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GEOLOGICAL SURVEY

LIMNOLOGICAL STUDIES OF THE MAJOR STREAMS IN CHESTER COUNTY, PENNSYLVANIA

By Bruce W. Lium

Open-File Report 77-462

Prepared in cooperation with the

Chester County Water Resources Authority,
and Chester County Board of Commissioners

Doraville, Georgia

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FACTORS FOR CONVERTING ENGLISH UNITS TO

INTERNATIONAL SYSTEM (SI) UNITS

Multiply English Units	By	To obtain (SI) Units
Inches (in)	25.40	Millimeters (mm)
Feet (ft)	.3048	Meters (m)
Miles (mi)	1.609	Kilometers (km)
Acres (a)	.4047	Hectare (ha)
Square miles (mi^2)	2.590	Square Kilometers (km^2)
Tons per square miles per yr [T/mi^2)/yr]	.3503	Tonnes per square kilometer per year [t/km^2)/yr]
Tons per acre per year [(T/a)/yr]	2.242	Tonnes per hectare per year [(t/ha)/yr]

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ABSTRACT

The major streams in Chester County, Pennsylvania were studied to determine their environmental state, and to relate this condition to land-use patterns. A biological numerical rating system on a scale of 1 to 10 was developed to classify stream conditions. One indicates extremely toxic conditions and 10 balanced biological conditions. The majority of the streams studied had ratings between 4 and 8, indicating they were experiencing varying degrees of enrichment and/or sediment deposition. The streams with high numerical ratings were generally found in rural and agricultural areas. Streams with low numerical ratings were found mostly in areas near waste treatment facilities or industry. Large changes in the numerical rating of a stream were related to changes in land-use patterns.

Relationships were developed between dissolved solids concentrations and the biological numerical ratings of the streams. Streams with ratings from 6 to 10 had dissolved solids concentrations of approximately 100 mg/L. At ratings of 5 to 1, the dissolved solids concentrations increased progressively from 122 to 310 mg/L.

Chemical data for the streams were related to the dominant orders of benthic invertebrates. The stoneflies were found to be the most sensitive to high levels of chemical constituents. The trueflies, mayflies, and caddis flies showed a wide tolerance to various chemical constituents.

INTRODUCTION

Chester County in the Piedmont physiographic province area of Pennsylvania (fig 1) is undergoing rapid transition from a rural to a suburban land-use due to population growth. This report describes chemical, biological, and physical measurements and observations made on the major streams in Chester County over a 5-year period. Chemical, biological, and physical data are published in an open-file report by Lium, (1976). These findings will be useful to those concerned with water-resources management as urbanization continues, and the data can be used to compare present conditions with those of the next several decades.

ACKNOWLEDGMENTS

This report was prepared by the U.S. Geological Survey in cooperation with the Chester County Water Resources Authority and the Chester County Board of Commissioners, West Chester, Pennsylvania as part of a program to provide limnological data for evaluating the environmental condition of streams. The author extends deep appreciation to Luna B. Leopold and Robert G. Struble, who conceived, helped direct, and provided many helpful comments and suggestions in this study. The author is also indebted to the members and staff of the Chester County Water Resources Authority, who have shown a sincere and continuous interest throughout the investigation.

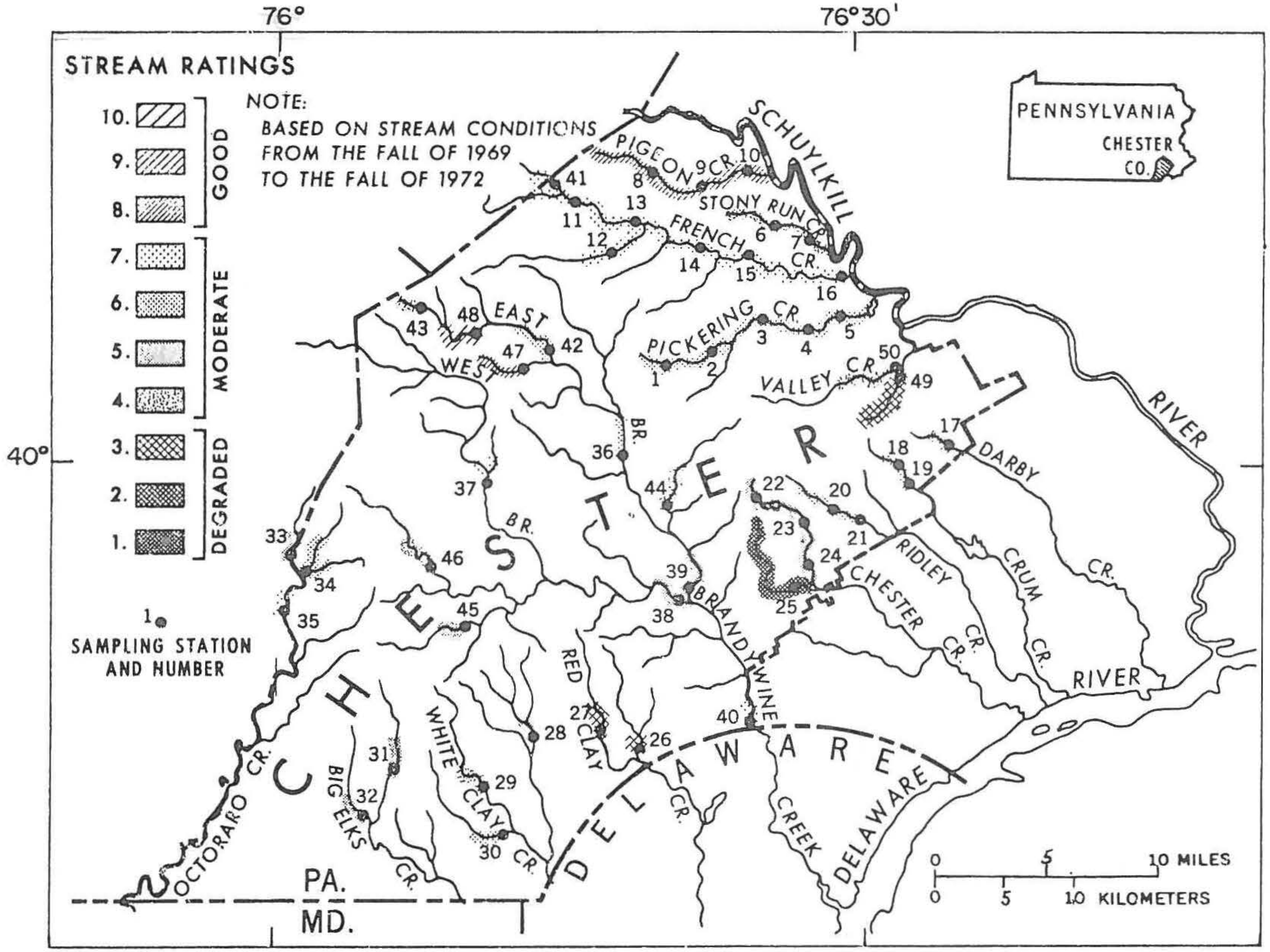


Figure 1.--Summary of environmental conditions on various stream reaches, Chester County, Pennsylvania.

David C. Yaeck, Executive Director, Chester County Water Resources Authority, generously devoted time to the study and preparation of the manuscript. In addition, many persons, particularly Richard Casson, Chester County Health Department, have been of utmost assistance, and appreciation is extended the Department's willingness to provide space for the field office.

THE BASINS AND LAND USE

Chester County encompasses 760 mi^2, of which 697 mi^2 are drained by the 13 basins discussed in this paper. The county, basins, and sampling sites are shown in figure 1. All streams originate within the boundaries of the county, except short reaches in the headwaters of the West Branch Brandywine Creek, French, and Octoraro Creeks. Octoraro Creek forms part of the western boundary of the county, and its headwaters lie in both Chester and Lancaster Counties.

Steepness of slope is a major factor determining urban, agricultural, and commercial land uses. Construction costs, soil erosion, soil thickness, water supply, and accessibility are all effected adversely as the slope steepens.

The Soil Conservation Service does not recommend building on slopes greater than 15 percent. Using this criterion, about 52 percent of the county is suitable for most building.

Approximately two-thirds of the county is suitable for agriculture. The Chester Silt Loam and Limestone Soils are considered to be the most productive cropland, and are located mostly in the Chester Valley and Southern Piedmont areas of Chester County. Major crops are hay, winter wheat, corn, garden crops, mushrooms, dairy cattle, and beef.

Deciduous hardwoods are the main timber in the area and commonly include red and black oak, tulip poplar, beech, sugar maple, and chestnut oak as the dominant types. Approximately 19 percent of Chester County, 96,000 acres, is considered woodland and is usually situated on steep, less productive soils. Many local efforts have been made to conserve the present woodland, and many new trees, particularly conifers, are planted each year through the efforts of the Soil Conservation Service and local conservation groups.

STUDY OBJECTIVES AND HISTORY

A major goal of the project is to further the understanding of stream changes in response to urbanization. The collection of physical, chemical, and biological data is necessary to establish a basis for comparing changes.

The investigation began in the fall of 1969 as a cooperative effort among the U.S. Geological Survey, the Chester County Water Resources Authority, and the Chester County Board of Commissioners. The project was conceived by Luna B. Leopold, former Chief Hydrologist, U.S. Geological Survey, and Robert G. Struble, former Director of the Chester County Water Resources Authority.

