AB-318

CONSTRUCTION PHASE

ECOLOGICAL MONITORING PROGRAM

MARBLE HILL NUCLEAR GENERATING STATION

UNITS 1 AND 2

FINAL REPORT

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APPLIED BIOLOGY, INC.

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TABLE OF CONVERSION FACTORS FOR METRIC UNITS

To convert	Multiply by	To obtain
centigrade (degrees)	(°C x 1.8) + 32	fahrenheit (degrees)
centigrade (degrees)	°C + 273.16	kelvin (degrees)
centimeters (cm)	3.937×10^{-1}	inches
centimeters (cm)	3.281×10^{-2}	feet
centimeters/second (cm/sec)	3.281×10^{-2}	feet per second
cubic centimeters (cm^3)	1.0×10^{-3}	liters
grams (g)	2.205×10^{-3}	pounds
grams (g)	3.527×10^{-2}	ounces (avoirdupois)
kilograms (kg)	1.0×10^{3}	grams
kilograms (kg)	2.2046	pounds
kilograms (kg)	3.5274×10^{1}	ounces (avoirdupois)
kilometers (km)	6.214×10^{-1}	miles (statute)
kilometers (km)	1.0×10^{6}	millimeters
liters (l)	1.0×10^{3}	cubic centimeters (cm^3)
liters (l)	2.642×10^{-1}	gallons (U.S. liquid)
meters (m)	3.281	feet
meters (m)	3.937×10^{1}	inches
meters (m)	1.094	yards
microns (μ)	1.0×10^{-6}	meters
milligrams (mg)	1.0×10^{-3}	grams
milligrams/liter (mg/l)	1.0	parts per million
milliliters (ml)	1.0×10^{-3}	liters (U.S. liquid)
millimeters (mm)	3.937×10^{-2}	inches
millimeters (mm)	3.281×10^{-3}	feet
square centimeters (cm^2)	1.550×10^{-1}	square inches
square meters (m^2)	1.076×10^{1}	square feet
square millimeters (mm^2)	1.55×10^{-3}	square inches

INTRODUCTION

Public Service Company of Indiana, Inc. (PSI), contracted Applied Biology, Inc. (ABI), to conduct a construction phase ecological monitoring program at the Marble Hill Nuclear Generating Station-Units 1 and 2, located near Madison, Indiana. This report presents the results of that monitoring program and the analyses of all ecological data collected between 24 March and 6 November 1980.

The objectives of this program were to 1) ascertain and document the existing ecological conditions in the immediate vicinity of the Marble Hill Nuclear Generating Station and 2) provide reference information to be used in the assessment and minimization of the effect of plant construction and operation on the local environment.

To meet these objectives, Applied Biology, Inc., conducted a sampling program based on specifications formulated in the Construction Phase Ecological Monitoring Program of Sargent and Lundy Engineers' Specification Y-2961 dated 15 April 1976. During 1980, the plankton, periphyton, macroinvertebrate, fish and larval fish communities, as well as chemical and physical parameters, were sampled at six aquatic sampling stations.

AQUATIC MONITORING PROGRAM

The aquatic sampling stations (Stations 1, 3, 5, 6, 8 and 14; Figure 1) were sampled in March, May, August and November 1980. Station 1, located in the Ohio River 183 meters upstream of Big Saluda Creek, was selected to represent conditions above the intake of the proposed plant. Station 3 is located in the area of the proposed intake and discharge, where construction impacts are most likely to occur. Station 5 is the downstream station selected to represent conditions after complete mixing of the thermal plume. Stations 6 and 8 are located in creeks that drain the northern and eastern margins, respectively, of the plant site. Stations 1, 3, 5 and 6 were established at locations sampled in a baseline study conducted during 1974-75. Station 8 was added in 1977 to study erosion from construction activities. Station 14, located 5 kilometers downstream from the proposed intake, was added in 1978 as a check on the typicality of Stations 1, 3 and 5. Station numbers of the present study are consistent with those used in the baseline study (Stations 2, 4, 7, 9, 10, 11 and 12 were sampled during the baseline study and were not sampled in this study).

1980 ECOLOGICAL MONITORING PROGRAM

Sampling at the aquatic and terrestrial stations was performed as outlined by Sargent and Lundy's Specification Y-2961. Samples for each parameter were analyzed and the data reduced. Dates and purposes of all field trips and personnel involved are presented in Table 1. The 1980 monitoring program was essentially a repeat of monitoring conducted during 1977-1979.

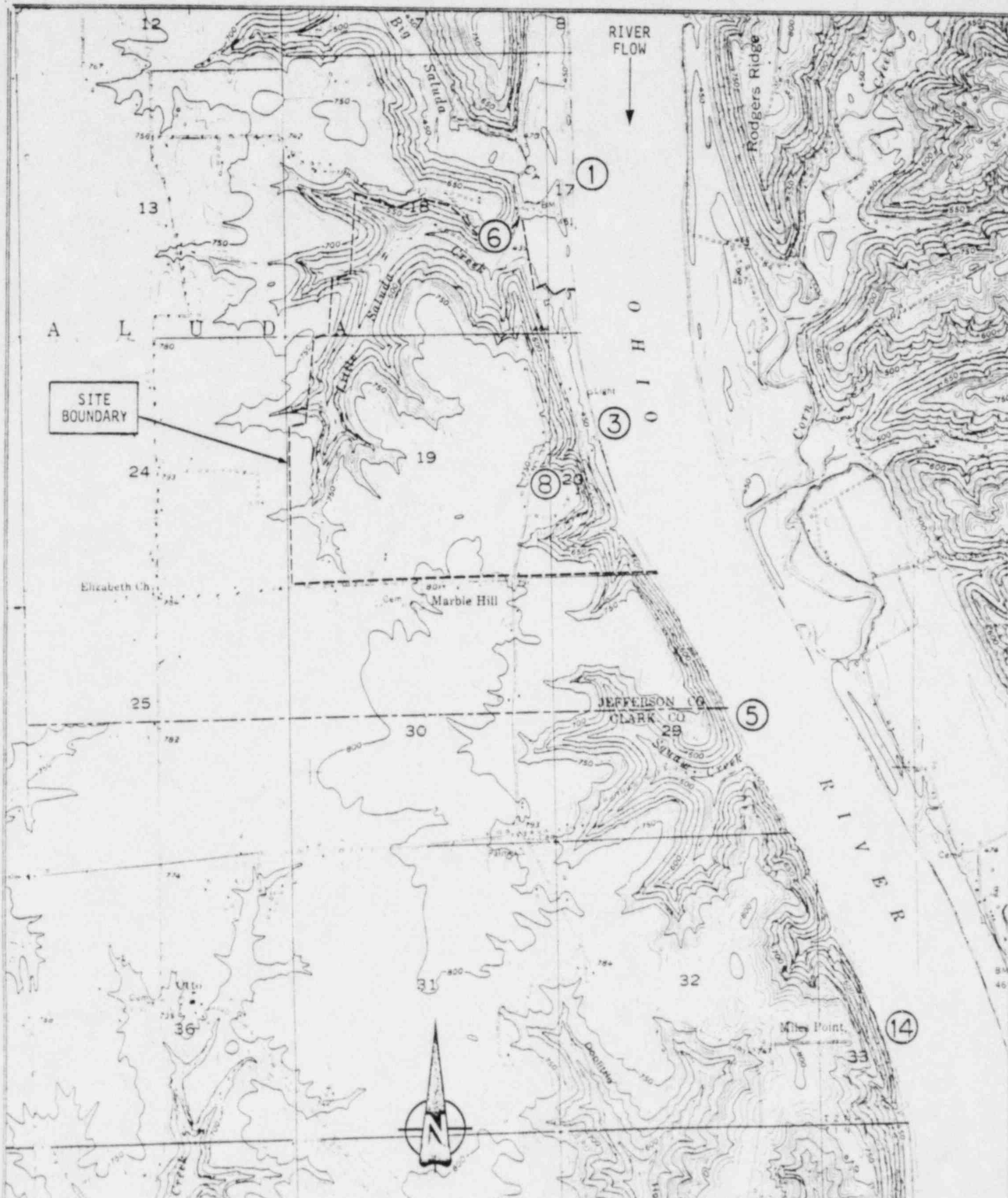

Figure 1. Locations of sampling stations. Marble Hill Plant site, 1980.

TABLE 1

FIELD WORK
MARBLE HILL PLANT SITE
MARCH - NOVEMBER 1980

Date	Purpose of field trip	ABI personnel
3 March	Placing of periphyton and macroinvertebrate samplers	J. Russell L. Mason
24-27 March	1st quarterly sampling	W. Rhodes J. Russell L. Mason H. Kania
9 April	1st fish eggs and larvae collection	L. Mason J. Russell
23 April	2nd fish eggs and larvae collection	L. Mason J. Russell
7 May	3rd fish eggs and larvae collection Placing of periphyton and macroinvertebrate samplers	L. Mason D. Webster
14 May	4th fish eggs and larvae collection	L. Mason T. Ratacjak
25-29 May	2nd quarterly sampling 5th fish eggs and larvae collection 6th fish eggs and larvae collection	W. Rhodes L. Mason J. Russell H. Kania
6 June	7th fish eggs and larvae collection	H. Kania
12 June	8th fish eggs and larvae collection	H. Kania
19 June	9th fish eggs and larvae collection	H. Kania
26 June	10th fish eggs and larvae collection	H. Kania
1 July	11th fish eggs and larvae collection	H. Kania
10 July	12th fish eggs and larvae collection	H. Kania
21 July	Placing of periphyton and macroinvertebrate samplers	W. Rhodes

TABLE 1
(continued)
FIELD WORK
MARBLE HILL PLANT SITE
MARCH - NOVEMBER 1980

Date	Purpose of field trip	ABI personnel
11-14 August	3rd quarterly sampling	W. Rhodes E. Lowe H. Kania
13 October	Placing of periphyton and macro-invertebrate samplers	W. Rhodes
3-6 November	4th quarterly sampling	W. Rhodes E. Lowe D. Herrema

A. CHEMICAL AND PHYSICAL PARAMETERS

INTRODUCTION

This study was designed to monitor the chemical and physical parameters of the Ohio River and Little Saluda Creek near the Marble Hill Plant site. Monitoring of these parameters is especially important to the biological community in aquatic environments because changes in these parameters can affect food chains. The purpose of monitoring was to: 1) determine whether the Marble Hill Plant construction affects chemical and physical parameters measured, 2) provide a more unified view of the aquatic habitat than would be obtained from sampling only the biotic components of the area, and 3) enable examination of the relationship between the abiotic and biotic components of the aquatic environment.

Data taken at downstream sampling stations were compared with those taken at an upstream sampling station that served as a control station for the study (Figure 1). Furthermore, results of the study were compared with Ohio River Valley Water Sanitation Commission (ORSANCO) data, Indiana Water Quality Standards (1977), baseline monitoring data (PSI, 1976), and 1977-79 construction monitoring data (ABI, 1978, 1979,1980).

MATERIALS AND METHODS

Duplicate subsurface water samples were collected at Stations 1, 3, 5 and 6 with a nonmetallic Kemmerer sampler. Water samples were preserved as prescribed by the EPA (1974) and analyzed according to Standard Methods (APHA, 1976). A list of the chemical parameters analyzed, preservation techniques, detection limits, and methodologies is given in Appendix Table A-1.

Current velocity, water temperature, Secchi depth, water depth and turbidity (Station 8 only) were determined on each sampling trip. In addition, quarterly sedimentation studies were conducted at Stations 6 and 8.

Current velocity was determined with a General Oceanics Model 2030 digital flowmeter and Model 2035 flowmeter readout. Determinations of pH were made in the field with an Orion Model 407A pH meter. Water depth was determined with a Heathkit Model 1031 depth meter. Oxygen determinations were made using a YSI Model 54 oxygen meter. Conductivity was determined with a YSI Model 33 salinity-conductivity-temperature meter. Temperature was measured electronically with the oxygen and conductivity meters. Turbidity was determined in the laboratory with a Hach Model 2100A nephelometric turbidimeter. All meters were calibrated in the laboratory before each field use.

The results from the chemical analysis of water samples collected quarterly at Stations 1, 3, 5, 6 and 8 during 1980 are tabulated in Appendix Tables A-2 through A-5. Replicate values and their averages are given in these tables.

The results (average of two replicates) obtained from Ohio River Stations 1, 3 and 5 are graphically compared for each chemical parameter in Figures A-1 through A-22 with baseline data from the Environmental Report, Construction Permit Stage (PSI, 1976) and, where available, ORSANCO data. Average monthly values from the closest ORSANCO sampling station (Mile Post 600.6 at Louisville, Kentucky) to the Marble Hill Plant site (Mile Post 570) were used for this comparison.

RESULTS OF WATER CHEMISTRY ANALYSIS

Water chemistry data for the Ohio River stations in 1980 generally varied considerably among seasons, but only slightly among stations. Chemical parameter values measured in 1980 were similar to those of the baseline study and 1980 ORSANCO values.

Little Saluda Creek Station 6 water chemistry data obtained in 1980 were compared to baseline (PSI, 1976) and previous construction phase monitoring results (ARI, 1978, 1979, 1980; Table A-1). Minimum and maximum values of each chemical parameter are presented for comparison.

Dissolved Oxygen

As in past years, Ohio River dissolved oxygen measurements during 1980 ranged from 6.0 to 14.0 mg/liter. Values were similar at all river stations within a sampling period but varied seasonally (Figure A-1). Dissolved oxygen values were highest in March and lowest in August and varied inversely with water temperatures. Measurements in Little Saluda Creek were generally higher than those for the Ohio River, ranging from 7.4 to 16.0 mg/liter (Table A-1). Regardless of the season, dissolved oxygen concentrations below 6.0 mg/liter were never recorded. This value is well above the minimum acceptable concentration of 4.0 mg/liter specified by Indiana Water Quality Standards (1977).

pH and Alkalinity

The pH values measured at the Marble Hill Plant site during the 1980 quarterly sampling program ranged from 6.0 to 7.3 in the Ohio River and from 6.6 to 8.0 in Little Saluda Creek (Figure A-2, Table A-1). These values are within the 6.0 to 9.0 range recommended by Indiana Water Quality Standards.

Alkalinity, the measure of the carbonate and bicarbonate buffering capacity of water, ranged from 55.0 to 85.0 mg/liter in the Ohio River (Figure A-3). The EPA (1976) has established 20 mg/liter as the minimum total alkalinity necessary to support freshwater aquatic life. Little Saluda Creek had alkalinity values between 193.3 and 213.3 mg/liter, well above this minimum acceptance value (Table A-1). The higher alkalinity of the creek is probably a result of water leaching through the surrounding limestone.

Conductivity, Total Dissolved Solids and Total Suspended Solids

Conductivity is a measure of the dissociated ions in water while total dissolved solids (TDS) is a measure of dissociated ions plus all other dissolved solids. Conductivity values varied between 177 and 390 µmhos/cm for the Ohio River and between 390 and 790 µmhos/cm for Little Saluda Creek (Figure A-4, Table A-1). Both ranges were similar to those reported in previous studies, but creek values were generally slightly higher during 1980. The TDS values varied between 158 and 296 mg/liter for the Ohio River and between 279 and 664 mg/liter for Little Saluda Creek (Figure A-5, Table A-1). The range of values at the river stations was similar to those observed in previous studies, but the creek range was much broader than previously observed. For Station 8, TDS values ranged from 463 to 473 mg/liter during March. No water was available for sampling at Station 8 during May, August or November. Indiana Water Quality Standards (1977) specify that for industrial water supplies the dissolved solids from sources other than naturally occurring ones shall not exceed 1000 mg/liter at any time. This limit for dissolved solids was not exceeded at any station during 1980.

Total suspended solids (TSS) are insoluble particles suspended in the water column that increase turbidity and reduce light penetration. Total suspended solids values varied between 22 and 306 mg/liter for the Ohio River, the highest values were recorded in March when runoff was high (Figure A-6). Total suspended solids' values for Little Saluda Creek Station 6 were between 7 and 88 mg/liter, which is lower than that recorded for Ohio River stations (Table A-1). TSS values were generally the same as those observed during baseline and 1977-78 construction monitoring. Values recorded during 1979 were generally lower, but data from all construction phase monitoring fell within the range of values recorded during baseline studies.

Biochemical Oxygen Demand, Chemical Oxygen Demand and Total Organic Carbon

Biochemical oxygen demand (BOD) is a measure of the biologically oxidizable material present in water, while chemical oxygen demand (COD) is a measure of the amount of material that can be oxidized by a chemically defined dichromate solution. Both of these tests, as well as that for total organic carbon (TOC), indicate the concentration of organic waste material present in water. BOD values for Ohio River stations ranged from 1.9 to 6.1 mg/liter (Figure A-7), COD values ranged from 4 to 42 mg/liter (Figure A-8), and TOC values ranged from 3.8 to 8.8 (Figure A-9). All of these ranges were slightly broader than observed in past monitoring. BOD values in Little Saluda Creek ranged from 1.0 to 2.6 mg/liter, COD values ranged from 5.6 to 32.2 mg/liter, and TOC values ranged from 1.8 to 4.9 mg/liter (Table A-1). During 1980, TOC values for Little Saluda Creek were lower than those for the Ohio River stations except in November and repeated a pattern observed in previous monitoring.

Phosphorous and Nitrogen

Phosphorous and nitrogen, which usually are the two limiting elements for primary production, were measured in the forms of total phosphorous, orthophosphate, nitrate nitrogen, ammonia, and organic nitrogen.

To prevent biological nuisances such as plankton blooms, it has been suggested that total phosphorous concentrations should not exceed 0.10 mg/liter at any point within a flowing stream (MacKenthum, 1969). This limiting value for total phosphorous content was repeatedly exceeded at Stations 1, 3 and 5 in the Ohio River during 1980; however, no blooms were observed. Because values at Station 1, the control station, also exceeded recommended values, these high values were not attributed to construction at the Marble Hill site. Concentrations of total phosphorous in Little Saluda Creek exceeded 0.10 mg/liter only in August. For the Ohio River stations, total phosphorous values ranged from 0.15 to 0.99 mg/liter (Figure A-10), and orthophosphate values ranged from 0.01 to 0.06 mg/liter (Figure A-11). Both ranges were broader than those observed in previous monitoring. For Little Saluda Creek, total phosphorous values ranged from 0.02 to 0.24 mg/liter and orthophosphate values ranged from 0.01 to 0.02 mg/liter. All the total phosphorous values were within the range recorded by ORSANCO.

Nitrate nitrogen values for stations in the Ohio River and Little Saluda Creek ranged from 0.24 to 0.99 mg/liter during the year (Figure A-12, Table A-1), always exceeding the 0.1 mg/liter concentration limit necessary to inhibit growth of algae and plants (MacKenthum, 1969). This range was somewhat smaller than that observed in previous monitoring.

Ammonia nitrogen values ranged from 0.09 to 0.24 mg/liter for the Ohio River stations and from 0.03 to 0.13 mg/liter for Little Saluda Creek (Figure A-13, Table A-1). These values frequently exceeded <0.02 mg/liter of un-ionized ammonia, which is the maximum acceptable value for maintenance of freshwater life (EPA, 1976). These excessive values were also recorded at Control Station 1; therefore, construction at the Marble Hill site was not their cause.

Organic nitrogen values ranged from 0.23 to 0.67 mg/liter for the Ohio River stations and from 0.14 to 0.41 mg/liter for Little Saluda Creek (Figure A-14, Table A-1). Both of these ranges were somewhat smaller than previously observed at the Marble Hill site.

Other Chemical Parameters

Quarterly values for silica, calcium and magnesium were similar for the three Ohio River stations (Figures A-15 through A-17), but they were considerably lower than those for Little Saluda Creek. The high concentrations of silica, calcium and magnesium were probably derived from minerals dissolving along the course of Little Saluda Creek.

Sodium values were lowest in August and highest in November and ranged from 7.2 to 30.7 mg/liter in the Ohio River (Figure A-18). This pattern was very similar to that observed in 1977 and 1978 but differed from data collected in 1974-1975 and 1979. Such pattern shifts occur naturally over the course of several years. Within the same sampling period there was little variation of sodium values at the Ohio River stations. In Little Saluda Creek, sodium concentrations were lower than Ohio River concentrations in March and May, and higher in August and November.

The highest value of sulfate (94 mg/liter) measured during 1980 (Figure A-19) was well below the Indiana Water Quality Standards (1977) recommended maximum value of 250 mg/liter. There was no significant difference in sulfate values among Ohio River stations. Sulfate values for the Ohio River were only slightly higher than those for Little Saluda Creek.

The highest value of chloride (32.3 mg/liter) measured during 1980 (Figure A-20) was well below the Indiana Water Quality Standards recommended maximum of 250 mg/liter. As in 1979, Little Saluda Creek chloride values were higher than those for Ohio River stations (May through November). Also, Little Saluda Creek chloride values were considerably higher than the values observed during baseline (PSI, 1976) and construction phase monitoring (ABI, 1978, 1979, 1980). Values remained below 250 mg/liter, however.

Both free residual chlorine and chloramine values for the Ohio River and for Little Saluda Creek were less than 0.01 mg/liter during each quarter of 1980.

Hexane soluble material levels were similar for the Ohio River and Little Saluda Creek, with ranges of <5.0 to 8.8 mg/liter for the Ohio River and <5.0 to 6.4 mg/liter for Little Saluda Creek (Figure A-21, Table A-1). Phenol levels varied between 0.003 and 0.020 mg/liter at the Ohio River and between 0.003 and 0.009 mg/liter in Little Saluda Creek (Figure A-22, Table A-1). Phenol values were usually below ORSANCO's maximum recommended criterion (0.010 mg/liter) for the mainstream of the Ohio River. All Ohio River stations exceeded this maximum during May while Stations 1 and 3 exceeded the maximum in November. On other occasions, however, phenol values were similar to those low values encountered in previous years. ORSANCO phenol data also exhibit such variability. Indiana Water Quality Standards does not list any standard for phenol.

Natural Variation in Chemical Parameters

The dynamic nature of the Ohio River is often reflected by wide variation in its chemical parameters. Such parameters are subject to varying seasonal fluctuations, depending on flow rates, as well as day-to-day variation in inputs of industrial or municipal effluents. The instantaneous measurement of these chemical parameters over the past 4 years serves only to record these irregularly occurring variations. Therefore, a pattern of variation noted in one year will not necessarily be repeated the next year.

The Ohio River is generally characterized in the spring by high water levels, fast currents and high turbidity levels and a great amount of debris. During the course of the year, water level and current speed fall to a minimum in August with a concomitant increase in water clarity. This pattern was observed in every year except in August 1980, when the river had a springtime appearance as a result of flooding in western Pennsylvania and West Virginia. Consequently, the levels of many chemical parameters in August 1980 differed from the levels recorded in preceding Augusts. These unusual values were, in many cases, responsible for the broader ranges in variation of chemical parameters noted in 1980. It must be stressed, however, that on no occasion were water quality standards or recommendations exceeded at stations downstream of the plant without similar values being recorded at the control station upstream of the plant. Therefore, no variation in chemical parameters of the Ohio River could be attributed to construction at the Marble Hill site. While Little Saluda Creek is more susceptible to construction impacts than the Ohio River, it is also subject to the same amount of natural variability.

RESULTS OF PHYSICAL PARAMETER MEASUREMENTS

The following physical parameters were measured in conjunction with the water chemistry sample collections: water temperature, current velocity, water depth and Secchi depth. These parameters were measured at Stations 1, 3, 5 and 6. Turbidity measurements were made on water samples taken quarterly at Station 8. The results of these measurements were tabulated in Appendix Tables A-6 through A-9.

Water temperatures ranged from 7.0° to 27.0°C for Ohio River stations and from 9.3° to 19.9°C for Little Saluda Creek. These values were lower than the maximum temperature limits recommended by Indiana Water Quality Standards for the maintenance of a well-balanced warmwater fish community.

Water depth ranged from 4.1 to 6.1 m for Ohio River stations and from 0.2 to 0.5 m for Little Saluda Creek. Current velocity ranged from 13 to 95 cm/sec for Ohio River stations and from <10 to 53 cm/sec for Little Saluda Creek. All values were similar to those recorded in previous monitoring.

Secchi depth ranged from 12 to 80 cm for Ohio River stations and the bottom was visible in Little Saluda Creek during each sampling. No correlation was observed between high current velocity and low Secchi depth.

Samples for turbidity measurements at Station 8 were collected only in March when there was enough water in the stream. The value of 9.1 nephelometric turbidity units (NTU) found in March is within the range recorded during 1977-79 construction monitoring (ABI, 1978, 1979, 1980). This wide variation in turbidity was probably due to the intermittent nature of the stream and to the extreme effects of heavy rainfall and subsequent runoff.

SEDIMENTATION STUDIES

Sedimentation studies were conducted at Stations 6 and 8, which are located in streams that drain the plant site. This study was designed to estimate erosion by measuring the sediment accumulated at measured rods placed in the stream bed. Photographs were taken at two locations on each stream to visually evaluate changes in stream bed appearance over time (Figures A-23 through A-38). At Station 8, the upstream location was about midway up the east-facing slope adjacent to the plant site. The Station 8 downstream location was just below the road on the narrow floodplain of the Ohio River. Upstream and downstream sedimentation study rods at Station 6 were located upstream and downstream, respectively, of the small bridge that crosses Little Saluda Creek on the northern boundary of the plant site (Figure 1). Construction at the plant site took place continuously throughout the year.

Between November 1979 and March 1980, approximately 2 cm of sediment accumulated at the upstream study rod at Station 8. Significant alteration of the stream bed was observed in May and appeared to have been the result of a storm-induced slide. As a result, accurate measurement of sediment accumulation could not be made, and another rod was installed. Only minor sediment accumulations were noted throughout the remainder of 1980. Because the configuration of the lower stream bed has changed many times due to intake caisson construction, it has proved impossible to keep a study rod installed at the Station 8 downstream position. No measurement of sediment accumulation has been made because the area is now riprapped.

Sedimentation in Little Saluda Creek has not been heavy during 1980 primarily because there is always some flow in the creek to flush out sediment accumulations. Sedimentation at Station 6 cannot be compared to the preconstruction condition of the stream because no sedimentation study was conducted in 1977. No sediment accumulations were found at either study rod during 1980. In fact, sediment accumulations appear to be substantially reduced from accumulations reported during 1978 and 1979. Algae is once again growing on the creek bottom, and the benthic macroinvertebrate community shows signs of returning to its preconstruction community structure (Section E. Benthic and Drift Macroinvertebrates). A reduction in sediment accumulation of 3 cm was visually estimated during the course of 1980.

CONCLUSIONS

Quarterly sampling, measurement, and analysis for chemical and physical parameters were performed at sampling stations in the Ohio River and Little Saluda Creek located close to the Marble Hill Plant site. The objective was to determine whether plant construction was altering the chemical nature of these water bodies.

Chemical and physical parameter values were similar at all the Ohio River stations during each of the quarterly sampling periods in 1980. They were similar to the values recorded during baseline and construction phase studies, although there were some exceptions. Construction at the Marble Hill site seems to have had no discernible effect on the chemical and physical parameters measured in this study.

The chemical parameter measurements indicate a degree of pollution at all the Ohio River stations, especially when compared to the station in Little Saluda Creek. In general, values for all parameters that indicate decreased water quality are higher in the Ohio River than in Little Saluda Creek; although, chemical and physical parameter values are usually within the range of water quality standards for the State of Indiana. Decreased water quality seems to be due to discharges upstream from the Marble Hill Plant site.

Sediment accumulations at Stations 6 and 8 during 1980 were generally smaller than reported during 1979. Minor accumulations continue to take place, however, at Station 8. At Station 6, sediment accumulations caused by construction activity appear to have stopped. The creek shows signs of returning to its preconstruction condition.

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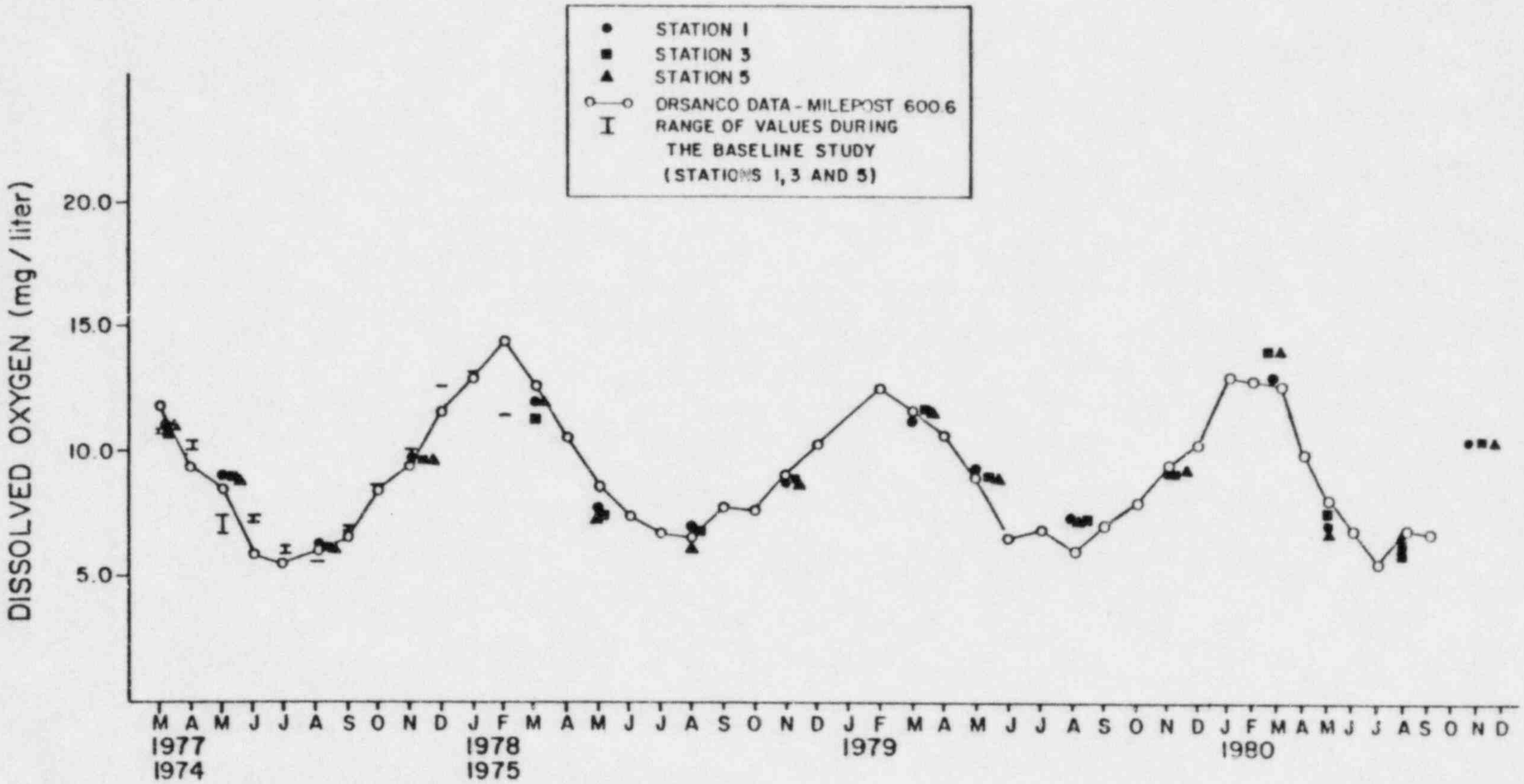

Figure A-1. Comparison of baseline, ORSANCO and construction phase dissolved oxygen data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

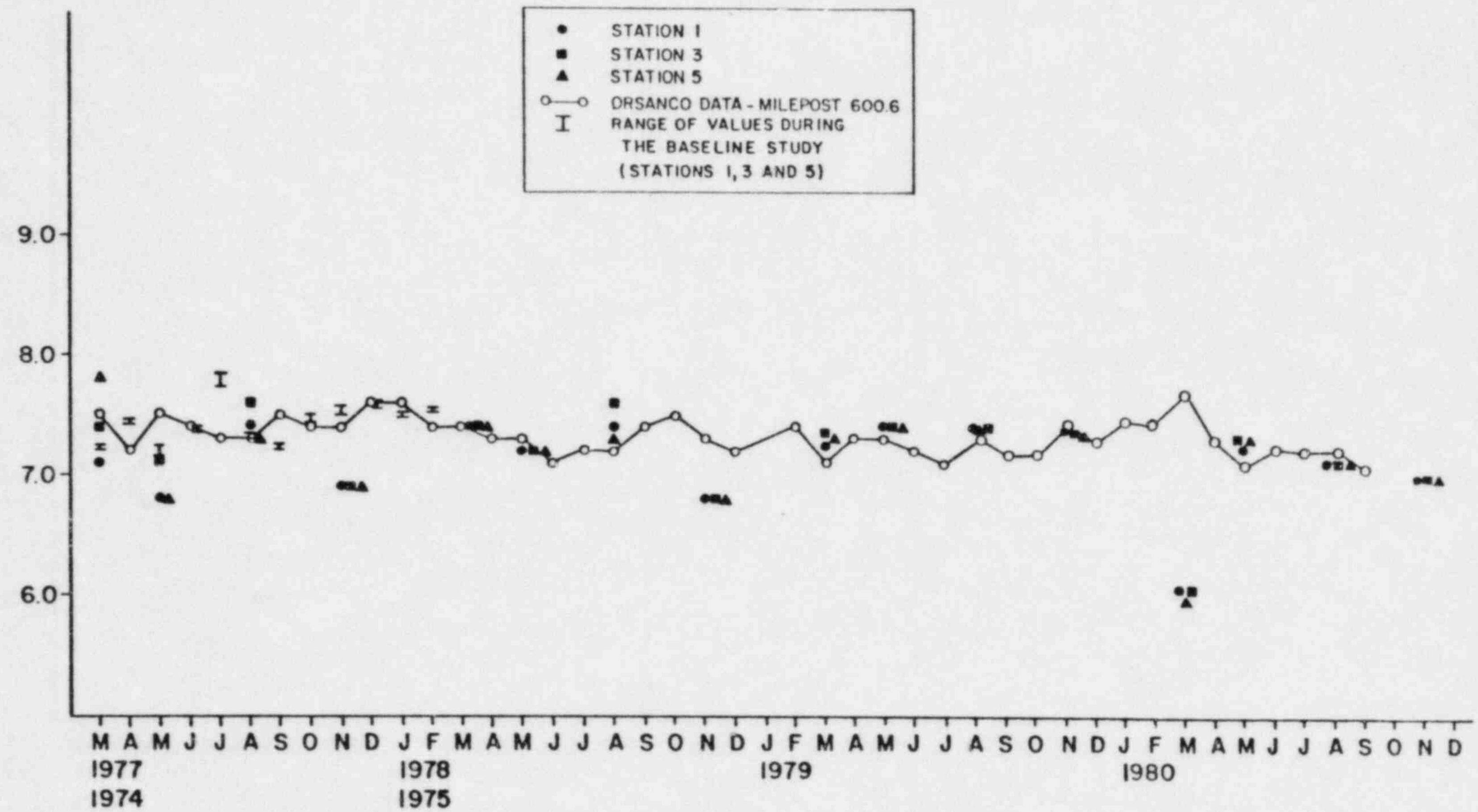

Figure A-2. Comparison of baseline, ORSANCO and construction phase pH data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

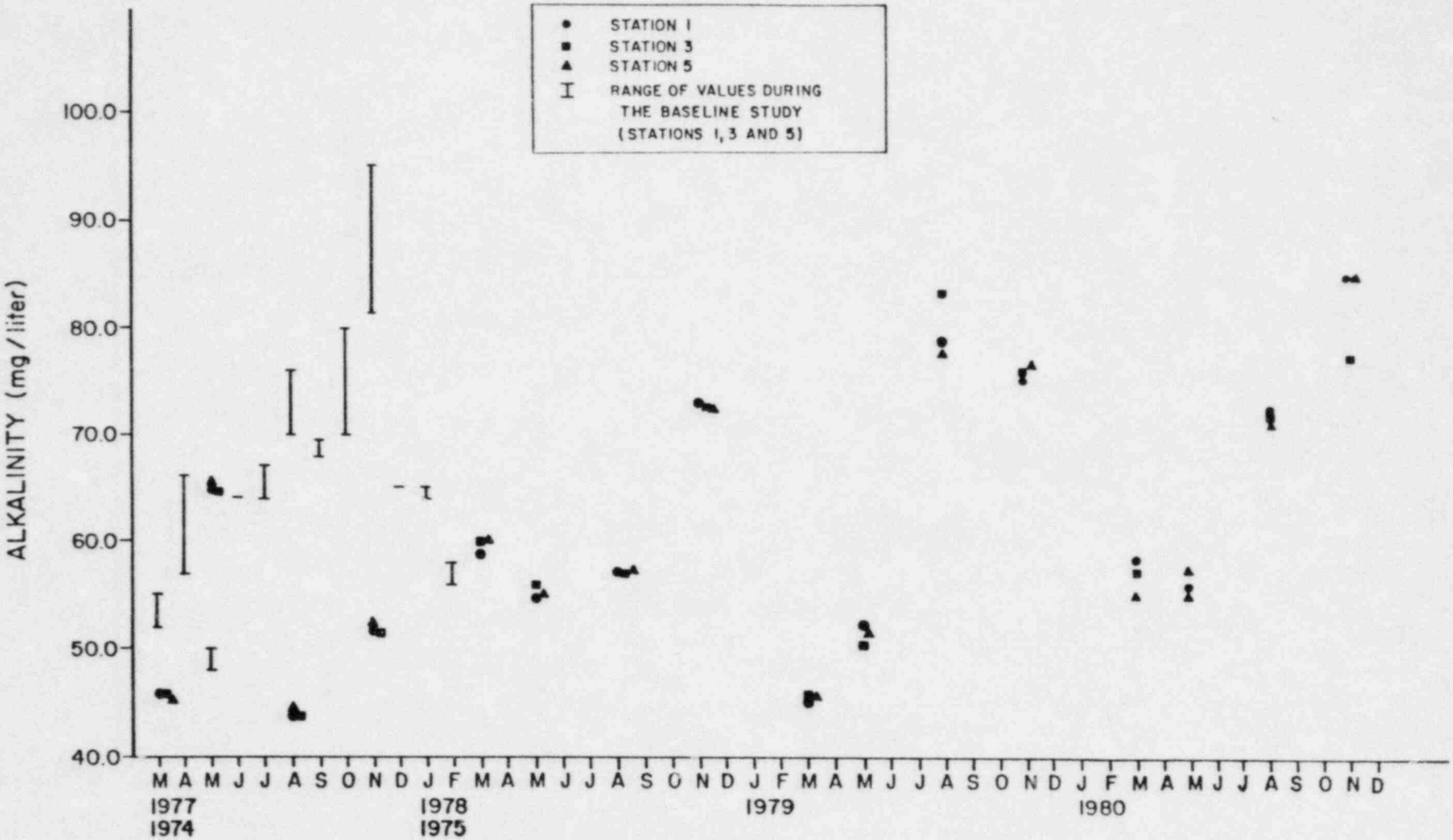

Figure A-3. Comparison of baseline and construction phase alkalinity data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

