for BOD and chloride. BOD and chloride, however, showed no significant correlation, indicating that the BOD in the New River and the South Fork of the Roanoke River was not principally due to the influence of domestic sewage.

The high correlation shown between organic phosphate and total phosphate was due to the fact that most of the phosphate in both rivers was present as organic phosphate. A significant negative correlation between temperature and condensed phosphate and orthophosphate also was apparent at two of the New River stations. One possible explanation for this phenomenon might be that during low-flow periods when temperatures were high, there was a detectable uptake of phosphorus from the water by phytoplankton and runoff from the surrounding farmland was not sufficient to replace it.

The high correlations obtained between alkalinity and hardness data was also predictable in view of the ionic species involved. Most of the alkalinity was present as calcium bicarbonate, and most of the hardness was due to divalent calcium cation.

Other statistically significant correlations were not readily explainable, and in fact may not be due to some cause and effect relationship in the river. A larger data base would be helpful in determining why these correlations were observed. In any case, these data would be useful to the plant manager of an industry locating at one of these stations, because they would allow him to predict what general trends in water quality to expect. If these data were used as baseline information, it would be possible to assess changes in water quality which were reflected in large deviations from these values.

To determine the effect of photosynthesis on the oxygen level in the New River, measurements of dissolved oxygen were made at Station 1 over a 24-hour period during the summer months of June, July, and August, 1972. The results of these determinations are summarized in *Figure 9.* From these diurnal D.O. curves, one can readily see that in the daytime the oxygen level reached supersaturation, while at night it dropped below saturation. One also may note that the turbulent flow of water passing over the riffle at this station actually decreases the oxygen level when the water is supersaturated. The small amount of fluctuation in the curve for July 10 and 11 was probably due to the influence of the flood of June, 1972. Water levels were high for 12 days after the flood peaked on June 21. Evidently, the large algal masses evident in Claytor Lake and the New River earlier in the summer were washed out by the flood and had not recovered to their previous high levels by the time these data were collected.

CONCLUSIONS

This investigation indicates that the New River and the South Fork of the Roanoke River support diverse populations of pollution-intolerant organisms, as measured by the Wilhm and Dorris [1968] diversity index. Values obtained from analysis of species diversity on the New River were much more variable for basket samplers using conservation webbing as a substrate than for kick samples. The South Fork of the Roanoke River supported a higher diversity of organisms than the New River, and the diversity in the New River decreased slightly in the downstream direction from Station 1 to 3.

Examination of water-quality data among the 18 parameters measured showed no effects that could be attributed to pollution, with the exception of nitrates in the New River.

The rate of photosynthesis was such that, in the summer months, levels of dissolved oxygen reached supersaturation during the daylight hours and dropped below saturation during the hours of darkness.

Both rivers have water quality that is considered high by both biological and chemical standards, and further loading of the systems should proceed with care. Both systems probably can tolerate higher loads of organic materials without experiencing undue stress. The assimulative capacities of these two rivers should be viewed as a valuable resource and therefore must be managed intelligently.

LITERATURE CITED

American Public Health Association; American Water Works Association and Water Pollution Control Federation, 1971. *Standard Methods for the Examination of Water and Wastewater.* 874 pp.

Brillouin, L., 1960.*Science and Information Theory.* 2nd edition. 254 pp.

Cairns, J., Jr. and Dickson, K.L., 1971. "A Simple Method for the Biological Assessment of the Effects of Waste Discharges on Aquatic Bottom-Dwelling Organisms." *J. Water Pollution Control Federation* 43:755-772.

———, 1972. *An Ecosystematic Study of the South River, Virginia.* Bulletin 54, Water Resources Research Center. Virginia Polytechnic Institute and State University. 104 pp.

———, 1973. *The Effects of Waste Discharge from the Radford Army Ammunition Plant on the Biota of the New River, Virginia.* Bulletin 57, Water Resources Research Center. Virginia Polytechnic Institute and State University. 57 pp.

Dickson, K.L. and Cairns, J., Jr., 1972. "The Relationship of Fresh-Water Macroinvertebrate Communities Collected by Floating Artificial Substrates to the MacArthur-Wilson Equilibrium Model." *American Midland Naturalist* 88:68-75.

Frison, T.H., 1929. "Fall and Winter Stoneflies or Plecoptera of Illinois." *Bulletin of Illinois Natural History Survey* 18:345-409.

Frost, S.; Huni, H. and Kershaw, W.E., 1971. "Evaluation of a Kicking Technique for Sampling Stream Bottom Fauna." *Canada Journal of Zoology* 49:167-173.

Hynes, H.B.N., 1970. *The Ecology of Running Waters.* 555 pp.

Margalef, R., 1969. "Diversity and Stability: A Practical Proposal and Model of Interdependence." In *Diversity and Stability in Ecological Systems.* Brookhaven Symposium in Biology No. 22. pp. 25-47.

Mason, W.T.; Anderson, J.B.; Kries, R.D. and Johnson, W.C., 1970. "Artificial Substrate Sampling, Macroinvertebrates in a Polluted Reach of the Klamath River, Oregon." *J. Water Pollution Control Federation* 42:315-328.

Mathis, B.J., 1968. "Species Diversity of Benthic Macroinvertebrates in Three Mountain Streams." *Transactions of the Illinois State Academy of Science* 81:171-176.

Mathis, B.J. and Dorris, T.C., 1968. "Community Structure of Benthic Macroinvertebrates in an Intermittent Stream Receiving Oil Field Brines." *American Midland Naturalist* 80:428-239.

Murphy, J. and Riley, J., 1962. "A Modified Single Solution Method for the Determination of Phosphates in Natural Waters." *Analytica Chimica Acta* 27:31.

Needham, J.G.; Traver, J.R. and Hsu, Y-C, 1935. *The Biology of Mayflies.* 759 pp.

Patrick, R., 1949. "A Proposed Biological Measure of Stream Conditions, Based on a Survey of the Conestoga Basin, Lancaster County, Pennsylvania." *Proceedings of Academy of Natural Science* 101:277-295.

Sawyer, C.N., 1947. "Fertilization of Lakes by Agricultural and Urban Drainage." *J. New England Water Works Association* 61:109.

Shoup, C.S., 1948. "Limnological Observations on Some Streams of the New River Watershed in the Vicinity of Mountain Lake, Virginia." *J. Elisha Mitchell Scientific Society* 64:1-2.

Simmons, G.M. and Winfield, A., 1971. "A Feasibility Study Using Conservation Webbing as an Artificial Substrate in Macrobenthis Studies." *Virginia Journal of Science* 71:52-59.

Spence, J.A. and Hynes, H.B.N., 1971. "Differences in Benthos Upstream and Downstream of an Impoundment." *J. Fisheries Research Board of Canada* 28:35-43.

Usinger, R.L., ed., 1956. *Aquatic Insects of California with Keys to North America Genera and California Species.* 508 pp.

Welch, P.S., 1948. *Limnological Methods.* 381 pp.

Wilhm, J.L. and Dorris, R.C., 1968. "Biological Parameters for Water Quality Criteria." *Bioscience* 18:477-481.

TABLES

TABLE 1
Diversity Analysis of Kick Samples Collected at Station 1 (After Wilhm and Dorris, 1968)

	DMAX	DMIN	R	$\bar{d}$	No. of Taxa	No. of Organisms
Jan 72	3.8478	1.3053	0.1956	3.3506	20	93
Feb 72	4.4199	0.7720	0.2752	3.4161	26	257
Mar 72	4.6566	0.4015	0.3200	3.2951	28	622
Apr 72	4.7126	0.5309	0.3171	3.3866	30	485
May 72	4.6585	0.3962	0.3697	3.0826	28	632
June 72	4.7130	0.5300	0.3265	3.3474	30	486
July 72	4.1092	0.7543	0.2133	3.3937	21	201
Aug 72	4.9551	0.3585	0.2585	3.7669	34	901
Sept 72	4.6832	0.3268	0.3666	3.0860	28	794
Oct 72	4.7417	0.3064	0.3590	3.1495	29	894
Nov 72	4.9131	0.3541	0.3406	3.3603	33	882
Dec 72	4.9096	0.3643	0.3462	3.3359	33	853
Jan 73	5.2179	0.2835	0.2900	3.7869	40	1441

TABLE 2
Diversity Analysis of Kick Samples Collected at Station 2 (After Wilhm and Dorris, 1968)

	DMAX	DMIN	R	$\bar{d}$	No. of Taxa	No. of Organisms
Jan 72	3.6589	0.8809	0.1398	3.2705	16	115
Feb 72	3.8864	0.7374	0.2692	3.0385	18	169
Mar 72	4.4699	0.6251	0.3713	3.0423	26	333
Apr 72	4.7091	0.3981	0.3893	3.0308	29	656
May 72	4.6949	0.2943	0.4839	2.5655	28	898
June 72	4.8765	0.3306	0.4337	2.9049	32	921
July 72	4.0380	0.5403	0.4043	2.6240	19	267
Aug 72	4.8580	0.5147	0.3650	3.2727	33	566
Sept 72	4.8892	0.1677	0.3650	3.1660	31	1954
Oct 72	4.5806	0.3120	0.3697	3.0025	26	766
Nov 72	4.7939	0.2986	0.3489	3.2256	30	960
Dec 72	4.8079	0.3943	0.3970	3.0559	31	720
Jan 73	4.9693	0.4404	0.3032	3.5962	35	732

TABLE 3

Diversity Analysis of Kick Samples Collected at Station 3 (After Wilhm and Dorris, 1968)

	DMAX	DMIN	R	$\bar{d}$	No. of Taxa	No. of Organisms
Jan 72	4.1193	0.7255	0.4268	2.6707	21	211
Feb 72	4.4333	0.3958	0.3708	2.9363	24	523
Mar 72	4.6269	0.4861	0.4041	2.9536	28	495
Apr 72	4.5907	0.4374	0.4032	2.9163	27	537
May 72	4.7007	0.4221	0.4563	2.7484	29	612
June 72	4.9286	0.5617	0.4963	2.7614	35	548
July 72	3.6808	0.8207	0.6017	1.9600	16	126
Aug 72	5.2118	0.5136	0.4607	3.0475	42	761
Sept 72	4.8092	0.2561	0.4136	2.9262	30	1149
Oct 72	4.4567	0.3315	0.3692	2.9338	24	646
Nov 72	4.9201	0.4607	0.4849	2.7576	34	670
Dec 72	4.7195	0.5108	0.4731	2.7286	30	508
Jan 73	4.6342	0.3157	0.3963	2.9230	27	791

TABLE 4
Diversity Analysis of Kick Samples Collected at Station 4 (After Wilhm and Dorris, 1968)

	DMAX	DMIN	R	$\bar{d}$	No. of Taxa	No. of Organisms
Nov 71	4.6243	0.6444	0.3479	3.2396	29	368
Dec 71	4.5588	0.5284	0.3578	3.1168	27	428
Jan 72	4.6211	0.3522	0.3062	3.3141	27	695
Feb 72	5.0014	0.2276	0.3668	3.2502	34	1532
Mar 72	4.8532	0.3971	0.3425	3.3270	32	742
Apr 72	4.8821	0.4440	0.3347	3.3965	33	675
May 72	4.5514	0.5498	0.3726	3.0603	27	408
June 72	4.8967	0.5300	0.2302	3.8916	34	567
July 72	4.1162	1.1339	0.2139	3.4782	23	135
Aug 72	4.6880	0.3134	0.2937	3.4031	28	834
Sept 72	5.1311	0.2081	0.3245	3.5334	37	1879
Oct 72	4.8536	0.2652	0.3591	3.2058	31	1148
Nov 72	4.8372	0.4435	0.2182	3.8787	32	651
Dec 72	4.7622	0.3880	0.3664	3.1595	30	705
Jan 73	4.7630	0.2477	0.3876	3.0126	29	1147

TABLE 5

Species Diversity ($\bar{d}$) for Basket Samplers from Station 1 (After Wilhm and Dorris, 1968)

	Left Bank	Midchannel	Right Bank	Composite
April 72	––	––	––	
May 72	3.0109	2.1651	––	2.5540
July 72	––	––	––	
Aug 72	2.6464	2.6189	2.6984	3.0408
Sept 72	2.2335	2.3244	2.1469	2.7291
Nov 72	2.0013	1.4426	2.1042	3.0830
Jan 73	––	3.0436	2.7149	3.1605
Mar 73	2.1808	––	––	2.1808

–– artificial substrate not recovered from river

TABLE 6
Species Diversity (d) for Basket Samplers from Station 2 (After Wilhm and Dorris, 1968)

	Left Bank	Midchannel	Right Bank	Composite
April 72	––	––	––	
May 72	3.0959	2.0067	––	2.2969
July 72	––	––	––	
Aug 72	2.8434	1.8875	3.1792	2.9871
Sept 72	1.1634	1.8676	1.8777	2.3021
Nov 72	2.2873	2.6150	2.6296	2.8901
Jan 73	––	––	3.2279	3.2279
Mar 73	––	––	2.6645	2.6645

–– artificial substrate not recovered from river

TABLE 7
Species Diversity (d) for Basket Samplers from Station 3
(After Wilhm and Dorris, 1968)

	Left Bank	Midchannel	Right Bank	Composite
April 72	––	––	––	
May 72	––	2.7251	3.2241	3.0286
July 72	––	––	––	
Aug 72	2.2548	2.5829	2.8489	2.8699
Sept 72	3.0324	2.2343	2.2121	2.4636
Nov 72	3.3124	2.2409	2.9814	3.1608
Jan 73	2.2855	1.4911	––	2.2120
Mar 73	––	2.4020	––	2.4020