In the fall of 1969, the area was reconnoitered to determine the general nature of streams and land-use practices and patterns. The reconnaissance served as a guide in establishing a water-quality network of 40 sampling sites in the 13 major stream basins. Each site in a given basin was established on equal cumulative square miles of drainage area within a basin. The locations of the present sites are shown in figure 1 and listed in table 1. Figure 2 consists of photographs of some typical stream reaches in Chester County.

During 1969 and 1970, sampling was conducted quarterly. During 1971 and 1972, sampling was conducted only during the spring and fall. In 1973, sampling was reduced to once a year and 10 new sampling sites were added.

DATA COLLECTION METHODS

During each visit to a site benthic invertebrates were sampled from riffles by collecting 10 rocks (45-90 mm in diameter) at random (Lium, 1974). All invertebrates from the rocks were placed in a vial containing 70 percent ethyl alcohol for later identification. Observations of the abundance of other benthic invertebrates were also made. A transect of 50 feet was made to determine percentage composition of diatoms, green algae, blue-green algae, and rooted aquatics on the streambed. The transects were made along the upper part of the riffle and in reaches where the width of the stream was less than 50 feet. Where the reaches were not 50 feet wide, several small transects were made to total 50 feet. The transects were measured using an anchored cloth tape, lying on the substrate. At each foot interval a visual estimate was made of the percentage composition of each kind of major floral type. A final percentage composition of each floral type was determined for the 50 feet. Observations were made as to the presence of sediment deposition on the substrate in the riffles, including the margins and in the adjacent pools.

TABLE 1.--

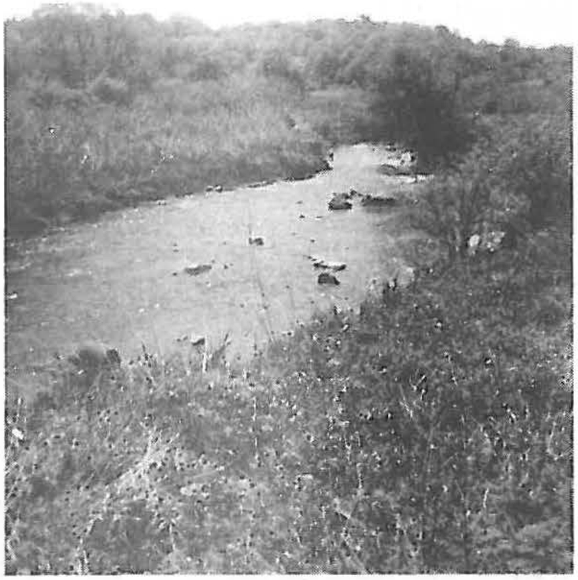
Station numbers and names

USGS station number	Sampling site	Name
01472170	1	Pickering Creek near Eagle
01472174	2	Pickering Creek near Chester Springs
01472186	3	Pickering Creek near Marlin
01472188	4	Pickering Creek near Charlestown
01472191	5	Pickering Creek near Phoenixville
01472109	6	Stony Run near Spring City
01472110	7	Stony Run at Spring City
01472054	8	Pigeon Creek near Bucktown
01472065	9	Pigeon Creek near Porters Mill
01472080	10	Pigeon Creek near Parker Ford
01472129	11	French Creek near Knaurertown
01472140	12	South Branch French Creek at Coventryville
01472139	13	French Creek near Coventryville
01472154	14	French Creek near Pughtown
01472157	15	French Creek near Phoenixville
01472162	16	French Creek at Phoenixville
01475300	17	Darby Creek at Waterloo Mills near Devon
01475830	18	East Branch Crum Creek near Paoli
01475840	19	West Branch Crum Creek near Paoli
01476430	20	Ridley Creek near Goshenville
01476435	21	Ridley Creek near Dutton Mill
01476790	22	Chester Creek near West Chester
01476830	23	Chester Creek near Milltown
01476835	24	Chester Creek at Westtown School
01476840	25	Goose Creek near West Chester
01479800	26	Red Clay Creek near Five Point
01479780	27	Red Clay Creek near Kennett Square
01478120	28	White Clay Creek near Avondale
01478190	29	White Clay Creek near Wickerton
01478220	30	West Branch White Clay Creek near Chesterville
01494900	31	Elk Creek at Elkview
01494950	32	Elk Creek near Oxford
01578340	33	Octoraro Creek near Atglen
01578343	34	Valley Creek near Atglen
01578345	35	Octoraro Creek near Steelville

TABLE 1.--

Station numbers and names--Continued

USGS station number	Sampling site	Name
01480700	36	East Branch Brandywine Creek near Downingtown
01480430	37	West Branch Brandywine Creek near Coatesville
01480640	38	West Branch Brandywine Creek at Wawaset
01480950	39	East Branch Brandywine Creek at Wawaset
01481000	40	Brandywine Creek at Chadds Ford
01472126	41	French Creek near Trythall
01480655	42	East Branch Brandywine Creek near Glenmore
01480647	43	East Branch Brandywine Creek near Struble Dam
01480803	44	Valley Creek at Mullsteins Meadows
01480632	45	Doe Run near Springdale
01480629	46	Buck Run near Doe Run
01480656	47	Indian Creek near Springton
01480648	48	East Branch Brandywine Creek near Cupola
01473167	49	Little Valley Creek near Valley Forge
01473168	50	Valley Creek near Valley Forge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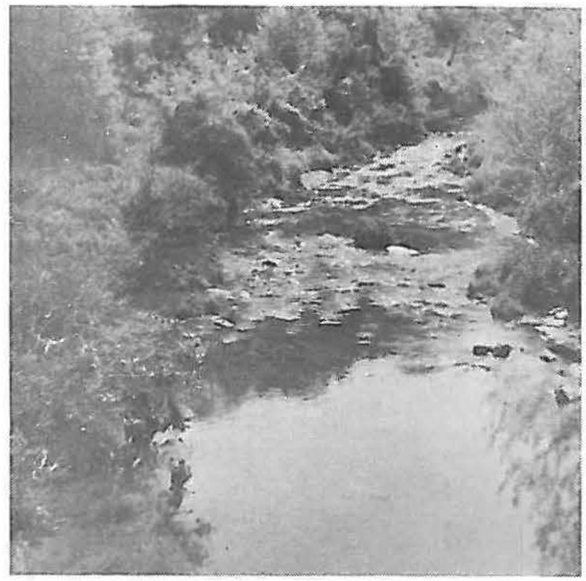
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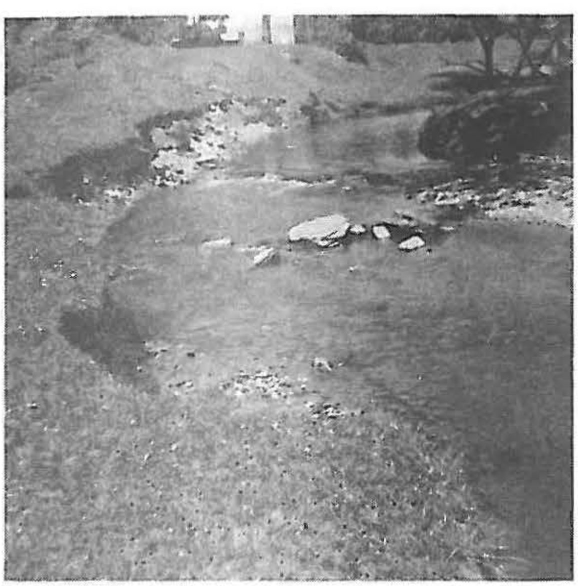
E


F

Figure 2.--Some typical stream reaches in Chester County.

A - Goose Creek (station 25) near West Chester and below a municipal waste treatment plant. Stream reach was always practically devoid of life.

B - Pristine area of Big Elk Creek (station 32), a typical riffle area of sampling.

C - Chester Creek (station 23) in an agricultural area.

D - Typical substrate from which benthic invertebrates were collected (Octoraro Crrk, station 33).

E - East Branch White Clay Creek (station 28), May 1971, prior to tropical storm Agnes.

F - East Branch White Clay Creek (station 28), May 1973. Stream bank erosion due primarily to tropical storm Agnes in 1972.

Field determinations were made of pH, dissolved oxygen, air and water temperature, and specific conductance. Discharge was measured and suspended-sediment samples were taken. Water samples were collected for laboratory determinations of chemical oxygen demand, total phosphate, orthophosphate, organic nitrogen, ammonium-N, nitrite-N, nitrate-N, sulfate, chloride, dissolved solids, sodium, calcium, magnesium, manganese, and potassium.

CHARACTERISTICS OF BENTHIC INVERTEBRATE POPULATIONS

Between the fall of 1969 and the fall of 1974, a total of 42,435 benthic invertebrates were collected from 255 samples. The identification for the most part was to genus, but in some cases, only to family. Ten orders, 10 families, and 61 genera are represented. The Diptera, Ephemeroptera, and Tricoptera were the three dominant orders. Individuals of Coleoptera, Hymenoptera, Lepidoptera, Megaloptera, Neuroptera, Odonata, and Plecoptera were scarce. In figure 3, the relative abundance of benthic invertebrates in each dominant order are shown by percentage for each of the sampling periods: spring and fall 1970 and 1971 and fall 1972. The greatest numbers of trueflies (Diptera) were consistently obtained in the spring and the fewest in the fall. The opposite was true of the caddis flies (Tricoperta). The midges (Chironomidae) and blackflies (Simulidae) were dominant families of trueflies; and Stenonema, Ephemerella, and Baetis were dominant genera of mayflies (Ephemeroptera). Hydropsyche and Cheumatopsyche were dominant genera of caddis flies (Tricoptera).