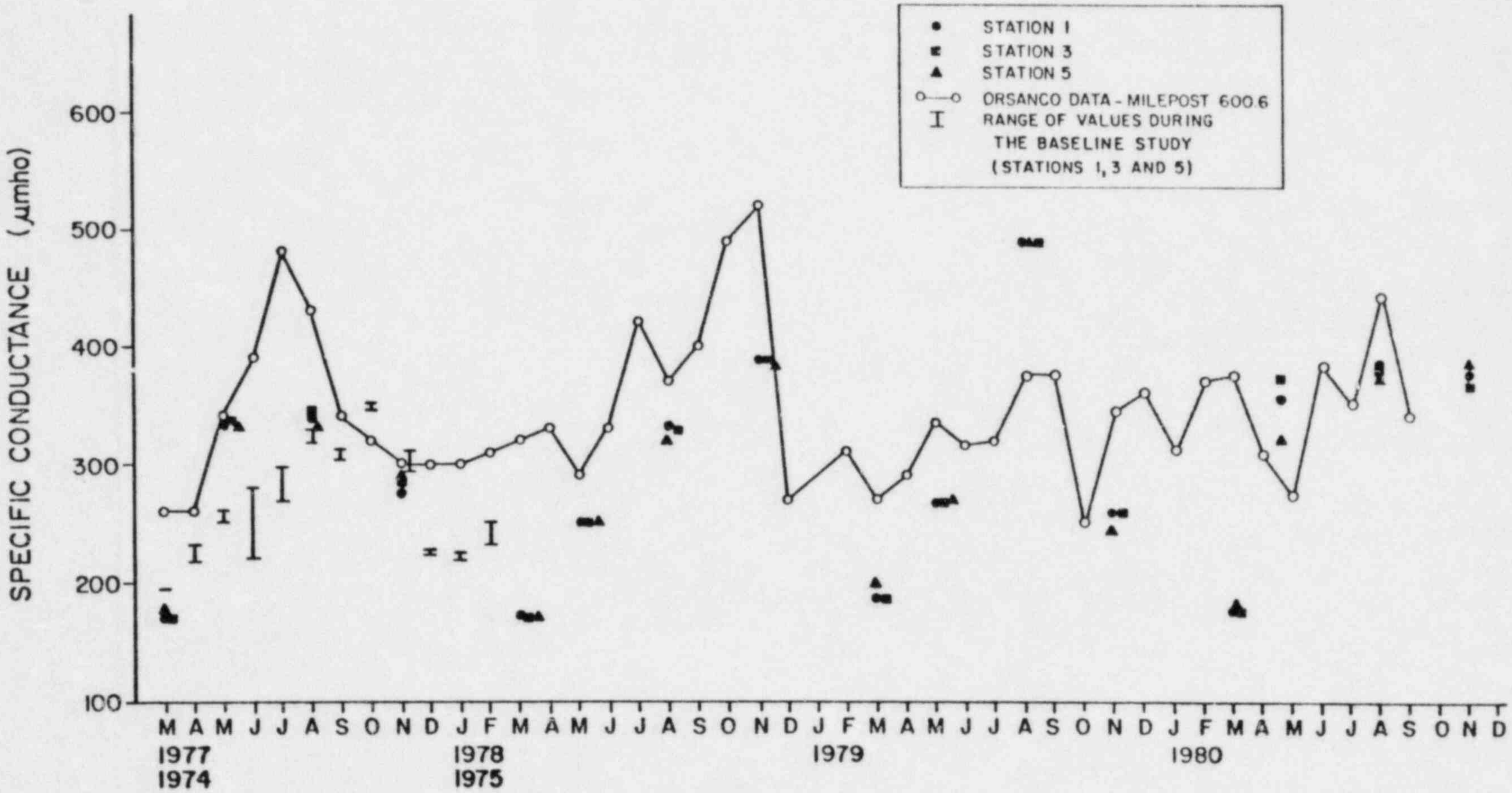

Figure A-4. Comparison of baseline, ORSANCO and construction phase specific conductance data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

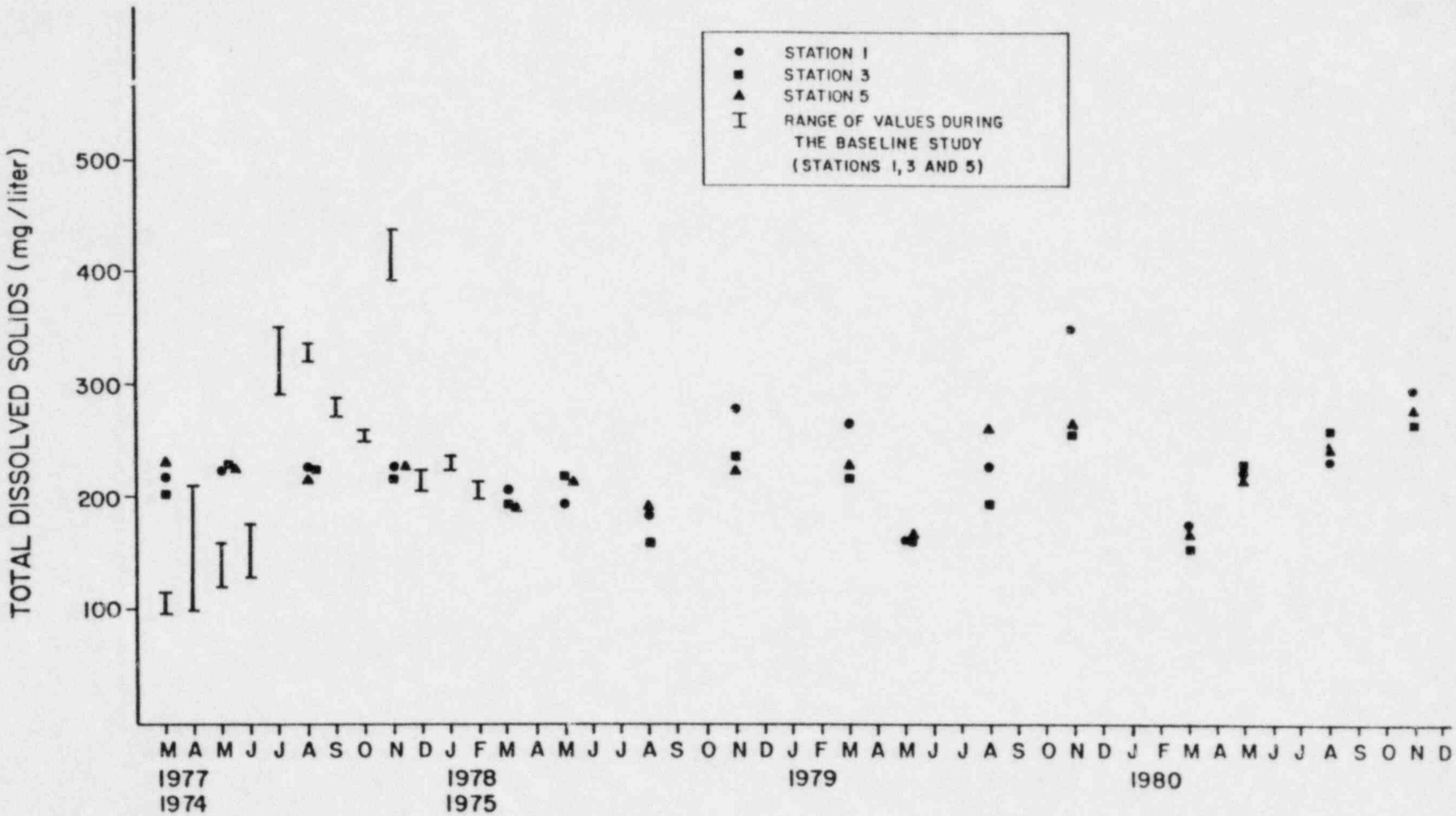

Figure A-5. Comparison of baseline and construction phase dissolved solids data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

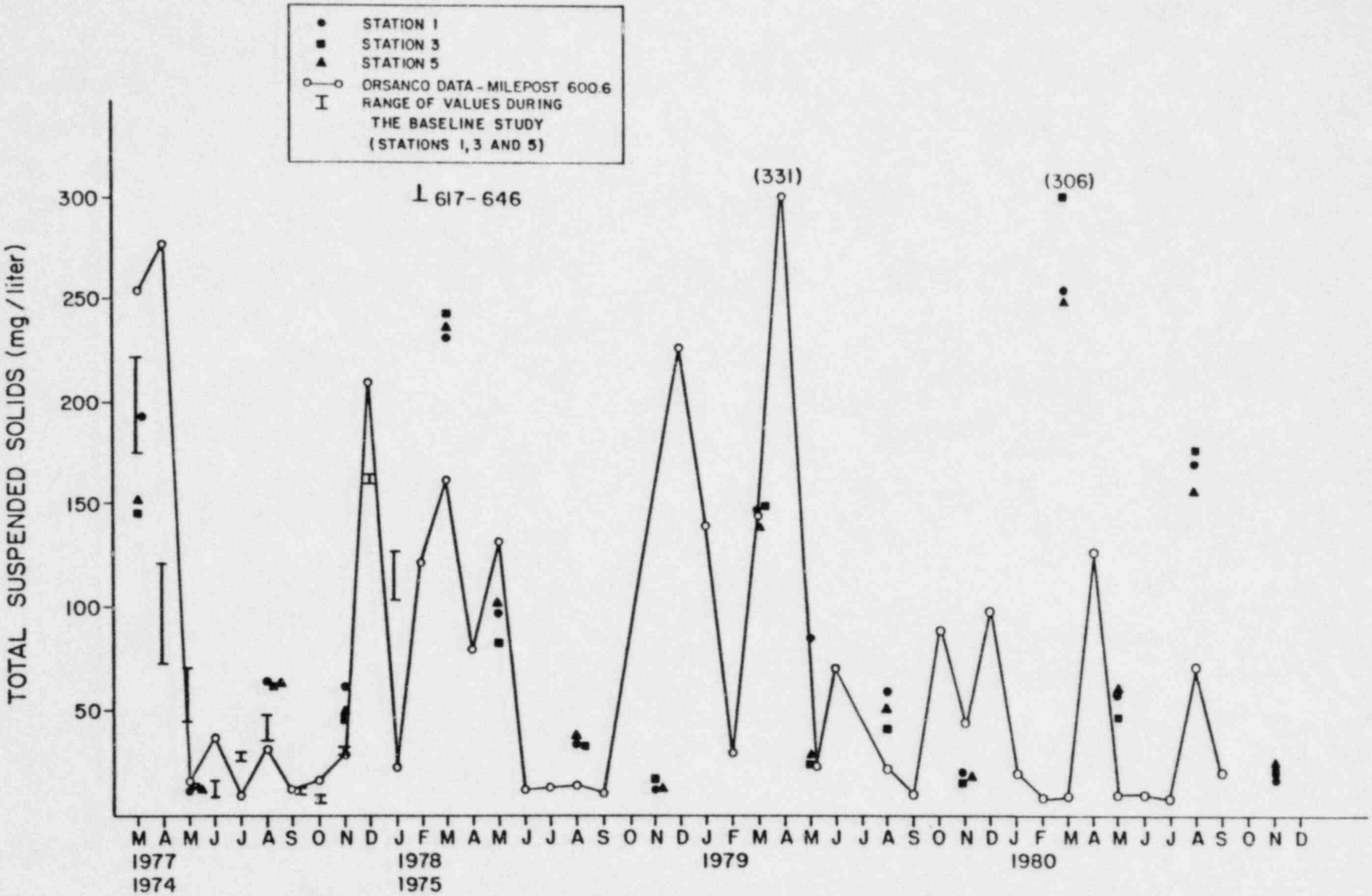

Figure A-6. Comparison of baseline, ORSANCO and construction phase suspended solids data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

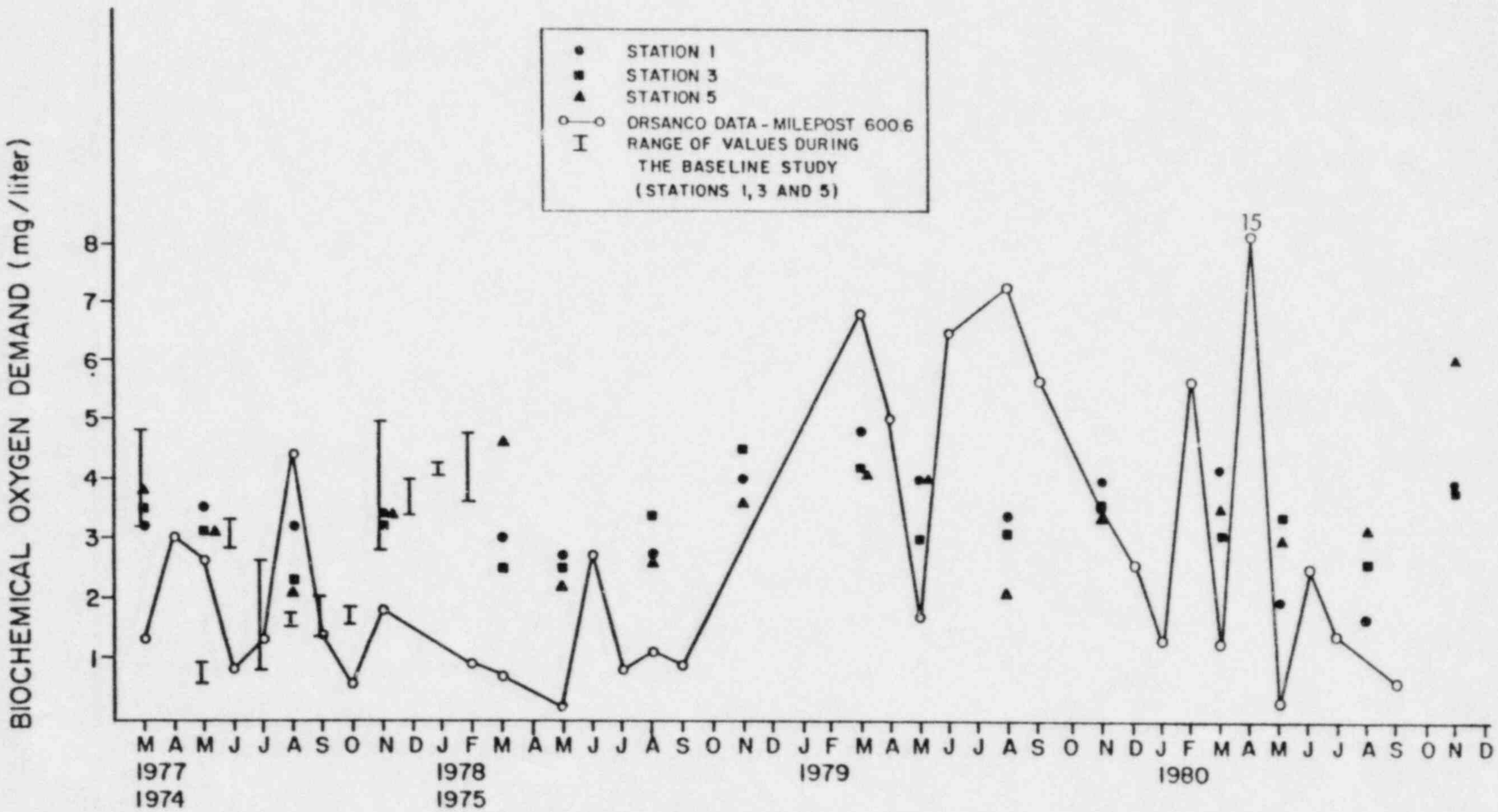

Figure A-7. Comparison of baseline, ORSANCO and construction phase biochemical oxygen demand data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

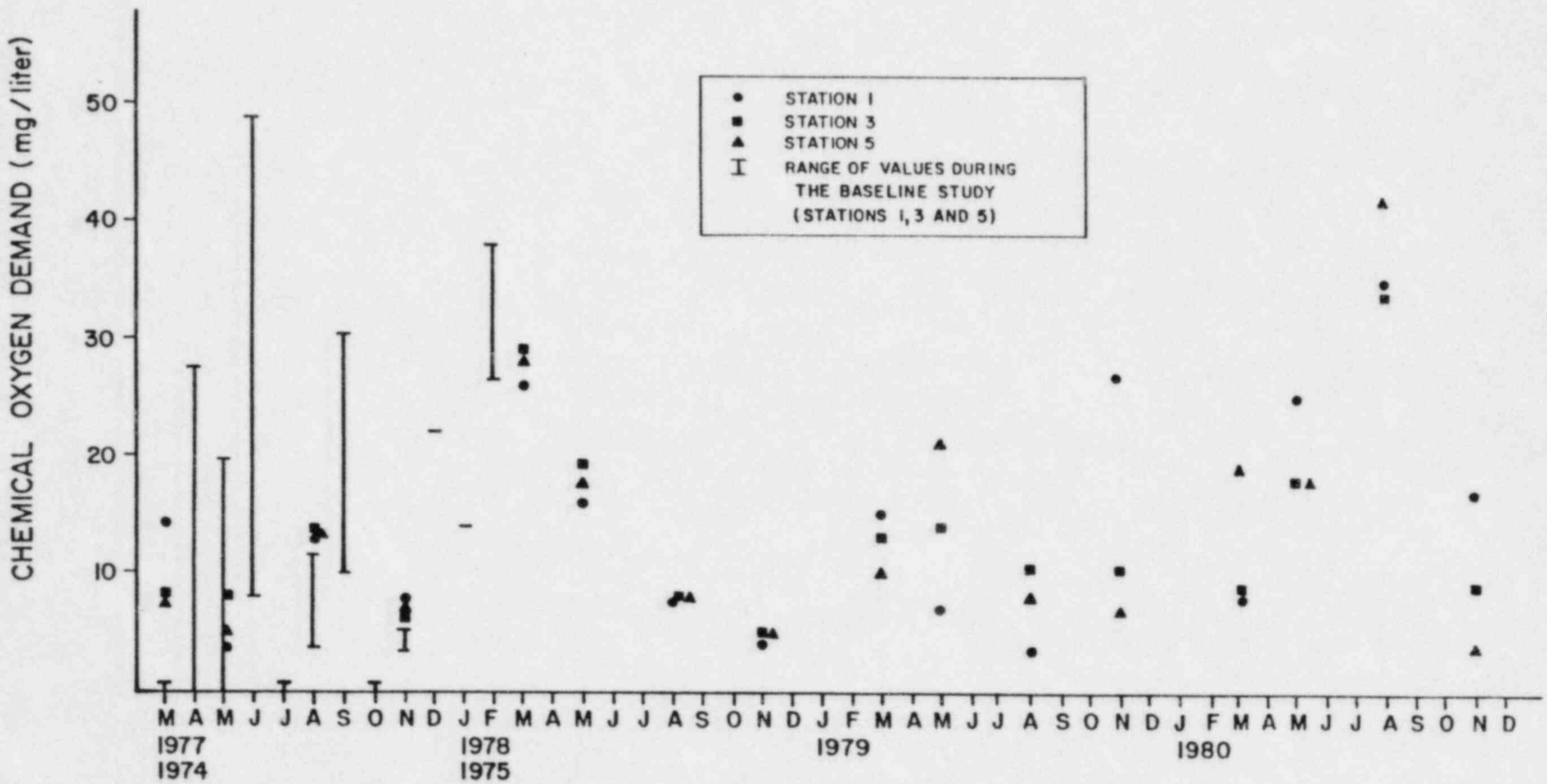

Figure A-8. Comparison of baseline and construction phase chemical oxygen demand data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

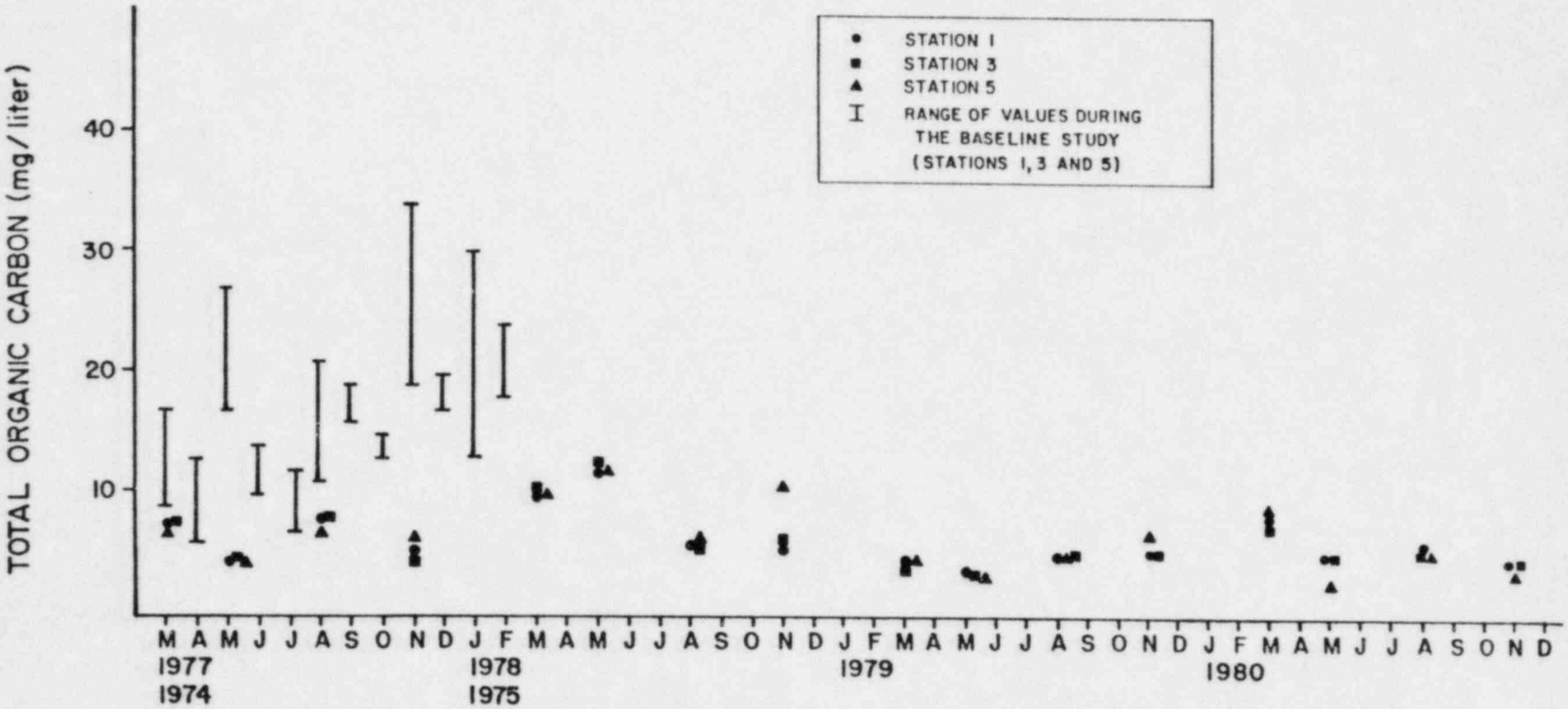

Figure A-9. Comparison of baseline and construction phase total organic carbon data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

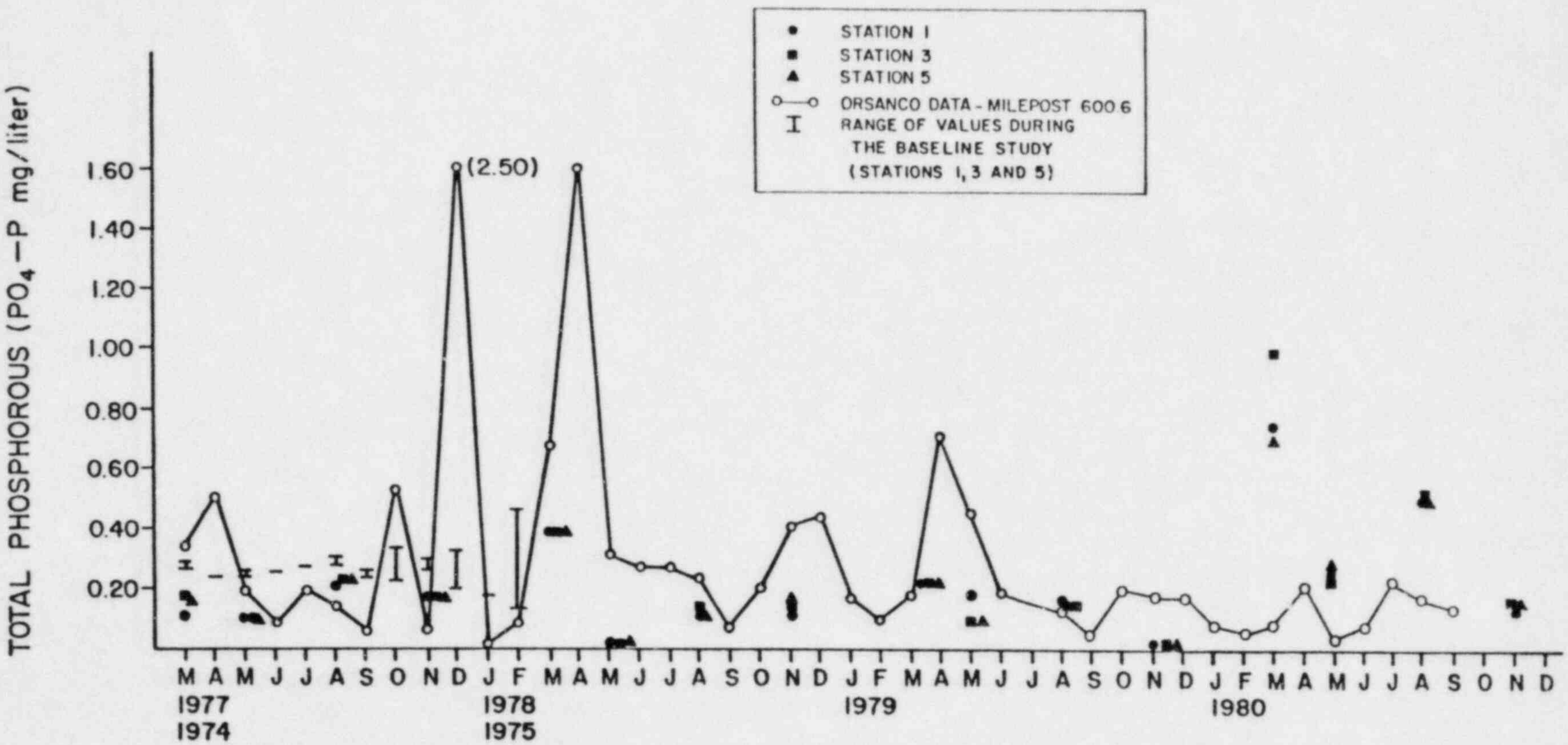

Figure A-10. Comparison of baseline, ORSANCO and construction phase total phosphorous data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

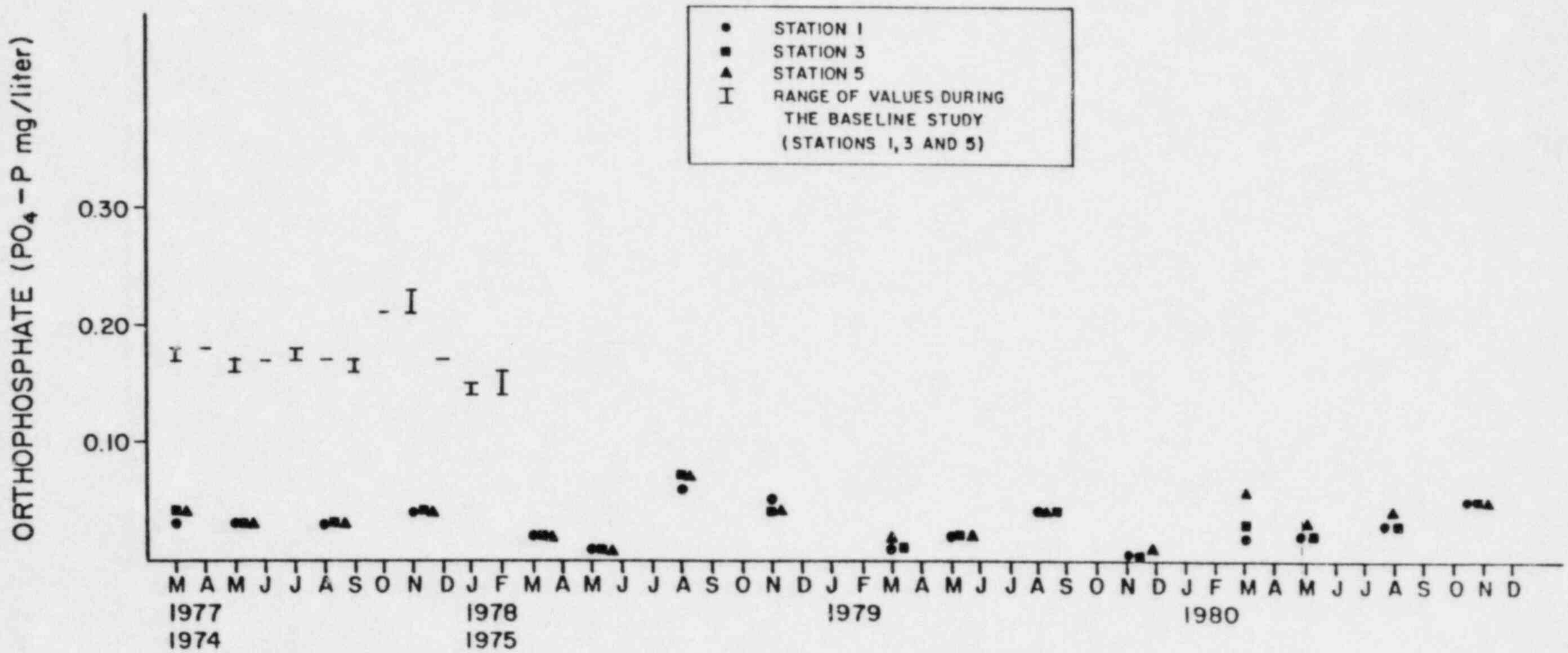

Figure A-11. Comparison of baseline and construction phase orthophosphate data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

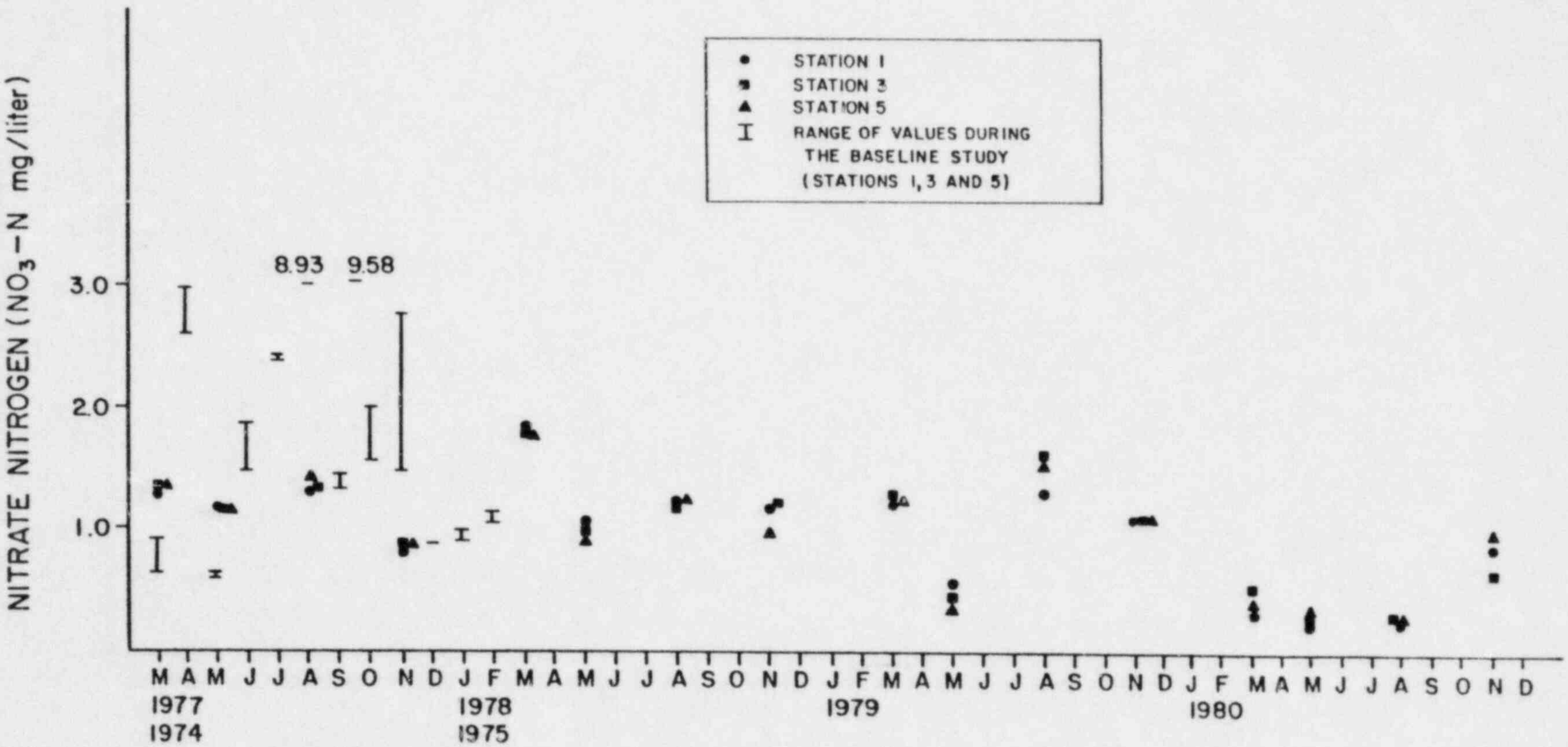

Figure A-12. Comparison of baseline and construction phase nitrate nitrogen data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

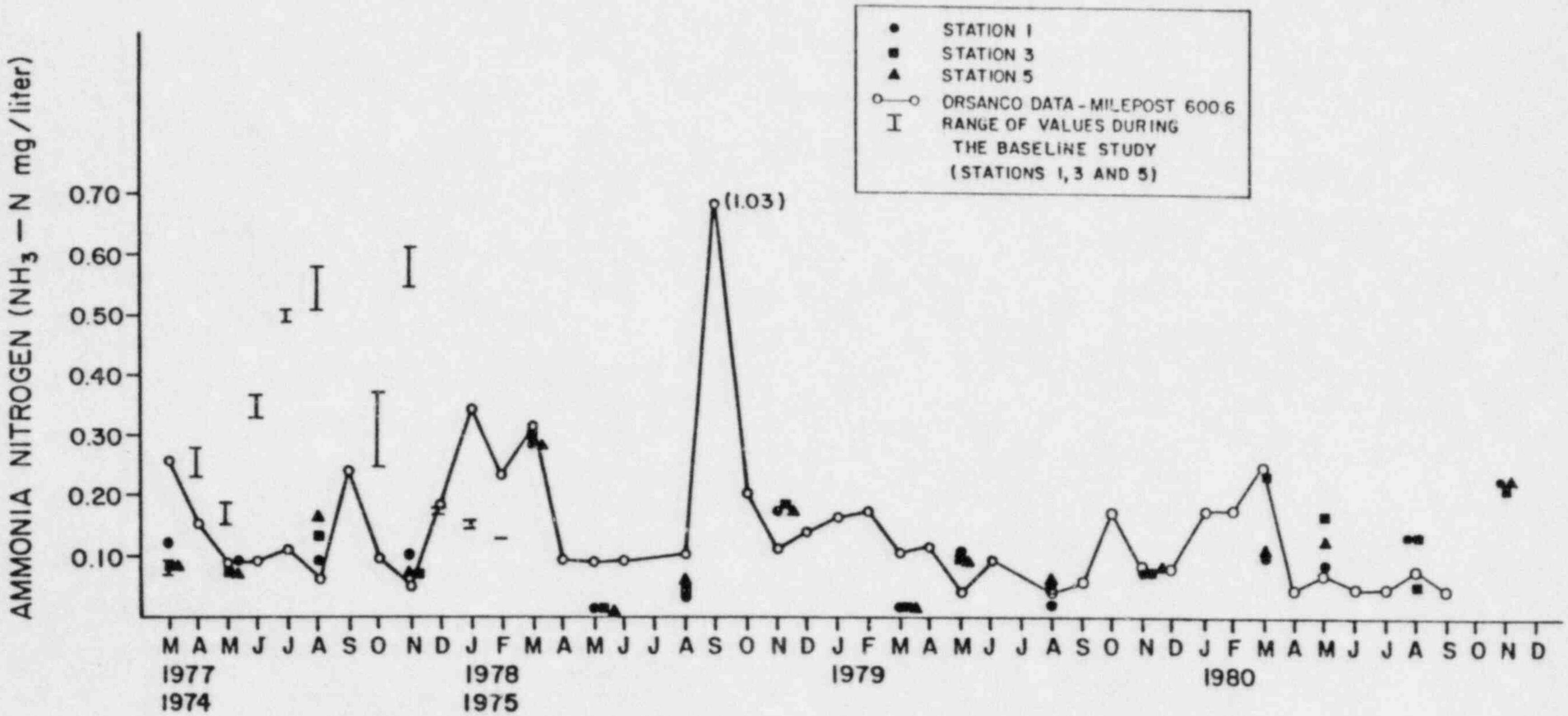

Figure A-13. Comparison of baseline, ORSANCO and construction phase ammonia nitrogen data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

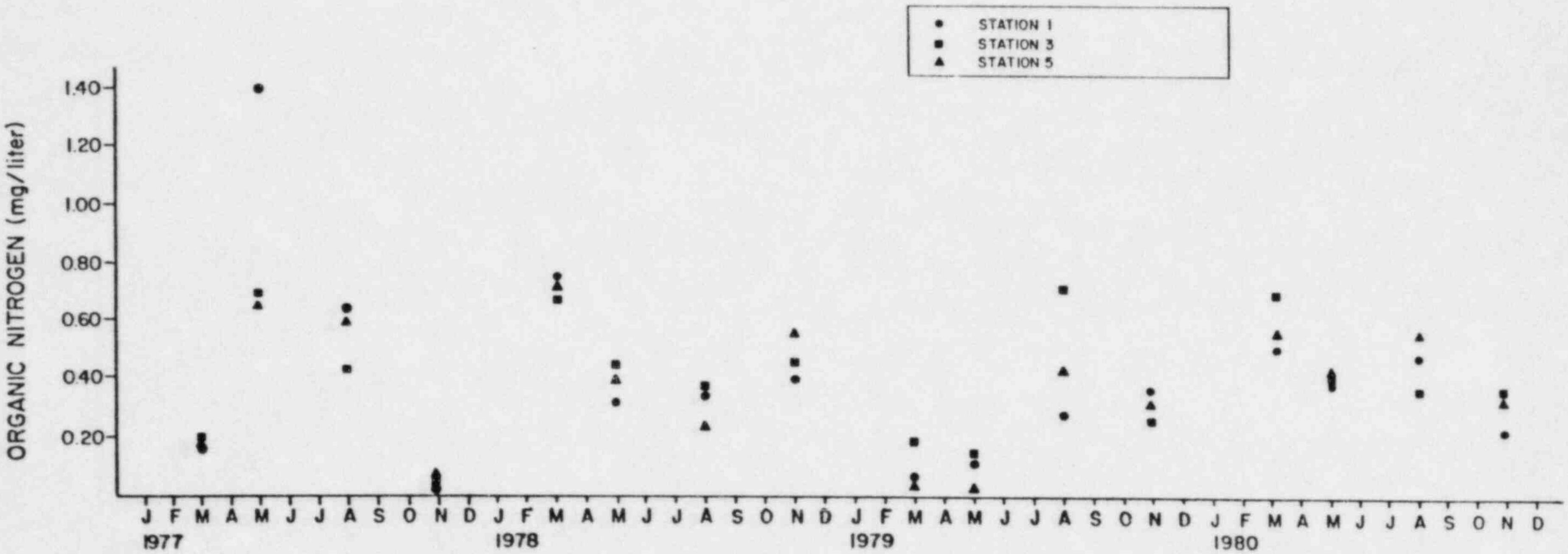

Figure A-14. Construction phase quarterly organic nitrogen data from samples taken in the Ohio River near the Marble Hill Plant site, 1977 - 1980.