–– artificial substrate not recovered from river

TABLE 8

Matrix Showing Significance Levels of Correlation Coefficients of Water Quality Data for Station 1

	DO	WT	AT	pH	Tot Alk	Cl	NO_3	Orth PO_4	Cond PO_4	Org PO_4	Tot PO_4	Cond	BOD	CA	Mg	Tot	SO_4
DO	1.00																
Water Temp	—**	1.00															
Air Temp	—**	+**	1.00														
pH	+*	——	——	1.00													
Total Alk	——	——	——	——	1.00												
Cl–	—**	+**	+**	——	——	1.00											
NO_3	NB	NB	NB	NB	NB	NB	1.00										
Orth PO_4	——	——	—*	——	——	——	NB	1.00									
Condensed PO_4	+*	—*	—*	——	——	——	NB	+*	1.00								
Organic PO_4	——	——	——	——	——	——	NB	——	——	1.00							
Total PO_4	——	——	——	——	——	——	NB	——	——	+**	1.00						
Conductivity	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	1.00					
BOD	——	+*	+*	——	——	——	NB	——	——	——	——	NB	1.00				
Ca# Hardness	——	——	——	——	+**	——	NB	—*	——	——	——	NB	——	1.00			
Mg# Hardness	——	——	——	——	——	——	NB	——	——	——	——	NB	——	——	1.00		
Total Hardness	——	——	——	——	+**	——	NB	——	——	——	——	NB	——	+**	+*	1.00	
SO_4	——	——	——	——	——	——	NB	——	——	——	——	NB	——	+*	——	——	1.00

NB = data do not fit bivariate normal distribution
\+ = indicates significant positive correlation
—— = not statistically significant at 0.05 level
** = significant at 0.01 level
— = indicates significant negative correlation
* = significate at 0.05 level

TABLE 9

Matrix Showing Significance Levels of Correlation Coefficients of Water Quality Data for Station 2

	DO	WT	AT	pH	Tot Alk	Cl	NO_3	Orth PO_4	Cond PO_4	Org PO_4	Tot PO_4	Cond	BOD	CA Hard	Mg Hard	Tot Hard	SO_4
DO	1.00																
Water Temp	—**	1.00															
Air Temp	—**	+**	1.00														
pH	——	——	——	1.00													
Total Alk	——	——	——	——	1.00												
Cl–	—*	+**	+*	——	——	1.00											
NO_3	——	——	——	——	——	——	1.00										
Orth PO_4	——	——	——	——	——	——	——	1.00									
Condensed PO_4	——	——	——	——	——	+*	——	——	1.00								
Organic PO_4	——	——	——	——	——	——	——	——	——	1.00							
Total PO_4	——	——	——	——	——	——	—*	——	——	+**	1.00						
Conductivity	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	1.00					
BOD	—**	+**	+**	——	——	——	——	+*	——	——	——	NB	1.00				
Ca# Hardness	——	——	——	——	+*	——	——	——	——	——	——	NB	——	1.00			
Mg# Hardness	——	——	——	——	+**	——	——	——	——	——	——	NB	——	+*	1.00		
Total Hardness	——	——	——	——	+**	——	——	——	——	——	——	NB	——	+**	+**	1.00	
SO_4	——	——	——	——	+*	——	——	—*	——	——	——	NB	——	——	+**	+*	1.00

NB = data do not fit bivariate normal distribution
\+ = indicates significant positive correlation
—— = not statistically significant at 0.05 level
** = significant at 0.01 level
— = indicates significant negative correlation
* = significate at 0.05 level

TABLE 10

Matrix Showing Significance Levels of Correlation Coefficients of Water Quality Data for Station 3

	DO	WT	AT	pH	Tot Alk	Cl	NO_3	Orth PO_4	Cond PO_4	Org PO_4	Tot PO_4	Cond	BOD	CA Hard	Mg Hard	Tot Hard	SO_4
DO	1.00																
Water Temp	—**	1.00															
Air Temp	—**	+**	1.00														
pH	——	——	——	1.00													
Total Alk	NB	NB	NB	NB	1.00												
Cl–	—**	+**	+**	——	NB	1.00											
NO_3	——	——	+*	——	NB	——	1.00										
Orth PO_4	——	—*	—*	——	NB	——	——	1.00									
Condensed PO_4	+**	—**	—**	——	NB	——	——	——	1.00								
Organic PO_4	——	——	——	——	NB	——	——	——	——	1.00							
Total PO_4	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	1.00						
Conductivity	—*	+**	——	——	NB	——	——	—*	——	——	NB	1.00					
BOD	——	+*	——	——	NB	——	——	—*	——	——	NB	+*	1.00				
Ca# Hardness	——	——	——	——	NB	——	——	——	——	——	NB	——	——	1.00			
Mg# Hardness	——	——	——	——	NB	——	+*	——	——	——	NB	——	——	+*	1.00		
Total Hardness	——	——	——	——	NB	——	+*	——	——	——	NB	——	——	+**	+**	1.00	
SO_4	——	——	——	——	NB	—*	——	——	——	——	NB	——	——	——	+*	+*	1.00

NB = data do not fit bivariate normal distribution
\+ = indicates significant positive correlation
—— = not statistically significant at 0.05 level
** = significant at 0.01 level
— = indicates significant negative correlation
* = significate at 0.05 level

TABLE 11

Matrix Showing Significance Levels of Correlation Coefficients of Water Quality Data for Station 4

	DO	WT	AT	pH	Tot. Alk	Cl	NO_3	Orth PO_4	Cond PO_4	Org PO_4	Tot PO_4	Cond	BOD	CA Hard	Mg Hard	Tot Hard	SO_4
DO	1.00																
Water Temp	—**	1.00															
Air Temp	—**	+**	1.00														
pH	—**	+**	+**	1.00													
Total Alk	——	——	——	——	1.00												
Cl—	—**	+**	+**	——	——	1.00											
NO_3	——	——	——	——	——	——	1.00										
Orth PO_4	——	——	——	——	——	——	——	1.00									
Condensed PO_4	——	——	——	——	——	——	——	——	1.00								
Organic PO_4	——	——	——	——	——	——	——	——	——	1.00							
Total PO_4	——	——	——	——	——	——	——	——	——	+**	1.00						
Conductivity	——	——	——	——	——	——	——	——	——	——	——	1.00					
BOD	—*	+*	——	+**	——	——	——	——	——	——	——	——	1.00				
Ca# Hardness	——	——	——	——	——	——	——	——	+*	——	——	——	——	1.00			
Mg# Hardness	——	——	——	——	——	——	——	——	——	——	——	——	——	+**	1.00		
Total Hardness	——	——	——	——	——	——	——	——	——	——	——	——	——	+**	+**	1.00	
SO_4	——	——	——	——	+**	——	——	——	——	——	——	——	——	——	——	——	1.00

NB = data do not fit bivariate normal distribution
\+ = indicates significant positive correlation
—— = not statistically significant at 0.05 level
** = significant at 0.01 level
— = indicates significant negative correlation
* = significate at 0.05 level