The number of individuals decreased between the spring of 1970 and the fall of 1971. In the spring of 1970, a total of 4,273 benthic invertebrates were found. In the fall of 1971, the number found was 1,123. This large reduction in the fall 1971 was probably due primarily to scouring as a result of high storm runoff preceding sampling. The fall 1972 sampling was made four months after Tropical Storm Agnes, which caused record high flow.

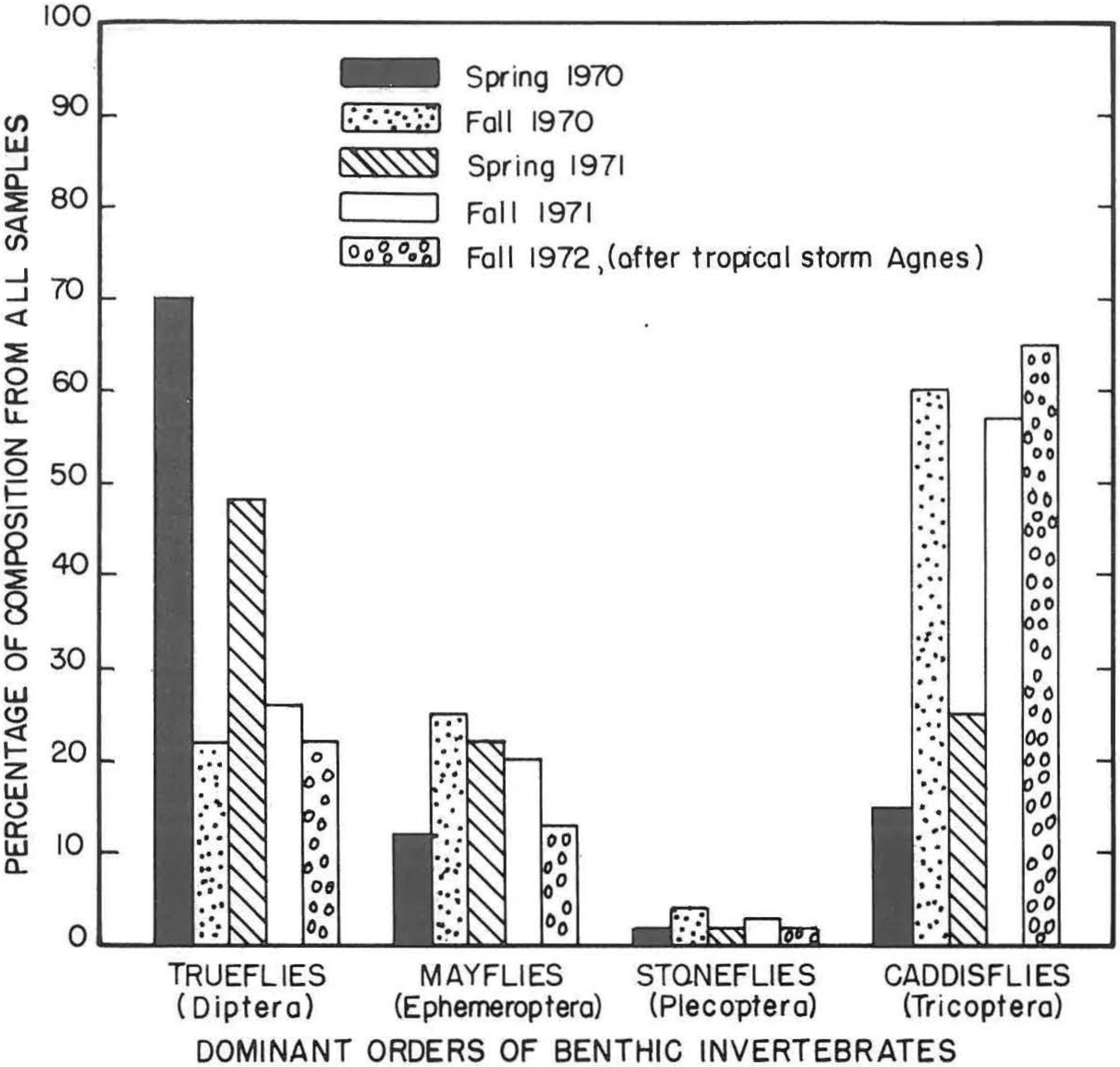

Figure 3.--Relative abundance of major groups of aquatic insects by season. Data from 10-rock samples.

The total number of individuals collected from the 40 stations during that sampling was 14,397. These findings are indicative of repopulation of areas scoured by high flows. The high populations in the fall of 1972 after flooding could possibly be explained by a reduction of predators coincident with a large increase in species having a short life cycle and able to reproduce quickly. Also, new organisms from headwater tributaries and areas unaffected by flooding could have drifted in subsequent to the flooding.

BENTHIC INVERTEBRATE DENSITY AS A FUNCTION OF ROCK SIZE

In agreement with data from streams in western United States, (Lium, 1974), a maximum density of invertebrates per square centimeter of rock-surface area was found on cobbles in the 45- to 90-mm size category, as determined by measurement of the B-axis (Leopold and others, 1964). Smaller and larger rocks, including sizes in the 22-, 32-, and 128-, and 180-mm categories, displayed lower density of individuals per square centimeter of rock area. As indicated in figure 4 for French and Pigeon Creeks, the number of individuals per unit area of rock surface was maximum in the medium size (45 to 90 mm rocks). The rock sizes sampled included the 22, 32, 45, 64, 90, 128, and 180 mm size categories.

BIOLOGICAL NUMERICAL RATING SYSTEM

Several systems have been proposed to describe stream conditions. Emphasis has usually been given to chemical and physical systems; only recently has interest in biological systems developed. Chutter (1972) reviewed the different systems that have been proposed and discussed their application. He emphasized the need for a system whose results could be expressed simply. This need fostered other attempts to classify streams and is particularly evident in a paper by Cairns and Dickson (1971) describing a simple method for assessing impact of waste discharge on benthic organisms.

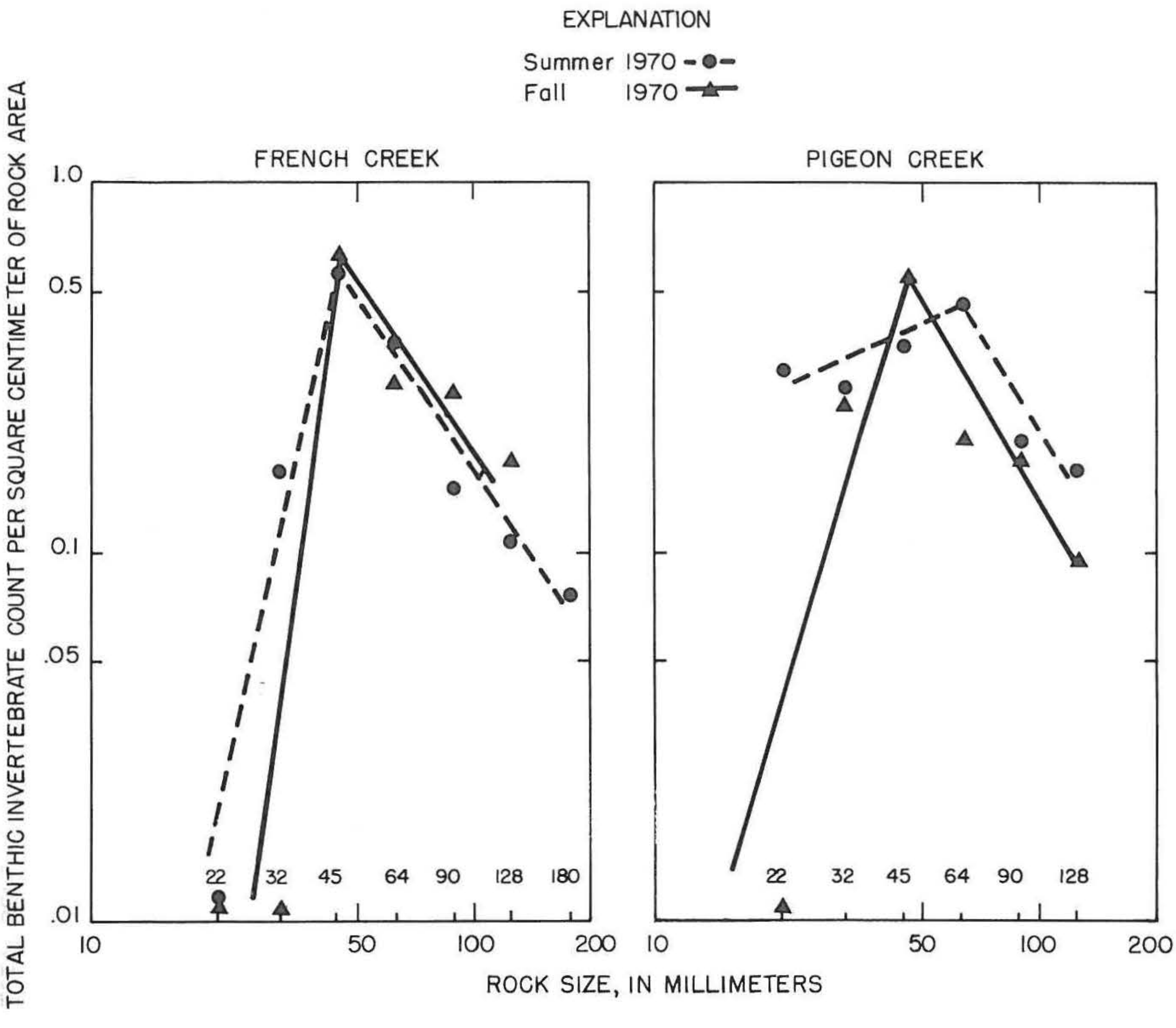

Figure 4.--Total benthic invertebrate count per square centimeter of rock areas as a function of rock size for French and Pigeon Creeks: Summer and fall, 1970.