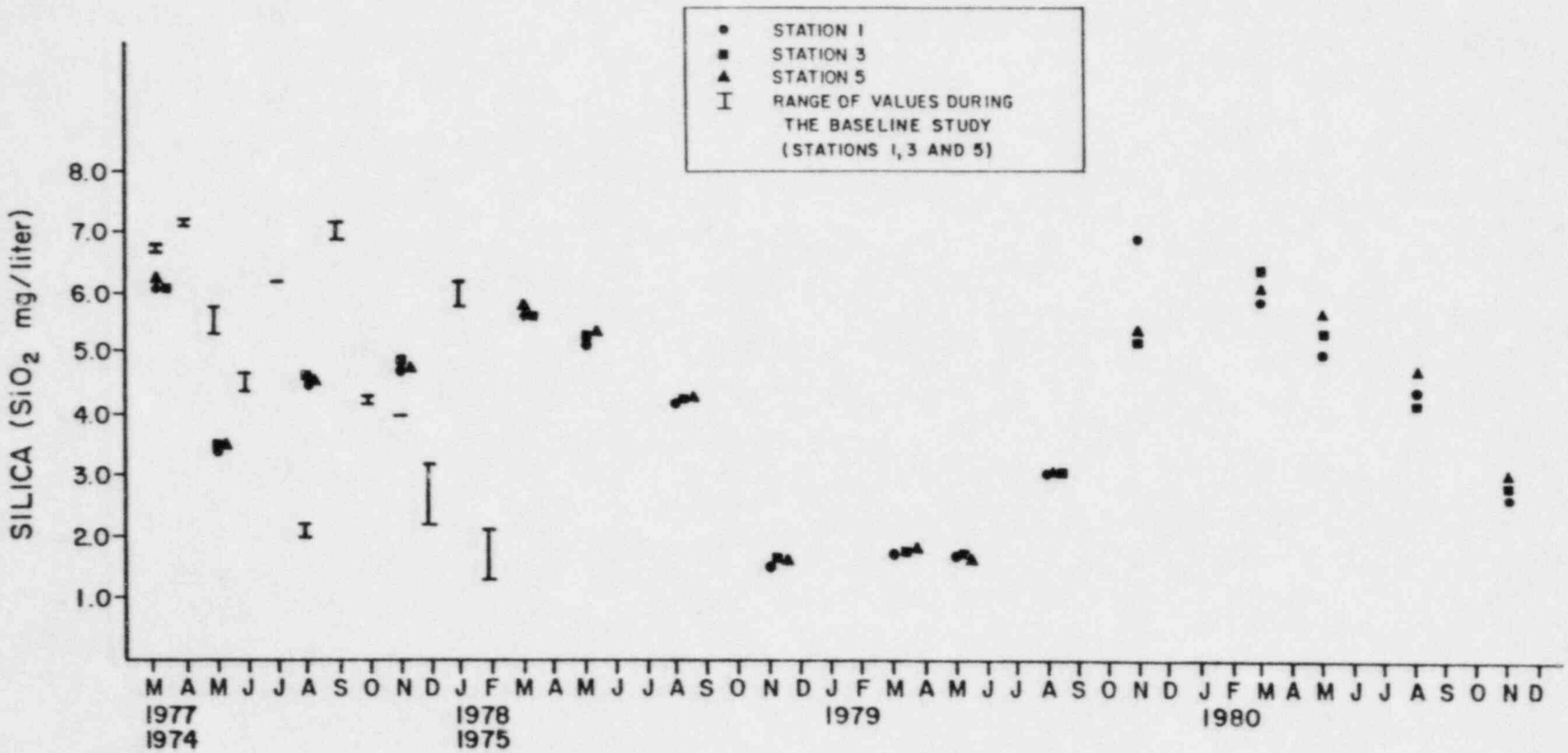

Figure A-15. Comparison of baseline and construction phase silica data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

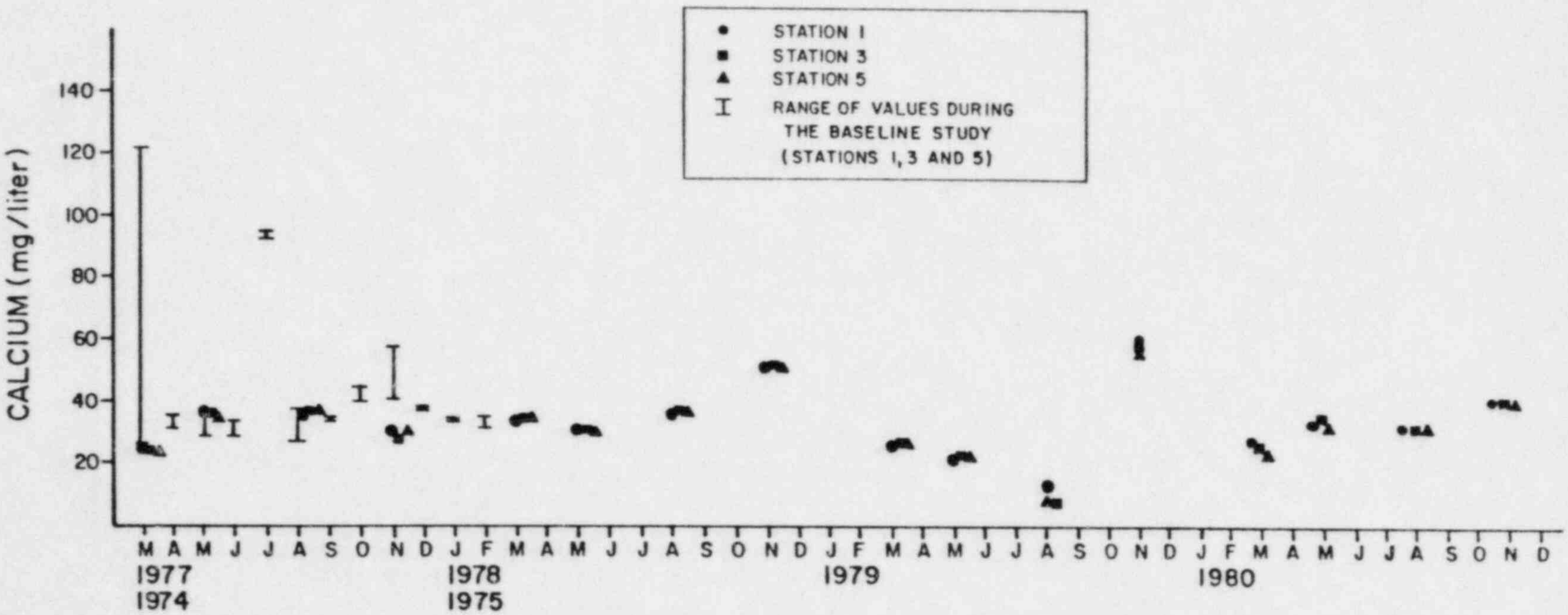

Figure A-16. Comparison of baseline and construction phase calcium data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

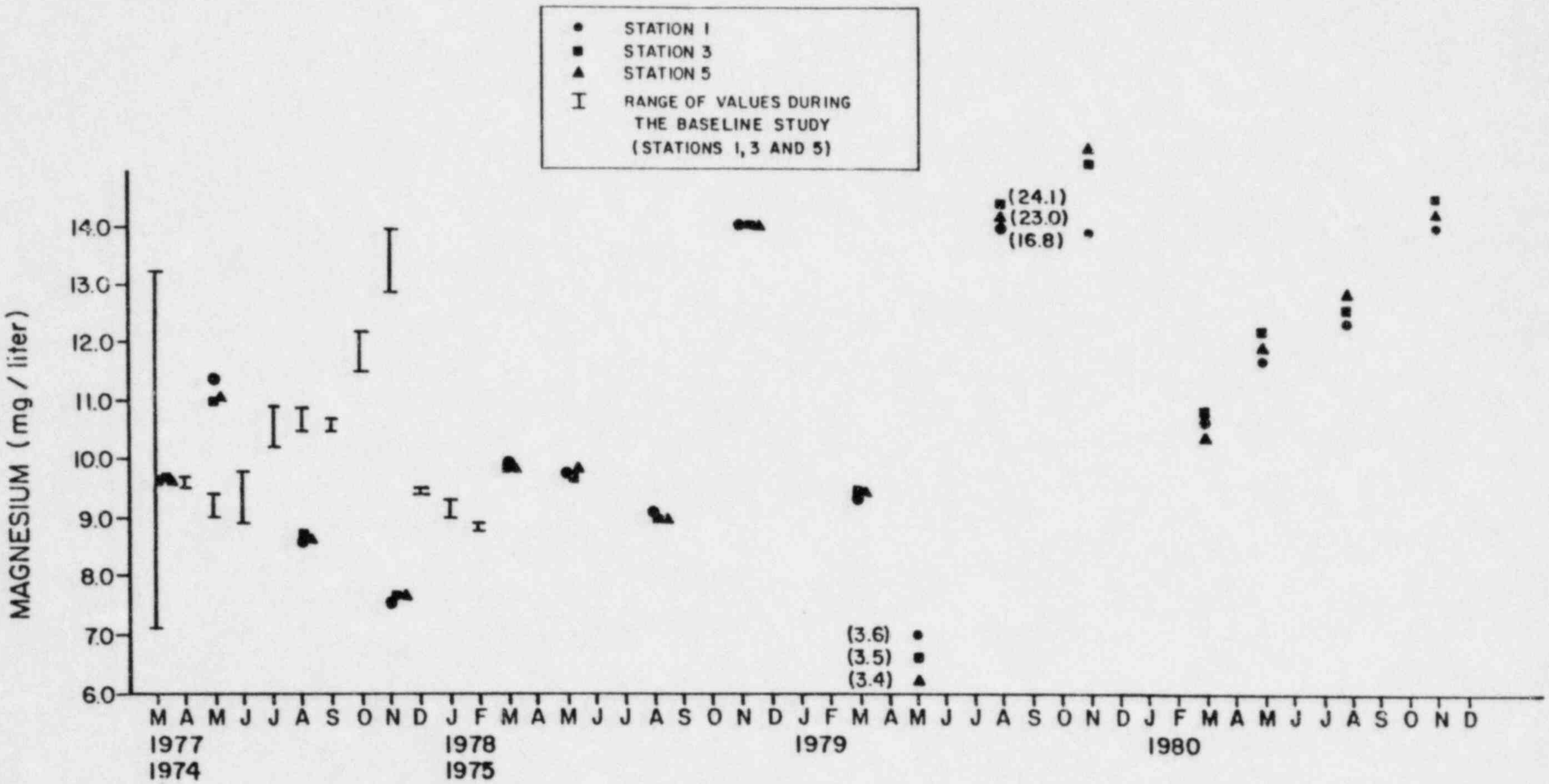

Figure A-17. Comparison of baseline and construction phase magnesium data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

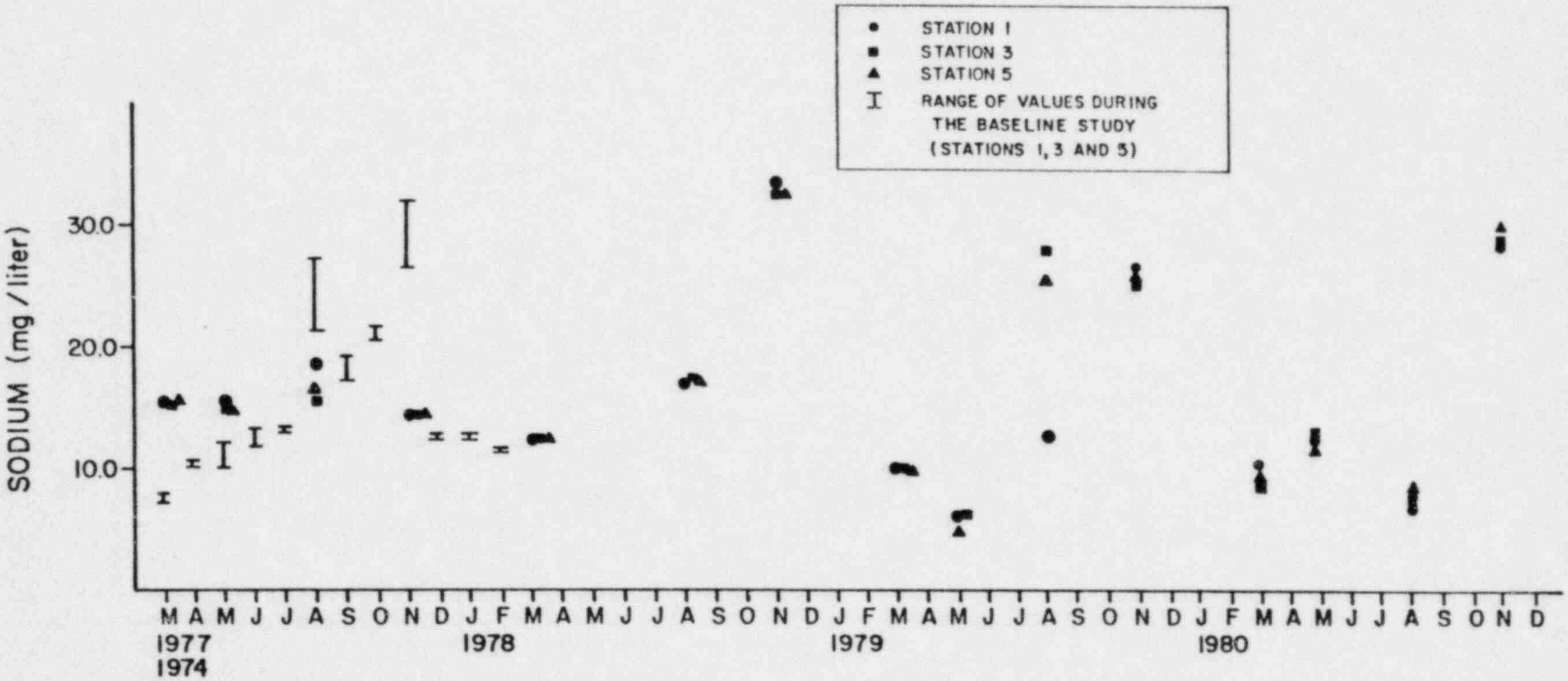

Figure A-18. Comparison of baseline and construction phase sodium data (average values) taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

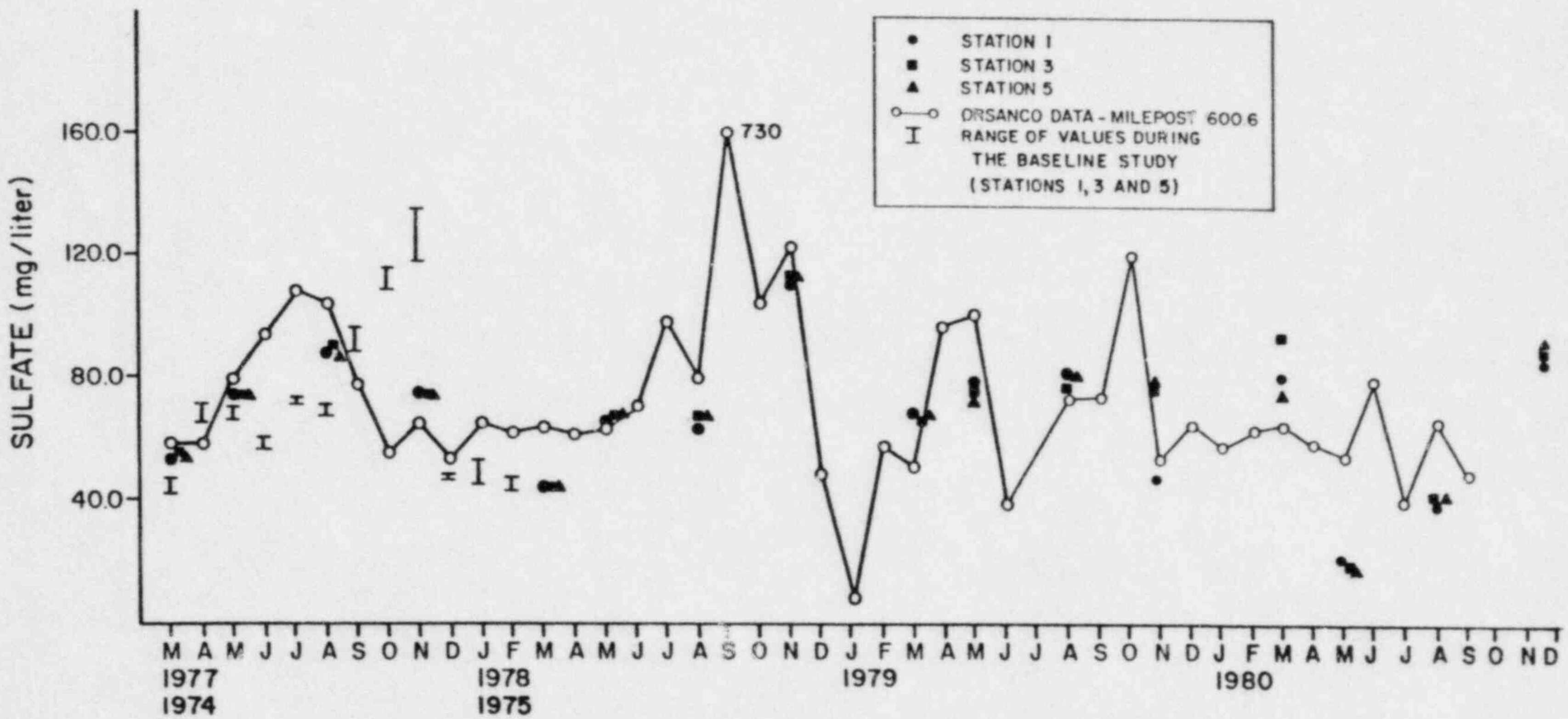

Figure A-19. Comparison of baseline, ORSANCO and construction phase sulfate data (average values) taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

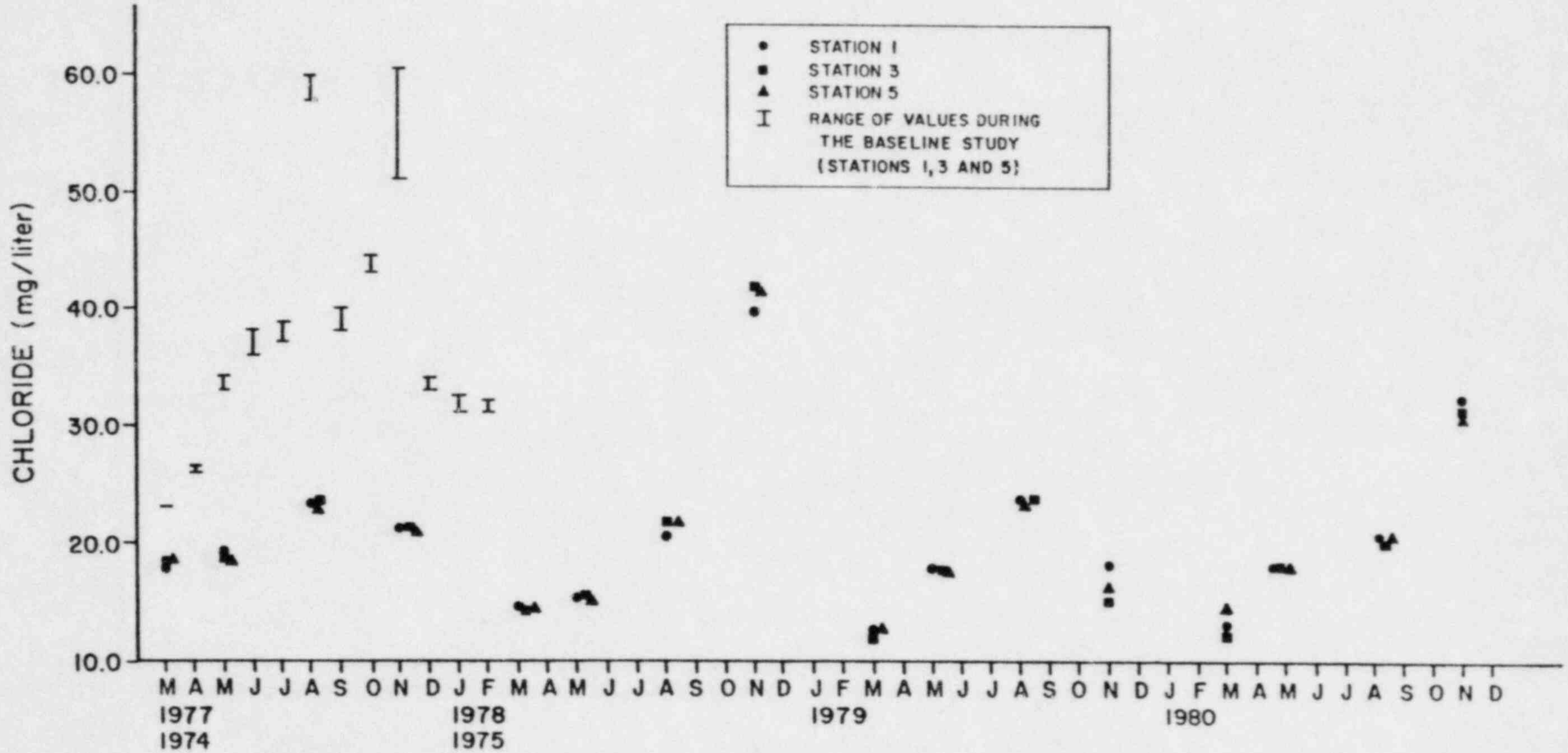

Figure A-20. Comparison of baseline and construction phase chloride data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

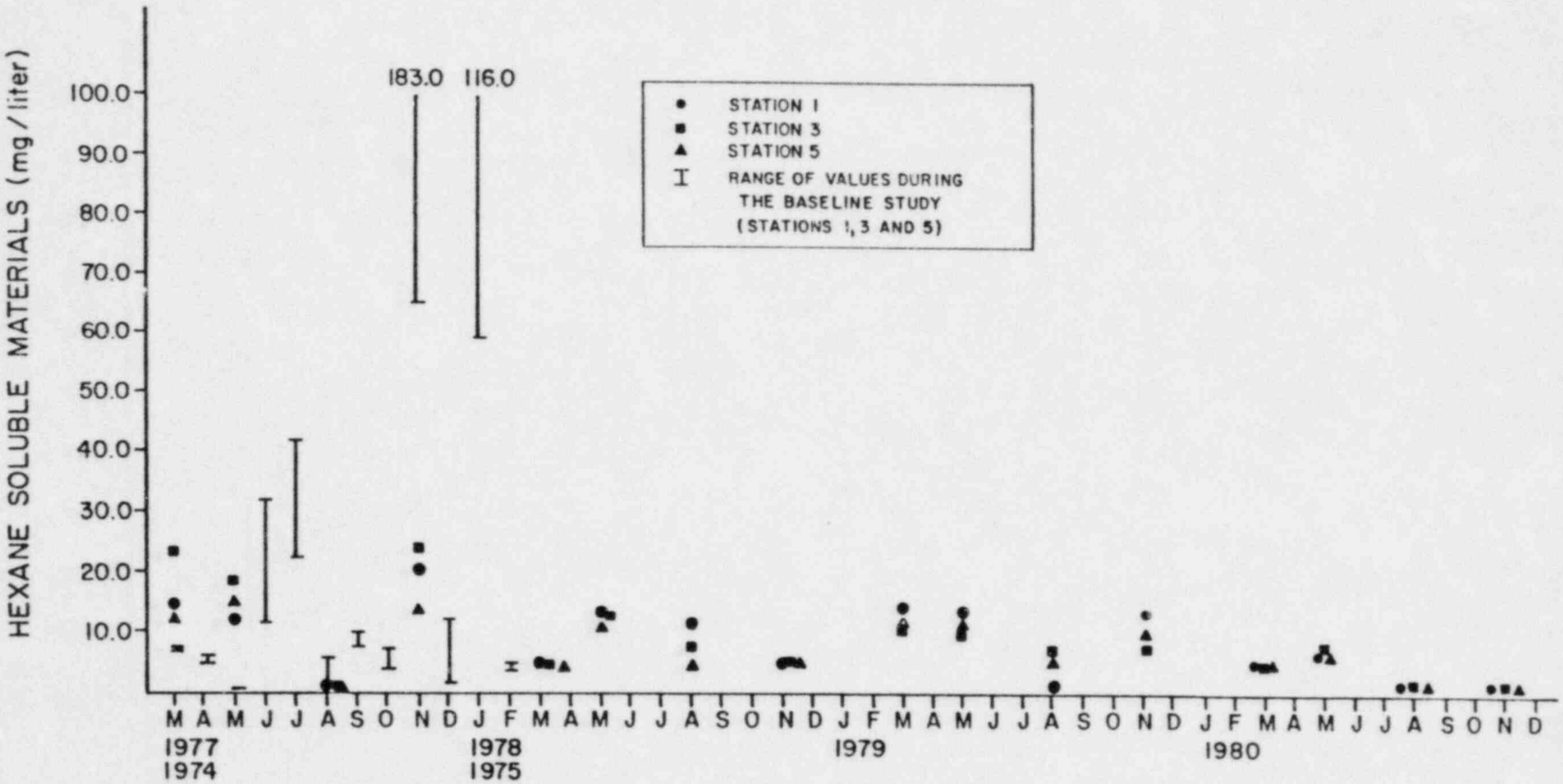

Figure A-21. Comparison of baseline and construction phase hexane soluble materials data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

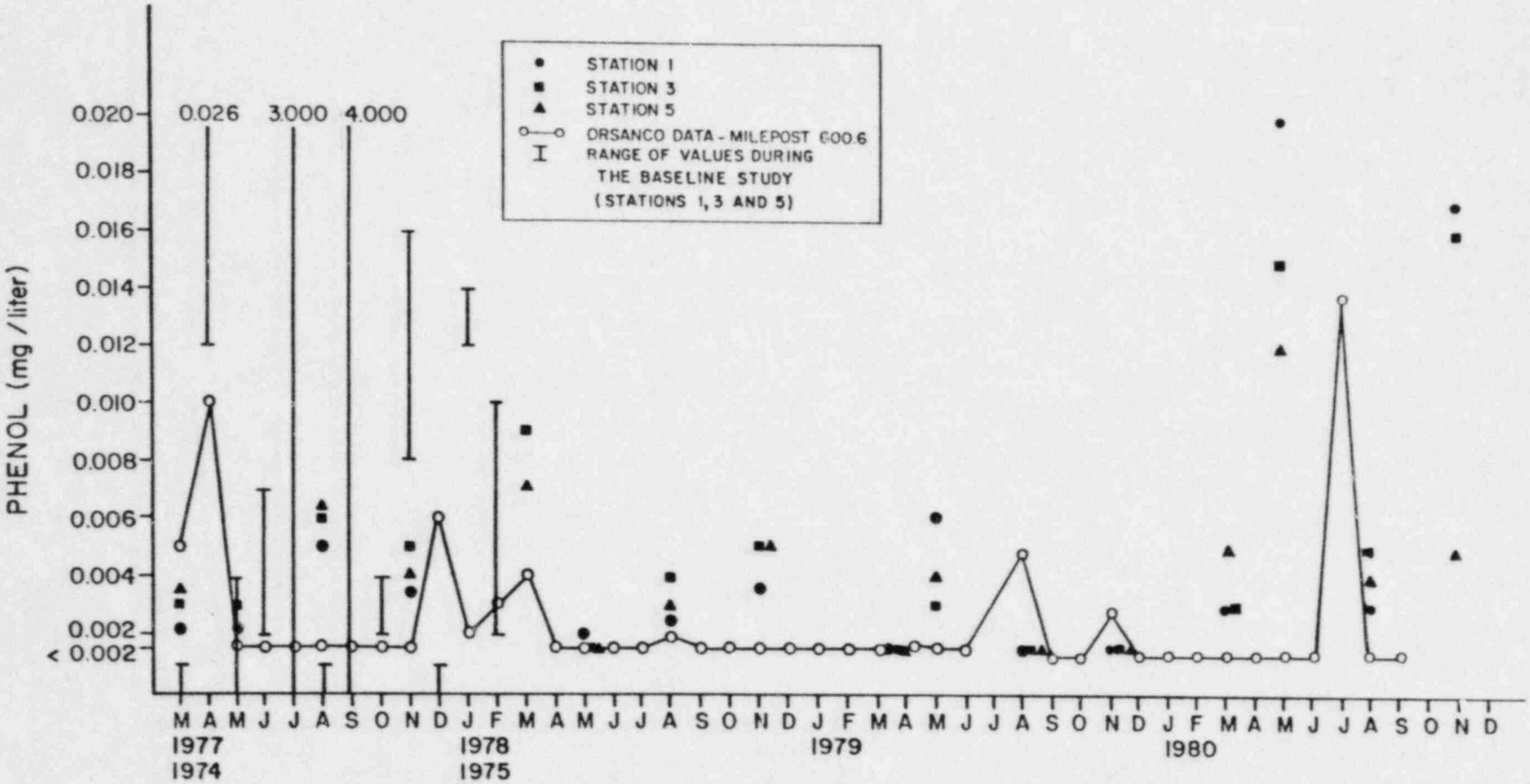

Figure A-22. Comparison of baseline, ORSANCO and construction phase phenol data (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

Figure A-23. Upstream sedimentation study rod at Station 8, 27 March 1980. Sediment accumulation of 2 cm since November 1979 was observed.

Figure A-24. Upstream sedimentation study rod at Station 8, 29 May 1980. Major erosion of stream banks had occurred since March, leaving rocks deposited behind the rod. Stream had altered course from the left to the right side of the stream bed. New study rod was placed to the right of the old rod.

Figure A-25. Upstream sedimentation study rod at Station 8, 13 August 1980. New study rod showed about 1 cm of new sediment since May.

Figure A-26. Upstream sedimentation study rod at Station 8, 3 November 1980. No new sediment accumulation since August.

Figure A-27. Downstream sedimentation study site at Station 8, 27 March 1980. Study rod was removed by significant construction activity and temporary alteration of stream flow direction.

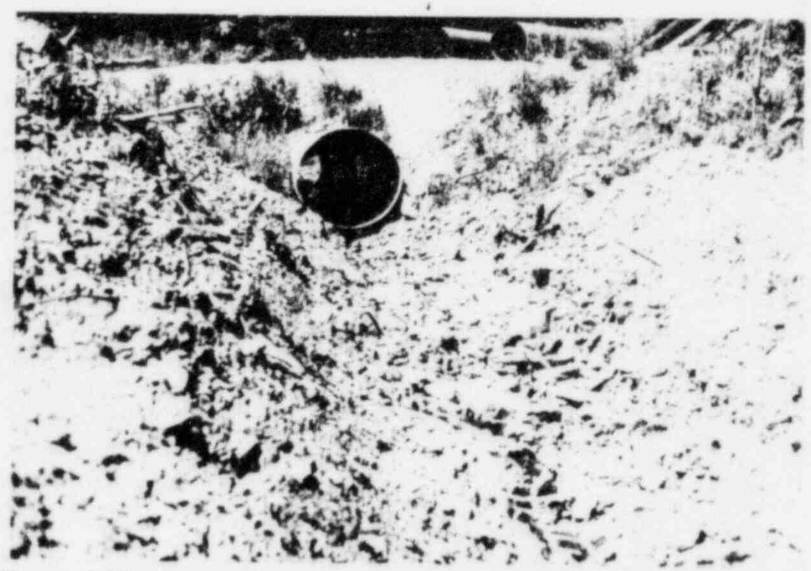

Figure A-28. Downstream sedimentation study site at Station 8, 29 May 1980. New study rod placed in March was again removed by continuing construction activity. No sediment accumulation was observed. Study rod was not replaced.

Figure A-29. Downstream sedimentation study site at Station 8, 13 August 1980. This is the final configuration of the altered stream bed. No sediment accumulation was noticeable on the riprapped stream bed.

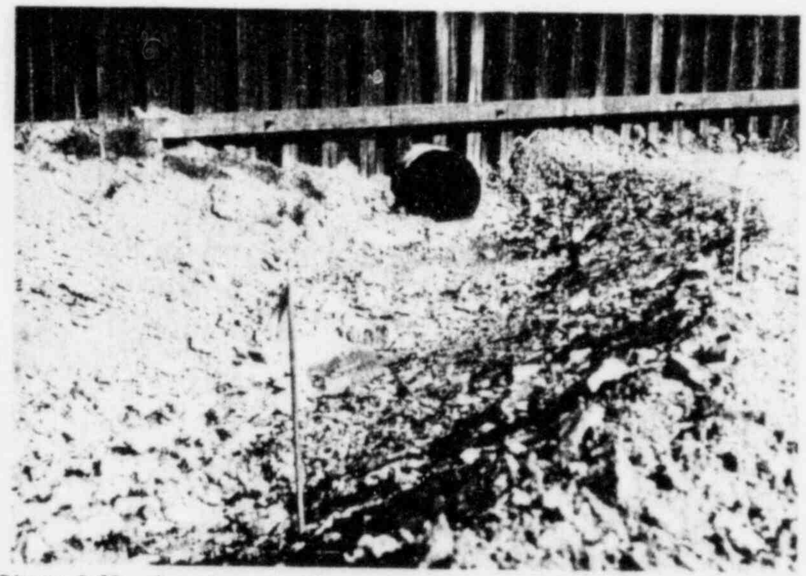

Figure A-30. Downstream sedimentation study site at Station 8, 3 November 1980. No new sediment accumulation was noticeable.

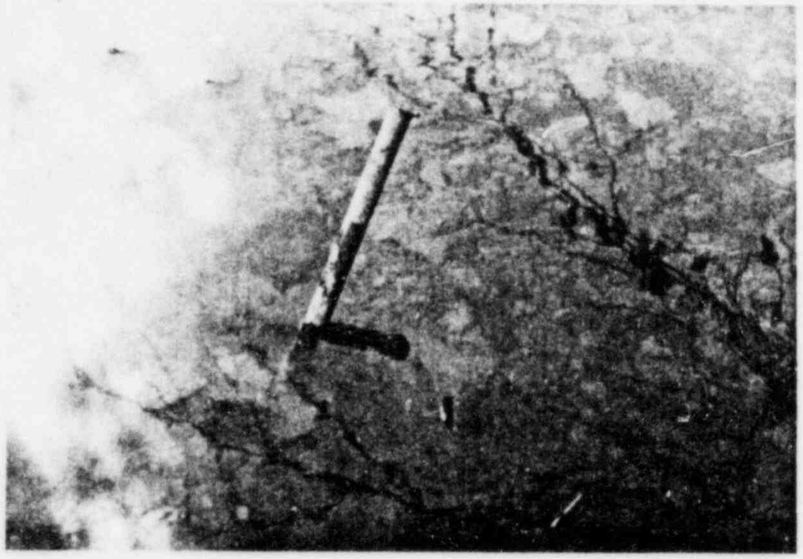

Figure A-31. Upstream (above bridge) sedimentation study rod at Station 6, 27 March 1980. No measurable sediment accumulation since November 1979.

Figure A-32. Upstream sedimentation study rod at Station 6, 29 May 1980. No measurable sediment accumulation since March 1980.

Figure A-33. Upstream sedimentation study rod at Station 6, 13 August 1980. No measurable sediment accumulation since May 1980.

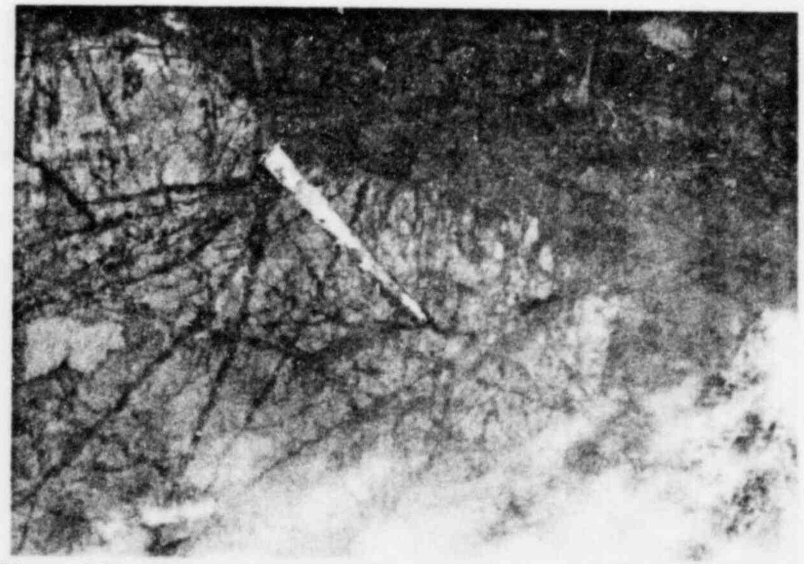

Figure A-34. Upstream sedimentation study rod at Station 6, 3 November 1980. No measurable sediment accumulation since August 1980.

Figure A-35. Downstream (below bridge) sedimentation study site at Station 6, 27 March 1980. Because there was no study rod at this location previously, one was placed here in March. Rocks in the stream bed were covered by a thin layer of silt. Algae was observed growing on rocks near the banks.

Figure A-36. Downstream sedimentation study site at Station 6, 29 May 1980. New study rod was missing. No new sediment accumulation was noticeable. A second study rod was placed in position.

Figure A-37. Downstream sedimentation study rod at Station 6, 13 August 1980. Thin sediment layer on rocks was noticeably absent and algal growth had extended into the center of the stream.

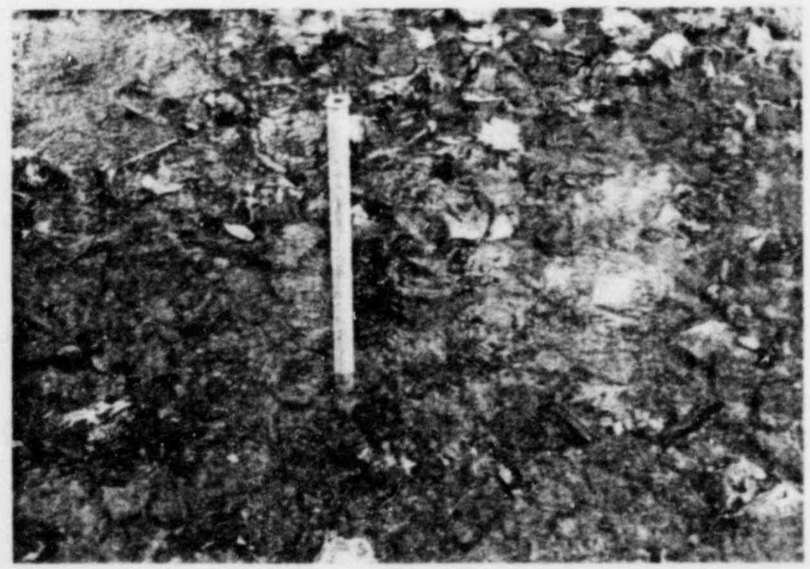

Figure A-38. Downstream sedimentation study rod at Station 6, 3 November 1980. No new sediment accumulation was observed.

TABLE A-1

RESULTS OF WATER CHEMISTRY ANALYSIS[a]
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1974-1980

Chemical parameter	Results from Environmental Report (PSI, 1976) March 1974-February 1975[b]	Results from 1977 Quarterly Sampling, Applied Biology, Inc.[b]	Results from 1978 Quarterly Sampling, Applied Biology, Inc.[b]	Results from 1979 Quarterly Sampling, Applied Biology, Inc.[b]	Results from 1980 Quarterly Sampling, Applied Biology, Inc.[b]
Dissolved oxygen	7.0 - 13.0	9.2 - 13.2	8.9 - 11.7	9.2 - 12.1	7.4 - 16.0
pH (standard units)	7.54 - 8.80	7.5 - 8.0	7.3 - 8.0	7.70 - 8.20	6.6 - 8.0
Alkalinity	184.0 - 275.2	192.4 - 245.0	111.2 - 196.3	206.5 - 217.0	193.3 - 213.3
Specific conductance (μmho)	311 - 429	218 - 445	168 - 478	390 - 580	390 - 790
Total dissolved solids	170 - 354	248 - 359	248 - 351	362 - 463	279 - 664
Total suspended solids	2 - 74	5 - 39	39 - 132	23 - 55	7 - 88
Biochemical oxygen demand	0.65 - 8.05	1.0 - 2.9	<1.0 - 4.2	1.7 - 3.5	1.0 - 2.6
Chemical oxygen demand	<0.1 - 11.4	2.6 - 5.3	3.2 - 10.4	10.5 - 22	5.6 - 32.2
Total organic carbon	7 - 50	1.71 - 5.33	3.50 - 13.43	1.5 - 9.9	1.8 - 4.9
Total phosphorus (PO_4-P)	0.20 - 0.28	0.02 - 0.09	<0.01 - 0.24	<0.01 - 0.10	0.02 - 0.24
Orthophosphates (PO_4-P)	0.15 - 0.19	<0.01 - 0.02	<0.01 - 0.09	<0.01 - 0.02	0.01 - 0.02
Nitrate nitrogen	0.05 - 1.85	0.66 - 1.52	1.39 - 1.97	0.51 - 1.57	0.25 - 0.46
Ammonia nitrogen	0.03 - 0.06	<0.02 - 0.08	<0.01 - 0.11	<0.01 - 0.03	0.03 - 0.13
Organic nitrogen	Not determined	<0.03 - 1.00	0.13 - 0.69	0.03 - 0.38	0.14 - 0.41
Silica (SiO_2)	1.50 - 9.8	6.50 - 9.14	3.7 - 6.7	1.64 - 6.7	6.04 - 7.09
Calcium	42.3 - 138.8	59.0 - 71.7	53.75 - 65.50	13.6 - 97.9	48.88 - 99.23
Magnesium	21.9 - 29.7	26.7 - 31.0	23.05 - 30.32	21.5 - 72.9	28.16 - 43.77
Sodium	2.5 - 30.8	1.4 - 6.9	3.47 - 14.11	4.8 - 30.9	7.70 - 42.62
Sulfate	23.2 - 38.4	33.0 - 64.0	43.2 - 121.0	65.4 - 114.5	17.7 - 84.8
Chlorides	18.1 - 22.0	4.4 - 13.8	7.2 - 25.7	14.6 - 45.1	14.0 - 120.5
Free residual chlorine	Not determined	<0.01	<0.01	<0.01	<0.01
Chloramines	<0.01	<0.01	<0.01	<0.01	<0.01
Hexane soluble material	<1.0 - 69	1.4 - 17.3	3.8 - 14.2	5.7 - 13.0	<5.0 - 6.4
Phenols	<0.001 - 0.20	<0.003 - 0.006	<0.002 - 0.009	<0.002	0.003 - 0.009

[a] Results are in milligrams per liter except when noted.