FIGURES

FIGURE 1
Stations 1, 2, 3: New River

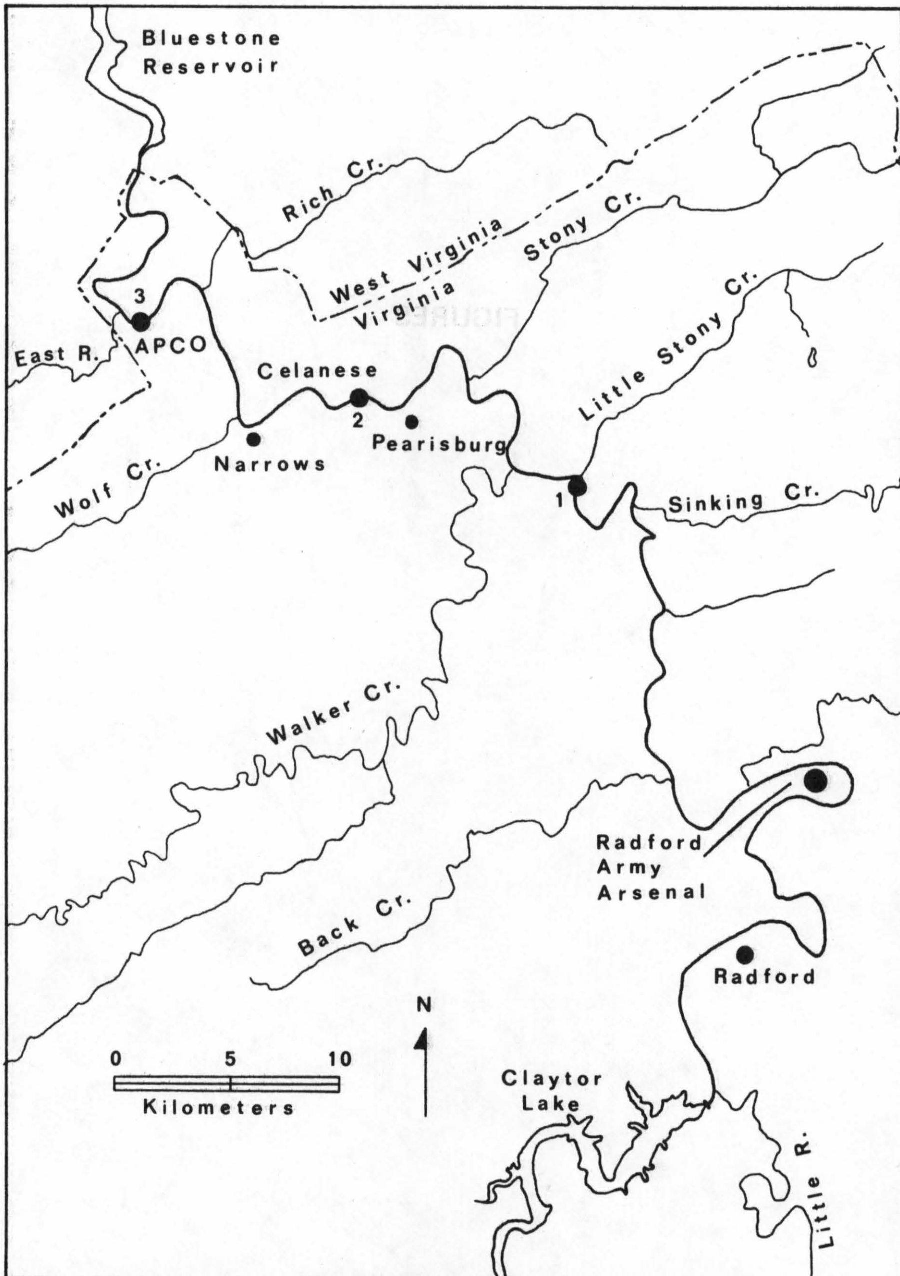


FIGURE 2
Station 1: Castle Rock Site

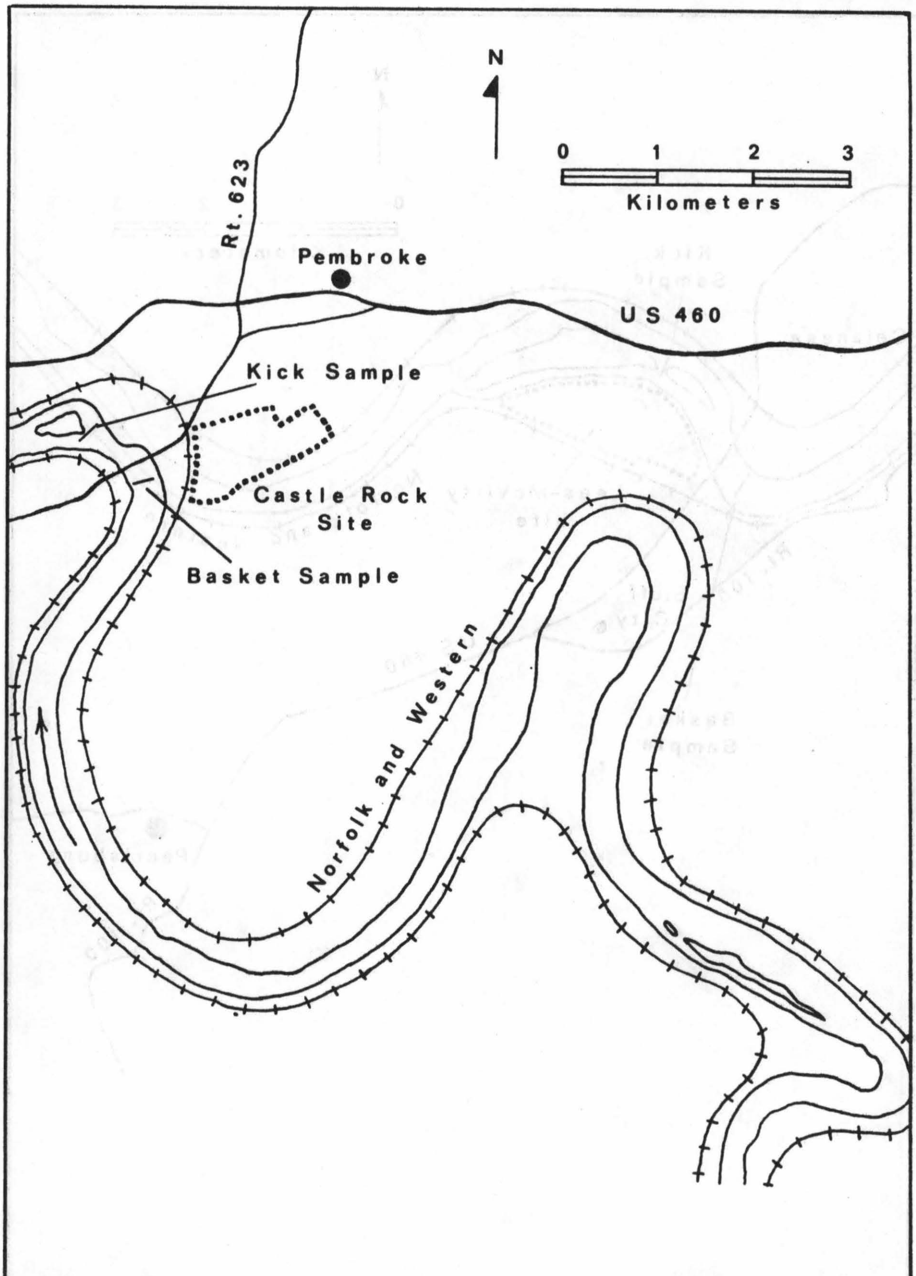


FIGURE 3
Station 2: Lees-McVitty Site

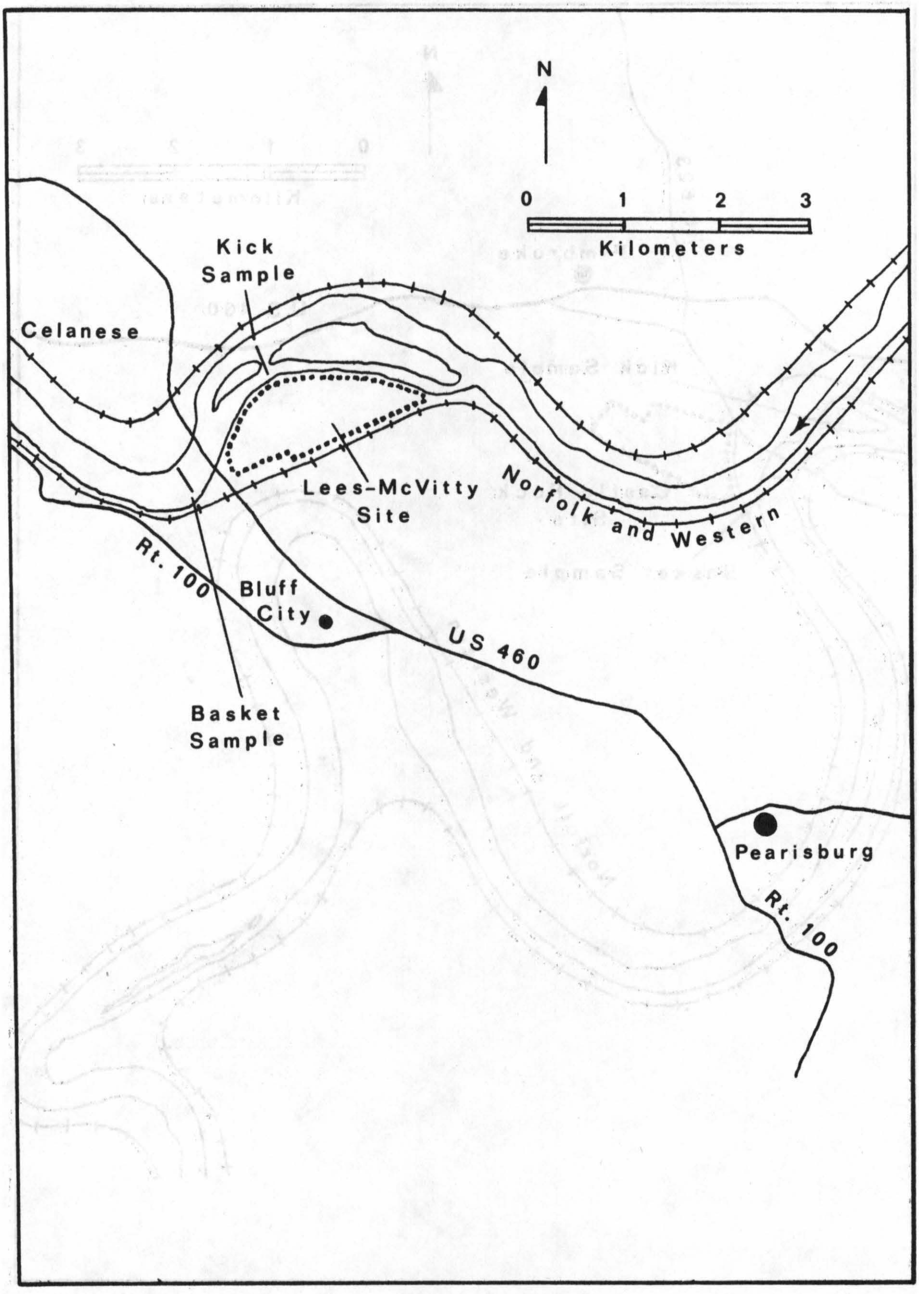


FIGURE 4
Station 3: Boxley White and Ould Sites

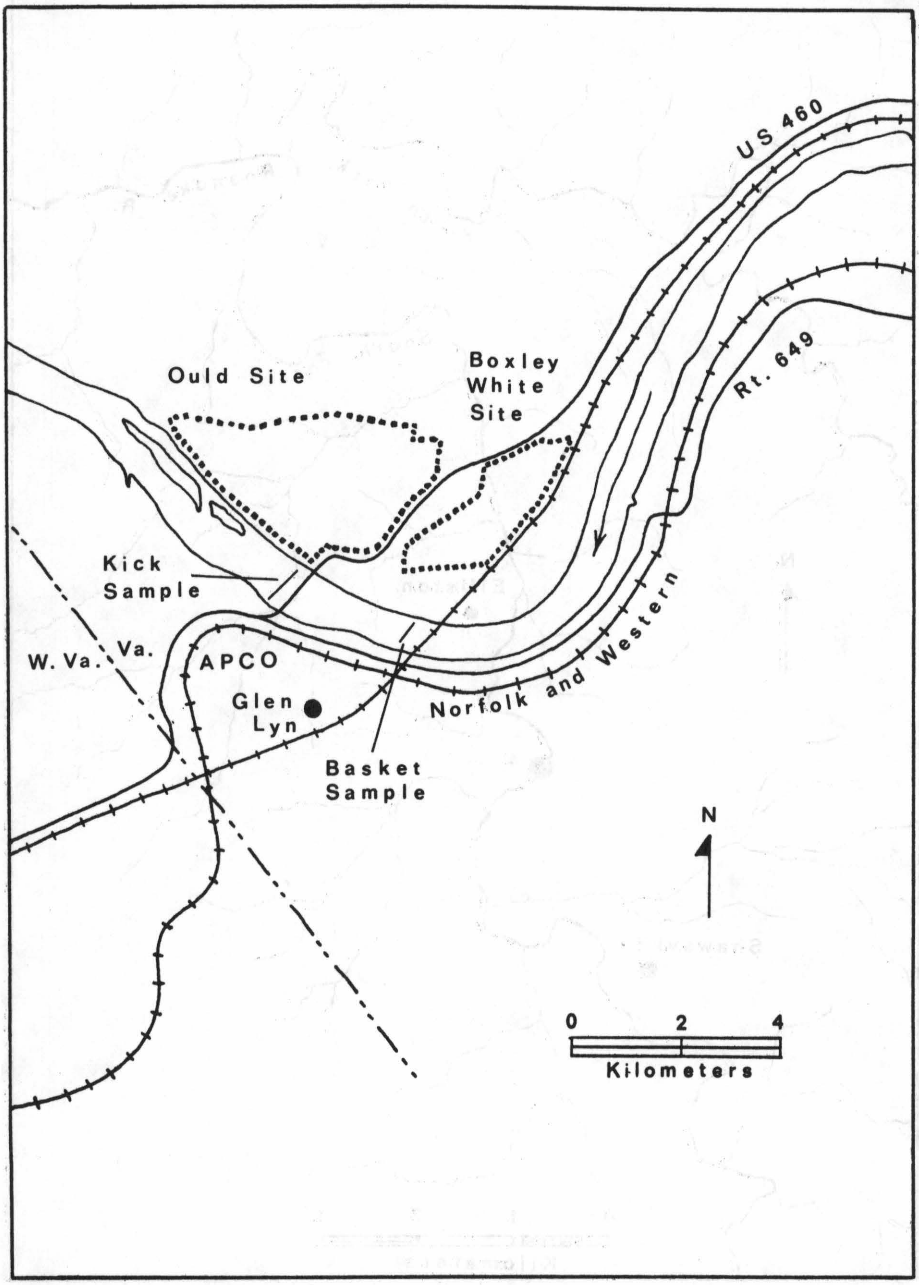


FIGURE 5
North and South Forks of Roanoke River

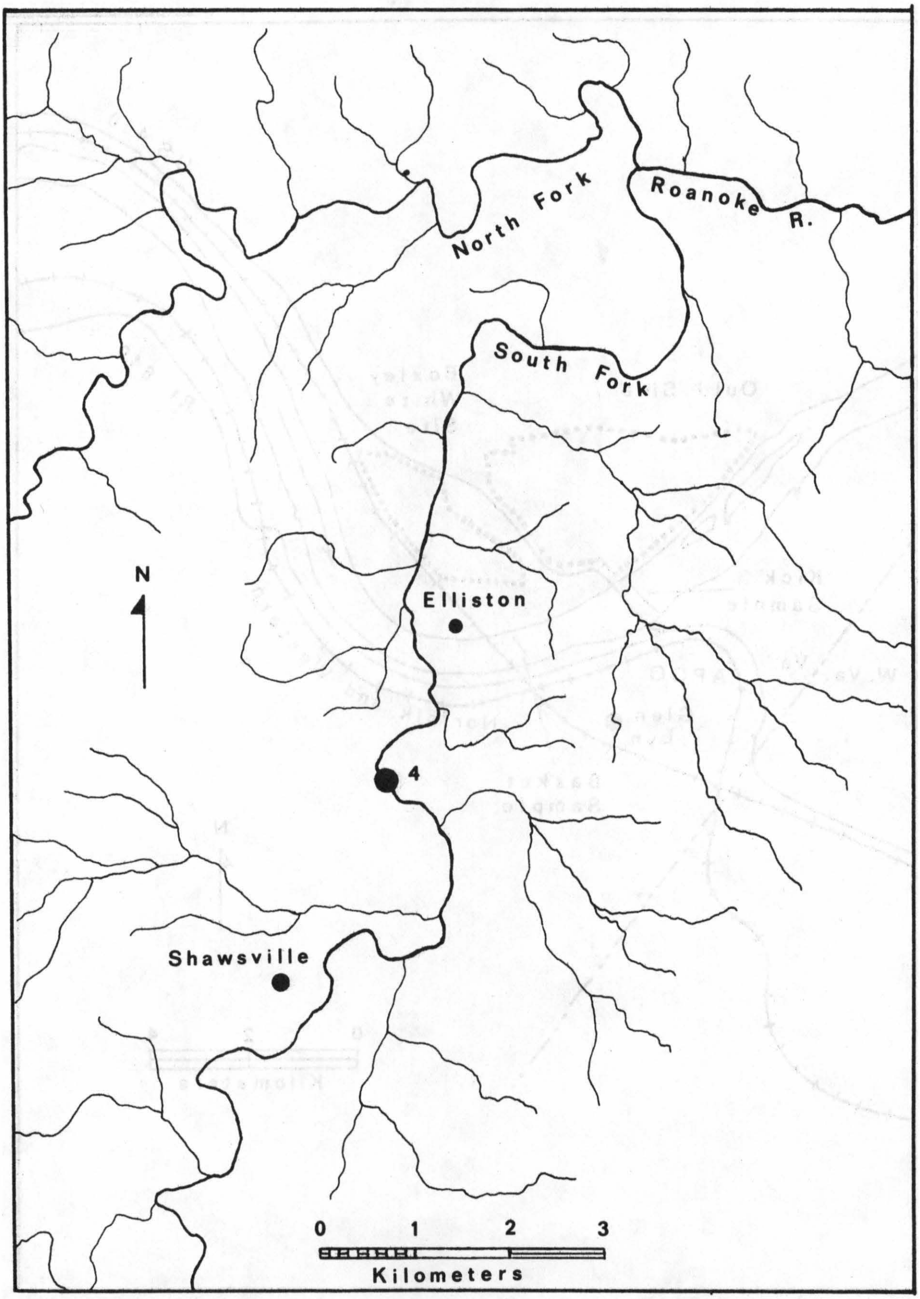


FIGURE 6
Station 4: Lafayette Site

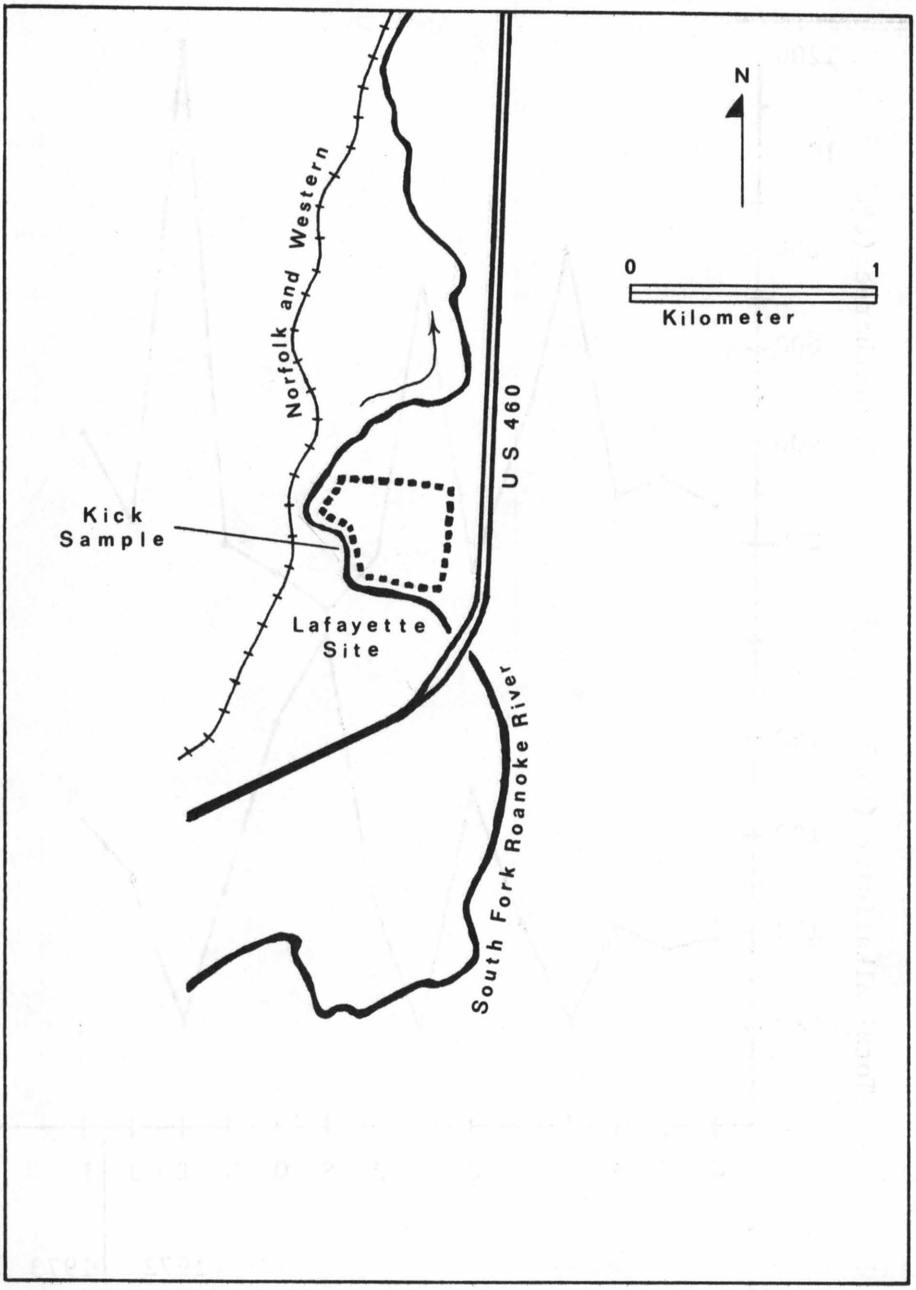


FIGURE 7
Comparison of Total Alkalinity and Flow Rate at Station 4

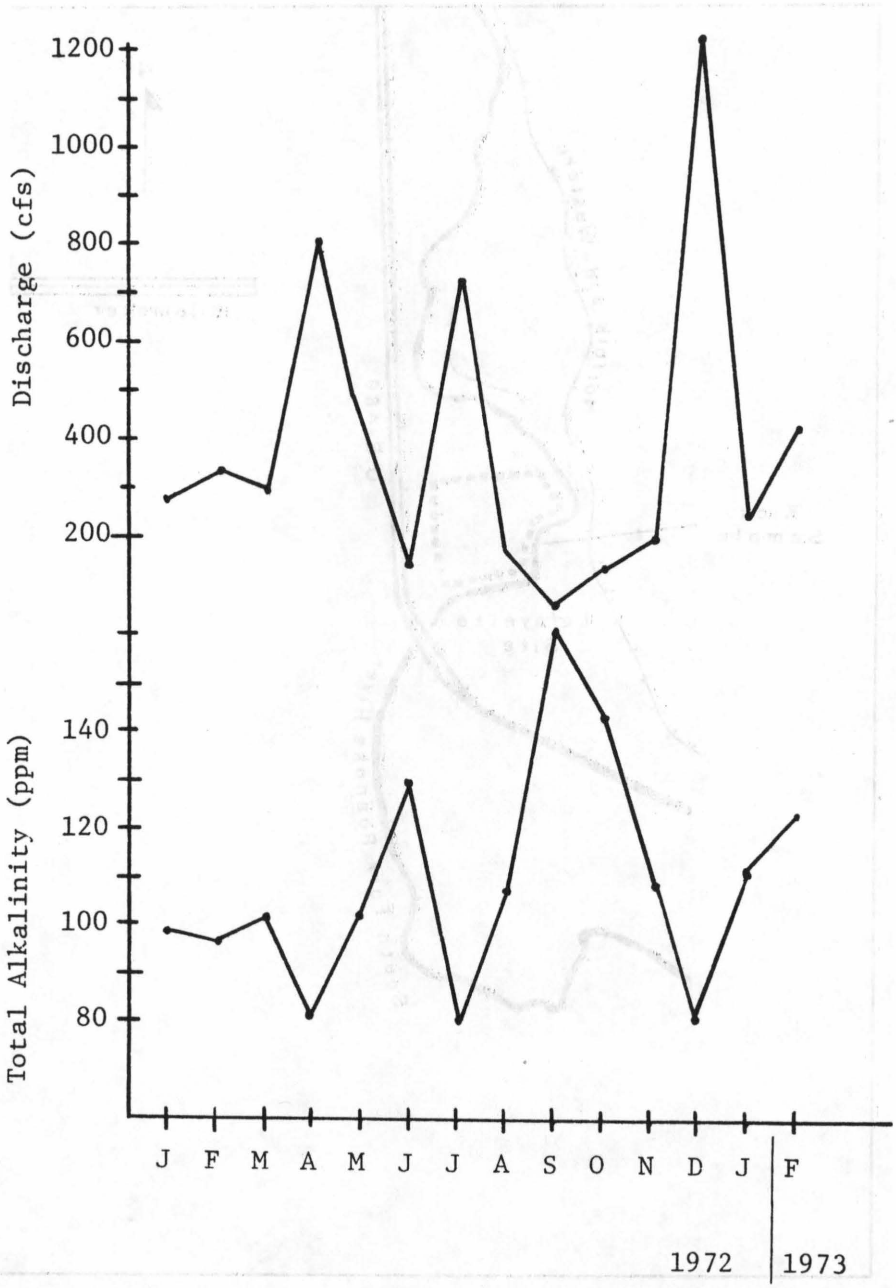


FIGURE 8
Comparison of Flow Rate and Nitrate Concentrations at Station 1

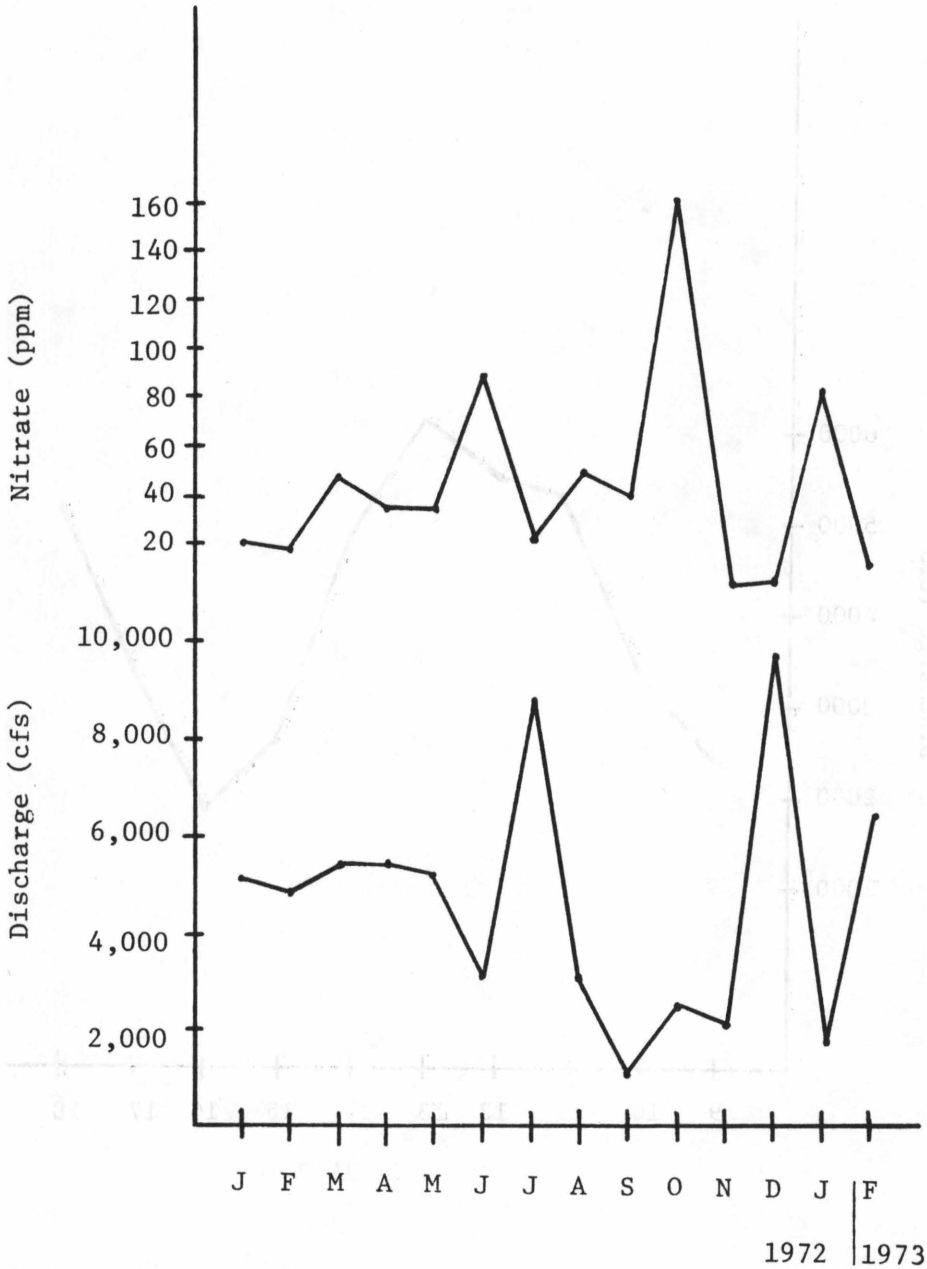


FIGURE 9
Variations in Flow Rate at Station 1 due to Claytor Lake Discharge

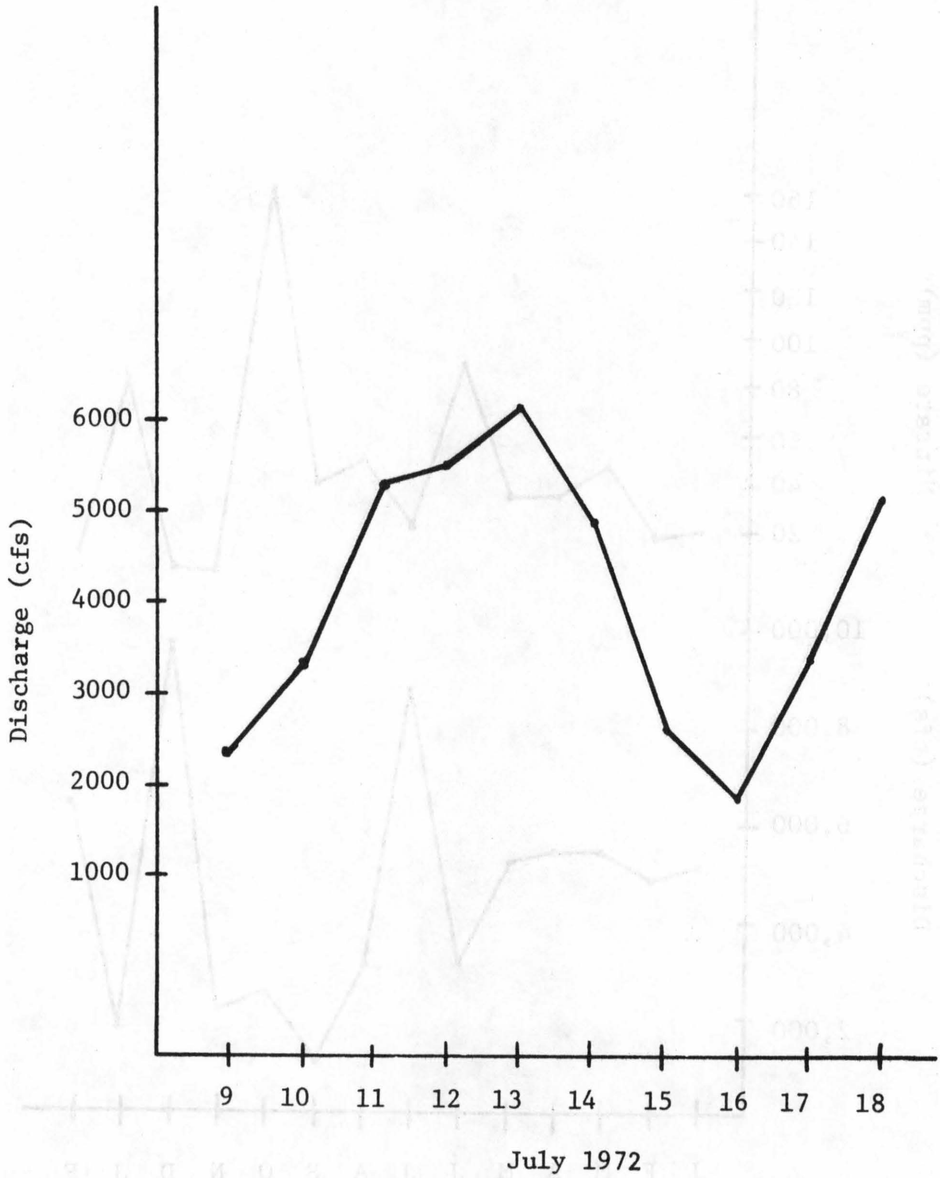
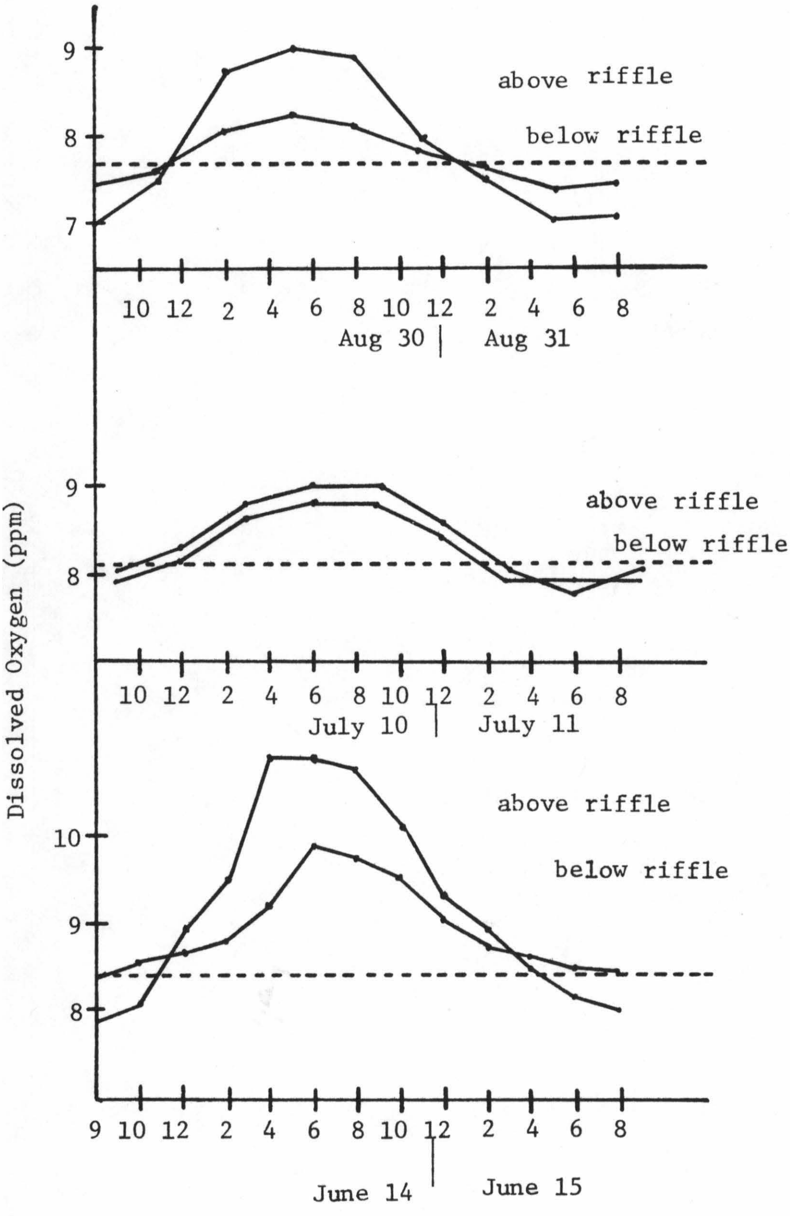


FIGURE 10
Diurnal Dissolved Oxygen Measurements for Summer, 1972 at Station 1



------- = Saturation

APPENDIX A

TABLE 1

Taxa of Benthic Macroinvertebrates by Month for Kick Samples at Station 1

Organisms	1972 Jan	Feb	Mar	Apr	May	Jun	1972 Jul	Aug	Sept	Oct	Nov	Dec	1973 Jan
Ephemeroptera													
Ephemeridae													
Hexagenia Walsh						2	2	24	12				
Heptageniidae													
Cinygma Eaton					1	1		15	9	4	1		
Iron Eaton							3						
Ironopsis Traver													1
Stenonema Traver	8	79	125	81	51	122	32	143	245	211	204	205	157
Baetidae													
Baetis Leach	2		1	2		3	24	91	90	24	25	23	47
Caenis Stephens								19	6	4	42		
Ephemerella Walsh	1	7	67	107	241			33	3	23		53	88
Isonychia Eaton	3	51	25	43	40	94	15	237	239	327	175	225	160
Paraleptophelebia Lestage					7								
Pseudocloeon Klapalek						1		76	15	6	11	15	17
Tricorythodes Ulmer								40	17	1	73		
Odonata													
Agrionidae													
Hetaerina Hagen													
Coenagronidae													
Argia Rambur			2	4	4	9		2	4	6	2	2	5
Enallagma Charpentier	1	2	5			1				1			
Hyponeura Selys		7											1
Ischnura Charpentier					1								
Gomphidae													
Gomphus Leach													
Hagenius Selys													
Lanthus Needham						1						1	
Aeshnidae													
Aeshna Fabricius													
Anax Leach													
Boyeria MacLachlan													
Libellulidae													
Macromia Rambur													
Neurocordulia Selys													
Plecoptera													
Nemouridae													
Allocapnia Claassen												12	
Brachyptera Newport													3
Nemoura Pictet						1							
Taeniopteryx Pictet											3	6	1

	1972												1973
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Perlidae													
<u>Acroneuria</u> Klapalek				1		1					1		
<u>Neophasganophora</u> Lestage				2									2
Perlodidae													
<u>Isogenus</u> Newman			8										5