The system for Chester County is shown in table 2 and is on a scale from 1 to 10. A value of 10 indicates balanced biological conditions, and a value of 1 indicates extreme toxic conditions. The ratings are summarized in table 3. An example of how the field data were utilized in the rating system is shown in table 4.

The system is applicable only to data collected from riffle areas and from biotypes within the riffle that are fully aquatic. The rating system in its present form may have application for the general eastern Piedmont province, but may be of limited usefulness outside the Piedmont.

BIOLOGICAL NUMBERICAL RATINGS FOR CHESTER COUNTY STREAMS

Figure 5 illustrates the ratings for each station for the spring and fall seasons of 1970, and the fall seasons of 1971 through 1974. These ratings are for selected reaches of the various streams and should not be interpreted to represent the condition of a stream along its entire length. Many reaches of the streams appeared to be pristine. Some reaches were experiencing problems from sewage treatment wastes, industrial waste, urbanization, and malfunctioning of drainfields, all of which can contribute undesirable materials. The Pigeon Creek stations showed the highest ratings of all the streams. The spatial differences in stream conditions are shown in figure 1.

Toxic conditions were found repeatedly at station 16 on French Creek and at station 25 on Goose Creek. Moderate to heavy enrichment was found at stations 26 and 27 on the Red Clay Creek. This was also the general case at station 24 on Chester Creek.

TABLE 2.--

Biological numerical rating system for

Chester County streams

Sediment deposition in pools, along stream margins, and on substrate	Rating	Indicators
Light	10	Diatoms covering 50-75 percent of the stream bed, green algae 0-25 percent; blue-green algae, 0-10 percent. Rooted aquatics absent or in small patches. Mayflies, caddis flies, or stoneflies are the more common benthic invertebrates. Other benthic invertebrates 0-25 percent of the fauna.
Light	9	Some of the major groups of benthic invertebrates absent or in small number, i.e.: filter feeders. All forms of algae and rooted aquatics moderate to sparse.
Light	8	Diatoms covering 0-75 percent of the stream bed, green algae, 0-25 percent; blue-green algae, 0-25 percent. Rooted aquatics may be present, but less than 25 percent of the stream bed covered. Mayflies and stoneflies 25-50 percent of the insect fauna. Other benthic invertebrates 0-25 percent of the fauna.
Moderate	7	Small populations of all organisms throughout most of the year or low due to natural phenomena. Mayflies and stoneflies 25 percent of the insect fauna.
Moderate	6	Caddis flies comprising 25-75 percent of the insect fauna, mayflies and stoneflies 0-25 percent. Blackflies and midges less common. Diatoms covering 0-75 percent greens, blue-green and rooted aquatics 0-25 percent.

TABLE 2.--

Biological numerical rating system for Chester Co. streams--Cont.

Sediment deposition in pools, along stream margins, and on substrate	Rating	Indicators
Moderate	5	Diatoms covering 0-50 percent of the stream bed, green algae 0-50 percent, blue-green algae 0-25 percent. Rooted aquatics may cover more than 25 percent of the stream bed. Caddis flies comprising 25-80 percent of the insect fauna and mayflies and stoneflies 0-25 percent. Blackflies and midges may be common. Flatowrms may be common. Other benthic invertebrates 0-25 percent of the fauna.
Moderate	4	Diatoms covering 0-25 percent of the stream bed, green and blue-green algae 25-75 percent. Rooted aquatic beds may cover 25-50 percent of stream bed. Stoneflies absent or rare, mayflies, comprising 0-25 percent of insect fauna, blackflies or midges 0-25 percent. Other benthic invertebrates 0-90 percent of the fauna.
Moderate to Heavy	3	Diatoms covering 0-25 percent of the stream bed, green and blue-green algae 50-75 percent rooted aquatics in small patches. Blackflies, midges or caddis flies comprising 50-100 percent of insect fauna if present. Flatworms and snails may be common. Other benthic invertebrates 0-50 percent of fauna.
Moderate to Heavy	2	All forms of algae may be sparse. Caddis flies, blackflies, and midges may be present, but rare. Other benthic vertebrates rare.
Moderate to Heavy	1	All forms of algae rare. No benthic invertebrates present or if present, rare.

TABLE 3.--

Numerical Rating Indications

Stream Conditions	Rating [1/]	Indication
Good	10	Balanced biological condition
Good	9	Slight imbalance in biological condition
Good	8	Signs of enrichment or some effects from sediment deposition
Moderate	7	Natural-induced phenomena, and/or scouring, or some enrichment
Moderate	6	Light enrichment
Moderate	5	Moderate enrichment
Moderate	4	Moderate to heavy enrichment
Degraded	3	Heavy enrichment
Degraded	2	Light toxicity
Degraded	1	Heavy toxicity

1/ Ratings of 9 to 3 may also be indicative of effects of sediment deposition.

TABLE 4.--

An example of how field data are utilized in the rating system

East Branch Brandywine Creek near Downingtown (Station 36)

Observations of benthic invertebrates from 10-rock sample

Common Name	Order	Genera	Number Found	Relative abundance in percent
Mayflies	Ephemeroptera	Stenonema	22	
		Baetis	13	
		Ephemerella	9	48.9
		Isonychia	1	
Caddis flies	Tricoptera	Hydropsyche	31	
		Cheumatopsyche	12	46.7
Stoneflies	Plecoptera	Perlesta	2	3.3
		Acroneuria	1	
Beetles	Coleoptera	Psephenus	1	1.1
		TOTALS	92	100.0

Observations of floral types from in-stream transects:

Diatoms covering 25 percent of the streambed.

Green Algae covering 16 percent of the streambed.

Blue-green Algae covering 4 percent of the streambed.

Rooted Aquatics covering 1 percent of the streambed.

Some sediment deposition observed.

Station rating - 8. Incicates signs of enrichment (fig 1, and table 1)

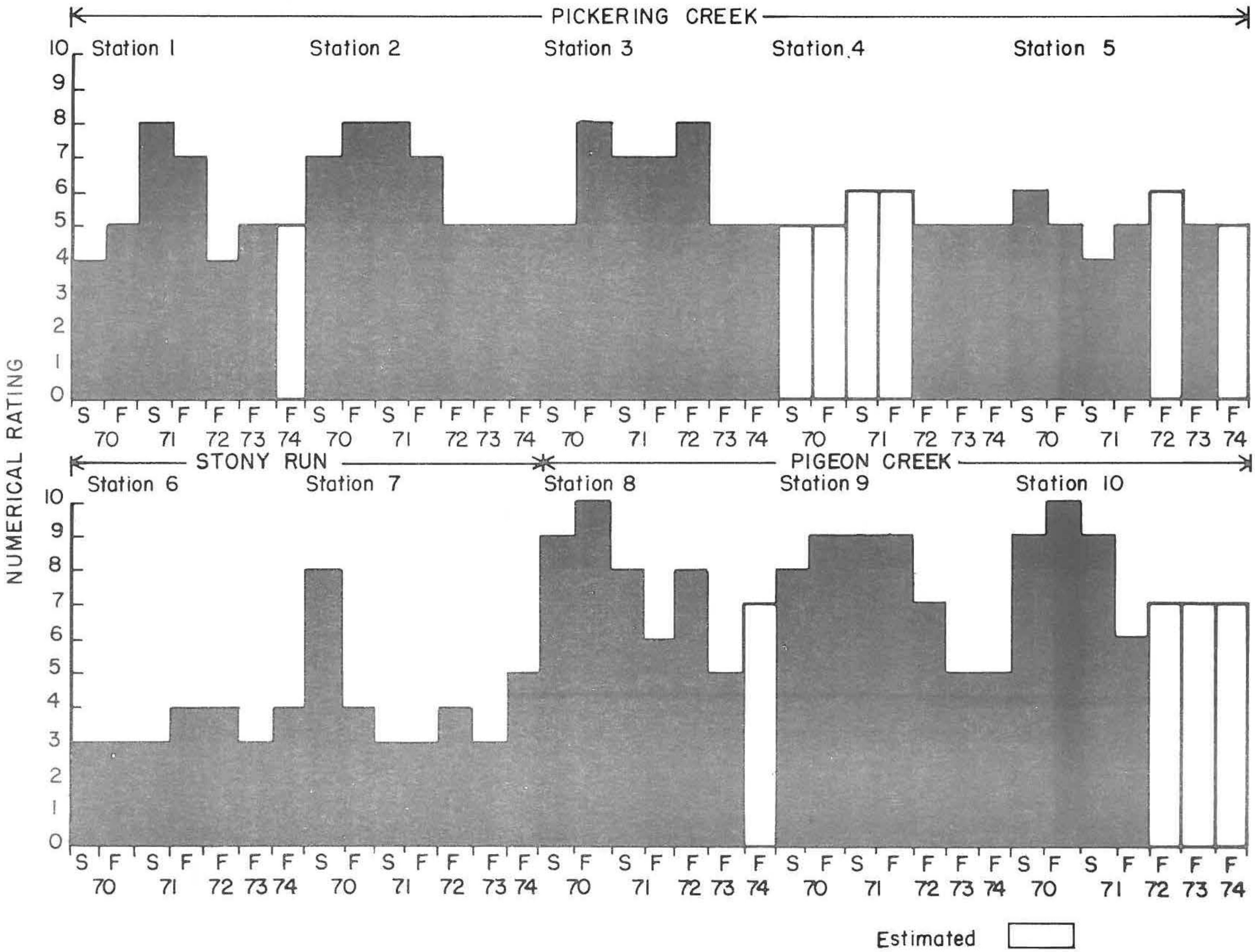

Figure 5.--Biological numerical ratings by station and season.