[b] Results are reported in milligrams per liter as a minimum to maximum range.

B. BACTERIA

INTRODUCTION

This study was conducted to monitor the fecal coliform, total coliform, and fecal streptococci of waters near the Marble Hill Plant site. Because certain coliform and streptococcal bacteria are normally found in the intestinal tract of man and other warm-blooded animals, these bacteria are good indicators of fecal contamination.

Coliforms are a diverse group of bacteria, the natural habitat of which includes soil, water, vegetation, and human and animal feces. In general, the presence of fecal coliform organisms in water indicates recent and possibly dangerous pollution while the presence of other coliform organisms suggests less recent pollution and contribution from non-fecal origins such as soil runoff water.

In addition to coliforms, fecal streptococci are a natural component of human and other warm-blooded animal intestinal tracts. The feces of man have been estimated to contain 4 times as many fecal coliforms as fecal streptococci, while fecal streptococci dominate in the excrement of other animals. A ratio of fecal coliforms to fecal streptococci has been used to indicate the source of fecal pollution in water systems (Geldreich, 1965). Ratios greater than 4:1 indicate contamination from human wastes, whereas ratios less than 0.6:1 indicate contamination from warm-blooded animals other than man.

The Indiana Stream Pollution Control Board, Indiana Water Quality Standards (SPC 1R-4, 1977) recommends a maximum permissible value of 400 counts per 100 ml for fecal coliforms during the months of April through October. During the months of November through March, fecal coliform bacteria counts are not to exceed 2000 per 100 ml. There are no specific recommendations for maximum permissible values of total coliform and fecal streptococci counts.

MATERIALS AND METHODS

Bacterial analyses were performed on duplicate samples from Stations 1, 3, 6 and 8 (Figure 1). Samples for bacterial examinations were collected in presterilized polyethylene containers, which were placed immediately in an iced cooler and shipped to the laboratory for analysis. The analyses were begun 6 to 10 hours after collection of the samples.

In the laboratory, the water samples were shaken vigorously to achieve homogeneity and were serially diluted with sterile, buffered water. The membrane filter technique (APHA, 1976) was used to analyze the appropriate dilutions for the number of total coliforms, fecal coliforms, and fecal streptococci. APHA-recommended media, incubation conditions, and colonial appearance criteria were utilized (Table B-1).

RESULTS AND DISCUSSION

The results of the 1980 quarterly analysis for total coliforms, fecal coliforms and fecal streptococci were reported as counts per 100 ml of sample (Appendix Tables B-1 through B-4). Total coliform counts and fecal streptococci counts were graphically compared to 1977-1979 ABI construction phase data and to baseline data (Figures B-1 and B-2). The Ohio River Valley Water Sanitation Commission (ORSANCO) does not report counts for these organisms. Fecal coliform counts for Stations 1 and 3 were graphically compared to baseline data (PSI, 1976), current ORSANCO data, and 1977-1979 construction phase monitoring data (ABI, 1978, 1979, 1980; Figure B-3).

Total Coliform

Total coliform counts for Ohio River Stations 1 and 3 ranged from less than 200 to more than 80,000 (Figure B-1, Table B-2). This was the broadest range of counts yet observed at the Marble Hill site. These counts are of approximately the same order of magnitude as those reported during the 1974 baseline study and the 1977-1979 construction phase monitoring programs. The only exceptional value was for August when total coliform counts for both stations exceeded 80,000. This was the highest total coliform count reported from the Ohio River during any monitoring near the Marble Hill site and may have been due to recent heavy rains. A similar coliform count was observed during 1979.

Total coliform counts at Station 6 in Little Saluda Creek were lower than those for Ohio River stations in March and May, and the same in August and November. However, August counts for Little Saluda Creek were as high as any found in previous monitoring.

Station 8, which is located in an intermittent stream near the Marble Hill Plant site, was sampled only during March and May when water was available for sampling. Counts for total coliforms were lower than for any other station and within the ranges found during the 1977-1979 construction monitoring programs (ABI, 1978, 1979, 1980).

Fecal Coliform

Fecal coliform counts for Ohio River Stations 1 and 3 ranged from 105 to 14,000 (Figure B-3, Table B-2). This was the broadest range yet observed in ecological monitoring at the Marble Hill site. Counts were similar to ORSANCO data and were highest in August. The source of the fecal coliform pollution must be upstream from the Marble Hill site, because Control Station 1 fecal coliform counts were usually higher than those of Station 3.

Fecal coliform counts for Station 6 in Little Saluda Creek were lower than or equal to those for the Ohio River stations and within the ranges found during the 1977-1979 construction monitoring programs. Fecal coliform counts at Station 8 were the lowest found at any sampling station during March and May. No water was available for sampling in August and November.

Fecal coliforms exceeded the maximum permissible limits of 2000 per 100 ml (SPC 1R-4, Indiana Water Quality Standards, 1977) at both Ohio River stations during March and August of 1980. At Stations 6 and 8, fecal coliform counts never exceeded the maximum permissible limit.

Fecal Streptococcus

During the 1980 monitoring program, fecal streptococcus counts were similar at both Ohio River stations (Figure B-2) and within the ranges found during the 1977-1979 construction monitoring programs (Table B-2).

Fecal streptococcus counts in Little Saluda Creek were higher than at the Ohio River stations in May, August and November, but counts were still within previously observed ranges. A similar seasonal variation was found during the 1977-1979 construction monitoring programs, which indicates the occurrence of a natural, seasonal trend uninterrupted by construction at the Marble Hill Plant site. Fecal streptococcus counts at Station 8 were the lowest ever observed at the plant site, but it should be noted that data could only be collected in March and May because no water was available for sampling in August and November.

The fecal coliform/fecal streptococcus (FC/FS) ratio for Ohio River Station 1 exceeded 4:1 during May, August and November. At Station 3, the FC/FS ratio exceeded 4:1 during March, August and November. These high ratios suggest human waste contamination of the Ohio River from sources upstream of the Marble Hill site. In Little Saluda Creek, FC/FS ratios were consistently below 1:1 suggesting bacterial contamination derived from the feces of warm-blooded animals other than man. It therefore appears that the high total coliform counts encountered at Stations 3, 6 and 8 in August were not the result of human contamination from the Marble Hill site.

CONCLUSIONS

Quarterly sampling and analysis for total coliform, fecal coliform, and fecal streptococcus bacteria were performed at sampling stations in the Ohio River and Little Saluda Creek near the Marble Hill Plant site. Compared to Ohio River Control Station 1, Station 3 exhibited no increase in fecal coliform or fecal streptococci counts attributable to runoff from the plant site. Furthermore, counts found during 1980 were in the same broad range as found during previous ecological monitoring programs. Total coliform counts were within the ranges of previous monitoring except during August at both Ohio River stations and in Little Saluda Creek. Excessive total coliform counts at these stations in August appear to occur as soil runoff from the plant site; however, FC/FS ratios indicate that this bacterial contamination is not derived from human feces.

Little Saluda Creek total coliform counts were higher in August than at any other time in which total coliform counts were made. This high count indicates either contamination by warm-blooded animals other than man or high soil bacteria populations. Fecal coliform and fecal streptococci counts were generally lower but within the ranges found during previous studies.

Because water was found at the Station 8 creek on only two dates, 1980 results cannot be considered adequate. Total coliform values were the lowest ever observed at the plant site. No human fecal contamination was indicated. Fecal coliform and fecal streptococci values were also lower than found during any previous monitoring program.

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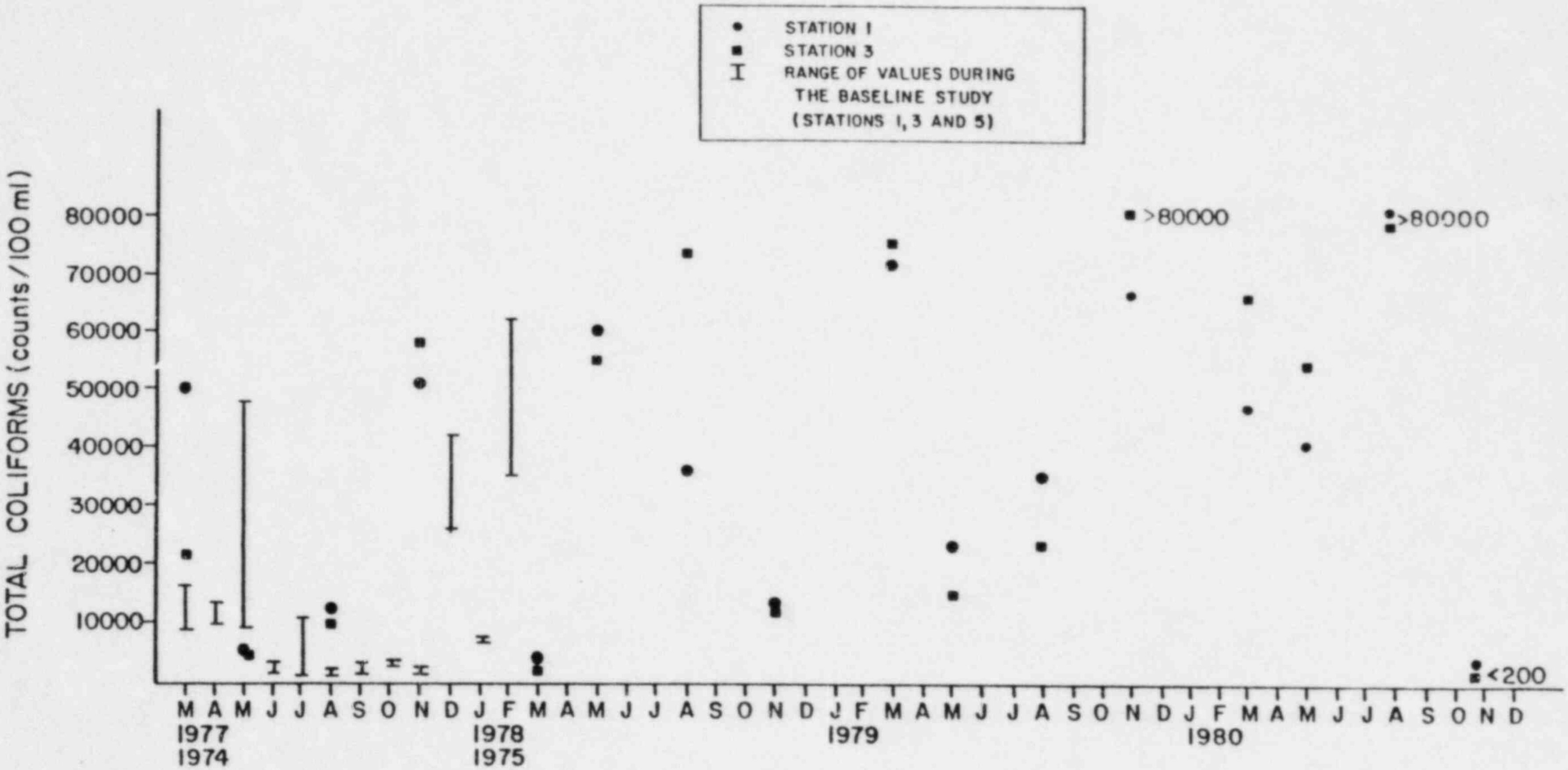

Figure B-1. Comparison of baseline and construction phase total coliform counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

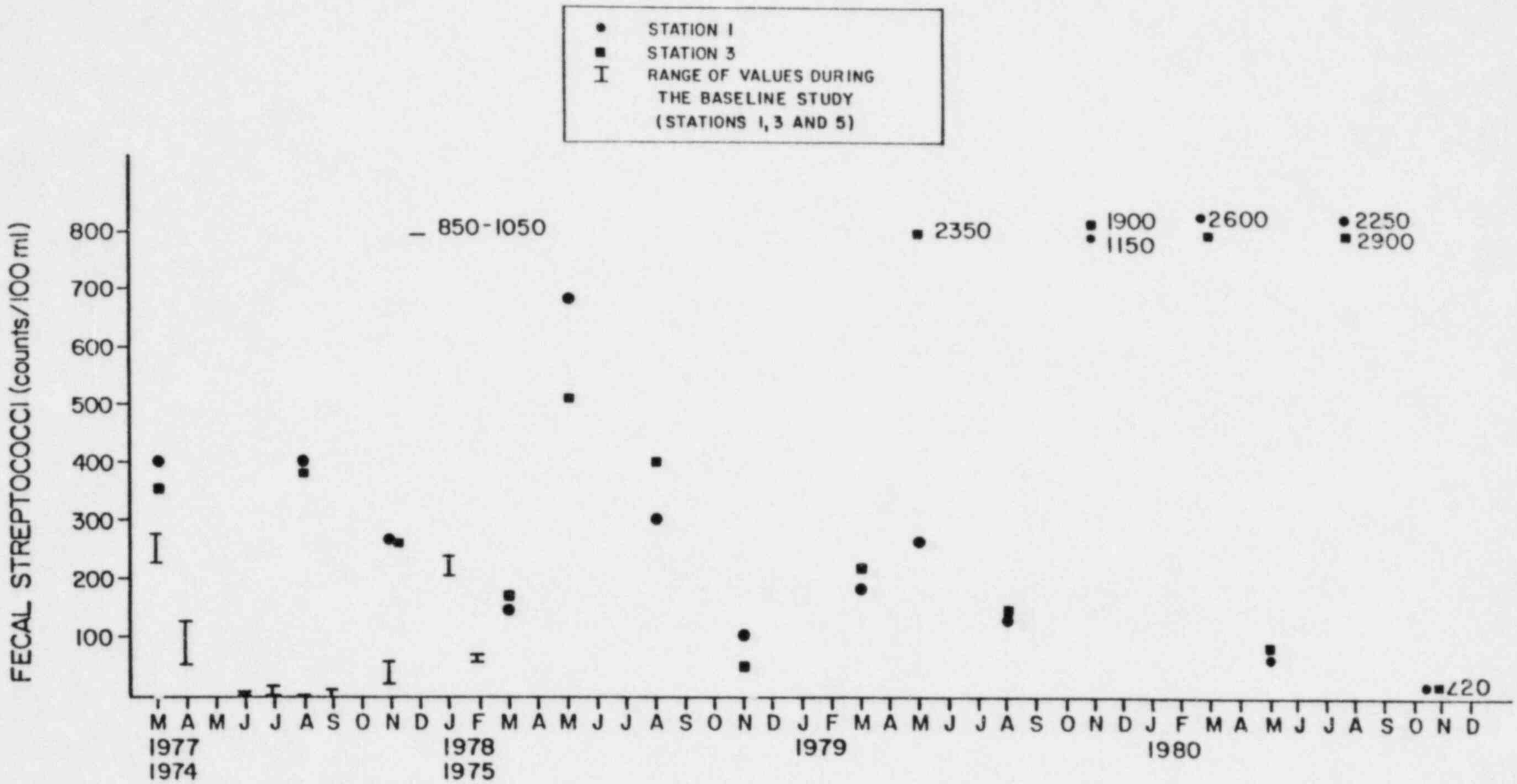

Figure B-2. Comparison of baseline and construction phase fecal streptococci counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

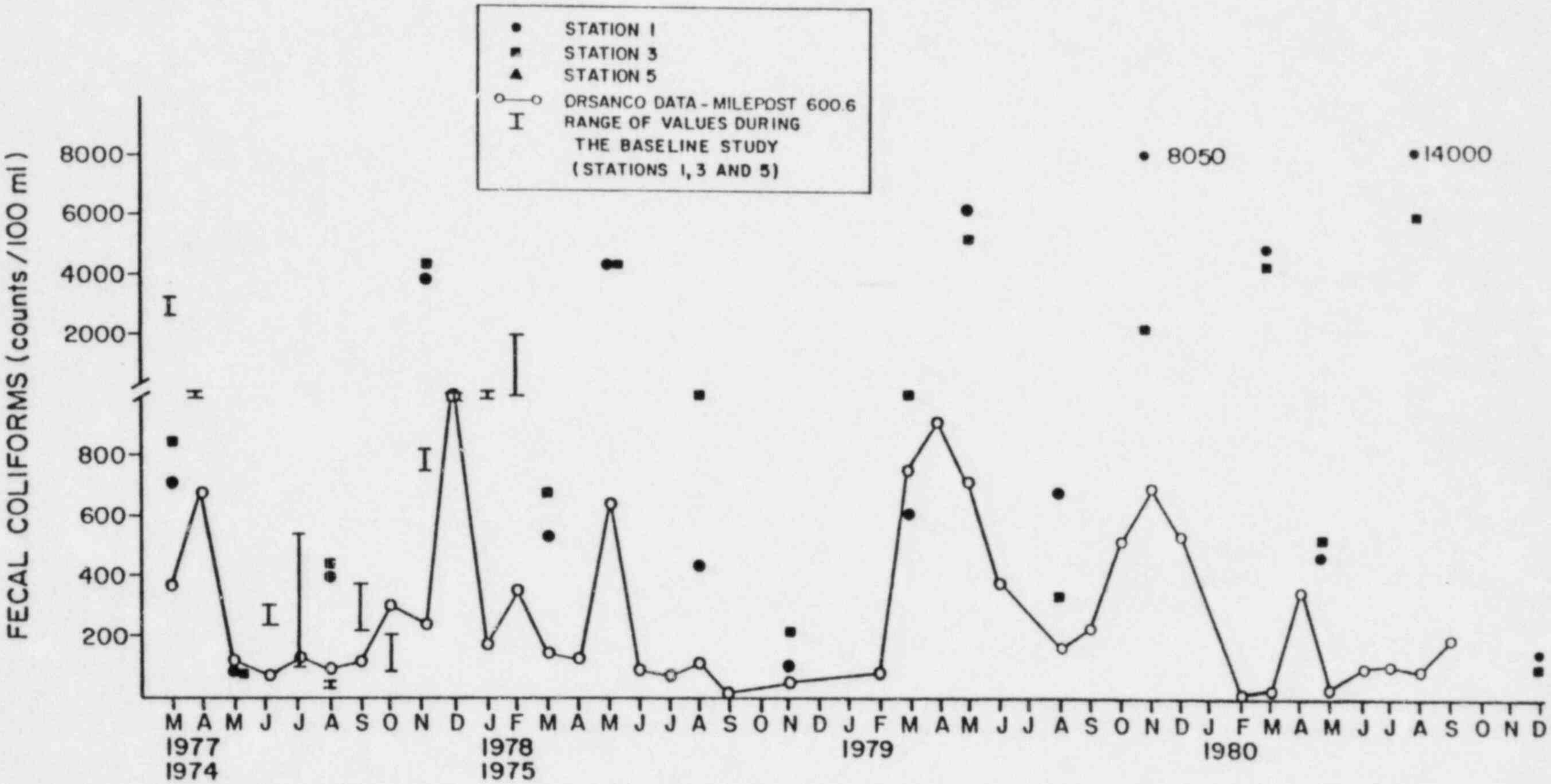

Figure B-3. Comparison of baseline, ORSANCO and construction phase fecal coliform counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site, 1974 - 1975 and 1977 - 1980.

TABLE B-1

CONDITIONS USED IN ANALYSES FOR
DETERMINATION OF BACTERIAL POPULATIONS
MARBLE HILL PLANT SITE
1980

Bacterial type	Medium used	Incubation conditions	Colonial appearance
Total coliforms	M-Coliform Broth	35°C, 24 hr	Dark red with metallic surface sheen
Fecal coliforms	M-FC Broth	44.5°C, 24 hr	Blue
Fecal streptococci	KF Streptococcal Agar	35°C, 48 hr	Dark red to pink

TABLE B-2

SUMMARY OF THE RESULTS OF BACTERIAL ANALYSES
MARBLE HILL PLANT SITE
1977-1980

Sampling station	Bacterial parameter	Range of mean counts per 100 ml			
		1977	1978	1979	1980
1	Total coliform	5400 - 51,000	4150 - 60,000	23,000 - 71,500	<200 - >80,000
	Fecal coliform	80 - 3800	90 - 4300	600 - 8050	125 - 14,000
	Fecal streptococci	10 - 400	110 - 685	130 - 1150	<20 - 2600
3	Total coliform	4800 - 58,000	2250 - 73,500	15,000 - >80,000	<200 - >80,000
	Fecal coliform	75 - 4350	180 - 4350	330 - 5250	105 - 6000
	Fecal streptococci	<10 - 380	55 - 510	145 - 2350	<20 - 2900
6	Total coliform	2200 - 17,500	80 - 70,000	710 - >80,000	<200 - >80,000
	Fecal coliform	<10 - 345	<20 - 1500	<20 - 535	10 - 1100
	Fecal streptococci	15 - 8800	45 - 4100	<20 - 2050	20 - 7450
8	Total coliform	1500 - 27,000	750 - 50,000	50,500 - >80,000	2800 - 26,000
	Fecal coliform	<10 - 445	<20 - 3450	55 - 2600	<20 - <20
	Fecal streptococci	10 - 3800	45 - 6900	860 - 2400	<20 - 105

C. PLANKTON

C.1 PHYTOPLANKTON

INTRODUCTION

Phytoplankton are chlorophyll-bearing algae that passively drift or have limited means of locomotion and, therefore, are subject to waves and currents in aquatic environments. Through photosynthesis, phytoplankton convert solar energy and inorganic nutrients into the protoplasm that forms the base of aquatic food chains. Consequently, phytoplankton abundance and composition determine, in part, the quantity and quality of larger organisms that depend directly or indirectly upon phytoplankters for their nutritional requirements.

True phytoplankters usually predominate in large rivers while benthic algae washed off the stream bottom typify small streams. Diatoms are most often the dominant phytoplankton group (Hynes, 1972), but green and blue-green algae and flagellates are abundant seasonally. Replenishment from backwater areas and tributaries is needed to maintain phytoplankton densities.

The purpose of the phytoplankton study at the Marble Hill Plant site was to determine phytoplankton species composition, abundance and biovolume at stations in the Ohio River and in Little Saluda Creek during plant construction. Data collected during the 1980 monitoring program were compared to baseline data (PSI, 1976) and to previous construction phase monitoring data (ABI, 1978, 1979, 1980) to evaluate plant construction effects on phytoplankton.

MATERIALS AND METHODS

Duplicate phytoplankton samples were collected quarterly at Stations 1, 3 and 5 in the Ohio River and at Station 6 in Little Saluda Creek. One-liter subsurface water samples were collected at a depth of 0.3 m with a nonmetallic Kemmerer sampling device and were preserved in the field with buffered 4-percent formalin.

In the laboratory, each 1-liter replicate sample was allowed to settle and then concentrated to approximately 200 ml. Duplicate subsamples (0.15 to 5.0 ml) of each replicate sample concentrate were settled in Utermohl chambers (Utermohl, 1958). The amount of detritus and number of phytoplankters in the sample determined the degree of sample concentration and the volume of subsamples. Strip counts totaling approximately 200 phytoplankters per replicate Utermohl chamber (400 phytoplankters per replicate sample) were made at 560X magnification.

All phytoplankters were counted individually except for filamentous and colonial green and blue-green algae. Filamentous green and blue-green species were counted as 100-μ standard lengths (PSI, 1976) with each standard length representing one counting unit. Colonial forms, exclusive of diatoms, were counted with each colony representing one counting unit. Phytoplankton density (N) was calculated as number of cells per milliliter by:

$$N = \frac{\frac{V_c}{V_e} C}{V_s}$$

where: V_c = Volume of sample concentrate, in milliliters;

$$V_e = \frac{A_s}{A_u} S$$

where: A_s = Area of strips counted, in square millimeters;

A_u = Area of Utermohl chamber, in square millimeters;

S = Subsample volume, in milliliters.

C = Count;

V_s = Volume of sample, in milliliters.

Diatoms were also counted in Utermohl chambers. Species identification to the lowest practicable taxon and proportional counts of diatoms were made from permanent mounts at 1000X magnification. Total diatom counts were used with diatom species proportional counts to obtain density by species (APHA, 1976). Representative permanent diatom mounts and aliquots of all samples analyzed will be retained for reference for the life of the plant.

Phytoplankton biovolume was estimated from optical measurements. The average volume for each predominant phytoplankter (5 percent or more of the total population at any station) was determined by measuring five individuals. Average dimensions were converted to volume using formulae for solids approximating the shape of each species (Kutkuhn, 1958; Hargraves and Wood, 1967; APHA, 1971; EPA, 1973). For phytoplankters making up less than 5 percent of the total population at any station, at least one biovolume measurement was made. Biovolume, expressed as cubic microns per milliliter, was calculated by the following equation:

$$\text{biovolume} = NV_s$$

where: N = Density of each species, in cells per milliliter;

V_s = Average volume of each species, in cubic microns.

Biovolume and density data were $\log_e$ transformed before statistical analysis to reduce the effect of nonhomogeneous variation in these data. The 95 percent confidence interval was used for all statistical analyses.

RESULTS AND DISCUSSION

A total of 242 phytoplankton species (Table C.1-1) were collected from the Ohio River and Little Saluda Creek during the 1980 monitoring. As in previous monitoring studies (PSI, 1976; ABI, 1978, 1979, 1980), diatoms continued to dominate the phytoplankton community.

Ohio River Stations

Phytoplankton densities ranged from 1020 cells/ml to 7485 cells/ml in 1980 (Tables C.1-2 through C.1-5). The annual mean density for the year was slightly higher than in 1979 but lower than in 1977 or 1978. Phytoplankton density patterns differed from prior years in that the highest densities in 1980 were in March and May rather than in May and August (Figure C.1-1). The absence of higher phytoplankton density in August 1980 coincided with reduced zooplankton densities and may be related to increased turbidity during this time. Minimum densities were found during November. Phytoplankton densities in 1980 were higher at

Station 1 than at Stations 3 or 5 in March and May, while density was higher at Stations 3 and 5 in November and August, respectively, than at Station 1. The lack of a consistent pattern in interstation density variation suggests that density differences among river stations were not related to plant construction.

Total biovolume ranged from 7750 x 10^2 μ^3/ml in August to 19,904 x 10^2 μ^3/ml in May (Tables C.1-2 through C.1-5). Mean annual biovolume was lower in 1980 than in prior monitoring years. Phytoplankton biovolume generally exhibited a trend similar to that for density (Figure C.1-2). Despite reduced densities in November, however, biovolume was either comparable to or increased from the low seen in August. Increased biovolume during November was apparently due to the dominance of larger species. With the exception of the November sampling, biovolume among river stations tended to be greatest at Station 1.

Little Saluda Creek

Habitat differences between Little Saluda Creek and the Ohio River were reflected in phytoplankton density, biovolume, and species composition. Density ranged from 96 cells/ml in November to 680 cells/ml in March, while biovolume ranged from 349 x 10^2 μ^3/ml in November to 2745 x 10^2 μ^3/ml in May (Tables C.1-2 through C.1-5). Although the trend in density was similar to that of previous survey years, the overall density in 1980 was greater than in 1977 or 1979. Maximum density and biovolume did not coincide because, although March and May densities were similar in magnitude, the phytoplankters collected in May were of generally larger species than those collected in March.

Community Composition

As in previous monitoring programs, the phytoplankton communities in the Ohio River and Little Saluda Creek were dominated by diatoms (Figure C.1-3). Diatom relative abundance ranged from 83 to 97 percent (Tables C.1-2 through C.1-5). This range was narrower and higher than that found in prior construction phase monitoring. Diatom relative abundance in Little Saluda Creek was higher than in earlier construction phase monitoring programs (ABI, 1978, 1979, 1980) but within the range found during the baseline study (PSI, 1976). During 1980, the relative abundance of diatoms in the Ohio River was stable over the year among the stations. This consistent pattern in diatom relative abundance indicated that differences among the stations and among preceeding sampling phases were probably related to general river conditions rather than to any impact from plant construction.

For both the Ohio River and Little Saluda Creek, the dominant diatom species (contributing $\geq$ 5 percent to the total phytoplankton at a minimum of one station on one date) were:

Cyclotella glomerata
*C. pseudostelligera**
Cyclotella sp. 1*
*Melosira distans**
*M. granulata**
M. islandica subsp. *helvetica**
Melosira sp. 1
*Achnanthes minutissima**
Achnanthes linearis f. *curta*
Asterionella formosa
*Gomphonema parvulum**
Navicula cryptocephala
N. viridula
*Nitzschia dissipata**
*N. palea**
Synedra fasciculata

The species' name with an asterisk were also dominant in two of three earlier construction phase monitoring periods. *Melosira distans*, *M. granulata*, *Asterionella formosa*, *Gomphonema parvulum*, *Navicula* cryptocephala, and N. virudula were also dominant during the baseline study.

Those species that were dominant in the river are generally considered to be true phytoplankters while those that were dominant in Little Saluda Creek tend to be periphytic (Lowe, 1974). Cyclotella sp. 1, C. glomerata, and Melosira distans were the most common diatoms in terms of density and occurrence. Melosira sp. 1 was noted only in August samples but composed from 20 to 29 percent of the density. Cyclotella sp. 1 was most abundant in March and May while C. glomerata codominated with either Melosira sp. 1 or M. distans in August and November.

The remaining major phytoplankton groups composed a smaller proportion of the phytoplankton community in 1980 than in previous construction phase monitoring (Tables C.1-2 through C.1-5). The green algae (Chlorophyta) remained second in relative abundance but never represented more than 8 percent of the total phytoplankton density. Blue-green algae (Cyanophyta) was the third most abundant group with a maximum relative abundance of less than 7 percent.

Interstation Variation and Ecological Relationships

Phytoplankton densities in 1980 were not found to differ significantly among the Ohio River stations (Table C.1-6). Significant seasonal differences were found, a result expected of quarterly Ohio River phytoplankton studies. Phytoplankton biovolume data showed no significant seasonal or station differences for the Ohio River stations (Table C.1-7).

There were no significant differences in density among river stations when phytoplankton density data for all four years of construction phase monitoring and appropriate baseline data were analyzed (Table C.1-8). Although densities were significantly higher in 1977 and 1978 than in any other year, density values for 1979 and 1980 were not significantly different from those of the baseline study. The biovolume data for baseline and construction phase monitoring showed no significant station effects (Table C.1-9). Again, there was a significant difference among years, although no construction phase monitoring data were statistically different from the baseline data.

The significant interaction between season and station for phytoplankton density (Table C.1-6), the nonsignificant station effects seen for biovolume and density in 1980 (Table C.1-7), and overall study results suggest that station variation in the river was the result of river conditions rather than plant construction effects.

Phytoplankton biovolume in Little Saluda Creek was not significantly different over all monitoring years (Table C.1-10). Density differences among years were indicated, but the multiple comparisons test showed that densities in 1980 were not significantly different from the densities found in any of the other sampling years. During 1980, impact from plant construction was not apparent.

Phytoplankton density was significantly correlated with temperature at all river stations, with nitrate nitrogen at Station 3, and ammonia nitrogen at Station 1 (Table C.1-11). Correlations between biovolume and all parameters tested were not significant (Table C.1-12). The strongest correlations with biovolume at the river stations were with temperature and Secchi depth. No correlation exhibited a relationship indicative of adverse impact due to plant construction.

CONCLUSIONS

Samples were collected to determine if construction at the Marble Hill Plant site was adversely impacting the phytoplankton community at three locations in the Ohio River and at one location in Little Saluda Creek. Density and biovolume data were reduced and analyzed for statistical differences among sampling stations and among seasons. Data were compared to baseline and previous construction phase monitoring data.

As in previous studies, diatoms dominated the phytoplankton community. Phytoplankton composition, number of species, density and biovolume were generally similar to previous construction phase monitoring data in both the Ohio River and Little Saluda Creek.

Significant differences among river stations for both density and biovolume were not apparent in 1980 or for the overall construction phase and baseline monitoring, and comparisons of density and biovolume among years yielded no significant differences indicative of plant construction impact on riverine phytoplankton populations. The absence of significant interstation differences for density and biovolume during 1980 or for the

1974, 1977-1980 monitoring programs in the Ohio River indicated that annual, seasonal, and station variations were the result of general riverine conditions rather than impact from plant construction. Impact on Little Saluda Creek was also not evident because annual phytoplankton density during baseline monitoring was significantly different from only one year of construction phase monitoring and there were no significant differences in biovolume among years.

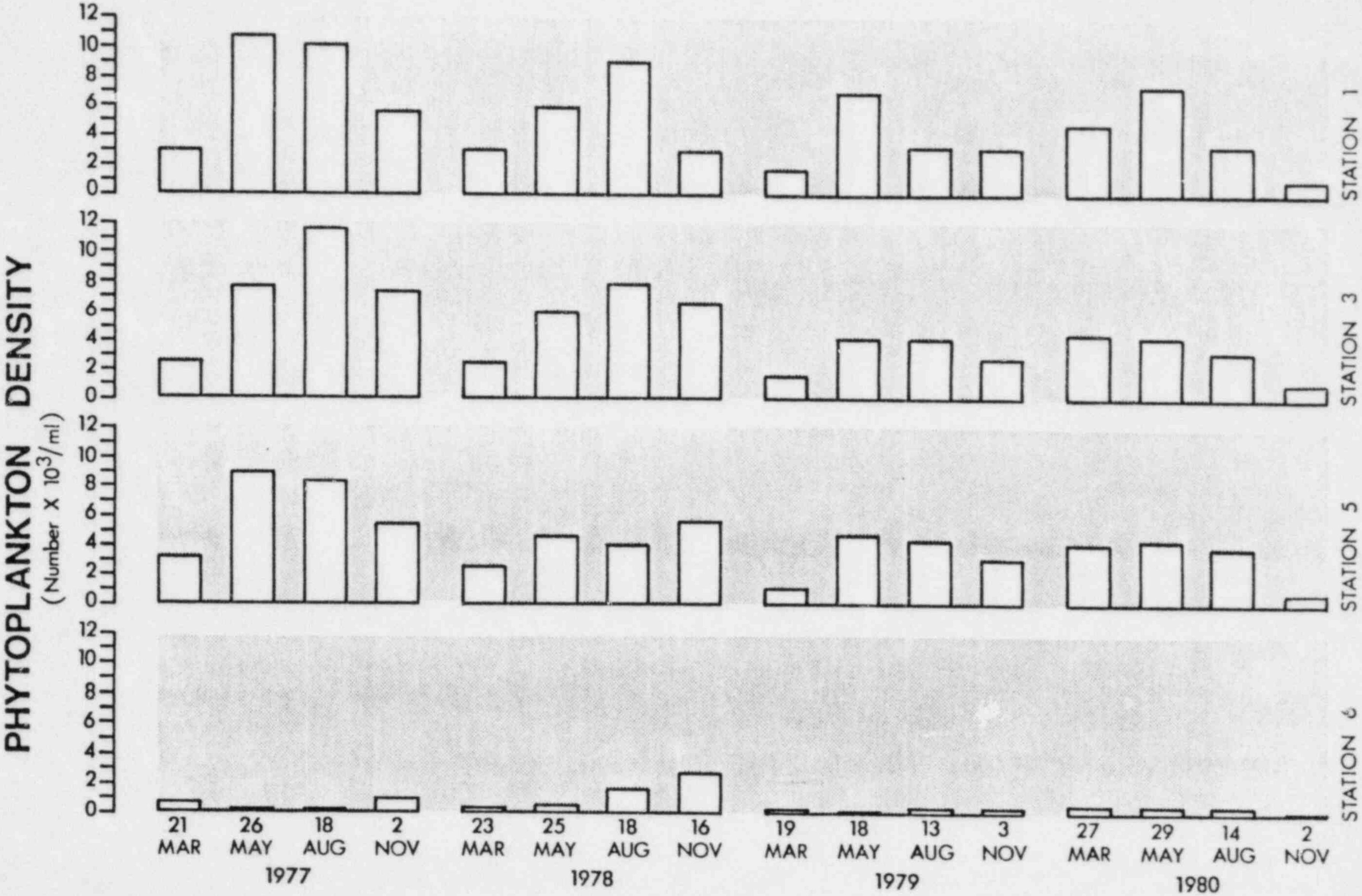

Figure C.1-1. Total phytoplankton density at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

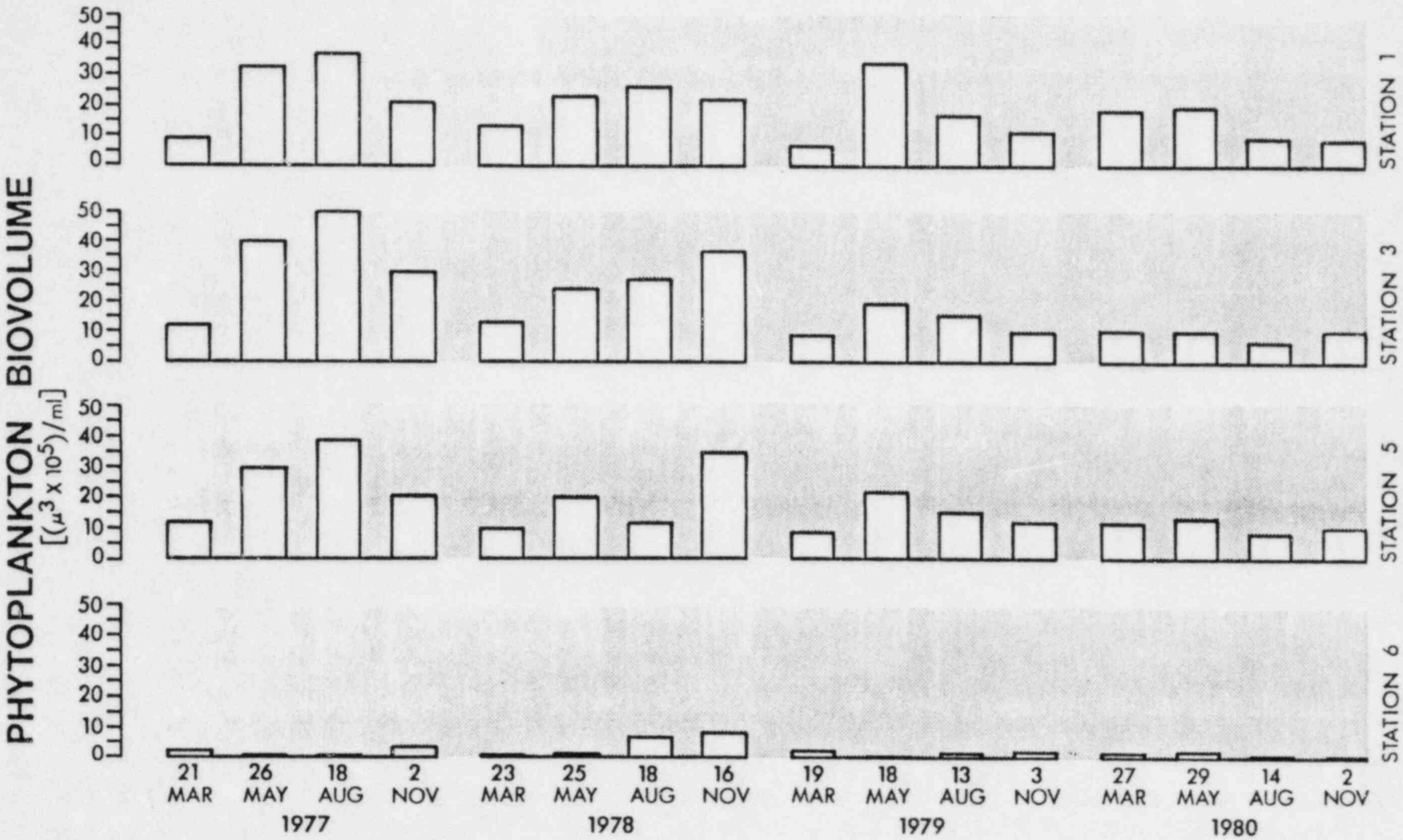

Figure C.1-2. Total phytoplankton biovolume at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