Megaloptera													
Sialidae													
<u>Sialis</u> Latreille		1											
Corydalidae													
<u>Corydalus</u> Latreille			15	7	18	6	6	17	20	29	3	11	25
<u>Nigronia</u> Banks					1					1			1
Trichoptera													
Rhyacophilidae													
<u>Agapetus</u> Curtis										1			2
<u>Glossosoma</u> Curtis			3			3						2	9
<u>Rhyacophila</u> Pictet								1					3
Philopotamidae													
<u>Chimarra</u> Stephens								5	12				37
Psychomyiidae													
<u>Neureclipsis</u> McLachlan				4							1	1	
<u>Psychomyia</u> Pictet					1			1					
Hydropsychidae													
<u>Cheumatopsyche</u> Wallengren		1	17	5	1	3	5	16	7	22	38	21	48
<u>Hydropsyche</u> Pictet	2	10	23	12	8	9	12	42	14	48	44	62	302
<u>Macronemum</u> Burmeister	7	1	47	47	39	35	21	74	23	45	81	87	96
Limnephilidae													
<u>Limnephilus</u> Leach				1		1		1			1	1	
<u>Neophalax</u> McLachlan								2	1	2			1
Leptoceridae													
<u>Athripsodes</u> Billberg			6		2			1			4	2	
<u>Oecetis</u> McLachlan								4					1
Brachycentridae													
<u>Brachycentrus</u> Curtis				2				3					
Helicopsychidae													
<u>Helicopsyche</u> Hagen			3	1		1					3	1	
Coleoptera													
Hydrophilidae													
<u>Berosus</u> Leach	2			2	1					3	1	1	3
Dryopidae													
<u>Pelonomus</u> Erichson	1												
Elmidae			15	2	5	3	1	6	2	27	4	3	63
Psephenidae													
<u>Psephenus</u> Haldeman	1		6	4	3	2	2	1		10	1	2	6
Diptera													
Tipulidae													
<u>Antocha</u> Osten Sacken	1	1	6	6	4	3	1				2	3	18
<u>Ormosia</u> Rondani		1									1		
<u>Tipula</u> Linnaeus		1	1	1								1	

Continued

TABLE 1 (continued)

	1972												197
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Ja
Blephariceridae													
Blephariceru*s* Kellogg													
Simuliidae													
Simulium Latreille			12		23	41	4	3	5	5	2	1	
Chironomidae	27	24	201	102	107	87	55	39	10	26	127	56	[illegible]
Tabanidae													
Chrysops Meigen		1											
Empididae													
Hemerodromia Meigen		3	2	2	1	1		5			1	2	
Turbellaria													
Planariidae													
Dugesia Girard				1		2		2	8				
Nematoda		5					1					2	
Hirudinea		1											
Oligochaeta													
Lumbriculidae	3	8			1				1				
Tubifecidae	21	21	4	10	6	11	3	1	2	12	4	5	
Branchiura Beddard			2	2			1	2	3	1		1	
Amphipoda													
Gammaridae													
Gammarus Say	1	6	6	6	3		5		3	1	2	12	
Decapoda													
Cambaridae													
Cambarus Erichson	1	1	3	2	2	1	1	2	9	2	1	3	
Isopoda													
Asellidae													
Asellus Geoffroy St.–Hillaire		4		1	1	12					1		
Gastropoda													
Ancylidae													
Ferrissia Walker	2	9	2					1	2	2	2		
Physidae													
Physa Draparnaud	3	2											
Pleuroceridae													
Nitocris Conrad		5	8	19	53	23	5	16	24	26	16	27	
Lymnaeidae													