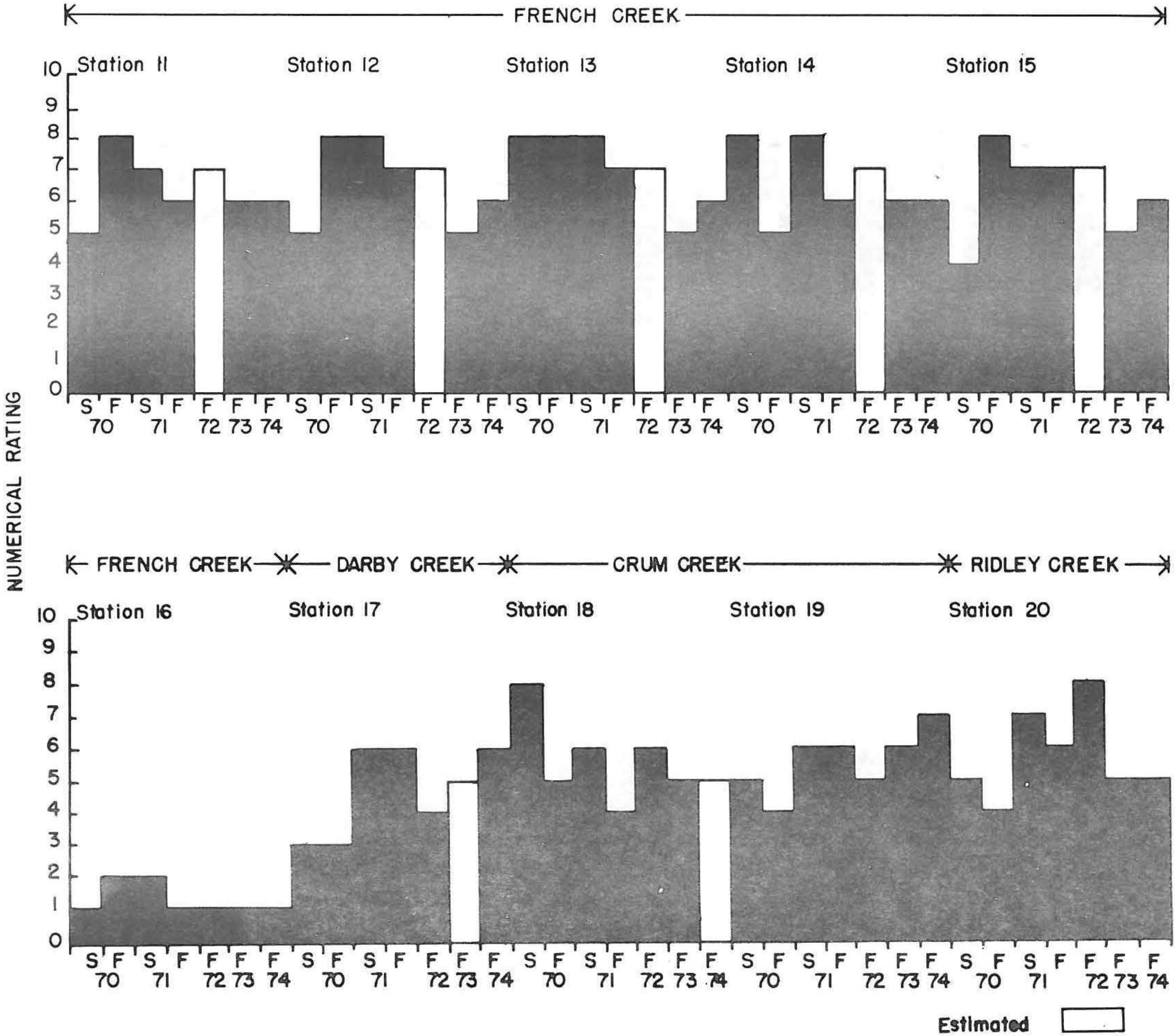

Figure 5.--Continued

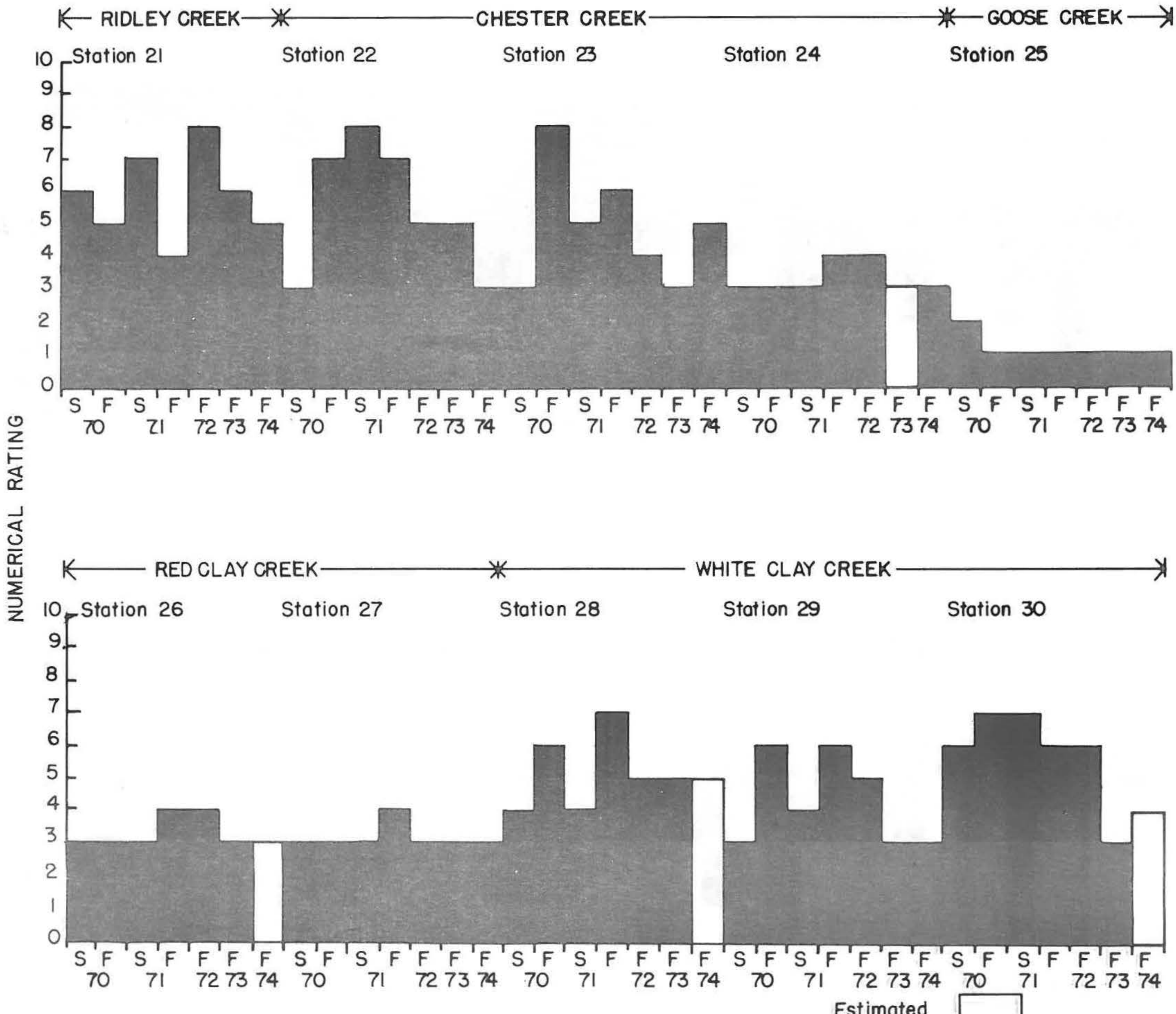

Figure 5.--Continued

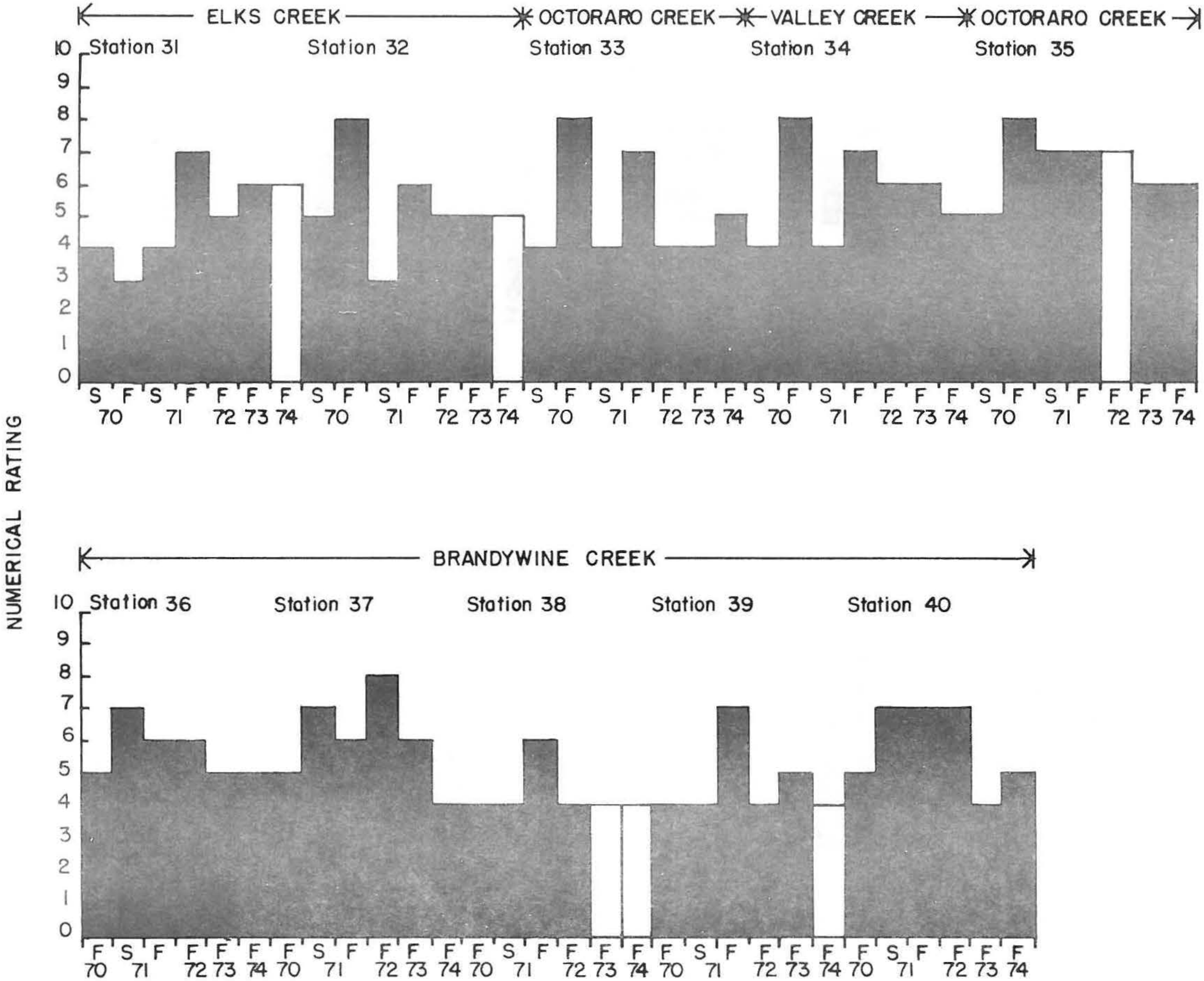

Figure 5.--Continued

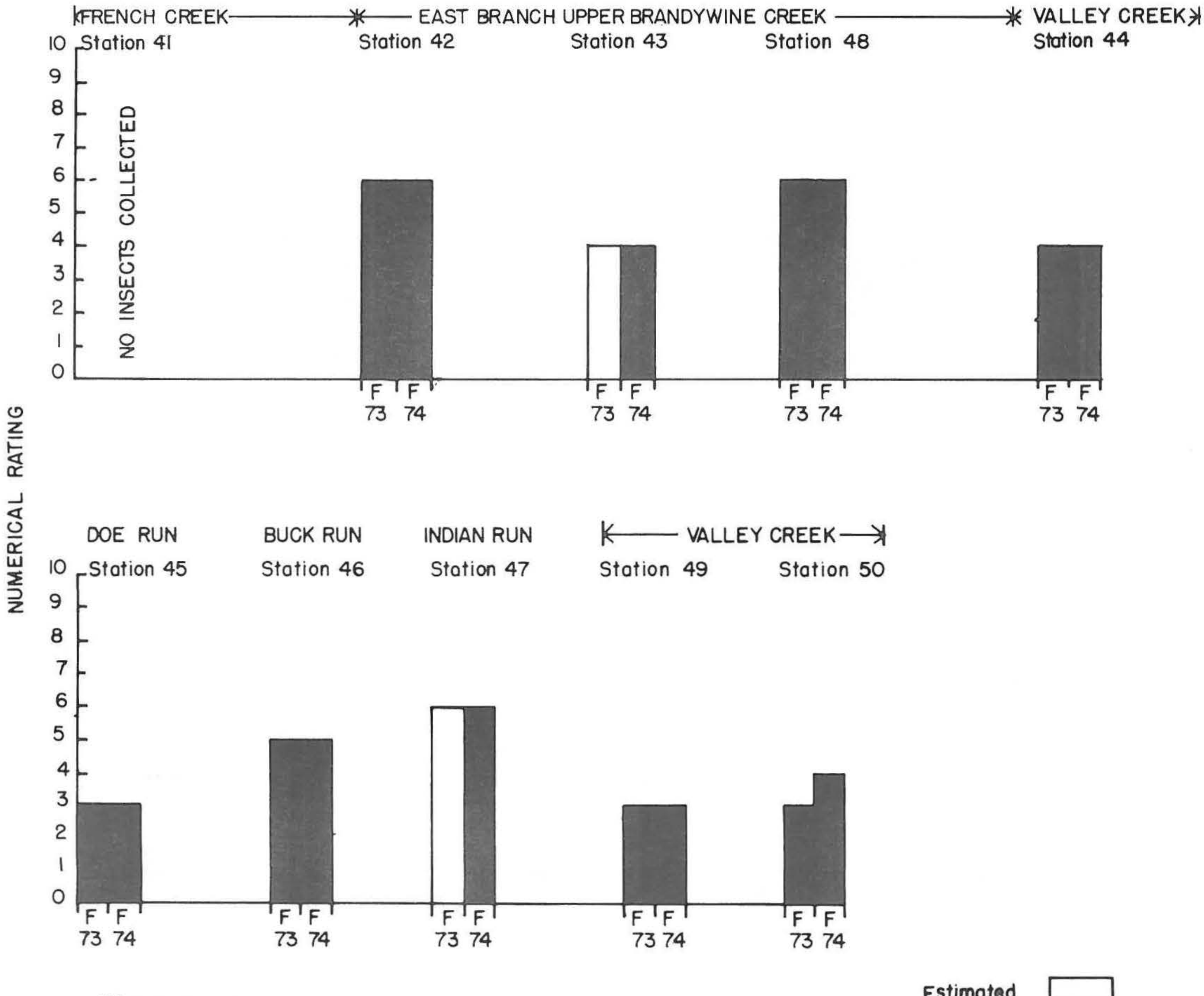

Figure 5.--Continued

A majority of the stream reaches were rated between values of 4 and 8, which indicate that most of the reaches were in moderate to good biological condition. Perhaps the most dramatic change in stream conditions occurred at station 7 on Stony Run. This reach of stream showed a decline from a rating of 8 in the spring of 1970 to a rating of 3 in fall of 1971 and of 4 in fall 1972.

A plot of the ratings of the first 40 stations versus the dominant land use in the vicinity of the station is shown in figure 6. The categories of land use are rural (nonfarm), farm, urban, municipal, industry, and waste treatment.

The lowest ratings (1.25 and 3.25) were those of stations near waste-treatment facilities and industries. The ratings of stations near municipalities ranged from 3.25 to 5.75, and those of stations near urban areas ranged from 4.50 to 7.75. The wide range of the ratings in the farming areas is probably indicative of differences in farming practices. It may also be indicative of whether winter crops are grown. Fields which are left uncultivated between growing seasons are susceptible to increased erosion, and therefore a greater potential exists for increased sediment yield to the stream. The ratings of stations in strictly rural or combined rural and farm ranged from 6.00 to 8.75.

Leopold (1968) summarized the effect of urban development on the hydrology of streams. Attention was given to sediment yield as a function of urbanization from data collected in other areas, and a forecast was made of the conditions which might be expected in the Brandywine as a result of urbanization. Wolman (1964) studied the effects of urbanization on sediment yield and found the yield in some areas of the eastern United States to range from 1,000 to greater than 100,000 tons per square mile per year.