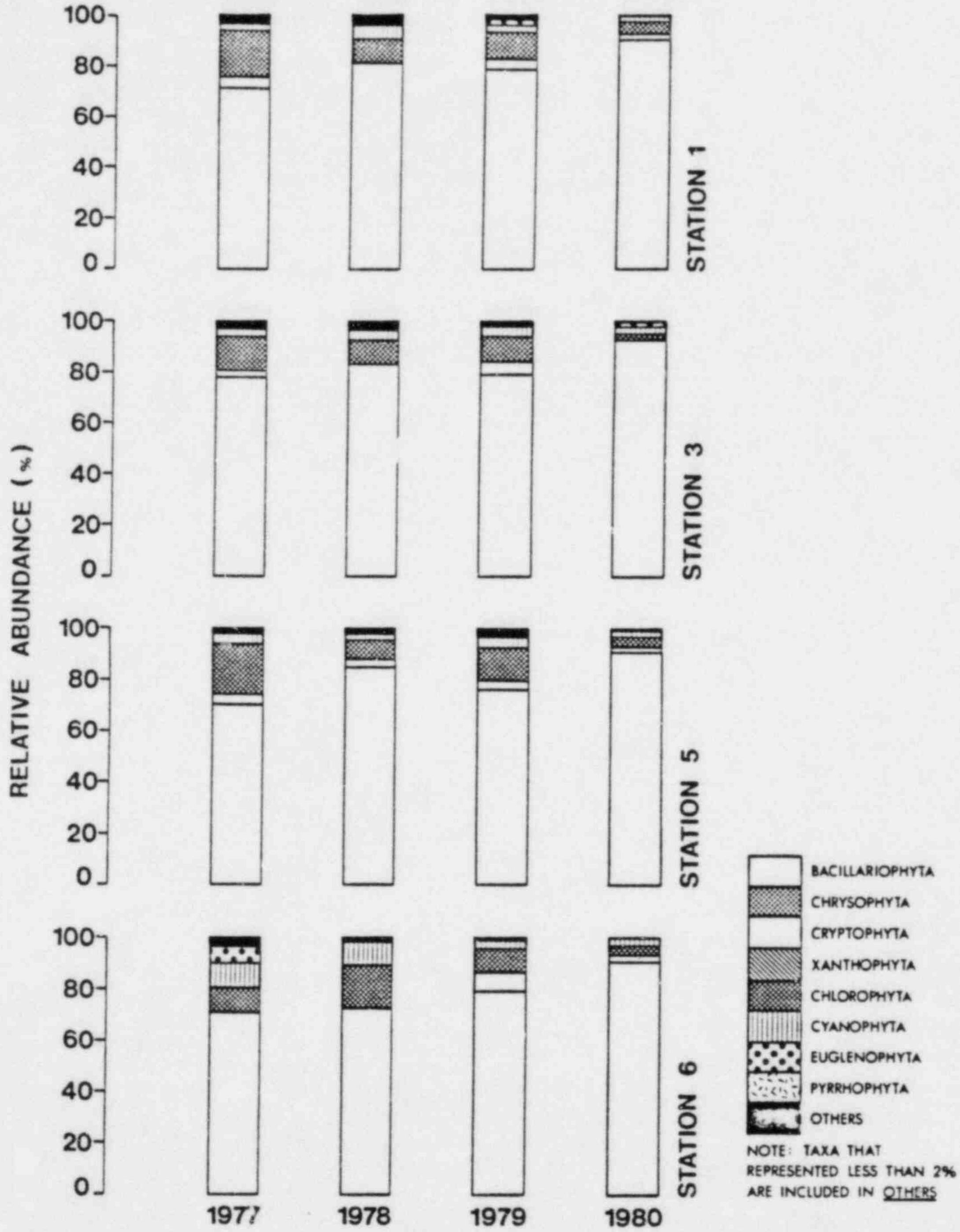

Figure C.1-3. Relative abundance of major phytoplankton groups at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

TABLE C.1-1

LIST OF PHYTOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1980

BACILLARIOPHYTA
Centrales
Coscinodiscus lacustris
Cyclotella comta
C. glomerata
C. ocellata
C. Meneghiniana
C. pseudostelligera
C. stelligera
C. striata
Cyclotella sp. 1
Melosira ambigua
M. distans
M. granulata
M. granulata v. angustissima
M. islandica subsp. helvetica
M. italica
M. varians
Melosira sp. 1
Stephanodiscus astraea
S. astraea v. minutula
S. dubius
unidentified centric sp. 1
unidentified centric sp. 2
Pennales
Achnanthes affinis
A. deflexa
A. exigua
A. lanceolata
A. lanceolata v. dubia
A. linearis
A. linearis f. curta
A. microcephala
A. minutissima
A. nollii
Amphora ovalis v. pediculus
A. perpusilla
A. submontana
Anomoeoneis vitrea
Asterionella formosa
A. formosa v. gracillima
Cocconeis pediculus
C. placentula
C. placentula v. lineata
Cymbella affinis
C. minuta f. latens
C. minuta v. silesiaca
C. tumida
C. tumidula
Cymbella sp. 1
Diatoma tenue v. elongatum
D. vulgare
Eunotia exigua
E. tenella
E. vanheurckii
Fragilaria capucina

BACILLARIOPHYTA (continued)
Pennales (continued)
Fragilaria capucina v. pumila
F. crotonensis
F. pinnata
F. vaucheriae
Frustulia rhomboides v.
Gomphonema affine
G. angustatum
G. angustatum v. citera
G. gracile
G. olivaceum
G. parvulum
G. tenellum
G. truncatum
Gyrosigma nodiferum
G. obtusatum
Hantzschia amphioxys
Meridion circulare
Navicula biconica
N. cincta
N. cryptocephala
N. cryptocephala v. veneta
N. graciloides
N. lanceolata
N. mutica
N. mutica v. cohnii
N. mutica v. undulata
N. radiosa v. parva
N. rhyncocephala
N. schroeteri v. escambia
N. tripunctata
N. tripunctata v. schizonemoides
N. viridula
N. viridula v. avenacea
N. viridula v. rostellata
Navicula sp. 2
Navicula sp. 4
Nitzschia acicularis v. closterioides
N. amphibia
N. capitellata
N. clausii
N. communis
N. communis v. abbreviata
N. dissipata
N. filiformis
N. gandersheimiensis
N. hungarica
N. linearis
N. palea
N. parvula
N. sublinearis
N. tryblionella v. levidensis
N. tryblionella v. victoriae
Pinnularia appendiculata
P. obscura

TABLE C.1-1
(continued)
LIST OF PHYTOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1980

BACILLARIOPHYTA (continued)
Pennales (continued)
Pinularia subcapitata
P. subcapitata v. paucistriata
Pinnularia sp. 1
Rhoicosphenia curvata
Stauroneis anceps
Surirella angustata
S. linearis
S. ovata
Synedra acus
S. delicatissima
S. delicatissima v. angustissima
S. fasciculata
S. filiformis v. exilis
S. incisa
S. minuscula
S. pulchella
S. radians
S. rumpens
S. rumpens v. familiaris
S. rumpens v. Meneghiniana
S. socia
S. ulna
S. ulna v. contracta

CHRYSOPHYTA
Dinobryon cylindricum
Mallomonas ? sp. 1

CRYPTOPHYTA
Cryptomonas ovata
cryptophyte sp. 1
cryptophyte sp. 2

XANTHOPHYTA
Ophiocytium parvulum

CHLOROPHYTA
Actinastrum hantzschii
Ankistrodesmus convolutus
A. falcatus
A. falcatus v. acicularis
A. falcatus v. mirabilis
A. fractus
A. spiralis
Carteria cordiformis
C. Klebsii
C. multifiliis
Carteria sp. 2
Characium ambiguum
Characium sp. 1
Chlamydomonas globosa
Chlamydomonas sp. 1
Chlamydomonas sp. 3
Chlamydomonas sp. 5
Chlorella ? sp.
Chlorogonium elongatum
Chlorogonium sp.

CHLOROPHYTA (continued)
Closteriopsis longissima
Closterium acutum v. variabile
Closterium sp. 2
Coelastrum sphaericum
Cosmarium sp. 3
Crucigenia quadrata
C. tetrapedia
Dictyosphaerium Ehrenbergianum
Gloeocystis sp.
Golenkinia radiata
Gonium pectorale
Kirchneriella contorta
K. lunaris v. irregularis
K. obesa
Lagerheimia quadriseta
Micractinium pusillum
Nephrocytium limneticum
Oocystis Borgei
Oocystis ? sp. 1
P. duplex v. clathratum
Pediastrum obtusum
Polyedriopsis quadrispina
Scenedesdesmus abundans
S. abundans v. longicauda
S. acuminatus
S. Bernardii
S. denticulatus
S. dimorphus
S. incrassatulus v. mononae
S. quadricauda
Scenedesmus sp. 2
Schroederia setigera
Selenastrum Bibrianum
S. gracile
S. Westii
Tetraedron caudatum
T. minimum
Tetrastrum glabrum
T. heteracanthum
T. punctatum
T. staurogeniaeforme
coccoid green sp. 2
coccoid green sp. 7
unidentified green sp. 2

CYANOPHYTA
Anabaena sp. 1
Aphanizomenon sp.
Aphanothece sp.
Chroococcus dispersus v. minor
C. limneticus
Dactylococopsis acicularis
D. fascicularis ?
D. Smithii
Gomphosphaeria lacustris
Lyngbya aestuarii
L. contorta
L. Diguetii

TABLE C.1-1
(continued)
LIST OF PHYTOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1980

CYANOPHYTA (continued)
- L. limnetica
- Lyngbya sp.
- Marssoniella elegans
- Merismopedia tenuissima
- Microcystis incerta
- Oscillatoria amphibia ?
- O. limnetica
- O. tenuis (sp. 4)
- Oscillatoria sp. (1,2)
- Rhabdoderma irregulare
- R. lineare
- Synechococcus sp.
- filamentous blue-green sp. 1

EUGLENOPHYTA
- Euglena acus
- E. convoluta
- E. proxima
- Euglena sp. 4

EUGLENOPHYTA (continued)
- Phacus assymetrica
- P. crenulata
- Trachelomonas hispida
- T. robusta
- Trachelomonas sp. 1
- Trachelomonas sp. 2
- Trachelomonas sp. 9
- euglenoid sp. 1
- euglenoid sp. 2

PYRRHOPHYTA
- Massartia sp. 1
- dinoflagellate sp. 1

OTHERS
- phytoflagellate sp. 4
- phytoflagellate sp. 9

TABLE C.1-2

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
27 MARCH 1980

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance (%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance (%)	Biovolume (μ^3x10^2)/ml
Bacillariophyta	4472.5	91.7	16095.39	4266.3	92.0	9304.55	3934.1	90.8	11270.84	642.8	94.3	1333.91
Chrysophyta	9.9	0.2	11.22	5.1	0.1	5.78	5.2	0.1	5.89	0.0	0.0	0.00
Cryptophyta	24.3	0.5	119.71	14.9	0.3	113.96	81.7	1.8	151.96	5.1	0.8	5.88
Xanthophyta	0.0	0.0	0.00	0.0	0.0	0.00	5.1	0.1	34.12	0.0	0.0	0.00
Chlorophyta	106.3	2.2	806.89	80.1	1.6	390.72	56.4	1.4	212.66	11.2	1.7	56.71
Cyanophyta	195.0	4.0	1140.11	175.4	3.7	299.70	119.7	2.8	235.04	15.4	2.3	38.88
Euglenophyta	57.8	1.2	360.44	89.5	1.9	580.82	127.9	2.9	1198.06	3.9	0.6	49.68
Pyrrhophyta	0.0	0.0	0.00	5.1	0.1	480.26	5.1	0.1	35.40	0.0	0.0	0.00
Others	9.6	0.2	5.43	14.7	0.3	8.32	0.0	0.0	0.00	1.9	0.3	4.14
TOTAL	4875.5		18539.19	4651.1		11184.11	4335.2		13143.97	680.3		1489.20
std. dev.	±523.92			±172.02			±503.64			±144.57		

TABLE C.1-3

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
29 MAY 1980

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml
Bacillariophyta	6374.8	85.8	15407.05	3974.0	89.3	9609.32	3828.0	85.2	11703.27	575.3	90.7	2602.63
Chrysophyta	-	-	-	-	-	-	-	-	-	-	-	-
Cryptophyta	246.8	3.3	351.69	148.1	3.3	318.77	177.7	3.9	340.37	24.7	3.8	40.94
Xanthophyta	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyta	484.6	6.0	2678.12	158.4	3.3	194.41	356.1	7.6	1736.29	29.2	4.6	91.90
Cyanophyta	269.6	3.6	274.11	59.5	1.3	34.21	84.1	1.8	35.67	3.5	0.5	5.33
Euglenophyta	108.7	1.3	1193.29	128.4	2.8	264.50	69.2	1.5	626.93	2.6	0.4	4.14
Pyrrhophyta	-	-	-	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	7484.5		19904.26	4468.4		10421.21	4515.1		14442.53	635.3		2744.94
std. dev.	±684.7			±778.5			±1147.8			±42.5		

TABLE C.1-4

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
14 AUGUST 1980

	Station 1			Station 3			Station 5			Station 6		
Taxon	Density (no./ml)	Relative abundance(%)	Biovolume ($\mu^3 x10^2$)/ml	Density (no./ml)	Relative abundance(%)	Biovolume ($\mu^3 x10^2$)/ml	Density (no./ml)	Relative abundance(%)	Biovolume ($\mu^3 x10^2$)/ml	Density (no./ml)	Relative abundance(%)	Biovolume ($\mu^3 x10^2$)/ml
Bacillariophyta	3129.5	90.4	7715.38	3186.0	93.2	6829.27	3747.9	95.0	7700.28	519.0	82.9	1058.13
Chrysophyta	-	-	-	-	-	-	-	-	-	-	-	-
Cryptophyta	46.3	1.4	430.75	11.6	0.4	96.24	34.7	0.9	381.91	30.6	4.9	3.76
Xanthophyta	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyta	174.0	5.5	518.40	156.6	4.9	440.36	144.7	3.4	274.59	33.1	5.1	91.09
Cyanophyta	56.8	1.8	583.44	42.3	1.2	143.08	35.5	0.7	72.04	43.9	6.9	92.90
Euglenophyta	29.0	0.9	476.67	8.7	0.3	240.57	0.0	0.0	0.00	1.1	0.2	1.98
Pyrrhophyta	-	-	-	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	3435.6		9724.64	3405.2		7749.54	3962.8		8428.82	627.7		1247.86
std. dev.	±372.0			±245.9			±399.2			±79.3		

TABLE C.1-5

SUMMARY OF PHYTOPLANKTON DENSITY, RELATIVE ABUNDANCE AND BIOVOLUME
MARBLE HILL PLANT SITE
2 NOVEMBER 1980

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml	Density (no./ml)	Relative abundance(%)	Biovolume (μ^3x10^2)/ml
Bacillariophyta	1061.5	88.6	7355.09	1276.4	91.7	9794.40	933.3	91.4	8399.57	92.5	96.6	334.55
Chrysophyta	0.0	0.0	0.0	1.6	0.1	5.56	3.2	0.3	11.12	0.0	0.0	0.0
Cryptophyta	0.0	0.0	0.0	3.2	0.2	5.49	6.4	0.6	9.89	0.4	0.4	0.41
Xanthophyta	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyta	89.4	7.5	369.85	76.7	5.5	316.69	60.7	6.0	390.59	1.8	1.9	2.12
Cyanophyta	41.3	3.[illegible]	168.24	31.4	2.2	241.18	12.8	1.3	85.32	0.6	0.6	1.83
Euglenophyta	3.2	0.7	439.36	4.8	0.3	659.04	3.2	0.4	1702.08	0.2	0.2	8.14
Pyrrhophyta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	1.57
Others	-	-	-	-	-	-	-	-	-	-	-	-
Total	1195.4		8332.54	1394.1		11022.36	1019.6		10513.25	95.8		348.62
std. dev.	±367.9			±289.2			±404.2			±17.7		

TABLE C.1-6

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST
FOR PHYTOPLANKTON DENSITY
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Stations (S)	2	0.09584	0.04792	0.73
Quarters (Q)	3	8.41748	2.80583	291.23*
S x Q Interaction	6	0.39404	0.06567	6.82*
Error	12	0.11561	0.00963	
Total	23	9.02297		

*Significant at P=0.05; Critical $F_{(2,6)}$ = 5.14;

Critical $F_{(3,12)}$ = 3.49; Critical $F_{(6,12)}$ = 3.00.

DUNCAN'S MULTIPLE RANGE TEST: QUARTERS[a]

Grouping	Log mean	N	Quarter
A	8.578500	6	May
B	8.434167	6	March
C	8.185833	6	August
D	7.070833	6	November

[a]Means with the same letter are not significantly different.
Alpha level=0.05; DF=12; MS=0.0096344.

TABLE C.1-7

STATISTICAL COMPARISON OF PHYTOPLANKTON BIOVOLUME
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Stations	2	0.151093	0.0755465	1.73
Quarters	3	0.588156	0.1960520	4.48
Error	6	0.262497	0.0437495	
Total	11	1.001746		

[a]Critical $F_{(2,6;\ P=0.05)}$ = 5.14; Critical $F_{(3,6;\ P=0.05)}$ = 4.76.

TABLE C.1-8

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST
FOR PHYTOPLANKTON DENSITY
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977-1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Stations (S)	2	0.23850	0.11925	0.38
Years (Y)	4	11.87330	2.96833	9.57*
S x Y Interaction	8	0.92604	0.11576	0.37
Error	93	28.83507	0.31005	
Total	107	41.87291		

*Significant at P=0.05; Critical $F_{(2,93)} = 3.11$;
Critical $F_{(4,93)} = 2.49$; Critical $F_{(8,93)} = 2.06$.

DUNCAN'S MULTIPLE RANGE TEST: YEARS[a]

Grouping	Mean	N	Year
A	8.761000	24	77
A	8.455125	24	78
B	8.067333	24	80
B	8.057875	24	79
B	7.753667	12	74

[a]Means with the same letter are not significantly different.
Alpha level=0.05, DF=93, MS=0.310055.

TABLE C.1-9

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST
FOR PHYTOPLANKTON BIOVOLUME
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977-1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Stations (S)	2	0.52304	0.26152	0.88
Years (Y)	4	4.37285	1.09321	3.69*
S x Y Interaction	8	1.64781	0.20598	0.70
Error	45	13.33092	0.29624	
Total	59	19.87462		

*Significant at P=0.05; Critical $F_{(2,45)}$ = 3.21;
Critical $F_{(4,45)}$ = 2.59; Critical $F_{(8,45)}$ = 2.16.

DUNCAN'S MULTIPLE RANGE TEST: YEARS[a]

Grouping			Mean	N	Year
	A		10.125417	12	77
B	A		9.907750	12	78
B	A	C	9.795333	12	74
B		C	9.571583	12	79
		C	9.344167	12	80

[a]Means with the same letter are not significantly different.
Alpha level=0.05, DF=45, MS=0.296243.

TABLE C.1-10

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST
FOR PHYTOPLANKTON DENSITY AND BIOVOLUME
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1974, 1977-1980

ANALYSIS OF VARIANCE: BIOVOLUME

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Year	4	13.65666	3.41417	2.66
Error	15	19.23145	1.28210	
Total	19	32.88811		

[a]Critical $F_{(4,15;\ P=0.05)} = 3.06$.

ANALYSIS OF VARIANCE: DENSITY

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Year	4	11.04202	2.76050	3.11*
Error	31	27.52552	0.88792	
Total	35	38.56754		

*Significant at P=0.05; Critical $F_{(4,31)} = 2.68$.

DUNCAN'S MULTIPLE RANGE TEST: DENSITY BY YEARS[b]

Grouping		Mean	N	Year
	A	6.818125	8	78
B	A	6.035875	8	77
B	A	5.987000	8	80
B		5.597250	8	79
B		4.952250	4	74

[b]Means with the same letter are not significantly different.
Alpha level=0.05, DF=31, MS=0.88792.

TABLE C.1-11

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON DENSITY WITH SELECTED PHYSICAL AND CHEMICAL PARAMETERS
MARBLE HILL PLANT SITE
1977-1980

	Ohio River Stations (N=32)			Little Saluda Creek (N=32)
Parameter	1	3	5	6
Temperature	0.5530*	0.5262*	0.4945*	-0.0824
Current speed	0.0934	0.0743	0.11732	-[a]
Secchi	-0.0735	0.1390	0.1247	-[a]
Nitrate nitrogen	-0.1535	0.4317*	0.0410	0.2471
Ammonia nitrogen	-0.4123*	-0.2355	0.1384	-0.2259
Orthophosphate	0.0486	-0.0009	0.0601	0.2694
Dissolved silica	0.1433	0.1114	0.1521	0.0980

*Significant at P=0.05; critical r = 0.349.

[a]Current speed and Secchi depth data were not required for Station 6.

TABLE C.1-·.2

SIMPLE CORRELATION COEFFICIENTS[a] (r) FOR PHYTOPLANKTON BIOVOLUME
WITH SELECTED PHYSICAL AND CHEMICAL PARAMETERS
MARBLE HILL PLANT SITE
1977-1980

	Ohio River Stations (N=16)			Little Saluda Creek (N=16)
Parameter	1	3	5	6
Temperature	0.4722	0.3257	0.3165	-0.1123
Current speed	0.0069	0.1111	-0.0109	-[b]
Secchi	0.2009	0.4712	0.4941	-[b]
Nitrate nitrogen	0.00287	0.3106	0.1539	0.3550
Ammonia nitrogen	-0.2635	-0.1131	-0.0054	-0.3558
Orthophosphate	-0.1217	-0.3721	-0.3641	0.0850
Dissolved silica	-0.1089	-0.1764	-0.2410	-0.1622

[a]Significant at P=0.05; critical r = 0.497.

[b]Current speed and Secchi depth data were not required from Station 6.

C.2 ZOOPLANKTON

INTRODUCTION

Zooplankters are aquatic invertebrates that have limited motility or passively drift with water currents. Most river plankters originate in still or gently flowing waters. Lakes and impoundments along the course of a river can supply great amounts of zooplankton to its lower reaches. Generally, zooplankters are representative of the second trophic level in aquatic food chains. They are the major consumers of primary producers such as phytoplankton and, in turn, provide an important food source for larger macroinvertebrates and fishes.

Zooplankters are sensitive to disturbances within the ecosystem and reflect the influences of water velocity, temperature, silt loads and pollutants. Zooplankton populations of a river community are, therefore, likely to vary considerably along the river's length in both space and time (Hynes, 1972), and changes in community composition and density may be used as a measure of environmental conditions.

The purpose of the 1980 zooplankton study was to examine species composition and relative abundance of zooplankton at three stations in the Ohio River and at one station in Little Saluda Creek (Figure 1). These findings were then compared to the baseline (1974) and previous construction phase monitoring data to evaluate the potential impact of construction at the Marble Hill Plant site.

MATERIALS AND METHODS

Duplicate zooplankton samples were taken quarterly at Stations 1, 3 and 5 in the Ohio River and at Station 6 in Little Saluda Creek. Samples were collected by pumping from subsurface, middle and bottom depths to accommodate potential variations in spatial distribution of zooplankton. At Stations 1, 3 and 5, 167 liters of water from each depth were filtered through an 80μ-mesh net. At each station, the concentrated samples from the three depths (500 liters total) were consolidated into a single polyethylene bottle. Because of low water levels in Little Saluda Creek, the entire 500-liter sample was taken from mid-depth only. Samples were preserved immediately after collection in a 5-percent formalin solution buffered to pH 7-8 with sodium borate.

In the laboratory, samples were allowed to settle for a minimum of 48 hours. Settled samples were concentrated to a final volume determined by zooplankton density and the amount of detritus. Identifications and counts were made by placing a well-mixed 1-ml subsample into a Sedgwick-Rafter counting chamber. All organisms in the chamber were enumerated at 100X magnification. When densities allowed, a minimum of 100 organisms per chamber were examined for each of four identically prepared subsamples. Organisms requiring dissection to achieve species identification were removed from the counting chamber and dissected. All zooplankters were identified to the lowest practicable taxon.

The number of zooplankters per liter (N) was calculated by:

$$N = \frac{\frac{V_s}{V_c} C}{V_i}$$

where: V_s = Volume of sample concentrate, in milliliters;

V_c = Volume of concentrate enumerated, in milliliters;

C = Count;

V_i = Initial volume of sample, in liters.

For the May sampling date, Replicate A from Station 3 was not enumerated because of excessive sediment in the sample. Entire zooplankton samples were retained as vouchers.

Prior to statistical analysis, zooplankton density data were transformed ($\log_e$ [number per liter + 1]) to reduce the effect of nonhomogeneous variation in the data. Analysis of variance (ANOVA, $P = 0.05$) was utilized to examine interstation and annual variation in zooplankton density for 1980 and for prior construction phase and baseline monitoring programs. The Duncan's multiple range test ($P = 0.05$) was used to test differences among calculated means. Simple correlations between zooplankton density and selected physicochemical parameters were used to evaluate factors potentially influencing the distribution and density of Ohio River zooplankters.

RESULTS AND DISCUSSION

The zooplankton collected during the fourth year of construction phase ecological monitoring at the Marble Hill Plant site were dominated by protozoans, rotifers and crustaceans (Figure C.2-1). Species composition in 1980 did not differ greatly from the baseline or prior construction phase monitoring programs (PSI, 1976; ABI, 1978, 1979, 1980). A total of 66 taxa were observed from Stations 1, 3, 5 and 6 (Table C.2-1). This number of taxa is within the range found during previous monitoring periods. Protozoans and the "others" category each accounted for approximately 18 percent of the taxa found, while the rotifers and crustaceans comprised 41 and 23 percent, respectively.

Total zooplankton densities ranged from a low of approximately 8 organisms per liter at Stations 1 and 3 in August to 147 zooplankters per liter at Station 1 in November (Tables C.2-2 through C.2-5). Station 6 zooplankton densities ranged from 2 to 21 organisms per liter (Tables C.2-2 through C.2-5). Zooplankton composition, density, and relative abundance by station and date for 1980 are presented in Appendix Tables C.2-1 through C.2-8.

Ohio River Stations

Zooplankton densities showed no significant difference among Ohio River Stations 1, 3 and 5 but did indicate a highly significant seasonal effect and a significant interaction between season and station during 1980 (Table C.2-6). Thus, seasonal effects were not consistent among stations. When individual quarters were examined, the Duncan's multiple range test indicated seasonal densities were significantly different from each other, a result common to quarterly zooplankton sampling programs and not a result of construction at the Marble Hill Plant site.

Species composition and density among the stations for any given season were generally similar. In May, oligochaetes were noticeably abundant at Station 1 as compared to Stations 3 and 5. The protozoan Tokophrya sp. had a disjunct distribution in August; it made up a sizable portion of the zooplankton community at Stations 1 and 5 but was absent at Station 3. It is likely that these interstation differences were due to temporal and spatial variations naturally found among zooplankton communities in rivers such as the Ohio.

The seasonal pattern of zooplankton abundance and composition varied considerably from prior monitoring programs. Densities in March were higher than those seen in previous studies (Figure C.2-2). Epibenthic protozoans such as Vorticella, Carchesium, and Centropyxis predominated. These forms are common to large river habitats where they live among the vegetation or on the bottom in shallow and slow moving waters. Rapid stream flows and associated heavy silt loads during March probably produced a scouring effect that was responsible for the high relative abundance of these protozoans in the plankton.

By late spring, total zooplankton densities were reduced, primarily because of a large reduction in the number of protozoans. As water temperature increased, rotifer populations, which have a greater intrinsic growth rate than cladocerans or copepods (Allen, 1976), expanded significantly from late winter densities. Rotifers made up approximately one half of the total density. Predominant species were Kellicotia longispina, Keratella cochlearis, and K. quadrata.

In August, zooplankton densities in the Ohio River were further reduced to levels approaching those found in 1978. High flow rates and turbid river conditions again coincided with a predominance of protozoans over rotifers. At the same time, densities in Little Saluda Creek were higher than in the river and greater than any prior summer sampling period (Figure C.2-2). It is possible that zooplankters from the Ohio River that were backwashed into the creek during high water levels earlier in the year found conditions in the creek temporarily suitable for growth and reproduction. The temporary nature of this population consisting largely of copepods is indicative of the overall unsuitable conditions for zooplankton in a riffle habitat like Little Saluda Creek. There is no data to suggest that the elevated copepod densities in Little Saluda Creek during August were due to plant construction effects.

During construction phase monitoring, November zooplankton densities had been very inconsistent, and late autumn 1980 was no exception. The high densities were due to large numbers of the cladoceran Bosmina longirostris in contrast to the normal dominance of protozoans and rotifers during this season.

Annual mean zooplankton density at the Ohio River stations was 68.2 organisms/liter. This density is greater than the 48.3 and 45.1 organisms/liter found in 1979 and 1978, respectively, but is less than the 95.4 and 80.3 organisms/liter for the years 1977 and 1974, respectively. Analysis of zooplankton densities over the 5 years of data indicated no significant differences among stations or years (Table C.2-7). This lack of significant variation suggests that even though there are sizable differences in densities among seasons, these differences are likely the result of natural variation in the flowing water environment. Overall, the data indicate no apparent adverse impact from plant construction on zooplankters in the Ohio River.

Total zooplankton density in the Ohio River showed significant correlations with Secchi depth at Stations 1 and 3 and with total phytoplankton density at Station 5 (Table C.2-8). Current velocity was consistently negatively correlated, although not significantly. The increased turbulence associated with greater current velocity may increase epibenthic protozoan densities while reducing densities of other zooplankters. Plant construction effects were not suggested by any of the correlations.

Little Saluda Creek

Zooplankton densities in Little Saluda Creek reflect the lack of environmental conditions conducive for plankton growth and reproduction. With the exception of the late summer samples, zooplankton densities were lower in Little Saluda Creek than at the Ohio River stations. The similar species composition between Little Saluda Creek and the Ohio River as well as the normally lower density in the creek suggests that the source of these zooplankters is the Ohio River. These zooplankters colonize the creek during high river flow when backwash occurs. Annual mean zooplankton density at Station 6 was 8.2 organisms per liter. Total zooplankton densities at Station 6 were compared among all monitoring programs and showed no significant difference among years (Table C.2-9). These results suggest that the variation in zooplankton density at Station 6 was not related to plant construction.

CONCLUSIONS

During 1980, zooplankton collections were taken quarterly at three Ohio River stations and a single station in Little Saluda Creek. Zooplankton species composition and density were compared to baseline (1974) and previous construction phase monitoring studies (1977-1979) to evaluate the potential impact of construction at the Marble Hill Plant site.

Zooplankton species collected in 1980 did not differ greatly from those collected during prior monitoring periods. Zooplankton densities in the Ohio River varied from year to year but, in general, densities were low in March, increased in May, and then decreased in late summer. November densities were variable, increasing in some years and decreasing in others. The November 1980 population was the largest of the year and larger than in the November samples of any previous monitoring programs. No significant differences were found among stations or sampling years when comparing the overall baseline and construction phase data. Statistically significant station differences were not found for the 1980 sampling period. Effects from construction at the Marble Hill Plant site were not apparent.

The zooplankton densities in Little Saluda Creek were higher than in past collection years but, overall, they remained lower than those in the Ohio River. The riffle habitat of Little Saluda Creek provides unfavorable conditions for zooplankton growth or reproduction. Comparison of all monitoring data for Little Saluda Creek showed no significant difference among the survey years. No plant-related construction effects were apparent at Station 6.

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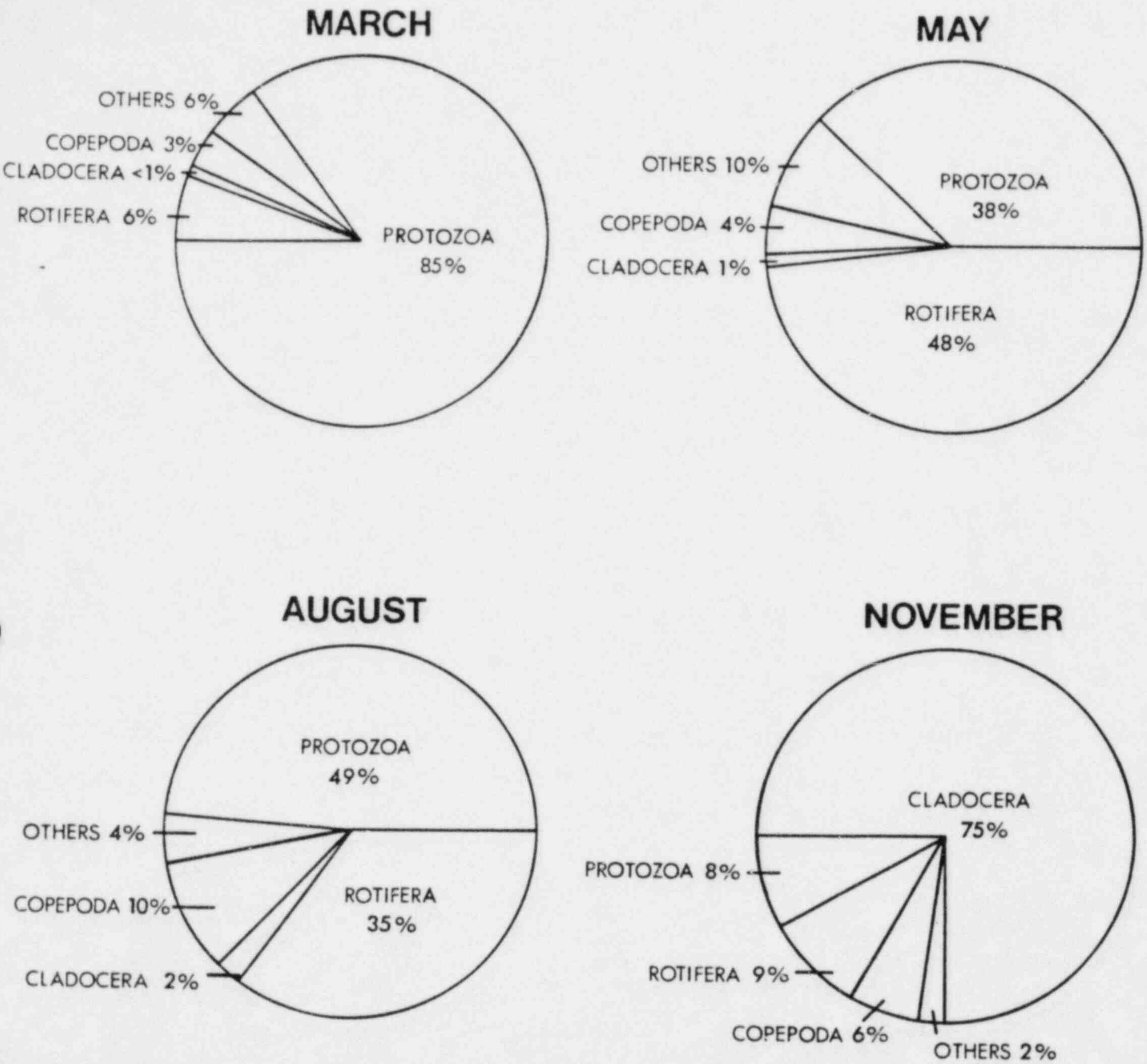

Figure C.2-1. Relative abundance of major zooplankton groups, Marble Hill Plant site, March - November, 1980.

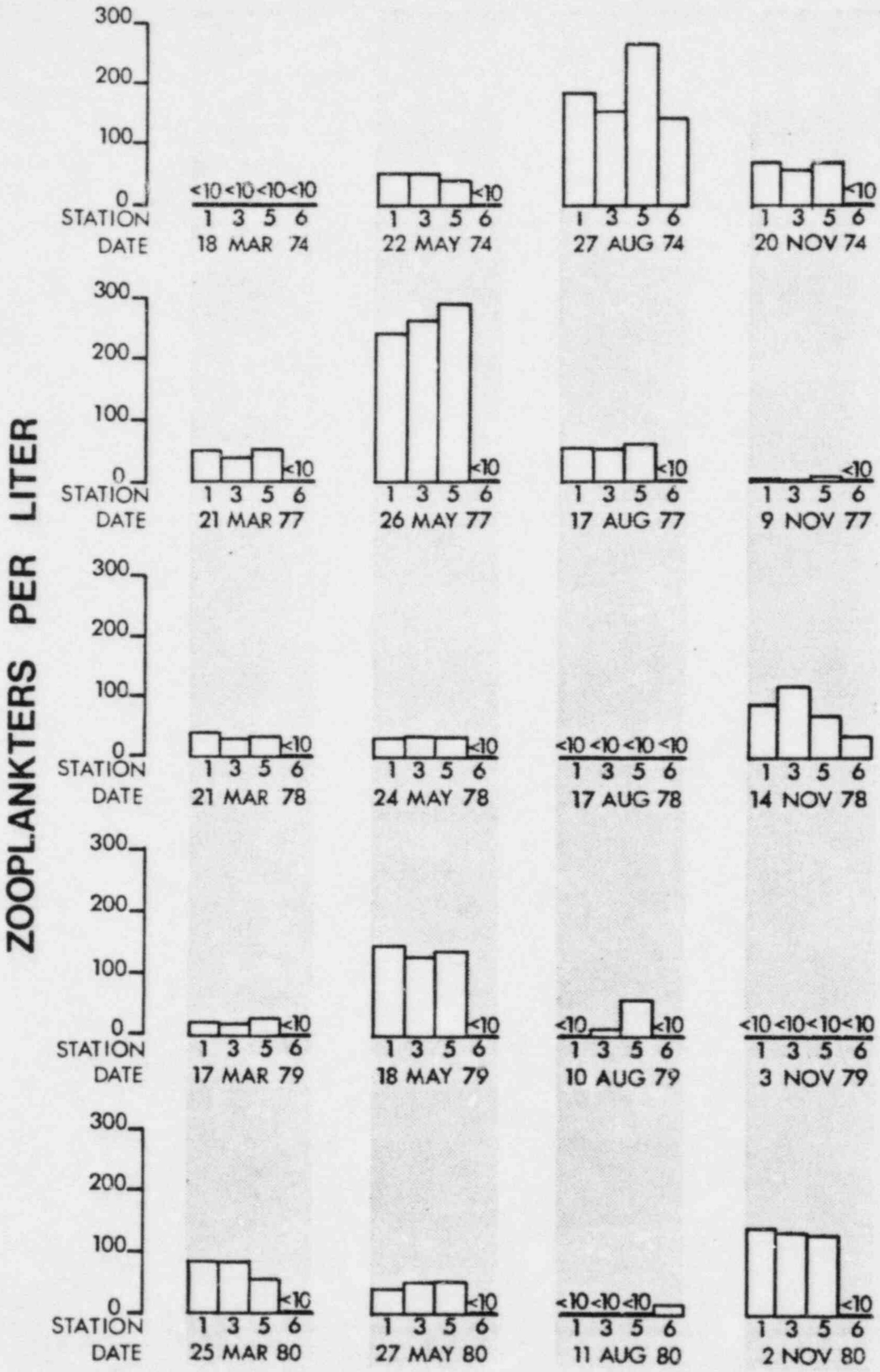

Figure C.2-2. Total zooplankton densities at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

TABLE C.2-1

LIST OF ZOOPLANKTON SPECIES COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1980

PROTOZOA
- *Acineta* sp.
- *Arcella* spp.
- *Carchesium* sp.
- *Centropyxis* spp.
- *Cothurina* sp.
- *Difflugia* spp.
- *Epistylis* sp.
- *Podophrya* sp.
- *Pyxicola* sp.
- *Tokophyra* sp.
- *Vorticella* sp.
- unidentified Suctoria

ROTIFERA
- *Asplanchna* sp.
- *Brachionus angularis*
- *B. calyciflorus*
- *B. caudatus*
- *B. havanaensis*
- *B. quadridentata*
- *Brachionus* sp.
- *Collotheca* sp.
- *Epiphanes* sp.
- *Euchlanis dilatata*
- *Euchlanis* sp.
- *Filinia longiseta*
- *Kellicotia bostoniensis*
- *K. longispina*
- *Keratella cochlearis*
- *K. quadrata*
- *K. valga*
- *Lecane* sp.
- *Monostyla lunaris*
- *Monostyla* sp.
- *Notholca* sp.
- *Platyias patulus*
- *Polyarthra* sp.
- *Synchaeta* sp.
- *Trichocerca* sp.