Fossaria Westerlund	1												
Pelecypoda													
Sphaeriidae													
Sphaerium Scopoli	2	5	9	6	6	9	2	9	8	21	5	4	
Total	93	257	622	485	632	486	201	901	794	894	882	853	[illegible]
Taxa	20	26	28	30	28	30	21	34	28	29	33	33	

TABLE 2
Taxa of Benthic Macroinvertebrates by Month for Artificial Substrates (Composite) at Station 1

Organisms	1972						1973	
	Apr	May	Jul	Aug	Sept	Nov	Jan	Mar
Ephemeroptera								
Ephemeridae								
Hexagenia Walsh								
Heptageniidae								
Cinygma Eaton								
Iron Eaton								
Ironopsis Traver								
Stenonema Traver		38		105	388	138	48	55
Baetidae								
Baetis Leach				8	4			4
Caenis Stephens				4	26	2		
Ephemerella Walsh		160				1		23
Isonychia Eaton		14		7	5	3	14	18
Paraleptophelebia Lestage				2				2
Pseudocloeon Klapalek				1				
Tricorythodes Ulmer				171	463	1		
Odonata								
Agrionidae								
Hetaerina Hagen		1		2			1	
Coenagronidae								
Argia Rambur				3	11	5	2	
Enallagma Charpentier						4		
Hyponeura Selys								
Ischnura Charpentier								1
Gomphidae								
Gomphus Leach				1		1		
Hagenius Selys		1		1				
Lanthus Needham								
Aeshnidae								
Aeshna Fabricius		1				2		
Anax Leach		1						
Boyeria MacLachlan				1				
Libellulidae								
Macromia Rambur							3	
Neurocordulia Selys		1		1	2			1
Plecoptera								
Nemouridae								
Allocapnia Claassen								
Brachyptera Newport								
Nemoura Pictet								
Taeniopteryx Pictet							1	
Perlidae								
Acroneuria Klapalek				1				
Neophasganophora Lestage								

Continued

TABLE 2 (continued)

	1972						1973	
	Apr	May	Jul	Aug	Sept	Nov	Jan	Mar
Perlodidae								
Isogenus Newman								
Megaloptera								
Sialidae								
Sialis Latreille								
Corydalidae								
Corydalus Latreille								
Nigronia Banks								
Trichoptera								
Rhyacophilidae								
Agapetus Curtis								1
Glossosoma Curtis								
Rhyacophila Pictet								
Philopotamidae								
Chimarra Stephens				1				
Psychomyiidae								
Neureclipsis McLachlan				2		6		
Psychomyia Pictet		1				3		1
Hydropsychidae								
Cheumatopsyche Wallengren				11	2	4	3	18
Hydropsyche Pictet		1		34	15	8	8	22
Macronemum Burmeister		2		3				
Limnephilidae								
Limnephilus Leach		2		1				2
Neophalax McLachlan						1		
Leptoceridae								
Athripsodes Billberg					1			
Oecetis McLachlan								
Brachycentridae								
Brachycentrus Curtis		9		11	2	2	3	1
Helicopsychidae								
Helicopsyche Hagen				1				
Coleoptera								
Hydrophilidae								
Berosus Leach								1
Dryopidae								
Pelonomus Erichson								
Elmidae		10		1	4			1
Psephenidae								
Psephenus Haldeman								
Diptera								
Tipulidae								
Antocha Osten Sacken				1				
Ormosia Rondani								
Tipula Linnaeus							1	
Blephariceridae								
Blephariceris Kellogg								