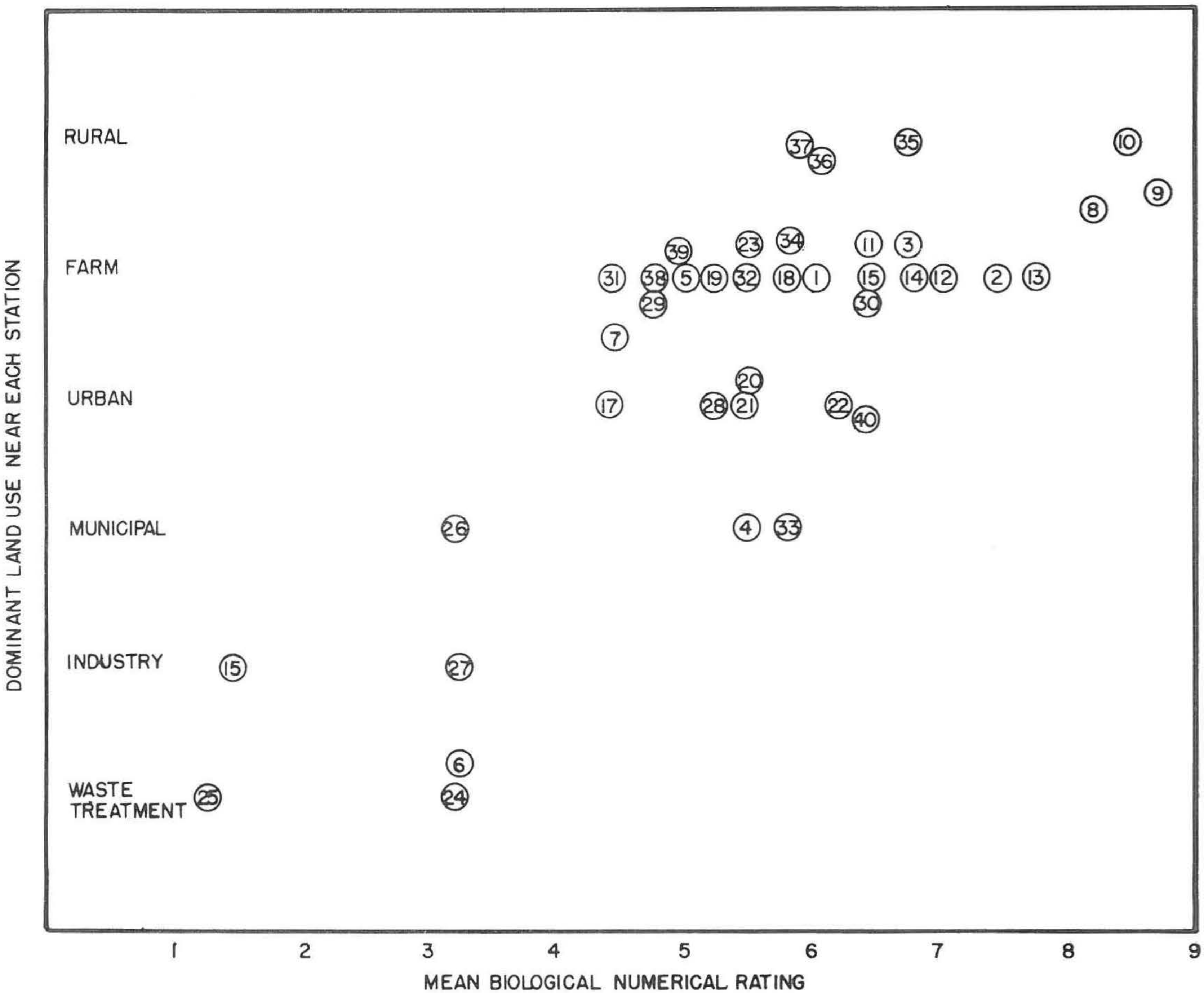

Figure 6.--Dominant land use near each station versis mean biological ratings.

Wolman stated that sediment yield from an acre of ground undergoing development, such as highway construction, could exceed 20,000 to 40,000 times the amount from farm and wooded areas over the same period.

An excessive amount of sediment deposition on the substrate in pools and riffles can have a significant effect on the biota of a stream. Detrimental effects of excessive sediment deposition include smothering of the organisms by interference with respiration, destruction of habitats by covering, elimination of food sources, and direct elimination of organisms through abrasion. One or more of these factors operating alone, or in combination might allow only a very few organisms of any kind to live successfully.

Stony Run at station 7 changed dramatically from a good biological condition to a degraded one. The biological numerical rating values were 8 in the summer 1970, 4 in the fall 1970, 3 in the summer and fall 1971, and 4 in the fall 1972. To determine the cause of this change, the effect of industrial pollution from upstream was investigated. The magnitude of the change, however, did not correlate with the upstream influence, as the upstream reach was in a good biological condition. Thus, this source could not be assigned as the major cause of stream degradation.

Further investigation revealed no other point sources of pollution entering the stream, and therefore changes in land use practices, which could produce an increase in the amount of sediment reaching the stream, may have been the major factor in the changes observed at station 7.

A field investigation of the Stony Run Basin was carried out with Mr. George E. Coller, District Conservationist, Soil Conservation Service, West Chester, Pennsylvania. With the aid of soil maps and aerial photographs, changes were observed in the types of crops now being grown as compared to previous years and in the degree of urbanization, both of which could cause an increase in the sediment load of the stream.

Using standard techniques of the U.S. Soil Conservation Service (1963) for estimating soil loss or sediment production, calculations were made to determine the possible increased soil loss from 1958 to 1971 in two areas on Stony Run. The areas were above stations 6 and 7, and were 485 and 510 acres, respectively. The results are shown in table 5. During the period from 1958 to 1971 there were major changes in land usage within two watershed areas that account for the increased loss of soil. In the areas above station 6, approximately 46 acres or 9.5 percent of the area were changed from grass-cover crops to cornfields, and approximately 4 acres or 8 percent were changed from farmland to an urban condition. The Soil Conservation Service reports that a change from grass-cover crops to cornfields can result in an increased soil loss of about 10 tons per acre per year. The soil loss that occurs when land changes from farmland to urban may range from several hundred to several thousand tons per acre per year during the transitional period.

The change in land usage above station 7 during the period 1958 to 1971 was more pronounced because approximately 37 acres or 7.3 percent of the area was changed from grass-cover crops to cornfields, and approximately 66 acres or 12.9 percent of the area was changed from farmland to an urban condition. Approximately 46 acres of the new urban development were under construction during the period from 1969 to 1971.

TABLE 5.--

Soil loss in two reaches of Stony Run Creek: (1958-71)

Station	(Acres) Above station	Year	Soil loss (tons per acre per year)
6	(485)	1958	9
		1971	12
7	(510)	1958	10
		1971	16

The above results were obtained using a modification of the techniques of the Soil Conservation Service because the study averages the effects of the changes in the two watersheds, whereas, in standard comparisons for soil loss, changes are shown by individual field or individual new home or housing development. The results in table 5 are, however, indicative of how changes in land use can affect soil loss, and also of the degraded biological condition at station 7 on Stony Run.

COMPARISON OF STREAM CONDITIONS WITH THOSE OF OTHER INVESTIGATIONS

In the summer and fall of 1967, Patrick and Grant (Miller and others, 1971) conducted surveys in six areas of the Pickering Creek and East Branch Brandywine Creek basins. Several areas in the basins were the same as areas studied in this investigation, so it is worth comparing the results of their observations and measurements with the results obtained for this paper.

Patrick and Grant found the corresponding reaches of Pickering Creek to be healthy, but to have different degrees of enrichment. They indicated the greatest enrichment was at their station P5 near the lower end of Pickering Creek which corresponds to station 5 in this study. Their results are in general agreement with the findings of this study.

Their results were also in general agreement with the author's in various areas of the East Branch Brandywine Creek. As was found in this study, Patrick and Grant also found the various reaches in this basin to be "healthy", but to have differing degrees of enrichment.

BIOLOGICAL CONDITIONS AS RELATED TO CHEMICAL CONSTITUENTS IN THE STREAMS

Chemical analyses of water made during the investigations included determinations of chemical oxygen demand, total phosphate, orthophosphate, organic nitrogen, ammonium-N, nitrite-N, nitrate-N, sulfate, chloride, dissolved solids, sodium, calcium, magnesium, manganese, and potassium. Field determinations were made of air and water temperature, specific conductance, and pH.

The objective of these analyses was to show the relation between chemical constituents in the water and the biological condition of the stream. Figure 7 shows the mean and the range of dissolved-solids concentrations for each numerical rating. The mean concentration of dissolved solids between the ratings of 1 and 5 decreased progressively from 310 to 122 mg/L. At ratings from 6 to 10 the mean concentration of dissolved solids was approximately equal to 100 mg/L. No other correlations were found between chemical constituents and biological conditions.

A summary relating the minimum and maximum values of the chemical data to the dominant orders of benthic invertebrates is presented in table 6. The minimum and maximum values of all chemical constituents were generally lower where the stoneflies (Plecoptera) were present, indicating that they are more sensitive to high levels of chemical constituents than the other orders of benthic invertebrates. Trueflies, mayflies, and caddis flies appeared to tolerate a wide range of chemical changes in the streams.