ROTIFERA (continued)
- unidentified Bdelloidia
- unidentified Rotifera

CLADOCERA
- *Bosmina longirostris*
- *Ceriodaphnia quadrangula*
- *Ceriodaphnia* sp.
- *Chydorus sphaericus*
- *Daphnia retrocurva*
- *Diaphanosoma brachyurum*
- immature Cladocera

COPEPODA
- Calanoida
  - *Diaptomus pallidus*
  - *Diaptomus* sp.
- Cyclopoida
  - *Cyclops bicuspidatus thomasi*
  - *C. vernalis*
  - *Eucyclops serrulatus*
  - *E. speratus*
  - *Tropocyclops prasinus mexicanus*
- Harpacticoida
  - *Attheyella illinoisensis*
- Copepodites
- Nauplii

OTHERS
- Nematoda
  - *Criconema* sp.
  - unidentified Nematoda
- Amphipoda
- Chironomidae
- Diptera larvae
- Ectoprocta statoblasts
- fish larvae
- Hydracarina
- Mollusc larvae
- Oligochaeta
- Ostracoda
- Tardigrada

TABLE C.2-2

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
25 MARCH 1980

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	71.0	85.3	69.8	84.3	45.0	83.9	0.2	9.0
Rotifera	3.3	4.1	5.2	6.2	3.7	7.1	0.4	18.2
Cladocera	0.0	0.0	0.0	0.0	0.3	0.6	0.2	9.0
Copepoda	3.0	3.6	2.2	2.7	2.1	4.0	0.6	27.2
Others	5.8	7.0	5.6	6.8	2.2	4.4	0.8	36.6
Total	83.1		82.8		53.3		2.2	

TABLE C.2-3

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
27 MAY 1980

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	11.6	28.2	22.3	44.2	21.9	40.8	2.2	36.2
Rotifera	19.9	48.6	24.4	47.5	25.9	48.3	1.2	19.7
Cladocera	0.5	1.2	0.4	0.8	0.6	1.1	0.3	4.9
Copepoda	1.2	2.9	0.9	1.8	1.7	3.2	0.7	11.4
Others	7.8	19.1	2.9	5.7	3.6	6.6	1.7	27.8
Total	41.0		50.9		53.7		6.1	

TABLE C.2-4

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
11 AUGUST 1980

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	3.2	40.3	3.7	46.7	5.3	58.2	0.8	3.7
Rotifera	3.1	39.3	2.9	36.6	2.7	29.7	3.4	16.0
Cladocera	0.1	1.3	0.3	3.9	0.1	1.1	4.1	19.2
Copepoda	1.1	13.9	0.8	10.2	0.5	5.5	12.5	58.8
Others	0.4	5.2	0.2	2.6	0.5	5.5	0.5	2.3
Total	7.9		7.9		9.1		21.3	

TABLE C.2-5

SUMMARY OF ZOOPLANKTON DENSITY AND RELATIVE ABUNDANCE
MARBLE HILL PLANT SITE
2 NOVEMBER 1980

	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	11.8	8.0	14.6	10.1	15.1	10.6	0.2	6.1
Rotifera	10.6	7.2	12.3	8.5	10.5	7.4	0.5	15.2
Cladocera	117.3	79.7	109.6	76.0	106.7	75.0	2.3	70.0
Copepoda	7.1	4.8	7.6	5.3	7.3	5.1	0.3	9.1
Others	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Total	147.1		144.3		142.2		3.3	

TABLE C.2-6

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST FOR
TOTAL ZOOPLANKTON DENSITIES
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Station	2	0.00895	0.00447	0.08
Quarter	3	26.21273	8.73758	669.45*
Station x quarter interaction	6	0.35530	0.052922	4.54*
Error	11	0.14357	0.01305	
Total	22	26.72055		

*Significant at P=0.05; critical $F_{(2,6)}$=5.14; $F_{(3,11)}$=3.59; $F_{(6,11)}$=3.09.

DUNCAN'S MULTIPLE RANGE TEST: QUARTERS[a]

Grouping	Log Mean	N	Quarter
A	4.9743	6	November
B	4.2697	6	March
C	3.8728	5	May
D	2.1373	6	August

[a]Means with the same letter are not significantly different.
Alpha level = 0.05, DF = 11, MS = 0.01305.

TABLE C.2-7

ANALYSIS OF VARIANCE AMONG TOTAL ZOOPLANKTON DENSITIES
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977 - 1980

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Station	2	0.60199	0.30099	1.75
Year	4	10.42279	20.60570	1.69
Station x year interaction	8	1.37487	0.17186	0.11
Error	92	141.59890	1.53912	
Total	106	153.99855		

[a]Critical F values for P=0.05 $F_{(2,8)}=4.46$; $F_{(4,92)}=2.49$; $F_{(8,92)}=2.06$.

TABLE C.2-8

SIMPLE CORRELATION COEFFICIENTS (r) FOR TOTAL ZOOPLANKTON DENSITIES VERSUS SELECTED PARAMETERS
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977-1980

Station	Parameter	Calculated r(P=0.05)
1	Temperature (°C)	-0.1426
3		-0.0091
5		0.1271
1	Dissolved oxygen (ppm)	0.1886
3		0.1212
5		0.0282
1	Current velocity (cm/sec)	-0.2625
3		-0.2537
5		-0.3084
1	Secchi (cm)	0.4702*
3		0.5047*
5		0.3760
1	Total phytoplankton density[a]	0.0372
3		-0.0007
5		0.5330*

*Critical r value at $P=0.05_{18}$ = 0.444; $_{14}$ = 0.497

[a]Phytoplankton data do not include baseline values.

TABLE C.2-9

ANALYSIS OF VARIANCE FOR TOTAL ZOOPLANKTON DENSITIES
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1974, 1977 - 1980

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Year	4	8.86082	2.21520	2.46
Error	31	27.92354	0.90076	
Total	35	36.78436		

[a]Critical F values for P=0.05; $F_{(4,31)}$=2.68.

D. PERIPHYTON

INTRODUCTION

The term "periphyton" is used to describe organisms that attach to submerged substrates but do not penetrate into them (APHA, 1976). In current usage, periphyton includes all organisms that, in the past, have been called aufwuchs by various authors. Examples of periphyton organisms include bacteria, yeasts, molds, algae, protozoa, and larger colonial forms such as bryozoans. Periphyton also includes free-living organisms (i.e., rotifers, worms, larvae) that may inhabit the mat of attached forms. Because of the wide variety of plants and animals included in the periphyton community and their varied range of adaptations, virtually all submerged substrates (living and nonliving) may be colonized. Periphyton colonization is common in aquatic habitats such as those in the vicinity of the Marble Hill Plant site.

The periphyton community is widely accepted as a valuable indicator of water quality and related environmental conditions. Periphyton organisms have comparatively brief life cycles coupled with intense competition for substrate space. Therefore, any natural or man-induced change in habitat parameters can result in rapid qualitative and quantitative alterations in the periphyton community.

The purpose of the periphyton study at the Marble Hill Plant site was to evaluate interstation and seasonal variability in periphyton species composition, density, diversity, equitability, and community biomass during power plant construction. Comparison of current data with baseline data (PSI, 1976) and previous construction phase monitoring data (ABI, 1978, 1979, 1980) was also used to assess possible construction-related effects on periphyton.

MATERIALS AND METHODS

Periphyton samples were collected quarterly from Ohio River Stations 1, 3 and 5 (Figure 1). Collections at these stations were made with floating diatometers, each of which contained eight standard-sized (2.5 x 7.6 cm) microscope slides. After a 3-week exposure period, three slides per station were preserved individually in jars containing approximately 100 ml of 5-percent buffered formalin solution and used for biomass determinations. Two slides per station were similarly preserved for species identifications and counts.

At Station 6 in Little Saluda Creek, measured areas of natural substrate were scraped clean of periphyton. For species identification, counts, and biomass determinations, three replicate scrapings were washed separately into bottles of 5-percent buffered formalin solution. Natural substrate composition and habitat types were noted and included in the data.

In the laboratory, diatometer slides were scraped on both sides, and detached periphyton was washed back into the collection jars. Natural and artificial substrate samples were allowed to settle for at least 24 hours and then concentrated to approximately 30 ml. Sample suspensions used for species identification and counts were transferred to graduated test tubes, allowed to resettle for at least 24 hours, and then further concentrated to a known volume.

The inverted microscope technique (Utermohl, 1958) was used with 25-ml chambers for species identifications and counts. Periphyton species other than diatoms were identified to the lowest possible taxon; these species as well as total diatoms were enumerated by random strip counts at 400X magnification. A minimum of 400 individuals per replicate were routinely counted in two identically prepared chambers. Total live diatom counts were used with diatom species proportional counts (obtained from permanent slides examined at 1000X magnification) to obtain diatom density by species (APHA, 1976).

All algal species, excluding certain greens and blue-greens, were counted as individual cells. Filamentous green and blue-green species were measured in 100-μ lengths with each length representing one counting unit. Colonial forms, exclusive of diatoms, were counted as individuals unless otherwise noted. Nonalgal species were counted as individual organisms. Periphyton density per 10 square centimeters (N) was calculated by:

$$N = \frac{\frac{V_c}{V_e} C}{A_s}$$

where: V_c = Volume of sample concentrate, in milliliters;

V_e = Volume of sample concentrate examined, in milliliters;

C = Number of cells counted;

A_s = Area of substrate sampled, in square centimeter units.

Permanent diatom mounts and vouchers of all samples analyzed were retained after microscopic analysis.

Ash-free dry weight (biomass) was determined for three replicate artificial substrate samples per station at Stations 1, 3 and 5 and for three rock substrate scrapings at Station 6 (APHA, 1976). Ash-free dry weight values were reported as milligrams per 10 square centimeters.

Species diversity was expressed in terms of the Shannon-Weaver mean diversity index ($\bar{d}$), which is recommended by EPA (1973). The equitability component of diversity (Lloyd and Ghelardi, 1964) was also applied to the data. A discussion of these calculations is contained in Section E. Benthos.

For statistical analysis, periphyton density and biomass data were transformed to $\log_e$ to reduce the effect of nonhomogeneous variation and skewness. Analysis of variance was used to examine interstation and annual variation in periphyton baseline data and combined monitoring data. Duncan's multiple range test was used to locate significant differences among station or annual means. All statistical analyses were performed at the 95 percent (P=0.05) confidence interval.

RESULTS AND DISCUSSION

Periphyton composition in the Ohio River and Little Saluda Creek was similar to that reported in baseline (PSI, 1976) and previous construction phase monitoring studies (ABI, 1978, 1979, 1980). Diatoms (Bacillariophyta) were 91 of the 145 species observed (Table D-1). Green algae (Chlorophyta) and blue-green algae (Cyanophyta) accounted for 29 and 14 species, respectively. Relative abundance of these three groups totaled more than 98 percent of the total periphyton density in most samples.

Total Periphyton Density

During 1980, total periphyton densities at Ohio River Stations 1, 3 and 5 ranged from 2321 x 10^3/10 cm^2 to 17,659 x 10^3/10cm^2 (Table D-2). Minimum colonization occurred in May with greater densities seen as the year progressed. Because of natural variations in river conditions, seasonal trends among all sampling years showed no consistent pattern.

Comparisons over all monitoring data, baseline and construction phase, revealed no significant differences in density among Ohio River stations (Table D-3). Comparisons among years indicated that periphyton density in 1977 was significantly lower than that observed in 1978 or

1980. This difference may be an artifact due to the lack of March samples in both 1978 and 1980. Mean periphyton densities for every year of construction phase monitoring were similar to baseline observations. The lack of a significant difference between construction phase monitoring and baseline data indicates that the variation in periphyton densities over the years is most likely caused by natural variation rather than adverse impact from plant construction.

Total periphyton densities for Little Saluda Creek Station 6 ranged from 2060 x $10^3/10cm^2$ in March to 3466 x $10^3/10cm^2$ in May (Table D-2). Maximum densities were found in May and November as generally observed in previous monitoring, however, the range in density variation over seasons was less than in any prior monitoring period (Figure D-1). March densities in Little Saluda Creek were much greater in 1980 than in previous monitoring, and August densities were more similar to densities in the same month during previous years.

The density ranges seen in Little Saluda Creek during 1980 indicate that periphyton were not adversely affected by plant construction. This was supported by the lack of a statistical difference in periphyton density among the years 1977 through 1980 (Table D-4). Station 6 was not sampled for periphyton during the baseline study.

Periphyton Composition

Diatoms continued to dominate the periphyton community in both the Ohio River and Little Saluda Creek (Figure D-2). The pattern of relative abundance in the river was most similar to baseline studies (PSI, 1976) and that observed in 1979 (ABI, 1980). As in previous years, diatom relative abundance was reduced in August, especially at Station 5. Diatom relative abundance in Little Saluda Creek was most like that observed in 1978.

Diatom species composition for Ohio River stations and Little Saluda Creek was similar to that observed in the baseline study and earlier construction phase monitoring. The most common diatom seen in the Ohio River was Gomphonema parvulum, which accounted for 8 to 64 percent of the total density seen at river stations and was abundant at each station on all sampling dates.

Melosira varians, Cocconeis placentula v. euglypta, Gomphonema olivaceum, G. parvulum and Navicula graciloides were among the more common Ohio River species in 1980. These diatoms have also occurred as major species in all previous studies. Because diatoms are sensitive to small changes or shifts in habitat conditions (Patrick, 1977), the maintenance of major diatom species during all studies suggests that plant construction has not produced long-term changes in environmental habitat conditions. As in previous studies, environmental requirements of major diatom species (Table D-5) reflect conditions that are generally associated with the Ohio River environment. Wide-range temperature tolerance, preference for somewhat alkaline conditions, and ability to grow in either standing or flowing water characterize most of these species.

The most frequently observed diatoms in Little Saluda Creek were Achnanthes minutissima, A. linearis f. curta, Amphora perpusilla, Nitzschia dissipata, N. palea and Surierella ovata. Most of these species were widespread during previous construction monitoring studies. The continued dominance of diatoms and the overall similarity of diatom species composition in Little Saluda Creek during construction monitoring suggests that diatom growth and community composition have not been adversely affected by construction.

The relative abundance of Chlorophyta and Cyanophyta was greatest during August when temperatures were highest. This pattern of relative abundance was most similar to that in 1978. The two most abundant green algae were Chlamydomonas globosa and Characium ambiguum. Major blue-green (Cyanophyta) species were Chamaesiphon incrustans at Station 5 in May and August and Oscillatoria sp. 3 at Stations 1 and 3 in August. The total number of Chlorophyta species collected in 1980 was higher than in 1979 and equal to the 29 species found in 1978. The number of cyanophyte species remained similar to that in prior construction phase monitoring studies. These similarities suggest that periphyton growth has not been affected by plant construction.

Community Similarity

Community similarity as indicated by Morisita's index (Horn, 1966) showed a wider variation at Ohio River stations in 1980 than during any prior sampling period, but showed a generally high degree of similarity between the stations (Table D-6). In August, community composition at

Stations 1 and 3 were similar but qualitatively different from that at Station 5. This difference was largely a result of the particularly heavy growth of Characium ambiguum and Chamaesiphon incrustans at Station 5. In view of the similarity of Station 5 with Stations 1 and 3 during the remainder of the year, the differences in August most likely resulted from natural environmental conditions rather than from the effect of plant construction. Index comparisons were not made between Little Saluda Creek and Ohio River communities because habitat differences result in naturally different species composition.

Species Diversity

Species diversity ($\bar{d}$) and equitability (e) values were within the range reported in prior studies. Interstation differences in November (Table D-7) were attritutable to variable growth of Gomphonema parvulum. Differences in the abundance of G. parvulum among the stations along with the abundant growth of Chamaesiphon incrustans at Station 5 in May and C. incrustans and Characium ambiguum at Station 5 in August explain species diversity differences in May and August.

For Ohio River stations, diversity and evenness indices had a greater variation among seasons than among stations for a given sampling period. This in conjunction with a range of values similar to previous studies does not indicate plant construction effects on the periphyton community in the river. Species diversity and evenness values for Little Saluda Creek were also typical of those observed in prior studies.

Periphyton Biomass

Periphyton biomass showed marked seasonal variation with change in values generally reflecting the density trends (Figures D-1 and D-3). In the Ohio River, biomass was lowest during March and increased with each sampling date as the year progressed. This trend was not unlike that seen in preceeding years.

Comparisons of biomass values for the 4 years of construction phase monitoring revealed no significant differences among Ohio River stations but did indicate significant variation among years (Table D-8). Comparisons of individual years showed biomass in 1979 to be greater than that during other construction phase monitoring. Results of the statistical analyses suggest no apparent impact of plant construction on periphyton biomass in the Ohio River.

In Little Saluda Creek, biomass values ranged from 2.4 mg/10 cm^2 in March to a high of 7.9 mg/10 cm^2 in May. Overall, the seasonal trend seen in 1980 was most like that seen in 1978. Statistical comparisons among the years from 1977 through 1980 demonstrated no significant differences (Table D-9). This lack of significant differences indicates that periphyton growth in Little Saluda Creek has not been adversely affected by plant construction.

CONCLUSIONS

During 1980, periphyton samples were collected from the Ohio River and Little Saluda Creek. Species composition, abundance, diversity and community biomass were measured to assess the potential impact of Marble Hill Plant construction.

Periphyton composition in the Ohio River and in Little Saluda Creek was comparable to earlier monitoring programs. Diatom dominance was again higher than that found in 1977 and 1978 and more closely resembled that of the 1979 and baseline studies. Morisita's community index values for August showed Station 5 to differ from Stations 1 and 3 and was largely the result of the particularly heavy growth of green and blue-green algae at Station 5. The short-term nature of this difference suggests it had been caused by natural habitat variation among stations rather than by effects of plant construction.

Interstation comparisons of densities and biomass revealed no differences among Ohio River stations over the 4 years of construction phase monitoring. Statistical analyses of density and biomass variation in Little Saluda Creek showed no differences over years. Significant yearly differences in the river are attributable to natural variation rather than impact from plant construction.

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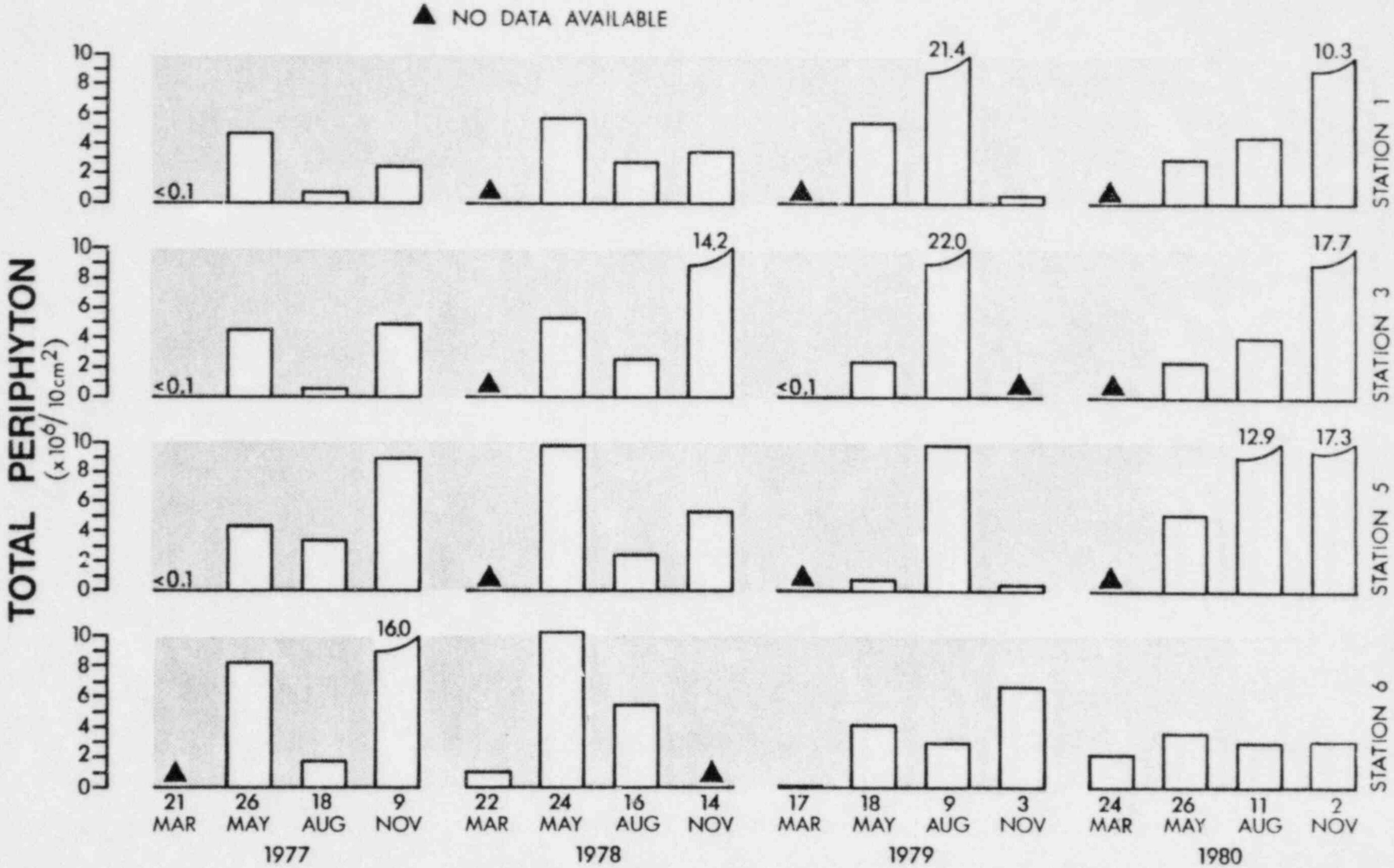

Figure D-1. Seasonal variation in total periphyton density at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

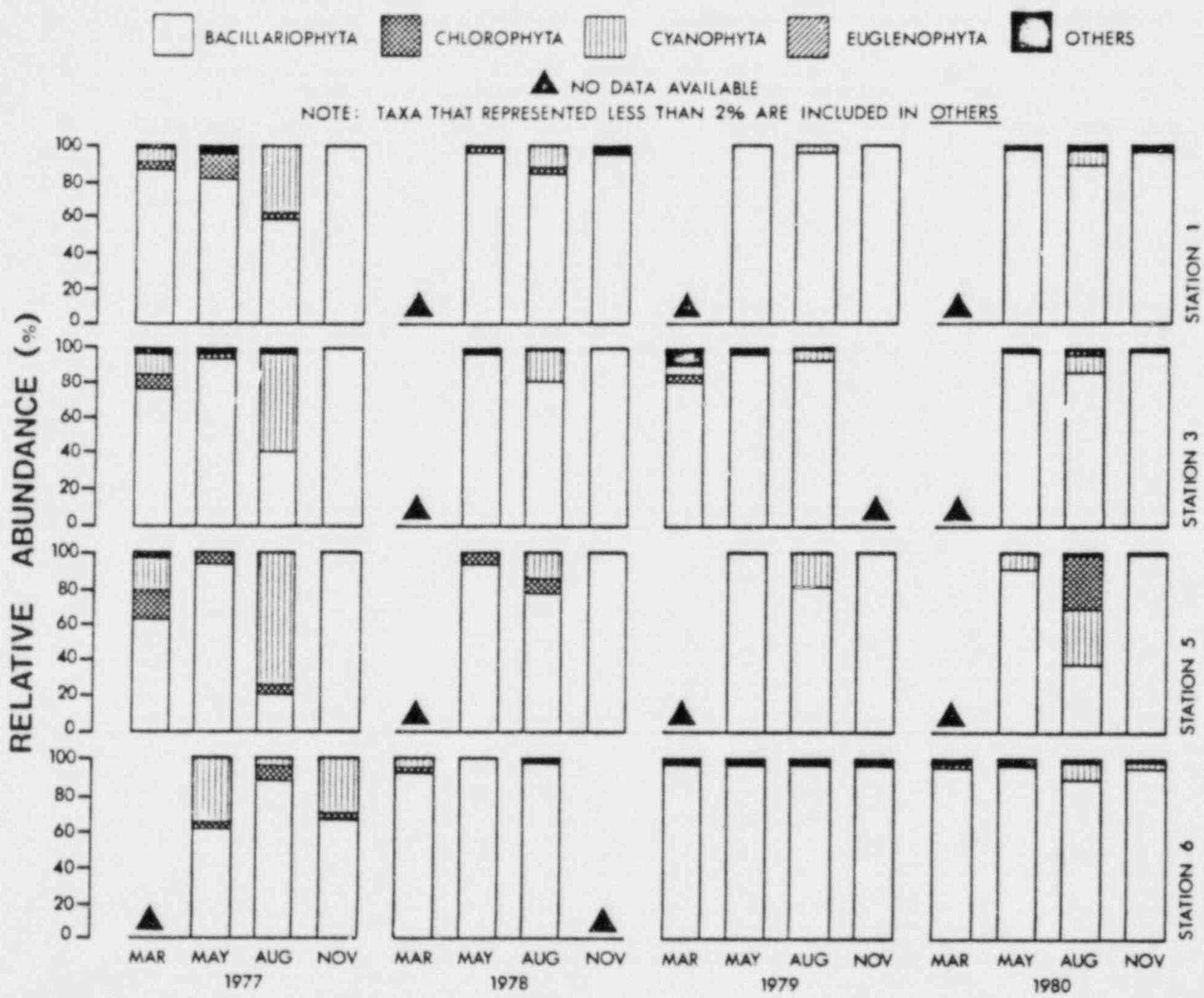

Figure D-2. Relative abundance of major periphyton taxa at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

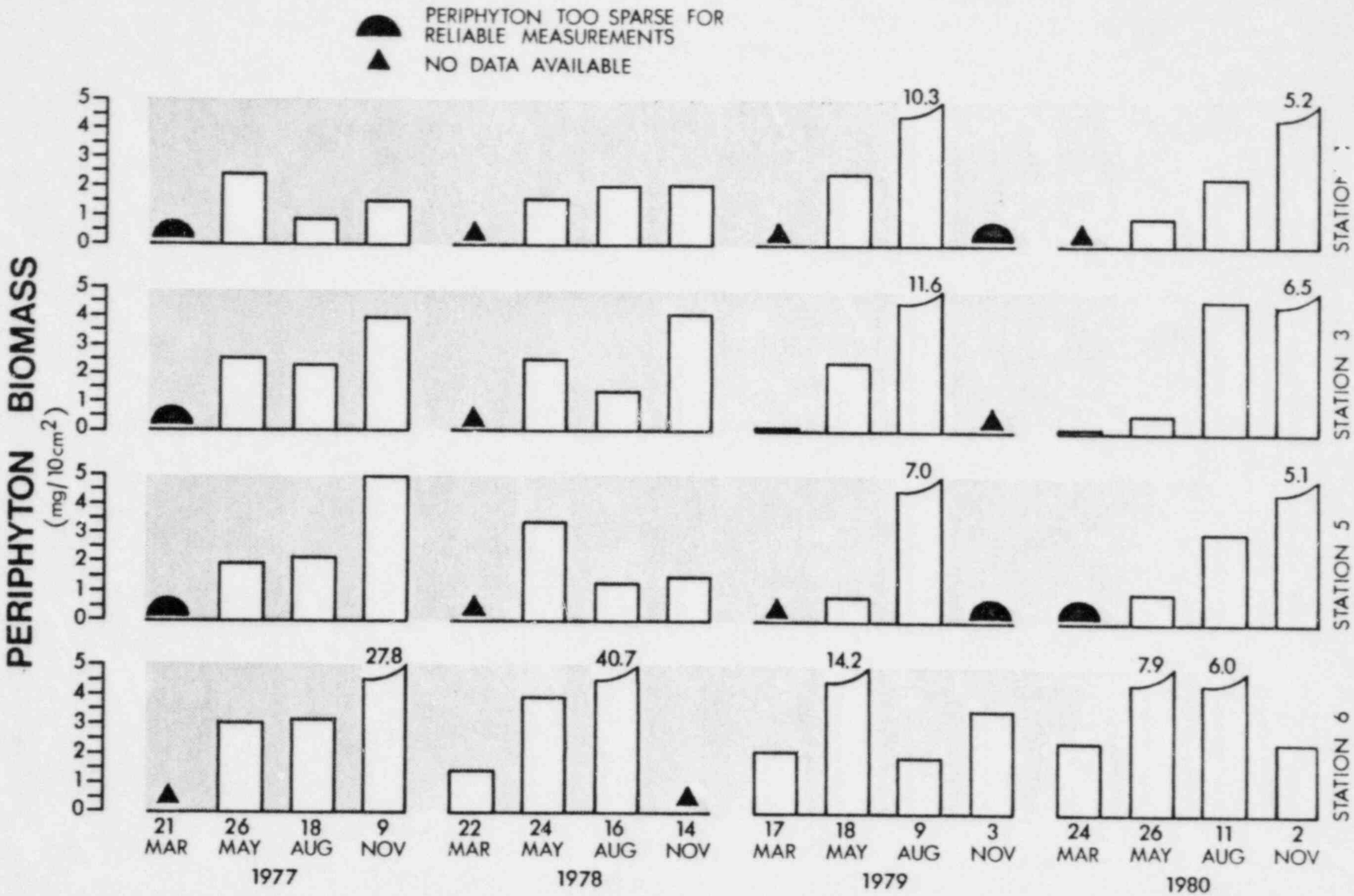

Figure D-3. Periphyton biomass at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

TABLE D-1

LIST OF PERIPHYTON SPECIES COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1980

BACILLARIOPHYTA
Centrales
Cyclotella glomerata
C. Kutzingiana
C. Kutzingiana v. planetophora
C. Meneghiniana
C. pseudostelligera
C. stelligera
Cyclotella sp.
Melosira distans
M. granulata
M. varians
Stephanodiscus astraea v. minutula
Pennales
Achnanthes affinis
A. deflexa
A. exigua
A. lanceolata
A. linearis f. curta
A. microcephala
A. minutissima
Amphora submontana
A. ovalis v. pediculus
A. perpusilla
Amphipleura pellucida
Asterionella formosa
Cocconeis pediculus
C. placentula v. euglypta
Cymbella affinis
C. minute v. silesiaca
C. tumida
Diatoma vulgare
Eunotia sp.
Fragilaria vaucheriae
Gomphonema angustatum
G. angustatum v. citera
G. dichotomum
G. gracile
G. instabilis
G. intricatum
G. olivaceum
G. parvulum
G. tenellum
Gyrosigma obtusatum
Meridion circulare
Navicula biconica
N. cincta
N. cryptocephala
N. cryptocephala v. veneta
N. gracilioides
N. mutica v. cohnii
N. mutuca v. undulata
N. notha
N. pupula
N. radiosa
N. rhyncocephala
N. rhyncocephala v. germainii
N. schroeteri v. escambia
N. tripunctata v. schizonemoides
N. viridula
N. viridula v. avenacea
N. viridula v. rostellata
Nitzschia acicularis
N. amphibia

BACILLARIOPHYTA (continued)
Pennales (continued)
Navicula capitellata
N. communis
N. communis v. abbreviata
N. dissipata
N. filiformis
N. gandersheimiensis
N. hungarica
N. Kutzingiana
N. linearis
N. obtusa
N. palea
N. paradoxa
N. parvula
N. recta
N. stagnorum
N. sublinearis
Pinnularia sp. 1
Rhoicosphenia curvata
Surirella augustata
S. linearis
S. ovata
Synedra acus
S. delicatissima
S. fasciculata
S. minuscula
S. rumpens
S. rumpens v. meneghiniana
S. ulna
S. ulna v.oxyrhynchus
Synedra sp.

CHRYSOPHYTA
Dinobryon bavaricum

CRYPTOPHYTA
cryptophyte sp. 1

CHLOROPHYTA
Ankistrodesmus convolutus
A. falcatus
Characium ambiguum
Chlamydomonas globosa
Chlamydomonas sp.
Chlorogonium elongatum
Closterium moniliferum
Cladophora sp.
Coelastrum microporum
Cosmarium binum
Cosmarium sp.
Dictyosphaerium Ehrenbergianum
D. pulchellum
Gloeocystis gigas
G. planctonica
Lagerheima subsalsa
Mougeotia sp.
Oocystis Borgei
Oocystis sp.
Scenedesmus bijuga
S. denticulatus
S. quadricauda
Scenedesmus sp.

TABLE D-1
(continued)
LIST OF PERIPHYTON SPECIES COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
1980

CHLOROPHYTA (continued)
- Stigeoclonium sp. 1
- Tetraedron minimum
- Tetrastrum staurogeniaeforme
- Ulothrix sp.
- unidentified coccoid sp. (10-11μ diam.)
- unidentified coccoid sp. (4-7μ diam.)

CYANOPHYTA
- Anabaena sp.
- Anacystis sp.
- Chamaesiphon incrustans
- Chroococcus sp.
- Lyngbya Diguetii
- Lyngbya sp. 1
- Merismopedia tenuissima
- Microcystis incerta
- Microcystis sp.
- Oscillatoria Agardhii
- Oscillatoria sp. 1

CYANOPHYTA (continued)
- Oscillatoria sp. 2
- Oscillatoria sp. 3
- Spirulina major

EUGLENOPHYTA
- Trachelomonas sp.
- Euglenoid sp. 1

PROTOZOA
- Amoeba sp.
- unidentified ciliated protozoan
- unidentified protozoan

OTHERS
- unidentified phytoflagellate sp. 2
- unidentified phytoflagellate sp. 3
- unidentified phytoflagettale sp. 4

TABLE D-2

PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3, AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1980

	24 March					
	Station 1		Station 3 and 5		Station 6	
Taxon	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)
Bacillariophyta					1942.29	94.27
Cryptophyta					33.01	1.60
Chlorophyta	Samplers were not recovered due to high water conditions		Stations 3 and 5 samples inadvertantly biomassed prior to species composition and density analysis		46.57	2.26
Cyanophyta					7.17	0.35
Euglenophyta					2.82	0.14
Others					28.41	1.38
Total					2060.27	

TABLE D-2
(continued)
PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1980

	26 May							
	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)
Bacillariophyta	2831.72	98.40	2305.86	98.83	4718.30	92.22	3418.34	98.63
Cryptophyta	0.00	0.00	0.00	0.00	0.00	0.00	7.72	0.22
Chlorophyta	11.27	0.41	4.60	0.20	28.19	0.55	17.55	0.51
Cyanophyta	22.06	0.78	7.92	0.34	368.10	7.19	20.39	0.59
Euglenophyta	1.61	0.06	0.84	0.04	0.00	0.00	0.00	0.00
Protozoa	0.00	0.00	0.00	0.00	0.00	0.00	1.90	0.05
Others	1.61	0.06	1.67	0.07	0.00	0.00	0.00	0.00
TOTAL	2868.27		2320.89		5114.59		3465.90	

TABLE D-2
(continued)
PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3, AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1980

	11 August							
	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)
Bacillariophyta	3845.03	90.42	3426.35	86.99	4968.89	38.31	2549.17	89.42
Chrysophyta	3.96	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Cryptophyta	71.21	1.67	22.54	0.57	43.02	0.33	11.22	0.39
Chlorophyta	54.62	1.26	157.15	3.98	3870.56	29.92	23.10	0.81
Cyanophyta	262.69	6.17	315.30	8.01	4003.93	30.95	249.87	8.77
Euglenophyta	7.92	0.18	4.10	0.01	21.51	0.16	17.11	0.60
Protozoa	0.00	0.00	3.59	0.09	0.00	0.00	0.00	0.00
Others	3.96	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Total	4249.39		3929.03		12921.48		2850.47	

TABLE D-2
(continued)
PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
OHIO RIVER STATIONS 1, 3 AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1980

	2 November							
	Station 1		Station 3		Station 5		Station 6	
Taxon	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)	Density (no.x10^3/ 10 cm^2)	Relative abundance (%)
Bacillariophyta	9919.26	95.89	17190.63	97.35	17133.84	98.82	2921.75	95.86
Cryptophyta	40.16	0.39	28.69	0.16	0.00	0.00	7.63	0.25
Chlorophyta	185.35	1.79	208.27	1.18	97.55	0.56	24.69	0.81
Cyanophyta	67.14	0.65	76.03	0.43	34.43	0.20	86.83	2.85
Euglenophyta	5.74	0.06	0.00	0.00	5.74	0.03	2.15	0.07
Protozoa	5.74	0.06	45.90	0.26	45.90	0.26	4.89	0.16
Others	120.49	1.16	109.01	0.62	22.95	0.13	0.00	0.00
TOTAL	10343.88		17658.53		17340.41		3047.94	

TABLE D-3

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST
FOR PERIPHYTON DENSITY
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1974, 1977-1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Years (Y)	4	100.8171	25.2043	4.67*
Stations (S)	2	1.3365	0.6683	0.49
Y x S Interaction	8	10.9160	1.3645	0.25
Error	72	388.7317	5.3991	
TOTAL	86	501.8013		

*Significant at P=0.05; Critical $F_{(4,72)}$ = 2.51; Critical $F_{(2,8)}$ = 4.46; Critical $F_{(8,72)}$ = 2.08.

DUNCAN'S MULTIPLE RANGE TEST: YEARS

Grouping	Log Mean	N	Year
A	8.7635	18	80
A	8.4896	18	78
B A	7.5225	18	79
B A	7.0167	9	74
B	6.0230	24	77

[a]Means with the same letter are not significantly different. Alpha level=0.05; DF=72; MS=5.3990.

TABLE D-4

ANALYSIS OF VARIANCE FOR PERIPHYTON DENSITY
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977-1980

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Years	3	6.1144	2.0381	1.36
Error	24	35.8803	1.4950	
Total	27	41.9947		

[a]Critical $F_{(3,24;P=0.05)} = 3.01$.

TABLE D-5

ENVIRONMENTAL REQUIREMENTS OF MAJOR DIATOM SPECIES
IDENTIFIED IN PERIPHYTON SAMPLES[a]
MARBLE HILL PLANT SITE
1980

Species	Occurrence: Ohio River	Occurrence: Little Saluda Creek	Temperature	pH	Current	Nutrients
Melosira varians	x		eurythermal and oligothermal to mesothermal	6.4 - 9.0 8.5 optimum	indifferent	eutrophic
Achnanthes linearis f. curta	x	x	-	-	-	-
A. minutissima	x	x	eurythermal	indifferent 7.5 - 7.8 optimum	indifferent	-
Cocconeis placentula v. euglypta	x	x	eurythermal	6.2 - 9.0	indifferent	-
Cymbella affinis	x	x	-	4.3 - 9.0 7.8 - 8.5 optimum	rheophilous	eutrophic
Gomphonema olivaceum	x		eurythermal to oligothermal to mesothermal	6.4 - 9.0	indifferent to rheophilous	eutrophic
G. parvulum	x	x	mesothermal to stenothermal	indifferent 4.2 - 9.0 7.8 - 8.2 optimum	rheophilous	nutrient enrichment, especially by sanitary or farm wastes
Navicula gracilloides	x		-	-	-	-
Nitzschia dissipata	x	x	eurythermal, oligothermal to mesothermal	5.5 - 9.0 8.0 ca. optimum	rheophilous	eutrophic
N. palea	x	x	eurythermal 0° to 30°C	indifferent 4.2 - 9.0 8.4 ca. optimum	indifferent	eutrophic
Rhoicosphenia curvata		x	-	5.4 - 9.0 8.0 ca. optimum	indifferent to rheophilous	eutrophic
Surirella ovata	x	x	oligothermal, eurythermal	6.4 - 8.2 7.5 - 8.0 optimum	rheophilous	-

[a]Adapted from Lowe (1974).

TABLE D-6

MORISITA'S COMMUNITY SIMILARITY INDEX VALUES FOR PERIPHYTON SAMPLES
OHIO RIVER STATIONS 1, 3 AND 5[a]
MARBLE HILL PLANT SITE
1980

Comparison	Sampling date[b]: 26 May	11 August	2 November
Sta. 1 x Sta. 3	0.96	0.83	0.98
Sta. 1 x Sta. 5	0.94	0.26	0.97
Sta. 3 x Sta. 5	0.98	0.33	0.94

[a]Index values $\geq$ 0.50 indicate paired communities similar.

[b]March samples were lost due to field conditions and inadvertent biomass analysis prior to species composition and density analysis.

TABLE D-7

PERIPHYTON SPECIES DIVERSITY INDEX AND EQUITABILITY VALUES[a]
MARBLE HILL PLANT SITE
1980

Station	24 March			26 May		
	S	$\bar{d}$	e	S	$\bar{d}$	e
1	--[b]	--[b]	--[b]	46	2.9562	0.24
3	--[b]	--[b]	--[b]	40	2.2362	0.16
5	--[b]	--[b]	--[b]	36	2.3169	0.19
6	43	3.5884	0.40	42	3.6235	0.42

Station	11 August			2 November		
	S	$\bar{d}$	e	S	$\bar{d}$	e
1	37	2.9311	0.29	52	3.2529	0.26
3	47	3.5391	0.36	45	2.7548	0.21
5	43	3.4335	0.36	41	3.1192	0.30
6	27	2.7148	0.34	37	2.8807	0.28

[a]S = number of species.

$\bar{d}$ = Shannon-Weaver species diversity index ($\log_2$).

e = equitability.

[b]Samples were lost due to field conditions and an inadvertent biomass estimation of all remaining sample slides.

TABLE D-8

ANALYSIS OF VARIANCE AND DUNCAN'S MULTIPLE RANGE TEST
FOR PERIPHYTON BIOMASS
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F[a]
Years (Y)	3	103.8581	34.6194	5.02*
Stations (S)	2	1.3039	0.6519	0.12
Y x S Interaction	6	32.7115	5.4519	0.79
Error	93	640.9250	6.8917	
TOTAL	104	778.7985		

*Significant at P=0.05; Critical $F_{(3,93)}$ = 2.72; Critical $F_{(2,6)}$ = 5.14; Critical $F_{(6,93)}$ = 2.21.