	1972						1973	
	Apr	May	Jul	Aug	Sept	Nov	Jan	Mar
Simuliidae								
Simulium Latreille		3		1				1
Chironomidae		189		371	158	235	4	239
Tabanidae								
Chrysops Meigen								
Empididae								
Hemerodromia Meigen		2		4	1			1
Turbellaria								
Planariidae								
Dugesia Girard		18		53	59	9	1	
Nematoda								
Hirudinea								
Oligochaeta								
Lumbriculidae							2	1
Tubifecidae		3		1	3	15	6	
Branchiura Beddard						5		
Amphipoda								
Gammaridae								
Gammarus Say		10		4	4	35	18	2
Decapoda								
Cambaridae								
Cambarus Erichson		4		1	4	5	4	3
Isopoda								
Asellidae								
Asellus Geoffroy St.–Hillaire		1				1		
Gastropoda								
Ancylidae								
Ferrissia Walker		1		1	48	12		
Physidae								
Physa Draparnaud		7		4	2	25	1	
Pleuroceridae								
Nitocris Conrad				2		3	2	
Lymnaeidae								
Fossaria Westerlund								
Pelecypoda								
Sphaeriidae								
Sphaerium Scopoli		5		13	2	1	8	1
Total		494		829	1204	527	128	399
Taxa		25		35	21	26	19	22

TABLE 3

Taxa of Benthic Macroinvertebrates by Month for Kick Samples at Station 2

Organisms	Jan 1972	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan 1973
Ephemeroptera													
Ephemeridae													
Hexagenia Walsh				1	4	7		6	1		1		
Heptageniidae													
Cinygma Eaton								12	3				
Iron Eaton										1			
Rhithrogena Eaton													1
Stenonema Traver	22	27	73	142	108	189	54	224	357	232	220	153	107
Baetidae													
Ameletus Eaton		1								2			
Baetis Leach			2	6	12	17	13	91	306	6	12	17	11
Caenis Stephens					1	2	1	29	3	8	43	6	
Ephemerella Walsh			14	89	283			4	1	14	1	23	70
Isonychia Eaton	11	35	64	128	132	201	21	37	593	202	173	168	64
Paraleptophlebia Lestage													
Pseudocloeon Klapalek						1	3	8	99	17	5	3	1
Tricorythodes Ulmer						1	2	2	13	1	128		
Odonata													
Agrionidae													
Hetaerina Hagen													
Coenagrionidae													
Argia Rambur			2	4	2	5		1	5		9	2	
Ischnura Charpentier													
Gomphidae													
Dromogomphus Selys													
Hagenius Selys													
Lanthus Needham					1							1	
Aeshnidae													
Aeshna Fabricius													
Libellulidae													
Didymops Rambur		1											
Macromia Rambur													
Neurocordulia Selys													
Plecoptera													
Peltoperlidae													
Peltoperla Needham										1			
Nemouridae													
Allocapnia Claassen		2	3								2	25	
Brachyptera Newport												3	1
Taeniopteryx Pictet											3	7	1
Perlidae													
Acroneuria Klapalek				1		1			6	2			
Neoperla Needham													

	1972												1973
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Neophasganophora Lestage				1									
Paragnetina Klapalek					1								
Perlesta Banks													
Perlodidae													
Hastaperla Ricker													
Isogenus Newman			4										1
Megaloptera													
Corydalidae													
Corydalus Latreille			4	4	4	19		3	52	12	11	8	15
Nigronia Banks													
Trichoptera													
Rhyacophilidae													
Agapetus Curtis												1	1
Glossosoma Curtis	16		1				1						2
Rhyacophila Pictet	1	1											
Philopotamidae													
Chimarra Stephens			1	4			6	1	69	10	23	15	9
Psychomyiidae													
Neureclipsis McLachlan													
Psychomyia Pictet	1					1						1	1
Hydropsychidae													
Cheumatopsyche Wallengren			11	17	8	22	17	1	25	11	5	4	41
Hydropsyche Pictet			23	32	15	55	11	3	98	40	18	9	146
Macronemum Burmeister								7	11	38		3	37
Phryganeidae													
Phryganea Linnaeus		1											
Limnephilidae													
Limnephilus Leach				2	1	2						1	
Neophalax McLachlan								1	1				
Leptoceridae													
Athripsodes Billberg								1					
Oecetis McLachlan	1												
Brachycentridae													
Brachycentrus Curtis			2		1	1		1					3
Helicopsychidae													
Helicopsyche Hagen						1		5	1		1		7
Coleoptera													
Dytiscidae													
Oreodytes Seidlitz								1					
Gyrinidae													
Dineutes MacLeay													
Hydrophilidae													
Berosus Leach				1									
Dryopidae													
Pelonomus Erichson													
Elmidae		12	4	2	3		4	15	28	7	8		10
Psephenidae													
Psephenus Haldeman	2	4	3	3	1		1	4	8	12	2		1

Continued

TABLE 3 (continued)

	1972											1973	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Diptera													
Tipulidae													
Antocha Osten Sacken			2	2	2	6	1	2			3	2	8
Eriocera Macquart												1	
Ormosia Rondani						1						1	
Tipula Linnaeus	4		1	1	1				1			1	
Blephariceridae													
Blephariceras Kellogg												3	1
Simuliidae													
Simulium Latreille			1	14	1	13	2		3	12	14	3	7
Chironomidae	11	41	101	169	284	329	123	39	180	123	253	238	137
Ceratopogonidae													
Palpomyia Meigen													
Tabanidae													
Chrysops Meigen		1											
Empididae													
Hemerodromia Meigen			1	3	2	3		1			1	2	1
Turbellaria													
Planariidae													
Dugesia Girard				2		2		1	9		2		5
Nematoda				1		1		3			2		
Hirudinea		1											
Oligochaeta													
Lumbriculidae	2	1			1	1		23		3	1		10
Tubifecidae	13	27	2		7	12	1	16	13	5	6	3	4
Brachiura Beddard			1	1	3	8			2		4		
Amphipoda													
Gammaridae													
Gammarus Say	23	4	2	3	2	7		2	6	2	5	7	1
Decapoda													
Cambaridae													
Cambarus Erichson	2		4	3	3	5	2	5	3	1	3	5	2
Isopoda													
Asellidae													
Asellus Geoffroy St.—Hillaire				1		2							
Gastropoda													
Ancylidae													
Ferrissia Walker	1	1				1			3	1			2
Physidae													
Physa Draparnaud													
Pleuroceridae													
Nitocris Conrad	3	6	5	12	8	4	3	14	48	4	2		15
Lymnaeidae													
Fossaria Westerlund													3

	1972 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1973 Jan
Pelecypoda													
Sphaeriidae													
Sphaerium Scopoli	2	3	1	7	7	3	1	5	7				6
Total	115	169	333	656	898	921	267	566	1954	766	960	720	732
Taxa	16	18	26	29	28	32	19	33	31	26	30	31	35

TABLE 4

Taxa of Benthic Macroinvertebrates by Month for Artificial Substrates (Composite) at Station 2

Organisms	1972 Apr	May	Jul	Aug	Sept	Nov	1973 Jan	Mar
Ephemeroptera								
Ephemeridae								
Hexagenia Walsh								
Heptageniidae								
Cinygma Eaton								
Iron Eaton								
Rhithrogena Eaton								
Stenonema Traver		13		244	364	175	12	22
Baetidae								
Ameletus Eaton								
Baetis Leach				5	5			
Caenis Stephens				12				
Ephemerella Walsh		114		32		23	1	12
Isonychia Eaton		2		259	4	2	1	20
Paraleptophlebia Lestage							16	
Pseudocloeon Klapalek								
Tricorythodes Ulmer				275	296	5		
Odonata								
Agrionidae								
Hetaerina Hagen				1				
Coenagrionidae								
Argia Rambur					1	1		
Ischnura Charpentier					1		10	2
Gomphidae								
Dromogomphus Selys							1	
Hagenius Selys				1	1			1
Lanthus Needham								
Aeshnidae								
Aeshna Fabricius				2	1			
Libellulidae								
Didymops Rambur								
Macromia Rambur							1	
Neurocordulia Selys		1						
Plecoptera								
Plecoptera								
Peltoperla Needham								
Nemouridae								
Allocapnia Claassen							1	
Brachyptera Newport							1	
Taeniopteryx Pictet								
Perlidae								
Acroneuria Klapalek				1		1		
Neoperla Needham				1				
Neophasganophora Lestage								1

	1972						1973	
	Apr	May	Jul	Aug	Sept	Nov	Jan	Mar
<u>Paragnetina</u> Klapalek								
<u>Perlesta</u> Banks		2						
Perlodidae								
<u>Hastaperla</u> Ricker		1						
<u>Isogenus</u> Newman								
Megaloptera								
Corydalidae								
<u>Corydalus</u> Latreille		2		5				
<u>Nigronia</u> Banks				3				
Tricoptera								
Rhyacophilidae								
<u>Agapetus</u> Curtis								
<u>Glossosoma</u> Curtis								
<u>Rhyacophila</u> Pictet								
Philopotamidae								
<u>Chimarra</u> Stephens				1			1	
Psychomyiidae								
<u>Neureclipsis</u> McLachlan				2		8	1	1
<u>Psychomyia</u> Pictet		1		5	1	1	3	
Hydropsychidae								
<u>Cheumatopsyche</u> Wallengren		6		57	3	33		2
<u>Hydropsyche</u> Pictet		7		99	15	54	2	7
<u>Macronemum</u> Burmeister							1	2
Phryganeidae								
<u>Phryganea</u> Linnaeus								
Limnephilidae								
<u>Limnephilus</u> Leach				3		2	1	3
<u>Neophalax</u> McLachlan								
Leptoceridae								
<u>Athripsodes</u> Billberg								
<u>Oecetis</u> McLachlan								
Brachycentridae								
<u>Brachycentrus</u> Curtis				8	2	2		2
Helicopsychidae								
<u>Helicopsyche</u> Hagen								
Coleoptera								
Dytiscidae								
<u>Oreodytes</u> Seidlitz								
Gyrinidae								
<u>Dineutes</u> MacLeay				1				
Hydrophilidae								
<u>Berosus</u> Leach				1	1	1	1	
Dryopidae								
<u>Pelonomus</u> Erichson				1				
Elmidae		2		11	6	1	2	
Psephenidae								
<u>Psephenus</u> Haldeman								
Diptera								
Tipulidae								
<u>Antocha</u> Osten Sacken								

Continued

TABLE 4 (continued)

	1972						1973	
	Apr	May	Jul	Aug	Sept	Nov	Jan	Mar
Eriocera Macquart								
Ormosia Rondani							1	
Tipula Linnaeus		1						
Blephariceridae								
Blephariceridus Kellogg								
Simuliidae								
Simulium Latreille				36				1
Chironomidae		44		142	174	42	50	94
Ceratopogonidae								
Palpomyia Meigen					1			
Tabanidae								
Chrysops Meigen								
Empididae								
Hemerodromia Meigen		3		3			1	2
Turbellaria								
Planariidae								
Dugesia Girard		1		7	81	28	8	
Nematoda								
Hirudinea								
Oligochaeta								
Lumbriculidae								2
Tubifecidae		2		1	5	1	23	
Brachiura Beddard					5			
Amphipoda								
Gammaridae								
Gammarus Say		2		3	4	3	50	6
Decapoda								
Cambaridae								
Cambarus Erichson		1		2	2		3	3
Isopoda								
Asellidae								
Asellus Geoffroy St.—Hillaire								
Gastropoda								
Ancylidae								
Ferrissia Walker						1		
Physidae								
Physa Draparnaud				1	1	3	2	
Pleuroceridae								
Nitocris Conrad		3		3	3	74		
Lymnaeidae								
Fossaria Westerlund								
Pelecypoda								
Sphaeriidae								
Sphaerium Scopoli								
Total		208		1228	980	454	194	18
Taxa		19		33	23	21	25	2

TABLE 5

Taxa of Benthic Macroinvertebrates by Month for Kick Samples at Station 3

Organisms	1972 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1973 Jan
Ephemeroptera								1					
Ephemeridae													
Hexagenia Walsh			2	1	2	12		42	9				
Potamonthus Pictet								1		1			1
Heptageniidae													
Cinygma Eaton						2		3	7		1	2	
Stenonema Traver	60	111	121	92	125	128	14	257	474	129	207	181	288
Baetidae													
Ameletus Eaton		1											
Baetis Leach	7		1		5	6		158	177	124	12		
Caenis Stephens						1		16	80	18	11		
Ephemerella Walsh	6	14	63	125	239			1		2	3	25	31
Isonychia Eaton	2	107	88	84	100	94	3	21	70	8	183	121	183
Pseudocloeon Klapalek					1	2		3	4		4		
Tricorythodes Ulmer						6		141	203	172	24		
Odonata													
Agrionidae													
Hetaerina Hagen					1			1					
Coenagrionidae													
Argia Rambur			2	2	4	1			1	9	2	2	5
Ischnura Charpentier					1			1					
Gomphidae													
Gomphus Leach								1					
Hagenius Selys													
Lanthus Needham					2	1		1	1		1		
Aeshnidae													
Aeshna Fabricius													
Anax Leach								1					
Boyeria MacLachlan									1				
Libellulidae													
Neurocordulia Selys													
Plecoptera													
Nemouridae													
Allocapnia Claassen	1	2										4	1
Brachyptera Newport		1										1	
Taeniopteryx Pictet											2	3	1
Perlidae													
Acroneuria Klapalek						2					1		
Neophasganophora Lestage				1		1							1
Paragnetina Kapalek						1							
Perlodidae													
Isogenus Newman			4										
Isoperla Banks								1					
Megaloptera													
Corydalidae													
Corydalus Latreille	1		8	3	7	6	1	2	9	2	4	5	2

Continued

TABLE 5 (continued)