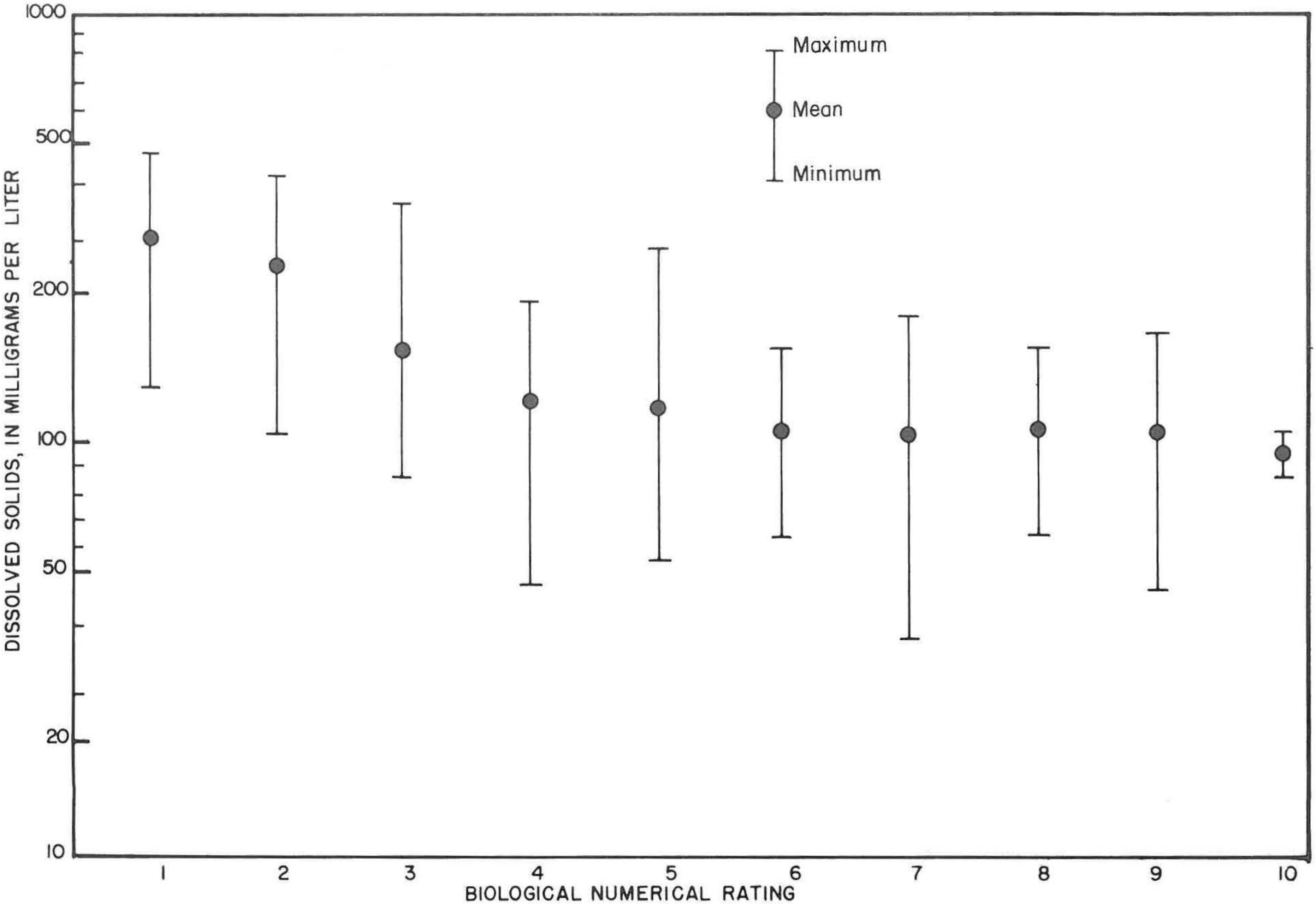

Figure 7.--Relation of dissolved-solid concentrations to biological numerical ratings.

TABLE 6.--

Ranges of Stream Quality parameters acceptable to the Dominant

Orders of Benthic Invertebrates (Results in mg/L except temperature, pH, and conductance)

DOMINANT ORDER

	Trueflies (Diptera)		Mayflies (Ephemeroptera)		Stoneflies (Plecoptera)		Caddis Flies (Tricoptera)	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Temperature (oC)	5	20	17	16	3	17		
pH	6.1	8.7	6.6	8.8	6.9	8.7	6.6	8.8
Specific Conductance (micromhos per centimeter at 25°C)	100	460	100	200	40	190	100	520
Chemical O_2 Demand	1	569	1	109	1	48	1	109
Total Phosphate	0.009	6.500	0.020	0.490	0.003	0.114	0.029	0.740
Ortho Phosphate	0.003	5.900	0.003	0.390	0.003	0.035	0.003	0.680
Organic Nitrogen	0.03	4.80	0.03	1.00	0.01	0.90	0.07	1.00
Ammonium-N	0.01	13.80	0.01	1.28	0.01	0.05	0.01	1.28
Nitrite-N	0.001	0.535	0.001	0.0036	0.001	0.008	0.001	0.054
Nitrate-N	0.067	8.100	0.067	5.400	0.050	2.300	0.248	5.400
Sulfate	7.70	89.30	9.10	89.30	6.90	43.90	9.10	89.30
Chloride	2.55	64.00	5.00	31.00	4.60	19.13	11.60	45.97
Dissolved Solids	62.0	228.0	100.0	187.0	62.0	188.0	103.0	272.0
Sodium	0.75	42.50	2.50	16.30	3.41	9.68	5.51	35.76
Calcium	2.7	35.3	11.6	19.4	7.6	17.3	11.6	23.4
Magnesium	0.8	15.1	4.1	7.0	1.9	6.2	4.2	17.0
Manganese	0.0	0.50	0.0	0.28	0.0	0.16	0.0	0.42
Potassium	0.75	13.25	0.75	3.35	0.92	2.23	0.75	5.85

BIOLOGICAL CONDITIONS AS RELATED TO SUSPENDED SEDIMENT CONCENTRATIONS

The relationship between suspended-sediment concentrations and biological conditions are illustrated in figure 8. The plotted points represent mean values of the maximum and minimum suspended-sediment concentration measured at each station compared to the numerical rating of the stream at that station. Mean suspended-sediment concentrations were greater than 100 mg/L in stream reaches which were rated as toxic. Mean concentrations less than 5 mg/L were measured in stream reaches which were rated as moderate or good.

SUMMARY

A biological numerical rating system, based on a scale of 1 to 10, was used to estimate the environmental conditions of streams. A value of 10 indicates balanced biological conditions and a value of 1 indicates toxic conditions.

Based on this rating system, Pigeon Creek had the most favorable biological conditions of all streams studied. Toxic conditions were found at station 16 on French Creek and at station 25 on Goose Creek. Moderate to heavy enrichment conditions were found at stations on Red Clay and Chester Creeks. The environment of Stony Run declined from a rating of 8 in the spring of 1970 to a rating of 3 in the fall of 1971 and of 4 in fall of 1972. Most stream reaches had ratings between 4 and 8, indicating that they were in relatively good environmental condition. Most sampling stations were in farming areas, a few in urban and non-farm (rural) areas and two to three in municipal, industrial, or waste-treatment areas.

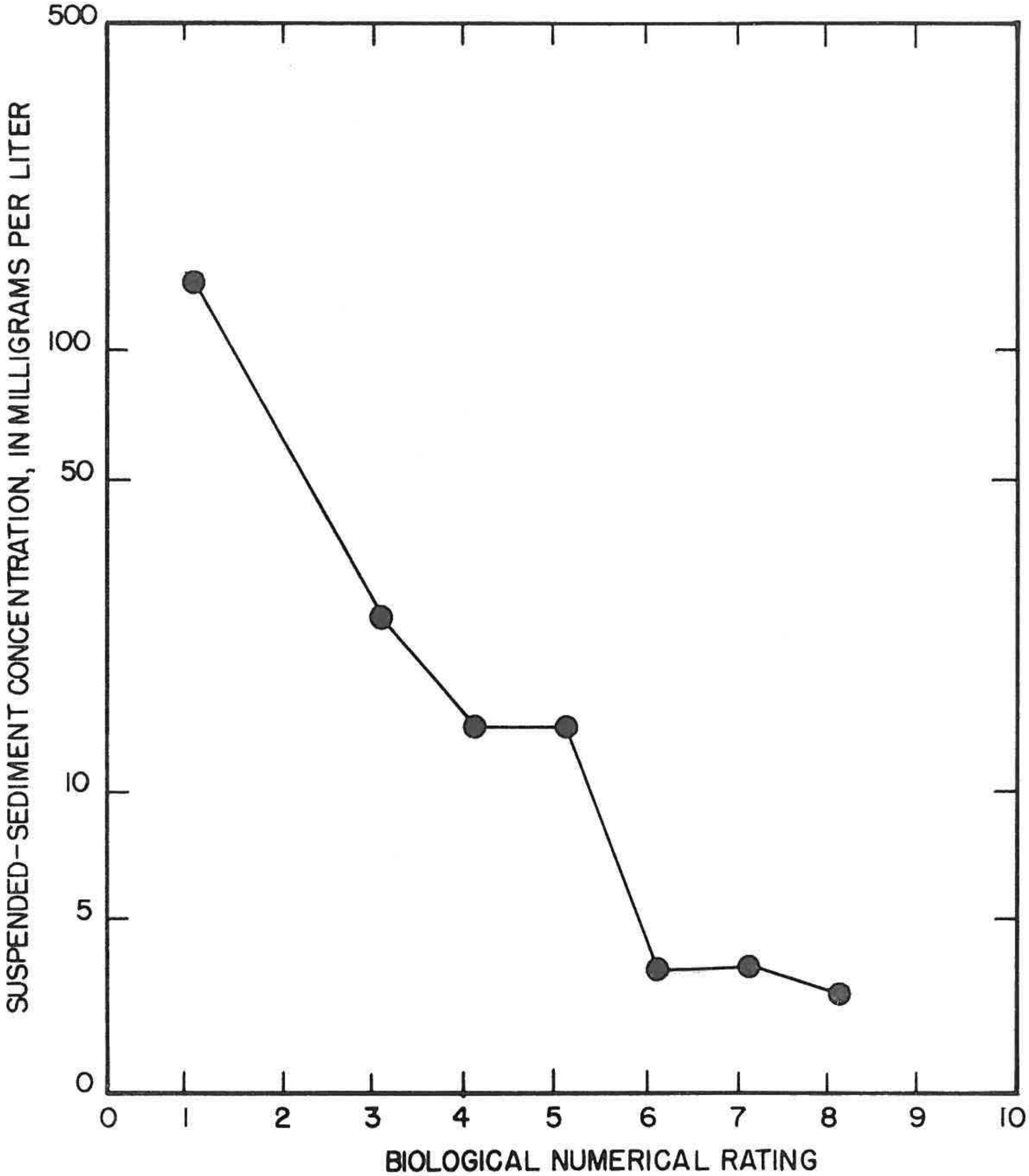

Figure 8.--Relation of suspended sediment concentrations to biological numerical ratings.

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