DUNCAN'S MULTIPLE RANGE TEST: YEARS

Grouping	Log Mean	N	Year
A	4.9762	21	79
B	2.9967	30	80
B	2.5037	27	77
B	2.2370	27	78

[a]Means with the same letter are not significantly different.
Alpha level=0.05; DF=70; MS=1.33229.

TABLE D-9

ANALYSIS OF VARIANCE FOR PERIPHYTON BIOMASS
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977-1980

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F^a
Years	3	615.1942	215.0647	1.73
Error	35	4352.7289	124.3637	
Total	38	4997.9231		

[a]Critical $F_{(3,35;P=0.05)} = 2.88$.

E. BENTHIC AND DRIFT MACROINVERTEBRATES

INTRODUCTION

Macroinvertebrates are animals large enough to be seen by the unaided eye and retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595-mm openings; EPA, 1973). They live at least part of their life cycles within or upon suitable substrata in a body of water.

A community of macroinvertebrates in an aquatic system responds to changes in environmental conditions such as temperature, salinity, depth, current, substratum, and the concentrations of chemical and organic pollutants. Because macroinvertebrates exhibit limited motility and relatively long life spans, the species composition of a macroinvertebrate community is a function of environmental conditions during the recent past. Thus, these communities are useful indicators of environmental perturbation (EPA, 1973).

The purpose of this construction phase monitoring program was to ascertain the character of the benthic and drift macroinvertebrate communities in the vicinity of the proposed Marble Hill Nuclear Generating Station. These data will provide information for comparison with baseline data (PSI, 1976) and previous construction phase data (ABI, 1978, 1979, 1980) to determine the effects of plant construction.

MATERIALS AND METHODS

Benthos

Spe imens from the benthic community were collected and analyzed in accordance with methods recommended by EPA (1973), APHA (1975), and NESP (1975). Benthic sampling was done with a Ponar grab at Stations 1, 3 and 5 in the Ohio River in March, May, August and November 1980. The Ponar grab samples a surface area of 0.0523 m^2. Two replicate Ponar samples were taken at both inshore (3 m from shore) and offshore locations (91 m offshore) at each station. Samples were then washed through a U.S. Standard No. 30 mesh sieve to remove fine sediment and particulate detritus. All material retained on the sieve was preserved in a 1:1 mixture of Eosin B and Biebrich Scarlet stains in a 1:1000 concentration with 5-percent formalin (Williams, 1974). Preserved samples were placed in labeled containers and taken to the laboratory where they were hand-sorted, and the macroinvertebrates were identified to the lowest practicable taxon. Dry weight biomass was determined for each major taxonomic group (Annelida, Mollusca, Arthropoda and miscellaneous).

At Little Saluda Creek (Station 6), benthic sampling was conducted with a Surber square-foot sampler in both riffle and pool habitats. A Surber sampler samples 0.0929 m^2. Surber samples were preserved, identified and analyzed for biomass in the same manner as the Ponar samples.

Drift Macroinvertebrates

Drift sampling at the three Ohio River stations (1, 3 and 5) was also conducted in March, May, August and November 1980 using a pair of bongo nets towed from a boat. Nets were 200 cm long with 20-cm diameters and 505-μ mesh. Tows were made at each station for 10 minutes each at the surface, mid-depth, and bottom of the river. The volume of flow through each net was measured with a General Oceanics Model 2030 flowmeter that was fixed in the mouth of the net. Samples were preserved and analyzed as previously outlined.

Macroinvertebrates

Long-term drift community analysis was conducted using multiple-plate artificial substrate samplers (Hester and Dendy, 1962; Fullner, 1971). Each sampler has a surface area of 0.1626 m^2. At Stations 1, 3 and 5, samplers were suspended approximately 1 m below the surface of the river. At Station 6, the samplers were hung just below the surface of Little Saluda Creek in areas where enough water was available to cover the samplers. All samplers were left in place for three weeks. Two replicate samplers were then retrieved from each station and scraped clean. The colonizing organisms were preserved, identified and analyzed for biomass using the methods previously outlined for benthic samples.

Statistical Analysis

Statistical analysis of the benthic and macroinvertebrate data was through the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS) which uses the regression approach to analysis of variance. All data were transformed before analysis by the standard log transformation ($\log_e[X + 1]$) to reduce the effect of nonhomogeneous variation and skewness (Zar, 1974). Duncan's multiple range test was used to locate significant differences among means.

RESULTS AND DISCUSSION

The benthic and macroinvertebrate faunas sampled during construction phase ecological monitoring near the Marble Hill Plant site were composed of oligochaete worms, molluscs, small crustaceans, immature insects, flatworms, hydrozoans and mites. No endangered or commercially valuable species were collected. A total of 9462 individuals of 81 benthic and macroinvertebrate species was collected (Table E-1). These were the highest numbers of individuals and species collected since construction phase monitoring began in 1977. Complete collection data are presented in Appendix Tables E-1 through E-28.

Ohio River Benthos

The benthic fauna of the Ohio River had a very patchy distribution. Density of individuals ranged from 10 to 2218/m^2 in deep water and from 0 to 6052/m^2 in shallow water (Figure E-1). Because the substrate at the three Ohio River sampling stations was fairly uniform, it is presumed that the transitory presence of various microhabitats was responsible for the patchy distribution of benthic specimens. Mean densities recorded during 1980 were somewhat higher than those reported in previous studies at the Marble Hill site.

Study	Density Range (no./m^2)
Construction phase, 1980	0-6052
Construction phase, 1979 (ABI, 1980)	19-3786
Construction phase, 1978 (ABI, 1979)	38-3499
Construction phase, 1977 (ABI, 1978)	10-2782
Baseline, 1974-1975 (PSI, 1976)	10-2865

Densities were highest in August (summer) and lowest in March (late winter). This pattern of density variation is typical of previous monitoring studies and of Midwestern freshwater systems in general (Hynes, 1972). In most cases, density at offshore sampling locations was lower than that of inshore sampling stations (Appendix Tables E-1 through E-12).

Biomass values were rather low because of the small size of the collected individuals; however, biomass in 1980 was higher than in previous years due to the general increase in density at all stations. The range of biomass values was 0.0 to 6.711 g/m^2 (Figure E-2). Biomass usually ranged from 0.2 to 0.8 g/m^2. Higher biomass values were caused by the irregular collection of a large, heavy-bodied animal, such as a mussel, or the collection of several small clams. As in previous studies, biomass was generally higher in the second half of the year. During 1980, this was particularly true in November when substantial numbers of Corbicula were found at all stations.

Diversity indices were generally low and ranged from 0.0 to 2.58. As with density and biomass, diversity was higher in the second half of the year (Figure E-3), a pattern observed during previous studies. Diversity indices at the river stations were lower than in previous years.

Study	Index of diversity range
Construction phase, 1980	0.00 - 2.58
Construction phase, 1979	0.00 - 4.02
Construction phase, 1978	0.93 - 3.20
Construction phase, 1977	0.00 - 2.83
Baseline, 1974-1975	0.00 - 2.69

With some exceptions, oligochaete worms dominated the benthic fauna at each of the river stations; the most numerous oligochaete worm species was Limnodrilus hoffmeisteri. Worms were more abundant at inshore locations where the bottom substrate was softer and more suitable for burrowing. The crustacean fauna was almost totally composed of the amphipod Gammarus pseudolimnaeus, and the most abundant mollusc was Corbicula fluminea. Both of these species were more abundant at offshore locations. The insect fauna was composed of immature individuals of many species of flies, mayflies and caddis flies.

When compared to previous construction phase monitoring data, the most notable change in the benthic fauna collected in 1980 was the increase in the number of Corbicula (Figure E-4). This exotic mollusc, commonly called the Asiatic clam, has clogged raw water intake lines at power plants and water treatment facilities in the midwestern United States (Sinclair, 1971). Although the increase was most dramatic in November, it should be noted that Corbicula populations were somewhat larger throughout 1980. While this increase was unusual, it is not viewed as being a point of concern at this time. Whether the Corbicula population continues to increase will be discovered by future monitoring programs.

Significant differences in density, biomass and diversity were observed when the benthic data were compared by year and quarter (or season; Tables E-2 through E-4). In each case, significant differences by year and quarter were a result of natural variations in the benthic community that were unrelated to any activity at the Marble Hill site. Compared to other years, 1980 had significantly higher density and biomass but significantly lower diversity. This was probably due to increased populations of only a few species, most notably to the immature Tubificidae and to Corbicula fluminea. As in previous years, the first quarter (March) of 1980 had significantly lower density, biomass and diversity data than the later quarters.

Significant differences were also observed when density and biomass were compared by station (Tables E-2 and E-3). In both instances, Station 1 was significantly lower than Stations 3 or 5. Because Station 1 is the upstream control station, any change in its benthic fauna cannot be a result of activity at the plant site. The differences may be substrate related. No significant differences in mean diversity were found among the stations (Table E-4).

Ohio River Macroinvertebrates

Density of the macroinvertebrate fauna of the three Ohio River stations was lowest in March, ranging from 0 to 37 individuals/m^2, and highest in August, ranging from 3287 to 3958 individuals/m^2 (Appendix Tables E-17 through E-20; Figure E-5). As with the benthic fauna of the Ohio River, the macroinvertebrate fauna had a greater mean density in 1980 than in any previous year.

Biomass followed the same pattern of variation as density, being lowest in March and highest in August (Figure E-6). August biomass ranged from 1.415 to 1.851 g/m^2 and was much higher than the biomass found in other months (range of 0.006 to 1.377 g/m^2). August biomass values were larger due to the appearance of numerous caddis flies, an annual occurrence well documented in previous Ohio River studies (Mason et al., 1971).

Diversity of the macroinvertebrate samples was generally higher than the benthic samples (0.00-3.30) and less variable (Figure E-7). The highest diversity was observed in November. Overall, macroinvertebrate diversity for 1980 appeared to be somewhat lower than in previous years and was probably attributable to the great increase in density of only a few caddis fly species in August.

Immature insects, mostly caddis flies, comprised over 98 percent of the total macroinvertebrate specimens collected during 1980. Crustaceans, primarily the amphipod Gammarus pseudolimnaeus, were present only in May and November in small numbers. Small numbers of molluscs, primarily Corbicula fluminea, were also present during these months. Worms were present in March, May and August.

Significant differences in density were found among years and quarters (Table E-5). No significant differences in density were found among the stations. Similar year and quarter significant differences were found with the biomass data, but again, no significant differences were found among stations (Table E-6). Significant differences in macroinvertebrate diversity were found among quarters but not years or stations (Table E-7).

Significant differences in density and biomass among years and quarters were due to cyclic and seasonal variations in the macroinvertebrate fauna and were unrelated to any activity at the Marble Hill site. The lack of any significant differences among stations emphasizes that plant construction has not influenced the macroinvertebrate community in any way.

Little Saluda Creek Benthos

Density of the benthos in Little Saluda Creek was usually higher in riffle habitats (up to 2198 individuals/m^2) than in pool habitats (up to 1023 individuals/m^2) and was highest in November for both habitats (Figure E-1; Appendix Tables E-13 through E-16). Biomass was also higher in riffle habitats and was lowest in May (0.258 g/m^2) and highest in November (4.034 g/m^2). Pool biomass followed a similar trend and ranged from 0.043 to 2.180 g/m^2 (Figure E-2). Major contributors to the high November biomass were some snails (*Somatogyrus* sp.) and some very large insect larvae (*Tipula* sp.).

Diversity indices ranged from 0.88 to 2.19 in riffles and from 1.16 to 2.44 in pools. Diversity appeared to be generally lower than in 1979 primarily as a result of increased populations of the isopod *Lirceus* (Figure E-3). *Lirceus* dominated the fauna in November while insect larvae dominated the fauna in other months.

Density and biomass generally declined from 1977 through 1979 while diversity simultaneously increased (Table E-8). These trends were statistically significant in riffle habitats but not in pool habitats (Table E-9). Little Saluda Creek is, however, primarily a riffle habitat. During 1980, all of these trends were reversed.

Decreasing density and biomass and increasing diversity were a result of changes in the benthic fauna of Little Saluda Creek caused by increased sedimentation in the form of erosion runoff from the Marble Hill site (ABI, 1980). During the baseline study and through May 1978 construction phase monitoring, the isopod Lirceus was the dominant benthic species in Little Saluda Creek (Figure E-8). The degree of dominance by Lirceus declined steadily through 1979 due to eroded sediment from the plant site settling in the stream and rendering Little Saluda Creek unsuitable for a large Lirceus population (Table E-8). During 1979, sedimentation was apparently curtailed, and deposits were washed from the creek by high water levels during spring 1980. This allowed recolonization by Lirceus from upstream areas and resulted in Lirceus forming a much larger segment of the benthic fauna. The increase in Lirceus density and biomass caused a concomitant decrease in diversity. Recolonization by Lirceus suggests that the creek is recovering from 1978 and 1979 plant construction impacts. Future monitoring will detect whether or not this trend continues.

Little Saluda Creek Macroinvertebrates

Macroinvertebrate density in Little Saluda Creek ranged from 188 to 420 individuals/m^2 in November and May, respectively (Appendix Tables E-21 through E-24). Density in 1980 was generally higher than in any previous year (Figure E-5). Biomass varied in the same manner with lowest values recorded in November (0.062 g/m^2) and highest values in March (1.562 g/m^2; Figure E-6). Macroinvertebrate diversity in the creek was lowest in May and highest in March (Figure E-7). Variation in the macroinvertebrate community of Little Saluda Creek bore little relationship to variation in the macroinvertebrate community of the Ohio River.

As with the benthic fauna of the creek, a clear trend toward increased Lirceus density was observed in August and November when Lirceus dominated the fauna. In addition, trends of decreasing density and biomass and increasing diversity through 1979 were reversed in 1980, as was observed with the benthic fauna (Table E-8). Few of these trends were significant, however (Table E-10).

Results of the 1980 macroinvertebrate monitoring program in Little Saluda Creek reinforce the hypothesis that the creek is recovering from past plant construction impacts. Future monitoring will detect whether or not this recovery process is continuing.

Ohio River Drift Macroinvertebrates

A total of 492 specimens representing 33 taxa were collected during drift macroinvertebrate sampling (Appendix Tables E-25 through E-28). The fauna was primarily composed of insect larvae, but oligochaete worms, clams, amphipod crustaceans and hydroids were also present. Hydroids were particularly abundant in November when they comprised nearly 85 percent of the specimens collected. Generally, the drift fauna was the same as the benthic or macroinvertebrate fauna.

When sampling began in late March, density ranged from 0.2 to 0.6 individuals/m^3. Densities were similar in May (<0.1 to 0.7/m^3) and lower in August (<0.1 to 0.3). Density was also generally low in November but the range was greater than in August (0.1 to 1.4/m^3). This pattern of seasonal density variation was somewhat different from previous years in which density was lowest in March, highest in May, and intermediate through August and November. However, as in previous years, samples taken near the bottom of the river usually had greater densities than either surface or mid-depth samples.

Two-way analysis of variance of the 1980 data showed several significant differences in density among seasons (Table E-11). Such seasonal variation is to be expected and cannot be related to any activity at the Marble Hill site. Other significant differences were observed among the mid-depth samples where Station 5 had significantly higher density than Stations 1 or 3 and among the bottom samples where Station 1 had significantly higher density than Stations 3 or 5.

When all depths at a given station were compared, the bottom samples at Stations 1 and 3 were found to have significantly greater density than the surface or mid-depth samples at those stations. At Station 5, the surface samples had significantly lower density than either mid-depth or bottom samples. In addition, densities in 1980 were found to be significantly greater than densities in 1979 (1979 was the only year with a sampling schedule similar to that of 1980.)

Because 1980 densities were higher than 1979 and because Stations 3 and 5 were usually similar to the control station, the significant differences encountered among stations or depths in 1980 were probably not related to construction at the Marble Hill site. Differences were most likely a function of river flow rates which have been known to vary between 12 and 275 cm/sec (ABI, 1978, 1979, 1980). A contributing factor is also the generally observed trend toward increased benthic and macroinvertebrate density.

CONCLUSIONS

The benthic and macroinvertebrate fauna of the Ohio River were generally of moderate density and biomass but low diversity. Data collected during the 1980 construction phase ecological monitoring program showed a somewhat higher density and biomass but lower diversity than was found at the Marble Hill Plant site during previous monitoring programs. Changes in the benthic and macroinvertebrate fauna of the Ohio River were a result of annual or seasonal changes in the environment rather than construction activity at the Marble Hill Plant site.

Prior to 1980, density and biomass decreased in Little Saluda Creek while diversity increased. These trends probably resulted from excessive sedimentation in the creek caused by erosion at the Marble Hill site. Procedures to stop sedimentation in the creek have apparently been successful and in 1980 these trends were reversed. This suggests that the benthic and macroinvertebrate communities of the creek are recovering their preconstruction structures.

Drift macroinvertebrate collections in the river had higher densities in 1980 than in 1979. No statistically significant differences were found among station densities that were related to plant construction. The drift community was sparsely populated by benthic invertebrates and was numerically dominated by zooplanktonic forms. Construction at the Marble Hill Plant site does not appear to have influenced or inhibited the drift macroinvertebrate community.

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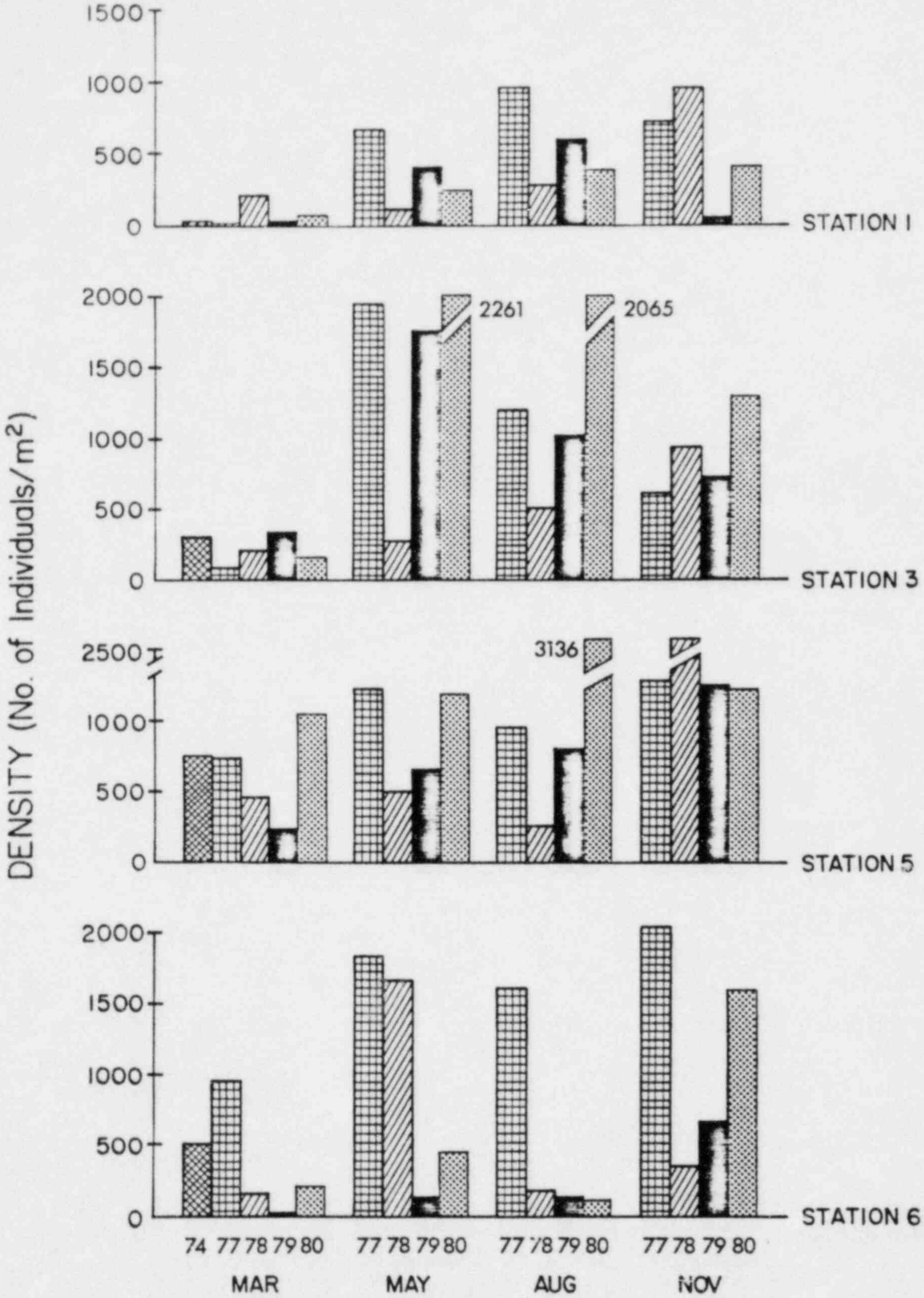

Figure E-1. Comparison of mean benthic density at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1974 and 1977-1980. (Each data point represents the mean of deep and shallow water samples.)

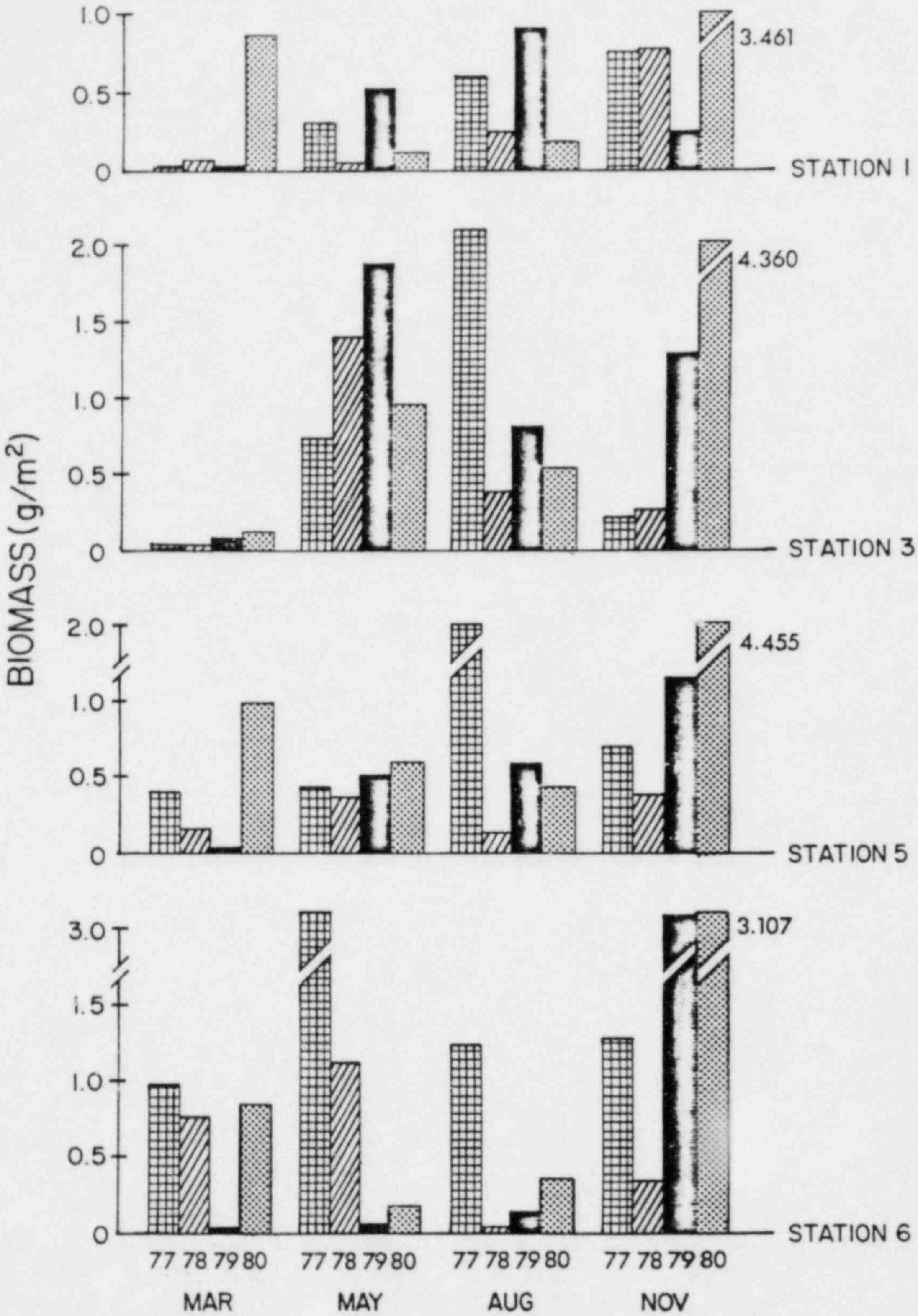

Figure E-2. Comparison of benthic biomass at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980. (Each data point represents the mean of deep and shallow water samples.)

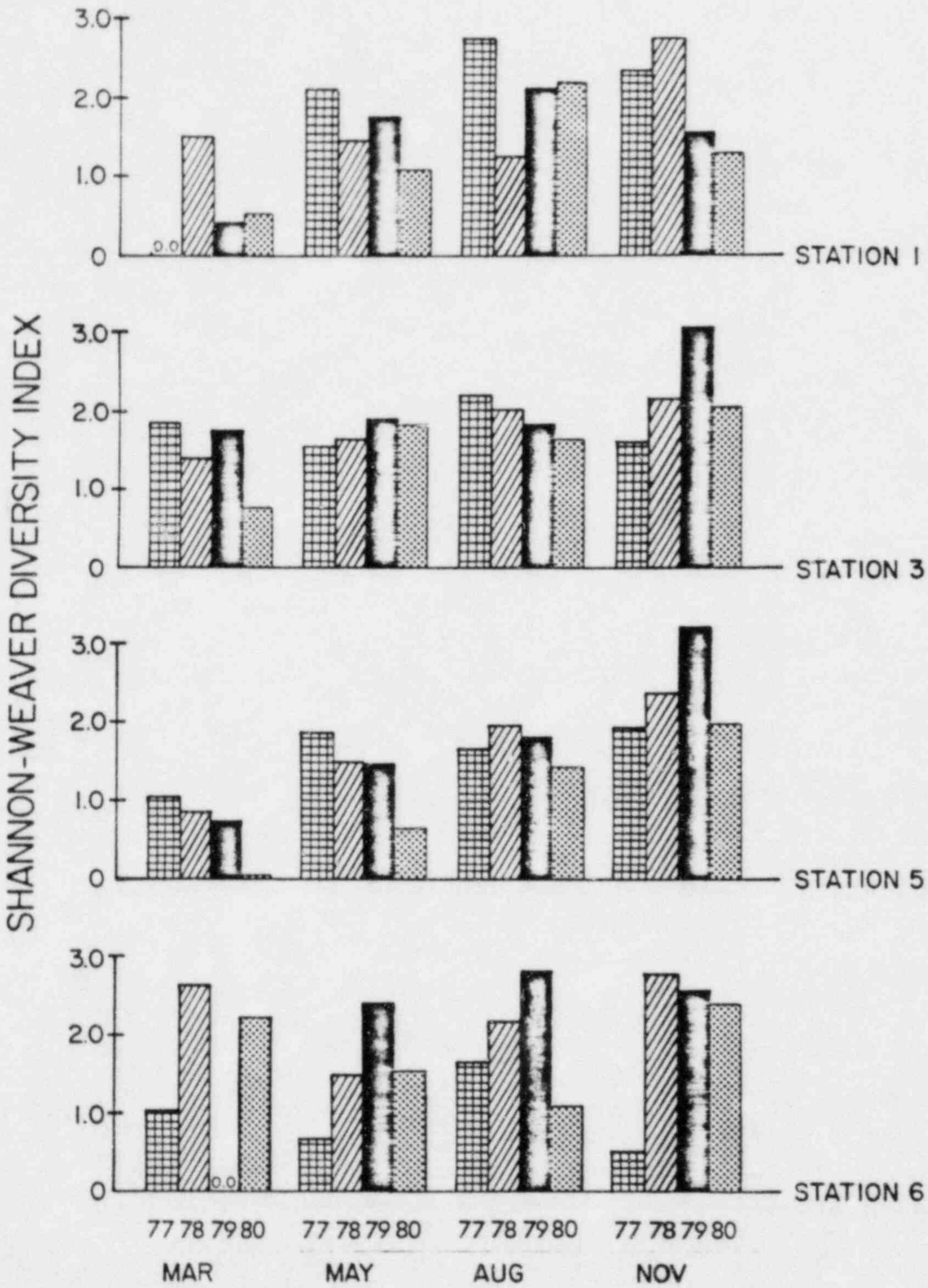

Figure E-3. Comparison of benthic diversity at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980. (Each data point represents the mean of deep and shallow water samples.)

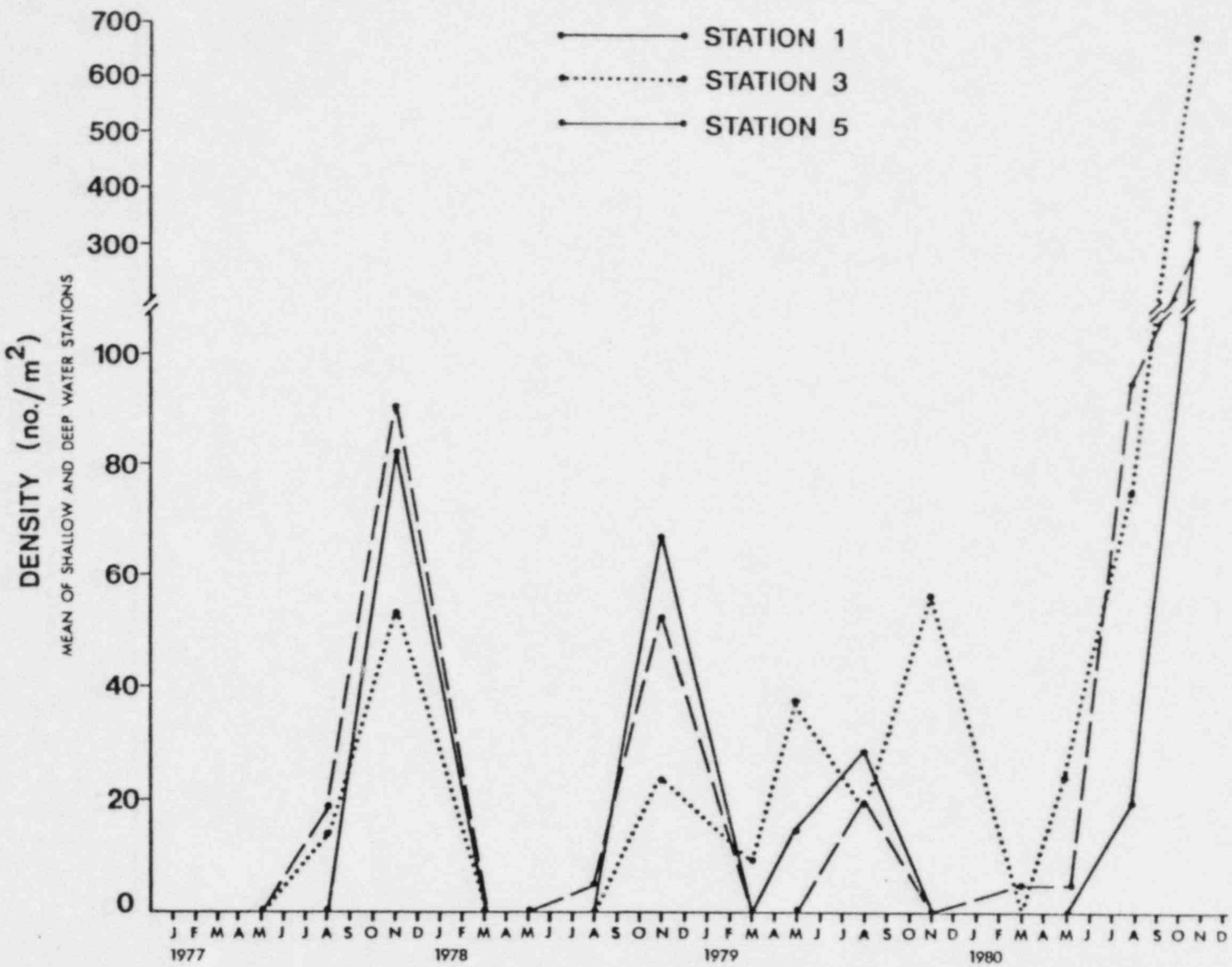

Figure E-4. Density of _Corbicula fluminea_ in the Ohio River at the Marble Hill Plant site, 1977-1980.

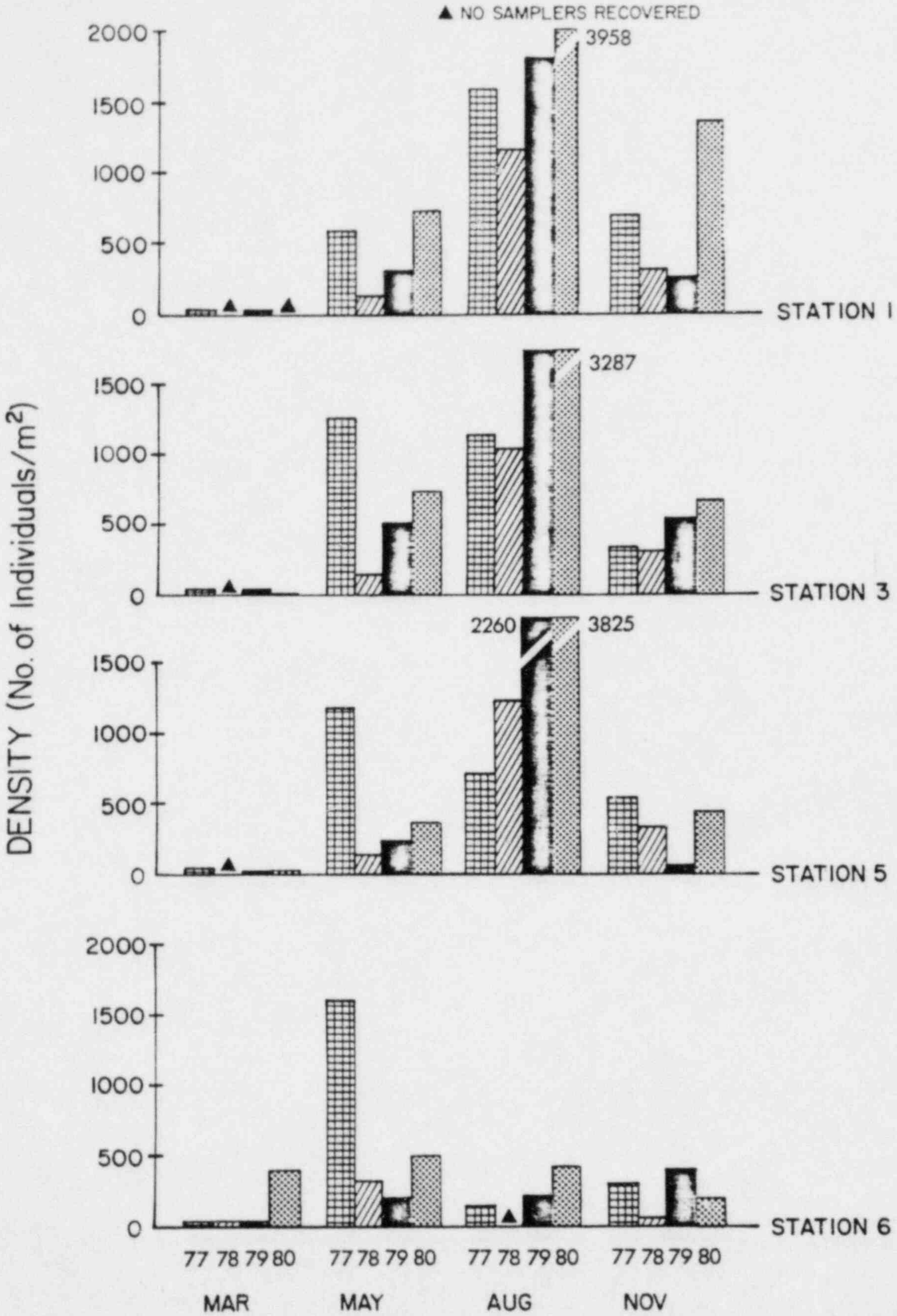

Figure E-5. Comparison of macroinvertebrate density at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

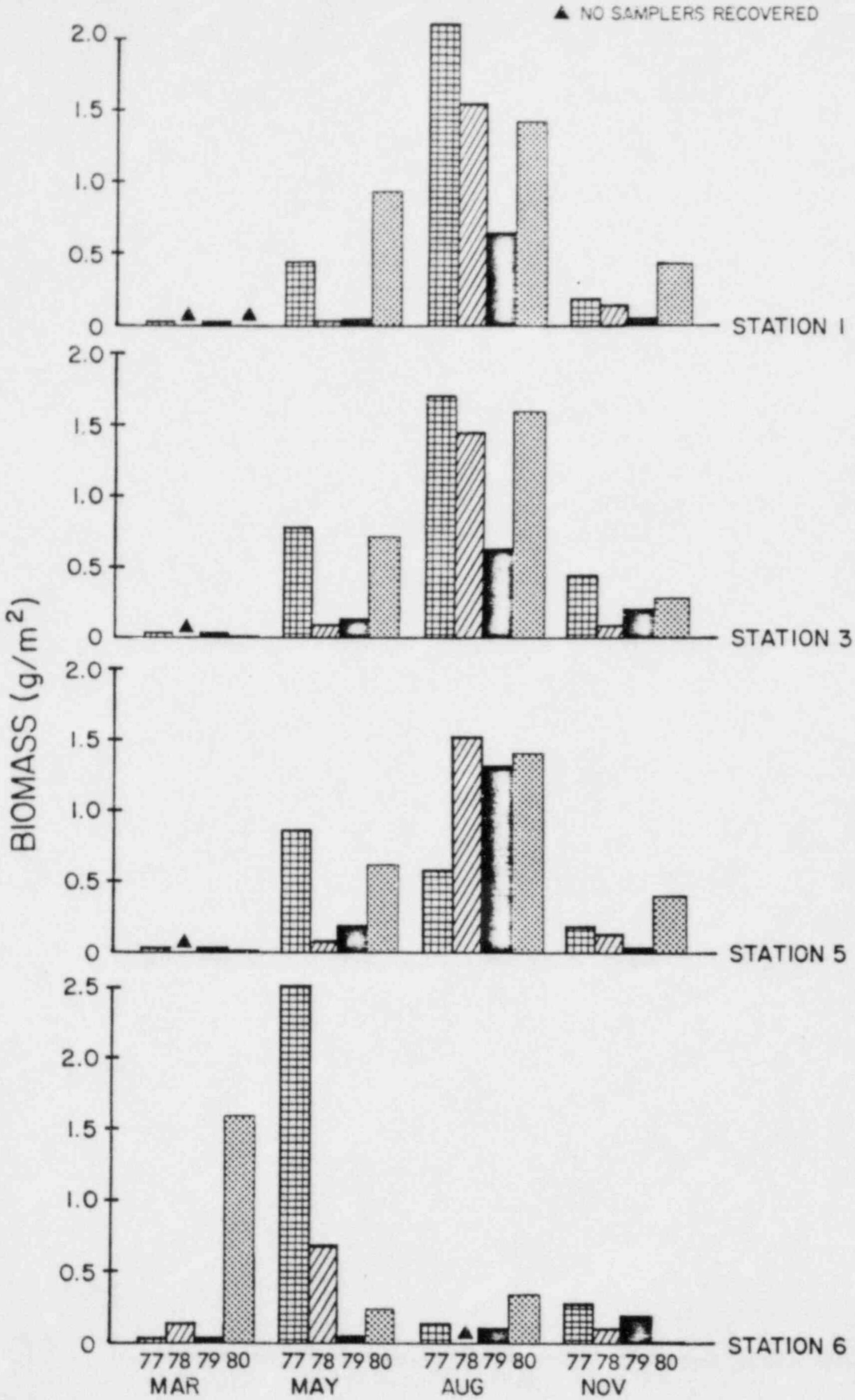

Figure E-6. Comparison of macroinvertebrate biomass at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

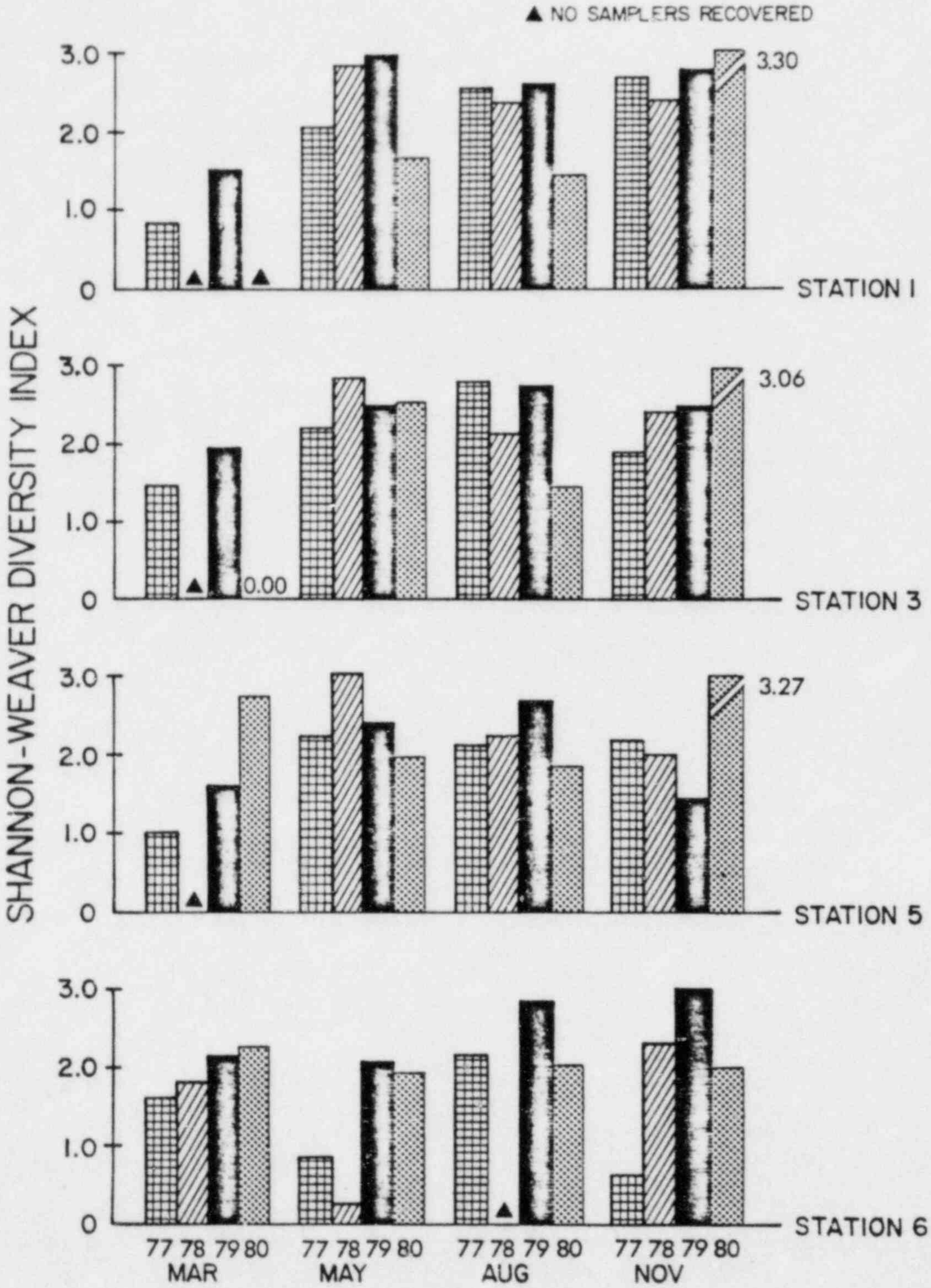

Figure E-7. Comparison of macroinvertebrate diversity at Ohio River Stations 1, 3 and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1980.