	1972												1973
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Nigronia Banks					1			1					
Trichoptera													
Rhyacophilidae													
Agapetus Curtis	1					1	1				1		
Glossosoma Curtis		1	1			2	1				2	1	
Protoptila Banks					1			5			1		
Philopotamidae													
Chimarra Pictet	1				7								
Psychomyiidae													
Neureclipsis McLachlan									1			1	3
Psychomyia Pictet		1		1		1		2			1		
Hydropsychidae													
Cheumatopsyche Wallengren	1	2	2	8	1	5		1	2	3	1	1	23
Hydropsyche Pictet	7	2	7	12	6	12	7	2	5	4	3	7	17
Macronemum Burmeister										1			
Limnephilidae													
Limnephilus Leach			1			1							
Neophalax McLachlan												1	
Leptoceridae													
Athripsodes Billberg												1	
Oecetis McLachlan								1					
Brachycentridae													
Brachycentrus Curtis			1				1					3	
Helicopsychidae													
Helicopsyche Hagen									7				
Hemiptera													
Gerridae													
Gerris Fabricius								1	2	1			
Coleoptera													
Gyrinidae													
Dineutes MacLeay			1			2		7	1		4		
Hydrophilidae													
Berosus Leach						1			5			3	1
Pemelus Horn								2					
Dryopidae													
Pelonomus Erichson						1		3	2				
Elmidae		9	6	15		5	1	14	18	8	5	4	2
Psephenidae													
Psephenus Haldeman	1		3	3		3		5	9	5	7	1	3
Diptera													
Tipulidae													
Antocha Osten Sacken			6	5	7		1	1				2	4
Eriocera Macquart											2		
Ormosia Rondani				1						1	1		
Tipula Linnaeus	1	1	2	1	2			1			1		1
Blephariceridae													

	1972												1973
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Blepharicerus Kellogg			6		5								
Simuliidae													
Simulium Latreille				12	1	6	1	2					
Chironomidae	87	131	143	150	83	202	84	34	21	117	158	102	154
Empididae													
Hemerodromia Meigen	2	4	3	3				2					
Turbellaria													
Planariidae													
Dugesia Girard		1		1	2			1	1		1	1	1
Nematoda	5	21	2										
Oligochaeta													
Lumbriculidae					1	1			2				
Tubifecidae	16	17	3	3	3	2	1	8	21	10	11	3	3
Branchiura Beddard		4		1	1	1		4		10	3		
Amphipoda													
Gammaridae													
Gammarus Say	3	3	7	2	9	7	1	1		2	5	8	16
Decapoda													
Cambaridae													
Cambarus Erichson	1	1	4	3	3	3	2	1	2	2	3	3	2
Isopoda													
Asellidae													
Asellus Geoffroy—St. Hill				1					2			1	12
Gastropoda													
Ancylidae													
Ferrissia Walker	2	1	3	1				6	7	12	3	3	25
Physidae													
Physa Draparnaud	3	73										11	
Pleuroceridae													
Nitocris Conrad			4	4	4	2	6	2	5	3	1	1	7
Lymnaeidae													
Fossaria Westerlund		1				1							1
Pelecypoda													
Sphaeriidae													
Sphaerium Scopoli	3	4	1	3	3	6	1	1			2	6	3
Total	211	523	495	537	612	548	126	761	1149	646	670	508	791
Taxa	21	24	28	27	29	35	16	42	30	24	34	30	27

TABLE 6

Taxa of Benthic Macroinvertebrates by Month for Artificial Substrates (Composite) at Station 3

Organisms	1972 Apr	May	Jul	Aug	Sept	Nov	1973 Jan	Ma
Ephemeroptera								
Ephemeridae								
Hexagenia Walsh								
Potamonthus Pictet								
Heptageniidae								
Cinygma Eaton					1			
Stenonema Traver		100		165	130	42	33	33
Baetidae								
Ameletus Eaton								
Baetis Leach				7	8			
Caenis Stephens				13	134			
Ephemerella Walsh		136				3		14
Isonychia Eaton		53		44	3	2	3	3
Pseudocloeon Klapálek				2	1			
Tricorythodes Ulmer				193	655			
Odonata								
Agrionidae								
Hetaerina Hagen		2						
Coenagrionidae								
Argia Rambur					1			
Ischnura Charpentier				3			1	1
Gomphidae								
Gomphus Leach		2		1				
Hagenius Selys		1		1	1			
Lanthus Needham						1		1
Aeshnidae								
Aeshna Fabricius		2						
Anax Leach		1						
Boyeria MacLachlan		1						
Libellulidae								
Neurocordulia Selys		1			2			
Plecoptera								
Nemouridae								
Allocapnia Claassen								
Brachyptera Newport								
Taeniopteryx Pictet								
Perlidae								
Acroneuria Klapalek								
Neophasganophora Lestage					1		3	2
Paragnetina Kapalek								
Perlodidae								
Isogenus Newman							1	
Isoperla Banks								
Megaloptera								
Corydalidae								
Corydalus Latreille								

				1972				1973
	Apr	May	Jul	Aug	Sept	Nov	Jan	Mar
Nigronia Banks								
Trichoptera								
Rhyacophilidae								
Agapetus Curtis								
Glossosoma Curtis								
Protoptila Banks								
Philopotamidae								
Chimarra Pictet								
Psychomyiidae								
Neureclipsis McLachlan				1	4	1		
Psychomyia Pictet		1		2	14			
Hydropsychidae								
Cheumatopsyche Wallengren				3	14	25	3	2
Hydropsyche Pictet		3		12	35	46	15	19
Macronemum Burmeister								
Limnephilidae								
Limnephilus Leach		4		3	2	1		6
Neophalax McLachlan					1	1		
Leptoceridae								
Athripsodes Billberg								
Oecetis McLachlan					2			
Brachycentridae								
Brachycentrus Curtis		13		8	2	1	2	3
Helicopsychidae								
Helicopsyche Hagen						1		
Hemiptera								
Gerridae								
Gerris Fabricius								
Coleoptera								
Gyrinidae								
Dineutes MacLeay								
Hydrophilidae								
Berosus Leach				1	1	1		
Pemelus Horn								
Dryopidae								
Pelonomus Erichson								
Elmidae		3		11	1	4		
Psephenidae								
Psephenus Haldeman					1			
Diptera								
Tipulidae								
Antocha Osten Sacken				1				1
Eriocera Macquart								
Ormosia Rondani								
Tipula Linnaeus							1	
Blephariceridae								
Blephariceras Kellogg								
Simuliidae								
Simulium Latreille		1		3	2	2	4	
Chironomidae		225		444	348	68	130	99
Empididae								
Hemerodromia Meigen		5		1				1

Continued

TABLE 6 (continued)

	1972						1973	
	Apr	May	Jul	Aug	Sept	Nov	Jan	Ma
Tubellaria								
Planariidae								
Dugesia Girard		40		54	86	32	3	
Nematoda				4				
Oligochaeta								
Lumbriculidae								
Tubifecidae		19		6	4	14	6	
Branchiura Beddard					1			
Amphipoda								
Gammaridae								
Gammarus Say		11		16	1		6	
Decapoda								
Cambaridae								
Cambarus Erichson		3		2	2		1	
Isopoda								
Asellidae								
Asellus Geoffroy–St. Hill		3		2				
Gastropoda								
Ancylidae								
Ferrissia Walker				1	17			
Physidae								
Physa Draparnaud		25		41	63	17	6	
Pleuroceridae								
Nitocris Conrad		3			6	8	1	
Lymnaeidae								
Fossaria Westerlund								
Pelecypoda								
Sphaeriidae								
Sphaerium Scopoli		8		2	3			
Total		665		1092	1804	266	225	2
Taxa		26		30	33	19	17	1

TABLE 7

Taxa of Benthic Macroinvertebrates by Month for Kick Samples at Station 4

	1971						1972								1973
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
phemeroptera															
Ephemeridae															
Ephemera Linnaeus	1			1				11			3	1	2	1	
Hexagenia Walsh										4	2				
Potamanthus Pictet											2				
Heptageniidae															
Cinygina Eaton											8				1
Iron Eaton		1	3	10	2	2	17	7		9			6	2	7
Ironopsis Traver			3	6											5
Rhithrogena Eaton			1	3	7	1	12	2			1				10
Stenonema Traver	89	64	36	126	96	72	19	7	7	25	223	99	119	132	114
Baetidae															
Baetis Leach	2		8	17	12	3		63	1	113	154	39	12	2	7
Caenis Stephens								3	13	11	126	21			
Gentroptilium Eaton						1	4		2						
Ephemerella Walsh	15	11	71	184	191	171	188	56	2	2		5	51	176	431
Isonychia Eaton	59	69	43	113	85	68	37	75	37	218	342	108	106	101	69
Paraleptophlebia Lestage	1	5	1	3	1	1	3	4		1			1		
Pseudocloeon Klapalek	1		12	20	15	1	3	25	1	24	22	29	16	1	1
Tricorythodes Ulmer										1	1				
donata															
Agrionidae															
Agrion Latreille											3				
Coenagrionidae															
Argia Rambur											1				
Gomphidae															
Lanthus Needham				3	1				1	1	4	1			
Aeshnidae															
Boyeria MacLachlan											3				
lecoptera															
Pteronarcidae															
Pteronarcys Newman								1							
Nemouridae															
Allocapnia Claassen	17	1	29	103						11	14	1	17	32	
Brachyptera Newport		2	24	21										2	15
Leuctra Stephens		4					3	16	11						
Nemoura Pictet								2							
Taeniopteryx Pictet	3	13	12	5									3	3	
Perlidae															
Acroneuria Pictet	1	1		1	1	2	3	2	2	6	3	3	2		4
Neophasganophora Lestage		1			1	1				1	2	1			1
Paragnetina Klapalek						1			1		12	2			2
Perlesta Banks								3	1						

Continued

TABLE 7 (continued)

	1971 Nov	Dec	1972 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1973 Jan
Perlodidae															
Hastaperla Ricker												2			2
Isoperla Banks				3	2		1	1			3			1	2
Megaloptera															
Sialidae															
Sialis Latreille		1													
Corydalidae															
Corydalus Latreille	3	3		2	3	6	4	1	2	2	12	7	3	1	[illegible]
Nigronia Banks	1	1			1		2		1	6	5	1		1	
Trichoptera															
Rhyacophilidae															
Agapetus Curtis						1				2		3	1	2	[illegible]
Glossosoma Curtis	1			1	1	2		4		1		2	1		[illegible]
Protoptila Banks						1	1								
Rhyacophila Pictet			1			1									
Philopotamidae															
Chimarra Stephens	1					1	3					2			
Hydropsydiidae															
Cheumatopsyche Wallengren	9	7	10	7	8	11	1	28	6	59	158	240	17	29	14[illegible]
Hydropsyche Pictet	8	9	1	8	9	7	4	12	7	64	122	148	23	28	13[illegible]
Leptoceridae															
Athripsodes Billberg	2											.	2	3	
Hemiptera															
Gerridae															
Gerris Fabricius											1	2			
Coleoptera															
Dytiscidae															
Oreodytes Seidlitz								1							
Dryopidae															
Pelonomus Erichson								3							
Elmidae	104	141	87	234	41	64	10	45	23	70	150	303	102	107	6[illegible]
Psephenidae															
Psephenus Haldeman	6	6	3	2	4	6	6	7	2		3	13	15	5	[illegible]
Diptera															
Tipulidae															
Antocha Osten Sacken		2	3	6	3	9		1	1	1			7	3	1[illegible]
Eriocera Macquart											3	1	1	1	
Ormosia Rondani			1	2										2	
Tipula Linnaeus	1	1		4	6	1	1				2		1	3	
Tanyderidae															
Protoplasa Osten Sacken	1														
Blephariceridae															
Blepharicerus Kellogg					5	21	47	2							
Simulidae															

	1971						1972								1973
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan
Simulium Latreille	6	11	123	280	61	81	9	78		48	227	54	13	1	6
Chironomidae	5	63	203	349	153	107	18	82	11	116	246	50	112	54	90
Ceratopogonidae															
Palpomyia Meigen							2				1		1		
Rhagionidae															
Atherix Walker	1	1	1	1							5		3		1
Empididae															
Hemerodromia Meigen				9	7	12		1		23	5	1	2	2	
ematoda		1	4					2				1	2		
igochaeta															
Tubifecidae	11	4	9	1	4	5		5	1	1	1	3	3	6	
Lumbriculidae	2			2	1		2	8						1	
ecapoda															
Cambaridae															
Cambarus Erichson	2	3	2	2	4	3	5	2	1	3	4	1	2	2	
opoda															
Asellidae															
Asellus Geoffroy St. Hillaire				2	2										
astropoda															
Ancylidae															
Ferrissia Walker	2		1		7	3							1		1
Pleuroceridae															
Nitocris Conrad	9	3	6	1	6	7	3	7	1	3	5	7	3	1	6
lecypoda															
Sphaeriidae															
Sphaerium Scopoli					3	2									
Total	368	428	695	1532	742	675	408	567	135	834	1879	1148	651	705	1147
Taxa	29	27	27	34	32	33	27	34	23	28	37	31	32	30	29

APPENDIX B

TABLE 1

Physio-Chemical Data Collected at the Castle Rock Site New River, near Pembroke, Virginia

	1972 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1973 Jan	Feb
Water Temperature (°C)	7.00	5.50	7.00	7.50	17.00	21.00	19.50	23.00	24.00	17.00	12.00	8.00	3.00	3.00
Air Temperature (°C)	9.00	2.00	17.00	10.00	16.00	22.00	17.00	24.00	26.00	21.00	17.00	5.50	4.00	−2.00
pH	7.68	7.95	7.80	7.95	7.80	7.73	7.50	7.78	7.80	7.75	7.73	7.78	8.06	7.80
Total Alkalinity (ppm)	41.50	42.00	44.00	24.00	43.00	47.50	43.50	48.50	50.00	57.00	55.00	51.50	61.00	42.00
Phenolphthalein Alkalinity (ppm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Oxygen (ppm)	10.80	12.60	11.40	10.55	8.60	8.50	7.75	7.85	7.80	9.15	10.00	11.00	12.35	12.40
Chloride (ppm)	1.90	2.50	1.49	1.99	2.98	2.20	2.50	2.98	2.70	3.72	2.20	1.49	0.99	0.49
Nitrate (ppm as N)	2.07	1.73	5.10	3.73	3.63	8.80	2.23	5.10	4.52	16.15	1.18	1.41	8.15	1.83
Orthophosphate (ppm as P)	0.092	0.093	0.115	0.121	0.170	0.045	0.084	0.069	0.070	0.071	0.066	0.120	0.105	0.140
Condensed Phosphate (ppm as P)	0.037	0.047	0.020	0.032	0.015	0.005	0.013	0.013	0.003	0.023	0.001	0.015	0.020	0.030
Organic Phosphate (ppm as P)	—	—	0.061	0.072	0.092	0.143	0.161	0.121	0.258	0.056	0.078	0.189	0.035	0.195
Total Phosphate (ppm as P)	—	—	0.196	0.225	0.277	0.193	0.245	0.203	0.290	0.150	0.143	0.325	0.160	0.365
BOD (ppm)	1.05	0.75	2.05	1.80	0.95	1.30	1.55	4.10	3.25	2.60	1.95	1.60	1.20	0.95
Calcium Hardness (ppm)	—	—	45.00	32.00	37.00	48.00	40.00	42.00	45.00	50.00	45.00	45.00	50.00	38.00
Magnesium Hardness (ppm)	—	—	20.00	11.00	14.00	17.00	18.00	19.00	12.00	17.00	15.00	17.00	15.00	17.00
Total Hardness (ppm)	—	47.00	65.00	43.00	51.00	65.00	58.00	61.00	57.00	67.00	60.00	62.00	65.00	55.00
Sulfate (ppm)	—	—	24.80	15.10	9.00	17.30	11.20	15.20	20.40	23.70	17.00	14.00	18.00	15.00
Conductivity (millimhos)	0.112	0.107	0.123	0.116	0.092	0.080	0.253	0.112	0.121	0.169	0.153	0.147	0.158	0.126

TABLE 2

Physio-Chemical Data Collected at the Lees–McVitty Site
New River, near Bluff City, Virginia

	1972												1973	
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Water Temperature (°C)	7.00	6.00	8.00	9.00	16.50	22.00	20.00	24.00	23.00	17.00	12.00	9.00	3.00	2.50
Air Temperature (°C)	9.00	2.00	18.00	14.00	16.00	22.00	25.00	25.00	26.00	21.00	18.50	5.50	4.00	–2.00
pH	7.75	7.90	7.80	7.97	7.80	7.85	7.49	7.70	7.95	8.04	7.83	7.87	8.00	7.80
Total Alkalinity (ppm)	44.00	48.50	55.50	26.00	47.00	52.00	42.00	43.50	58.50	57.00	52.00	45.00	63.00	50.50
Phenolphthalein Alkalinity (ppm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Oxygen (ppm)	10.80	12.35	11.10	10.60	9.30	8.40	7.95	7.85	7.90	9.20	10.00	10.75	12.40	12.50
Chloride (ppm)	2.20	2.20	1.05	1.05	3.22	1.98	2.20	2.20	2.50	3.47	2.20	1.74	0.99	0.49
Nitrate (ppm as N)	1.91	1.22	4.66	3.28	2.58	7.80	2.10	4.80	6.60	10.05	0.92	1.23	6.10	1.60
Orthophosphate (ppm as P)	0.080	0.068	0.070	0.115	0.140	0.084	0.092	0.072	0.045	0.094	0.070	0.135	0.084	0.115
Condensed Phosphate (ppm as P)	0.042	0.035	0.045	0.037	0.020	0.046	0.006	0.009	0.007	0.015	0.015	0.029	0.022	0.035
Organic Phosphate (ppm as P)	––	––	0.068	0.093	0.086	0.162	0.173	0.123	0.248	0.026	0.254	0.306	0.069	0.205
Total Phosphate (ppm as P)	––	––	0.183	0.245	0.246	0.292	0.265	0.204	0.290	0.135	0.309	0.470	0.175	0.355
BOD (ppm)	0.90	0.75	2.55	1.20	1.05	3.80	4.80	3.45	5.60	3.10	2.70	2.10	1.10	0.90
Calcium Hardness (ppm)	––	––	45.00	30.00	40.00	50.00	45.00	45.00	40.00	45.00	43.00	41.00	45.00	40.00
Magnesium Hardness (ppm)	––	––	23.00	11.00	15.00	20.00	15.00	18.00	20.00	20.00	18.00	20.00	20.00	15.00
Total Hardness (ppm)	––	42.00	68.00	41.00	55.00	70.00	60.00	63.00	60.00	65.00	61.00	61.00	65.00	55.00
Sulfate (ppm)	––	––	21.90	11.00	8.30	19.40	9.40	13.60	20.60	17.50	21.30	17.00	19.00	16.00
Conductivity (millimhos)	0.119	0.109	0.127	0.115	0.097	0.084	0.296	0.129	0.115	0.152	0.137	0.122	0.153	0.125

TABLE 3

Physio-Chemical Data Collected at the Boxley White and Ould Sites, New River, near Glen Lyn, Virginia

	1972 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1973 Jan	Feb
Water Temperature (°C)	8.00	6.00	6.50	9.00	17.00	21.00	20.00	24.00	24.00	16.00	11.50	9.00	3.50	2.50
Air Temperature (°C)	10.00	1.50	16.00	17.00	22.00	22.00	17.00	25.00	25.00	21.00	18.00	7.50	5.00	–1.00
pH	7.73	8.00	7.80	7.95	7.83	7.80	7.68	7.72	8.05	8.01	7.79	7.85	7.90	7.80
Total Alkalinity (ppm)	46.00	51.00	44.00	23.00	48.00	54.00	52.50	45.00	61.00	59.00	53.00	46.50	61.50	59.00
Phenolphthalein Alkalinity (ppm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Oxygen (ppm)	10.70	12.30	11.50	10.55	8.70	8.50	7.80	7.95	7.80	9.20	10.20	10.70	12.30	12.50
Chloride (ppm)	2.20	2.20	0.99	1.49	2.98	1.98	1.90	2.70	2.20	1.49	1.05	0.99	0.99	0.49
Nitrate (ppm as N)	1.83	1.03	5.33	3.51	3.55	6.00	1.83	4.50	5.66	7.00	0.87	1.15	3.55	1.33
Orthophosphate (ppm as P)	0.085	0.075	0.090	0.130	0.160	0.071	0.098	0.087	0.012	0.131	0.111	0.165	0.131	0.140
Condensed Phosphate (ppm as P)	0.041	0.030	0.040	0.027	0.014	0.003	0.005	0.007	0.003	0.004	0.010	0.056	0.022	0.060
Organic Phosphate (ppm as P)	––	––	0.059	0.062	0.078	0.157	0.187	0.164	0.180	0.105	0.190	0.274	0.052	0.165
Total Phosphate (ppm as P)	––	––	0.189	0.219	0.252	0.231	0.285	0.258	0.195	0.240	0.311	0.495	0.205	0.365
BOD (ppm)	1.80	0.75	1.85	0.40	0.75	1.05	2.70	3.85	5.10	2.95	2.10	2.40	1.80	1.10
Calcium Hardness (ppm)	––	––	51.00	30.00	40.00	50.00	45.00	48.00	45.00	50.00	40.00	47.00	45.00	35.00
Magnesium Hardness (ppm)	––	––	22.00	15.00	15.00	25.00	15.00	17.00	18.00	20.00	18.00	15.00	20.00	15.00
Total Hardness (ppm)	––	37.00	73.00	45.00	55.00	75.00	60.00	65.00	63.00	70.00	58.00	62.00	65.00	50.00
Sulfate (ppm)	––	––	20.70	9.80	8.10	23.10	11.20	6.80	15.70	19.00	20.50	22.00	19.10	13.70
Conductivity (millimhos)	0.119	0.098	0.116	0.109	0.095	0.202	0.267	0.278	0.239	0.153	0.147	0.135	0.162	0.131

Physio-Chemical Data Collected at the Lafayette Site, South Fork, Roanoke River, Shawsville–Elliston, Virginia

	1972												1973	
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Water Temperature (°C)	4.00	2.00	4.00	7.00	14.00	17.00	17.00	19.00	19.00	11.50	10.00	9.00	2.00	0.25
Air Temperature (°C)	9.00	1.00	6.00	17.00	18.00	24.00	18.50	20.00	26.00	12.00	18.00	8.50	5.00	−5.00
pH	8.07	8.10	8.10	8.20	8.17	8.26	8.30	8.29	8.50	8.11	8.10	8.14	8.08	8.10
Total Alkalinity (ppm)	89.00	87.00	91.75	72.00	93.00	120.50	70.00	97.00	152.00	133.00	97.50	72.50	103.00	113.50
Phenolphthalein Alkalinity (ppm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Oxygen (ppm)	12.15	12.60	12.40	11.65	9.75	9.10	9.00	8.55	8.60	10.50	10.60	10.75	12.60	13.10
Chloride (ppm)	0.49	0.98	0.99	1.49	2.73	2.45	2.50	2.98	2.70	2.98	2.50	1.49	0.99	0.49
Nitrate (ppm as N)	0.56	0.49	3.16	1.84	1.32	1.16	0.97	1.30	1.43	2.51	0.51	1.13	2.40	1.06
Orthophosphate (ppm as P)	0.023	0.042	0.030	0.073	0.120	0.042	0.103	0.068	0.045	0.101	0.057	0.080	0.075	0.005
Condensed Phosphate (ppm as P)	0.034	0.021	0.030	0.041	0.020	0.038	0.012	0.009	0.007	0.010	0.021	0.010	0.005	0.001
Organic Phosphate (ppm as P)	––	––	0.054	0.071	0.062	0.134	0.130	0.127	0.148	0.001	0.063	0.195	0.045	0.104
Total Phosphate (ppm as P)	––	––	0.174	0.185	0.202	0.214	0.245	0.204	0.20	0.112	0.141	0.285	0.125	0.110
BOD (ppm)	0.25	0.70	1.30	0.55	0.40	1.15	1.65	1.90	2.55	1.50	0.80	1.20	1.00	0.30
Calcium Hardness (ppm)	––	––	70.00	65.00	60.00	70.00	55.00	65.00	60.00	48.00	50.00	50.00	55.00	55.00
Magnesium Hardness (ppm)	––	––	50.00	45.00	37.00	55.00	40.00	50.00	45.00	37.00	39.00	40.00	40.00	40.00
Total Hardness (ppm)	––	90.00	120.00	110.00	97.00	125.00	95.00	115.00	105.00	85.00	89.00	90.00	90.00	95.00
Sulfate (ppm)	––	––	17.30	8.90	11.30	15.50	12.60	14.20	17.90	19.00	15.70	12.50	14.30	13.60
Conductivity (millimhos)	0.106	0.117	0.122	0.113	0.098	0.175	0.254	0.156	0.142	0.265	0.197	0.177	0.123	0.115

TABLE 5

Values for Heavy Metals Determinations from New River From Route 114 Crossing—Radford, Virginia

Average for 3 years		1970–1971			1971–1972			1972–1973			
		Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	
.147	Aluminum	0.125	0.003	0.500	0.070	0.005	0.376	0.245	0.004	1.585	ppm
2.181	Chromium	1.665	0.100	6.600	1.685	0.130	4.230	3.194	0.530	8.720	ppb
1.739	Copper	2.202	0.530	6.080	1.585	0.790	2.380	1.431	0.260	2.640	ppb
1.768	Lead	1.904	0.260	3.430	2.090	0.260	4.490	1.310	0.130	2.640	ppb
2.685	Mercury	5.217	0.260	87.180	0.598	0.010	1.850	2.241	0.030	15.590	ppb
1.865	Nickel	2.239	0.130	5.280	1.837	0.130	3.430	1.519	0.260	2.910	ppb
6.177	Zinc	5.702	1.850	18.230	6.759	1.850	15.590	6.070	2.640	17.900	ppb

*From a three year report—preimpoundment ecological reconnaissance of the New River in the area of the proposed Appalachian Power Company's Blue Ridge Project by Benfield and Cairns.

TABLE 6
Monthly Flow Data at Stations 1, 2, 3, and 4 for the Dates of Collection of Water Quality Data*

	Station 1	Station 2	Station 3	Station 4
Jan 72	5,520	6,350	7,150	297
Feb 72	4,880	6,010	7,160	333
Mar 72	5,610	6,170	7,680	317
Apr 72	5,680	6.180	6,720	802
May 72	4,990	5,150	5,320	482
June 72	3,210	3,410	3,620	156
July 72	5,000	6,910	8,800	732
Aug 72	3,520	3,860	4,170	173
Sept 72	1,270	1,450	1.620	76
Oct 72	1,150	1,420	1,700	117
Nov 72	2,130	4,210	2,300	196
Dec 72	9.890	13,450	17,000	1,240
Jan 73	1,870	1,970	2,080	245
Feb 73	6,520	6,750	6,980	435

*values obtained from U.S.G.S. Gauging Stations, and expressed in cubic feet per second (cfs)

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