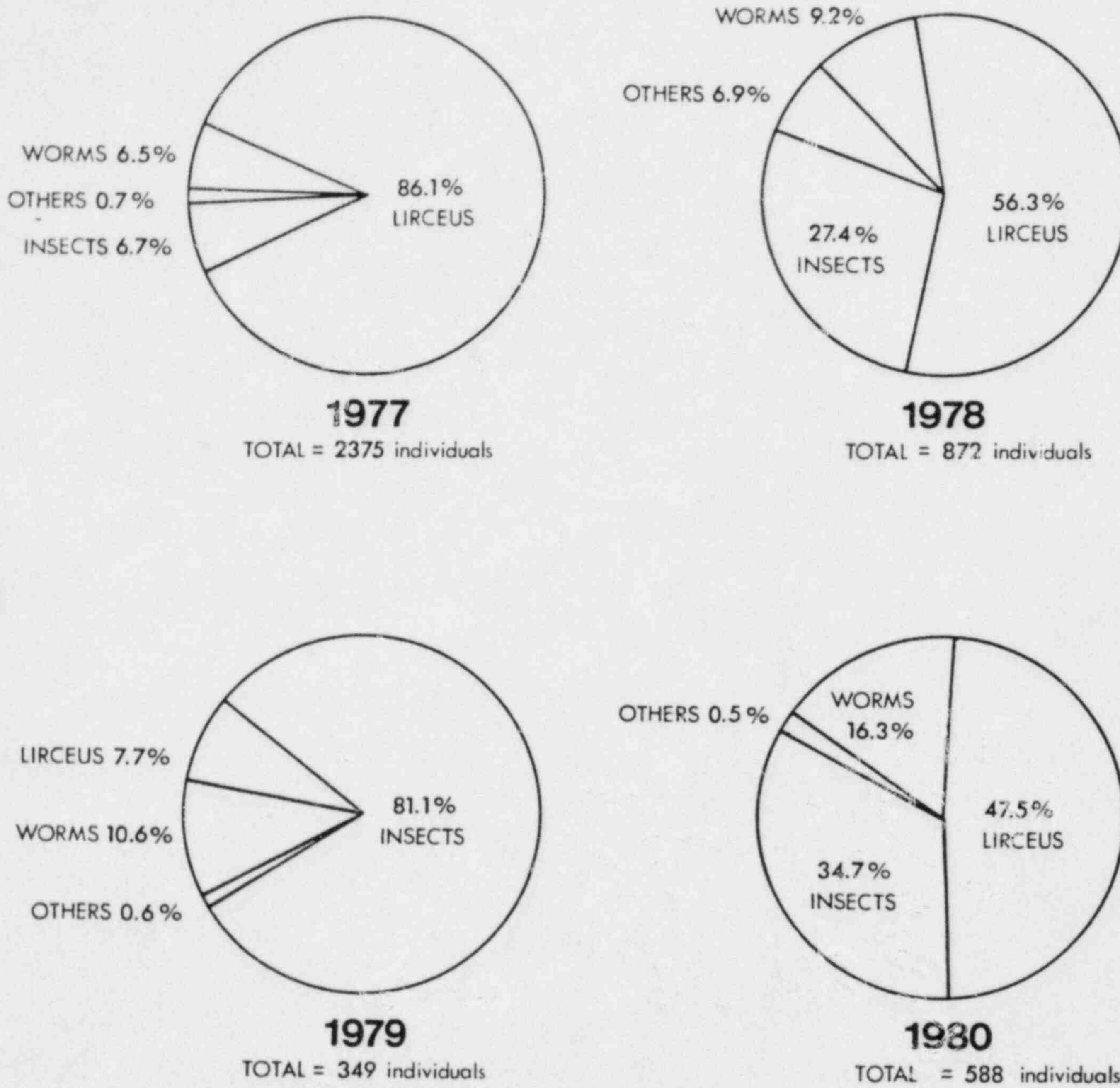

Figure E-8. Percentage composition of the benthic fauna in Little Saluda Creek, Marble Hill Plant site, 1977-1980.

TABLE E-1

OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1980

Species	Station 1	3	5	6
Class Hydrozoa				
Hydra sp. A	X	X	X	
Hydra sp. B	X	X	X	
Class Turbellaria				
Phagocata velata		X		
Class Oligochaeta				
Branchiura sowerbyi	X	X	X	
Limnodrilus hoffmeisteri	X	X	X	
L. maumeensis				X
L. undekemianus		X	X	
Nais communis			X	X
Peloscolex sp.			X	
Pristina breviseta		X	X	X
immature Tubificidae	X	X	X	X
Class Hirudinea				
unidentified leech		X		
Class Arachnida				
Hydrachna sp.		X		
Class Crustacea				
Lirceus fontinalis		X	X	X
Gammarus pseudolimnaeus	X	X	X	
Hyalella azteca	X			
Orconectes sloanii				X
Synurella dentata				X
Class Insecta				
Order Diptera				
Ablabesmyia rhamphe		X	X	X
Cardiocladius sp.	X			X
Chaoborus punctipennis	X	X	X	
Chironomus attenuatus	X	X	X	X
Cladotanytarsus sp.				X
Coelotanypus scapularis	X	X	X	
Cricotopus sp.	X	X	X	X

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1980

Species	Station 1	3	5	6
midges (continued)				
Cryptochironomus fulvus	X	X	X	X
Dicrotendipes modestus	X	X	X	
Epoicocladius sp.	X	X	X	
Eukiefferiella sp.	X	X	X	X
Harnischia sp.		X		
Hemerodromia sp.	X		X	X
Larsia sp.				X
Limnophora sp.			X	
Micropsectra sp.				X
Microtendipes sp.	X	X	X	X
Orthocladius sp.	X	X	X	X
Polypedilum halterale	X	X	X	X
Procladius sp.	X	X	X	
Pseudochironomus sp.	X	X	X	
Rheocricotopus sp.			X	
Rheotanytarsus sp.	X		X	X
Simulium sp.				X
Stenochironomus sp.	X	X		
Stichtochironomus sp.				X
Tanypus sp.		X		
Tanytarsus sp.	X	X		X
Thienemanniella sp.				X
Tipula sp.				X
Tribelos sp.				X
Order Trichoptera				
Cheumatopsyche sp.	X			
Cyrnellus fraternus	X	X	X	
Hydropsyche orris	X	X	X	X
Potamyia flava	X	X	X	X
Neureclipsis crepuscularis	X	X	X	
Ochrotrichia (viesi)				X
Symphitopsyche sp.	X	X	X	X
Order Ephemeroptera				
Baetis sp.				X
Caenis sp.	X			
Callibaetis sp.			X	
Hexagenia limbata		X	X	
Stenacron interpunctatum	X	X	X	
Stenonema exiguuma	X	X	X	X
unidentified specimen	X		X	

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1980

Species	Station 1	3	5	6
Order Plecoptera				
Isogenus sp.		X		
Isoperla sp.			X	X
Isoperla clio	X	X		X
Order Odonata				
Gomphus quadricolor		X	X	
Macromia illinoisense	X	X	X	
Nehalennia sp.				X
Order Megaloptera				
Nigronia serricornis		X		
Sialis sp.				X
Order Coleoptera				
Ectopria nervosa				X
Stenelmis (*sexlineata*)				X
Psephenus herricki				X
Order Collembola				
Isotomurus palustris	X			
Class Gastropoda				
Helisoma sp.			X	
Pleurocera acutum	X			
Somatogyrus sp.	X	X	X	X
Class Pelecypoda				
Corbicula fluminea[b]	X	X	X	
Quadrula nodulosa		X		
Sphaerium sp.	X	X	X	
Taxa per station-1980	42	47	[illegible]	43
1979	30	52	38	35
1978	31	31	33	35
1977	32	37	34	29

Total taxa-		
	1980	81
	1979	77
	1978	61
	1977	54

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1980

Species			Station 1	3	5	6
Individuals/station-	1980		2380	2816	3271	995
	1979		1199	2215	1960	616
	1978		800	875	1340	994
	1977		1486	1542	1696	3044
Total individuals-	1980	9462				
	1979	5990				
	1978	4009				
	1977	7768				

[a]Identified as Stenonema heterotarsale in previous reports.

[b]Identified as Corbicula manilensis in previous reports.

TABLE E-2

STATISTICAL ANALYSIS (GENERAL LINEAR MODELS PROCEDURE) OF BENTHIC DENSITY DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

Dependent Variable: Benthic Density

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
Model	29	59.90517	2.06570	5.96	0.0001
Error	18	6.23871	0.34659		Standard Deviation
Corrected Total	47	66.14388			0.58872

SOURCE	DF	TYPE I SS	F VALUE	PR > F
Year	3	2.85230	2.74	0.0733
Station	2	18.18620	26.24	0.0001*
Quarter	3	19.72144	18.97	0.0001*
Year x quarter	9	11.03466	3.54	0.0108*
Year x station	6	3.13630	1.51	0.2315
Quarter x station	6	4.97428	2.39	0.0708

*Significance level greater than P=0.05.

TABLE E-2
(continued)
GENERAL LINEAR MODELS PROCEDURE
DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE BENTHIC DENSITY[a]
MARBLE HILL PLANT SITE
1977-1980

OVERALL YEAR COMPARISON

GROUPING	MEAN(no./m^2)	N	YEAR
A	724	12	80*
B A	531	12	77
B	409	12	78
B	394	12	79

OVERALL QUARTER COMPARISON

GROUPING	MEAN(no./m^2)	N	QUARTER
A	775	12	3
A	720	12	4
A	673	12	2
B	164	12	1*

OVERALL STATION COMPARISON

GROUPING	MEAN(no./m^2)	N	STATION
A	885	16	5
A	661	16	3
B	212	16	1*

[a]Means with the same letter are not significantly different.

*Significance level greater than P=0.05.

TABLE E-3

STATISTICAL ANALYSIS (GENERAL LINEAR MODELS PROCEDURE) OF BENTHIC BIOMASS DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

Dependent Variable: Benthic Biomass

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
Model	29	7.49786	0.25855	5.23	0.0003
Error	18	0.89056	0.04948		Standard Deviation
Corrected Total	47	8.38842			0.22243

SOURCE	DF	TYPE I SS	F VALUE	PR > F
Year	3	1.08726	7.33	0.0021*
Station	2	0.38343	3.87	0.0399*
Quarter	3	1.77249	11.94	0.0002*
Year x quarter	9	3.33764	7.50	0.0002*
Year x station	6	0.26928	0.91	0.5116
Quarter x station	6	0.64776	2.18	0.0933

*Significance level greater than P=0.05.

TABLE E-3
(continued)
GENERAL LINEAR MODELS PROCEDURE
DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE BENTHIC BIOMASS
MARBLE HILL PLANT SITE
1977-1980

OVERALL YEAR COMPARISON

GROUPING	MEAN(g/m^2)	N	YEAR
A	0.997	12	80*
B	0.623	12	77
C B	0.563	12	79
C	0.307	12	78*

OVERALL QUARTER COMPARISON

GROUPING	MEAN(g/m^2)	N	QUARTER
A	1.098	12	4*
B	0.643	12	3
B	0.575	12	2
C	0.220	12	1*

OVERALL STATION COMPARISON

GROUPING	MEAN(g/m^2)	N	STATION
A	0.737	16	3
A	0.678	16	5
B	0.416	16	1*

[a]Means with the same letter are not significantly different.

*Significance level greater than P=0.05

TABLE E-4

STATISTICAL ANALYSIS (GENERAL LINEAR MODELS PROCEDURE) OF BENTHIC DIVERSITY DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

Dependent Variable: Benthic Diversity

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
Model	29	3.81226	0.13146	2.70	0.0154
Error	18	0.87667	0.04870		Standard Deviation
Corrected Total	47	4.68893			0.22069

SOURCE	DF	TYPE I SS	F VALUE	PR > F
Year	3	0.47849	3.27	0.0451*
Station	2	0.20702	2.13	0.1484
Quarter	3	2.33793	16.00	0.0001*
Year x quarter	9	0.26672	0.61	0.7743
Year x station	6	0.12740	0.44	0.8453
Quarter x station	6	0.39470	1.35	0.2866

*Significance level greater than P=0.05.

TABLE E-4
(continued)
GENERAL LINEAR MODELS PROCEDURE
DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE BENTHIC DIVERSITY[a]
MARBLE HILL PLANT SITE
1977-1980

OVERALL YEAR COMPARISON

GROUPING	MEAN	N	YEAR
A	1.80	12	79
A	1.69	12	78
A	1.62	12	77
B	1.16	12	80*

OVERALL QUARTER COMPARISON

GROUPING	MEAN	N	QUARTER
A	2.15	12	4*
B	2.00	12	3
B	1.52	12	2
C	0.79	12	1*

OVERALL STATION COMPARISON

GROUPING	MEAN	N	STATION
A	1.81	16	3
A	1.45	16	1
A	1.43	16	5

[a]Means with the same letter are not significantly different.

*Significance level greater than P=0.05

TABLE E-5

STATISTICAL ANALYSIS (GENERAL LINEAR MODELS PROCEDURE) OF MACROINVERTEBRATE DENSITY DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

Dependent Variable: Macroinvertebrate Density

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
Model	28	130.12581	4.64735	22.45	0.0001
Error	15	3.10479	0.20699		Standard Deviation
Corrected Total	43	133.23060			0.45496

SOURCE	DF	TYPE I SS	F VALUE	PR > F
Year	3	9.14426	14.73	0.0001*
Station	2	1.21136	2.93	0.0845
Quarter	3	107.40298	172.96	0.0001*
Year x quarter	8	8.55945	5.17	0.0031*
Year x station	6	1.99184	1.60	0.2138
Quarter x station	6	1.81593	1.46	0.2564

*Significance level greater than P=0.05.

TABLE E-5
(continued)
GENERAL LINEAR MODELS PROCEDURE
DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE MACROINVERTEBRATE DENSITY[a]
MARBLE HILL PLANT SITE
1977-1980

OVERALL YEAR COMPARISON

GROUPING	MEAN(no./m^2)	N	YEAR
A	714	11	80*
B	353	9	78
B	313	12	77
C	187	12	79*

OVERALL QUARTER COMPARISON

GROUPING	MEAN(no./m^2)	N	QUARTER
A	1717	12	3*
B	506	12	4
B	383	12	2
C	16	8	1*

OVERALL STATION COMPARISON

GROUPING	MEAN(no./m^2)	N	STATION
A	427	14	1
A	343	15	3
A	299	15	5

[a]Means with the same letter are not significantly different.

*Significance level greater than P=0.05.

TABLE E-6

STATISTICAL ANALYSIS (GENERAL LINEAR MODELS PROCEDURE) OF MACROINVERTEBRATE BIOMASS DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

Dependent Variable: Macroinvertebrate Biomass

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
Model	28	5.57599	0.19914	9.18	0.0001
Error	15	0.32537	0.02169		Standard Deviation
Corrected Total	43	5.90136			0.14728

SOURCE	DF	TYPE I SS	F VALUE	PR > F
Year	3	0.93849	14.42	0.0001*
Station	2	0.03190	0.74	0.4958
Quarter	3	3.72146	57.19	0.0001*
Year x quarter	8	0.72215	4.16	0.0085*
Year x station	6	0.12130	0.93	0.5004
Quarter x station	6	0.04068	0.31	0.9205

*Significance level greater than P=0.05.

TABLE E-6
(continued)
GENERAL LINEAR MODELS PROCEDURE
DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE MACROINVERTEBRATE BIOMASS[a]
MARBLE HILL PLANT SITE
1977-1980

OVERALL YEAR COMPARISON

GROUPING	MEAN(g/m^2)	N	YEAR
A	0.843	11	80*
B	0.493	12	77
B	0.427	9	78
C	0.234	12	79*

OVERALL QUARTER COMPARISON

GROUPING	MEAN(g/m^2)	N	QUARTER
A	1.308	12	3*
B	0.349	12	2
B	0.341	12	4
C	0.014	8	1*

OVERALL STATION COMPARISON

GROUPING	MEAN(g/m^2)	N	STATION
A	0.520	14	1
A	0.478	15	3
A	0.446	15	5

[a]Means with the same letter are not significantly different.

*Significance level greater than P=0.05.

TABLE E-7

STATISTICAL ANALYSIS (GENERAL LINEAR MODELS PROCEDURE) OF MACROINVERTEBRATE DIVERSITY DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977-1980

Dependent Variable: Macroinvertebrate Diversity

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
Model	28	2.36661	0.08452	2.04	0.0742
Error	15	0.62122	0.04141		Standard Deviation
Corrected Total	43	2.98783			0.20351

SOURCE	DF	TYPE I SS	F VALUE	PR > F
Year	3	0.22858	1.84	0.1833
Station	2	0.01894	0.23	0.7983
Quarter	3	1.02952	8.29	0.0017*
Year x quarter	8	0.51475	1.55	0.2200
Year x station	6	0.29398	1.18	0.3664
Quarter x station	6	0.28083	1.13	0.3917

*Significance level greater than P=0.05.

TABLE E-7
(continued)
GENERAL LINEAR MODELS PROCEDURE
DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE MACROINVERTEBRATE DIVERSITY[a]
MARBLE HILL PLANT SITE
1977-1980

OVERALL YEAR COMPARISON

GROUPING	MEAN	N	YEAR
A	2.47	9	78
A	2.28	12	79
A	1.93	12	77
A	1.92	11	80

OVERALL QUARTER COMPARISON

GROUPING	MEAN	N	QUARTER
A	2.47	12	4
A	2.40	12	2
A	2.22	12	3
B	1.24	8	1*

OVERALL STATION COMPARISON

GROUPING	MEAN	N	STATION
A	2.21	14	1
A	2.13	15	5
A	2.04	15	3

[a]Means with the same letter are not significantly different.

*Significance level greater than P=0.05.

TABLE E-8

COMPARISON OF BENTHIC AND MACROINVERTEBRATE COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1974 - 1980

Benthic collections

Year	Habitat	Range		
		Density(no./m^2)	Biomass(g/m^2)	Diversity
1974-1975	riffle	0-4469	0.0-26.969	0.0-2.12
	pool	0-3762	0.0-33.922	0.0-2.85
1977	riffle	1646-3658	1.786-6.209	0.40-1.65
	pool	145-603	0.172-0.516	0.47-1.65
1978	riffle	108-1727	0.054-1.571	1.27-3.23
	pool	65-1587	0.049-0.732	1.68-2.69
1979	riffle	0-1001	0.0-818	0.0-3.26
	pool	0-420	0.0-0.086	0.0-2.52
1980	riffle	151-2198	0.640-4.034	0.88-2.19
	pool	43-1023	0.012-2.180	1.16-2.44

Macroinvertebrate collections

Year	Range		
	Density(no./sampler)	Biomass(g/sampler)	Diversity
1974-1975	0-125	0.0-1.241	0.0-2.22
1977	0-264	0.0-0.463	0.60-2.39
1978	2-66	0.006-0.140	0.24-2.29
1979	5-78	0.004-0.048	2.07-3.00
1980	188-480	0.062-1.562	1.90-2.29

TABLE E-9

STATISTICAL ANALYSIS OF BENTHOS COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977-1980

I. Comparison of Riffle Habitats by Year

Community parameter	Mean values	Comparison	Critical t (P=0.05)	Calculated t (P=0.05)
Density ($no./m^2$)	1977 = 3009	1977 vs. 1978	2.145	4.212*
	1978 = 699	1977 vs. 1979	2.145	4.955*
	1979 = 324	1977 vs. 1980	2.145	4.478*
	1980 = 597	1978 vs. 1979	2.145	1.517
		1978 vs. 1980	2.145	0.124
		1979 vs. 1980	2.145	-1.428
Biomass (g/m^2)	1977 = 3.112	1977 vs. 1978	2.145	3.538*
	1978 = 0.505	1977 vs. 1979	2.145	4.065*
	1979 = 0.198	1977 vs. 1980	2.145	2.172*
	1980 = 1.230	1978 vs. 1979	2.145	1.907
		1978 vs. 1980	2.145	-1.709
		1979 vs. 1980	2.145	-2.559*
Diversity	1977 = 0.80	1977 vs. 1978	2.447	3.167*
	1978 = 2.32	1977 vs. 1979	2.447	1.230
	1979 = 2.16	1977 vs. 1980	2.447	-2.100
	1980 = 1.63	1978 vs. 1979	2.447	0.450
		1978 vs. 1980	2.447	1.308
		1979 vs. 1980	2.447	0.179

TABLE E-9
(continued)
STATISTICAL ANALYSIS OF BENTHOS COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977-1980

II. Comparison of Pool Habitats by Year

Community parameter	Mean values	Comparison	Critical t (P=0.05)	Calculated t (P=0.05)
Density ($no./m^2$)	1977 = 375	1977 vs. 1978	2.228	0.501
	1978 = 475	1977 vs. 1979	2.228	1.775
	1979 = 145	1977 vs. 1980	2.228	1.522
	1980 = 194	1978 vs. 1979	2.145	1.363
		1978 vs. 1980	2.145	1.049
		1979 vs. 1980	2.145	-0.350
Biomass (g/m^2)	1977 = 0.342	1977 vs. 1978	2.228	0.248
	1978 = 0.470	1977 vs. 1979	2.228	3.401*
	1979 = 0.031	1977 vs. 1980	2.228	-0.014
	1980 = 0.358	1978 vs. 1979	2.145	1.479
		1978 vs. 1980	2.145	0.283
		1979 vs. 1980	2.145	-1.516
Diversity	1977 = 1.09	1977 vs. 1978	2.776	2.279
	1978 = 2.16	1977 vs. 1979	2.776	0.391
	1979 = 1.71	1977 vs. 1980	2.776	-0.972
	1980 = 1.57	1978 vs. 1979	2.447	0.836
		1978 vs. 1980	2.447	0.496
		1979 vs. 1980	2.447	-0.114

*Significant difference.

TABLE E-10

STATISTICAL ANALYSIS OF MACROINVERTEBRATE COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977-1980

Community parameter	Mean values	Comparison	Critical t (P=0.05)	Calculated t (P=0.05)
Density (no./m^2)	1977 = 516	1977 vs. 1978	2.179	0.924
	1978 = 1[illegible]	1977 vs. 1979	2.145	-1.433
	1979 = 203	1977 vs. 1980	2.160	-1.037
	1980 = 358	1978 vs. 1979	2.179	0.055
		1978 vs. 1980	2.201	-3.196*
		1979 vs. 1980	2.160	2.022
Biomass (g/m^2)	1977 = 0.720	1977 vs. 1978	2.179	0.855
	1978 = 0.289	1977 vs. 1979	2.145	1.647
	1979 = 0.074	1977 vs. 1980	2.160	0.649
	1980 = 0.393	1978 vs. 1979	2.179	1.851
		1978 vs. 1980	2.201	-0.385
		1979 vs. 1980	2.160	-1.709
Diversity	1977 = 1.36	1977 vs. 1978	2.571	0.007
	1978 = 1.44	1977 vs. 1979	2.447	-2.386
	1979 = 2.51	1977 vs. 1980	2.447	-1.779
	1980 = 2.06	1978 vs. 1979	2.571	-1.655
		1978 vs. 1980	2.571	-1.209
		1979 vs. 1980	2.447	1.782

*Significant difference.

TABLE E-11

STATISTICAL ANALYSIS OF DRIFT MACROINVERTEBRATE DENSITY DATA
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1980

Two-Way ANOVA

Depth	Comparison	Critical F (P=0.05)	Calculated F (P=0.05)	Reason for significant difference
Surface	among seasons	3.49	4.87*	March higher
	among stations	3.89	0.34	N/A
Mid-depth	among seasons	3.49	13.69*	November lower
	among stations	3.89	10.95*	Station 5 higher
Bottom	among seasons	3.49	9.38*	May higher
	among stations	3.89	6.10*	Station 1 higher
All depths	Station 1 by season	3.49	2.12	N/A
	by depth	3.89	4.34*	Bottom higher
	Station 3 by season	3.49	9.01*	August lower
	by depth	3.89	6.16*	Bottom higher
	Station 5 by season	3.49	5.60*	November lower
	by depth	3.89	8.12*	Surface lower
All depths	1979 vs. 1980	4.00	12.53*	1980 higher

*Significant difference.

F. FISH

INTRODUCTION

Riverine habitats are often characterized by rapidly fluctuating environmental conditions. Chemical composition, current velocities, water levels and stream widths vary, and waters are often turbulent and muddy. While the fish communities found in these habitats are adapted to a fluctuating environment, the effects of industrial development could alter fish populations or community composition by causing additional stresses.

The purpose of this study was to determine the species composition and abundance of fish in the vicinity of the Marble Hill Plant site during plant construction. Results of this study were compared with those obtained during the 1974 baseline study (PSI, 1976) to determine if changes in fish community composition have occurred as a result of plant construction activity. Comparisons were also made with the 1977 through 1979 construction phase ecological monitoring programs (ABI, 1978, 1979, 1980).

MATERIALS AND METHODS

Gill Netting

Collections were made during each quarterly sampling period at Ohio River Stations 1, 3, 5 and 14 with gill nets measuring 30.5 m long by 1.8 m deep. The nets were constructed of three 10.2-m panels sewn end-to-end with mesh sizes of 25.4-, 38.1- and 50.8-mm^2. The nets were set on the bottom and held perpendicular to the shore from nearshore shallows to depths of about 4 m. The nets were fished for two consecutive 24-hour periods; fishes were removed from the nets and analyzed after each period. Two nets were fished about 30 m apart at each station. Results were expressed as number of fish per net-hour.

Electrofishing

Electrofishing collections were made during daylight hours during each quarterly sampling period at Ohio River Stations 1, 3, 5 and 14 and at Little Saluda Creek Station 6. River stations were sampled with a direct-current (DC) shocking assembly (Smith-Root Model VI-A) powered by a Honda 3500-watt, 115-volt, single-phase generator connected to two electrodes suspended approximately 2 m in front of the boat. Current was pulsed by a deadman foot switch. A shocking run was completed by running the boat upstream as close to the shore as boat draft would allow. The Little Saluda Creek station was electrofished with a battery-powered Smith-Root Model VII backpack shocker that produced a 500-volt DC charge pulsed between hand-held electrodes. Fishes stunned by the electric current were removed from the water by operators using wooden-handled dip nets.

Electrofishing effort was measured at each station by distance fished, which was 150 m at Ohio River stations and 50 m in Little Saluda Creek. Two replicate samples were taken over these distances at each station. Results were expressed as number of fish per meter of shoreline electrofished.

Seining

Collections were made by seining during each quarterly sampling period at Little Saluda Creek Station 6. The seine was 9.1 m long by 1.2 m deep and of 3-mm^2 mesh. Two replicate seine hauls were made over a distance of 50 m during each sampling period. Results were expressed as number of fish per meter of shoreline seined.

Analytical Methods

Fish were identified to the lowest practicable taxon, counted, measured, weighed and examined for ectoparasitic infestations. Taxonomic nomenclature is in accordance with Bailey et al. (1970). The total length (TL) of each fish was measured to the nearest millimeter and weight was measured to the nearest gram. Fish were individually analyzed, with the exception of small (TL <50 mm) species such as shiners. The range of total lengths and the combined weights were recorded for individuals of each of these small species. Live fish were released after sampling unless needed for taxonomic verification.

The coefficient of condition (K) is an expression of the condition, plumpness or well-being of a fish (Carlander, 1969). The coefficient of condition was calculated as follows for each individual weighed and measured:

$$K = \frac{W10^5}{L^3}$$

where: W = Weight, in grams;

10^5 = Factor to bring the value of K near unity;

L = Length, in millimeters.

For statistical analysis, the catch per unit effort (CPUE) data were transformed to $\log_e$ (CPUE + 1) to reduce the effect of skewness in these data. One-way analysis of variance (ANOVA) was used at the 0.05 level of significance to test for interstation and annual variation in CPUE. Tukey's HSD procedure was used to test for differences between calculated means. Because the sampling methodologies of the baseline study differed from those of subsequent studies in the size and configuration of the gill nets and determination of effort expended electrofishing and seining, catch per unit effort comparisons were made only among the 1977 through 1980 studies.

RESULTS AND DISCUSSION

A total of 32 fish taxa representing 10 families were collected during the 1980 monitoring program (Table F-1). Larger sized species such as gizzard shad, freshwater drum and longnose gar were the most abundant fishes at the Ohio River stations, whereas, smaller sized fishes in the minnow family were the most abundant species in Little Saluda Creek. A complete list of fishes collected with length, weight and condition factor by date, station and collection method is presented in Appendix Tables F-1 through F-16. Because the Ohio River and Little Saluda Creek represent two entirely different habitats having separate indigenous fish communities, they will be discussed separately.

Ohio River

A total of 314 fish representing 22 species were collected by gill netting and electrofishing at Ohio River Stations 1, 3, 5 and 14 (Table F-2). Of these fish, eight species are categorized as sport or commercial in the Ohio River. Sport fishes include white bass, longear sunfish, largemouth bass and sauger while the commercial fishery utilizes smallmouth and black buffalo, channel catfish and freshwater drum (Preston and White, 1978). No rare, threatened or endangered species were found.

Gill netting yielded the majority of the fish collected in the Ohio River, and most of these were collected during the November sampling period (Figure F-1). As in previous years, the fewest number of fish were collected during the March sampling period. This was primarily attributed to the annual spring runoff that produces turbulence and high water levels. At this time, considerable debris accumulated in the nets making them more visible to fish and more easily avoided.

The 1980 gill netting CPUE ranged from 0.000 at Station 5 during March to 0.646 fish per net-hour at Station 1 during November (Table F-3). The annual CPUE was 0.227 fish per net-hour at Station 1, 0.146 at Station 3, 0.224 at Station 5 and 0.159 at Station 14. The differences in CPUE among stations were not significantly different (Table F-4).

Annual variation was observed in gill netting CPUE. The CPUE at Station 1 was higher during 1980 than during the previous year, while the

CPUE at Stations 3, 5 and 14 was lower (Figure F-2). This variation among years was due to natural fluctuations in fish populations. Overall, there was no significant difference in CPUE among years (Table F-5).

The 1980 electrofishing CPUE ranged from 0.000 to 0.023 fish per meter of shoreline. Overall, the CPUE was 0.010 fish per meter of shoreline at Station 1, 0.005 at Station 3, 0.002 at Station 5 and 0.004 at Station 14 (Table F-3). No significant difference in CPUE was found among stations electrofished (Table F-4).

The electrofishing CPUE during the present study was lower than during previous studies except for 1977 CPUE at Station 1 (Figure F-2). Because no consistent upward or downward trends were observed in CPUE among studies, the generally lower CPUE found during 1980 was probably due to natural yearly variations in fish populations. Statistically, there was no significant difference in CPUE among years (Table F-5).

Gizzard shad was the most abundant species of fish collected in the Ohio River and accounted for 33.8 percent of the total number of fish (Table F-2). The majority (89.6 percent) of the gizzard shad were collected during the November sampling period and none were found during March when the water level was high.

Gizzard shad are schooling fish that feed primarily on plankton. They have no sport or commercial value, but juveniles are important as forage for larger fish (Scott and Crossman, 1973; Preston and White, 1978). Condition factors for gizzard shad ranged from 0.41 to 1.52 with an overall mean of 0.98 during the 1980 study.

Freshwater drum was the second most abundant species collected and accounted for 13.7 percent of the total number of fish (Table F-2). Freshwater drum were found during all four sampling periods and at all stations. This species is primarily a bottom feeder that prefers large, silty lakes and rivers (Lee et al., 1980). Freshwater drum attain a relatively large size and enter into the commercial catch in the Ohio River (Preston and White, 1978). Condition factors for freshwater drum ranged from 0.74 to 2.19 with an overall mean of 1.12.

Longnose gar made up 11.5 percent of the total number of fish collected and ranked third in abundance (Table F-2). This species was collected during every sampling period except March and was found at all stations. Longnose gar are large carnivores common in the middle Ohio River. They have no sport, commercial or forage value (Preston and White, 1978). Condition factors for longnose gar ranged from 0.14 to 0.30 with an overall mean of 0.21.

Channel catfish was the fourth most abundant fish collected and accounted for 8.9 percent of the total number of fish (Table F-2). This species was found at all stations and during every sampling period except March. This omnivorous species has both sport and commercial importance in the Ohio River. Condition factors for channel catfish ranged from 0.67 to 1.19 with an overall mean of 0.88.

All other species individually accounted for 4.2 percent or less of the total number of fish collected. These were skipjack herring, goldeye, mooneye, goldfish, carp, emerald shiner, seven species of suckers, flathead catfish, white bass, longear sunfish, largemouth bass and sauger (Table F-2).

Interstation comparisons indicated that all stations were basically similar with regard to the fish communities present. Differences were observed in the relative abundance of fishes between stations; however, these were minor and were not consistently found from one year to another. Overall observations indicate that the fish communities at these stations are typical of those found at the other Ohio River stations.

Depending upon the study year, the most abundant species collected during all five monitoring programs was either the gizzard shad or emerald shiner (Table F-6). The relative abundance of both these species has varied widely among years. Because both are schooling species, annual changes in relative abundance may be attributed to their chance occurrence during the quarterly sampling periods. Annual variations may also be caused by natural yearly variations in fish populations. For example, emerald shiner populations are known to fluctuate widely in abundance from year to year (Scott and Crossman, 1973). The relative abundance of other taxa was generally similar among studies (Table F-6). All of the species collected during 1980 were reported in one or more of the previous monitoring programs.

When condition factors from 1980 were compared with those of past studies, variation was observed in all the species analyzed over the years. Nevertheless, the range of K values for individual species overlapped considerably and no consistent upward or downward trends were observed between the baseline and subsequent studies. The variation found is not unusual in the Ohio River and can be attributed to natural causes. Carlander (1969) stated that condition factors vary with season, sex, sexual maturity, age and various other factors. Plant construction activities had no apparent effect on the condition of the resident fishes.

Little Saluda Creek

A total of 667 fish representing 12 taxa were collected by electrofishing and seining at Little Saluda Creek Station 6 (Table F-7). No rare, threatened or endangered species were found.

The electrofishing CPUE ranged from 0.140 fish per meter of shoreline distance in November to 2.500 in August with an annual mean of 1.128 (Table F-3). Although some variation was observed in CPUE among years, no significant differences were found (Figure F-2; Table F-8).

The seining CPUE was lowest in March at 0.010 fish per meter of stream distance and increased through the year to a high of 1.640 in November. The annual mean CPUE in Little Saluda Creek was 0.540 fish per meter of stream sampled (Table F-3). Considerable variation was observed in CPUE seining among years (Figure F-2). The seining CPUE during 1979 was significantly higher than during 1977 and 1980 (Table F-8). Differences in CPUE among years are most likely a result of the wide fluctuations commonly observed in emerald shiner populations.

The vast majority (96.8 percent) of the fishes collected in Little Saluda Creek were members of the minnow family. The creek chub was the most abundant species collected and accounted for 54.7 percent of the total number collected (Table F-7). Second in abundance was the stoneroller, which accounted for 24.3 percent of the total number of fish.

The relative abundance of fishes has changed over the years studied. During 1974, blacknose dace was the most abundant species, whereas from 1977 through 1979, emerald shiner was the dominant species (Table F-9). The changes observed in relative abundance are attributed to natural yearly variations in fish populations. For example, emerald shiners were extremely abundant during 1977 through 1979, however, during 1974 and 1980 their numbers were drastically reduced. These wide year-to-year changes in population occur commonly in nature. Scott and Crossman (1973) reported that periods of scarcity followed by great abundance have been characteristic of emerald shiner populations for over 50 years. Year-to-year changes are especially common in small streams of intermittent flow and depth such as Little Saluda Creek. Plant construction activities did not appear to have an impact on the composition of the fish community.

CONCLUSIONS

Fish samples were collected quarterly by various netting and electrofishing methods to determine if construction at the Marble Hill Plant site was impacting the fish communities at four Ohio River stations and one station in Little Saluda Creek. The catch per unit effort (CPUE), relative abundance and condition factors (K) were calculated and compared with similar data collected in previous studies of the same area.

In the Ohio River, the gill netting and electrofishing CPUE did not differ significantly among stations or years studied. Of the 22 species of fish collected, gizzard shad was the most abundant. The relative abundance of most fishes was similar among the years studied; however, emerald shiner populations were considerably lower during 1980, 1977 and 1974 than during the 1978 and 1979 studies. Wide natural year-to-year variations in emerald shiner populations occur naturally and are documented by other investigators. Condition factors for certain fish did vary from one study to another. However, there were no upward or downward trends in K values for any of the species analyzed. Minor differences in species occurrence, abundance and condition of Ohio River fishes among stations and years were not considered unusual and were attributed to natural causes.

During studies in Little Saluda Creek, members of the minnow family were the dominant taxa, however, the most abundant minnow species has changed between years. Differences in the occurrence, abundance and CPUE of fishes in Little Saluda Creek were attributed to natural yearly variations in fish populations. No apparent adverse impact upon the fish community was attributed to construction activities at the Marble Hill Plant site.

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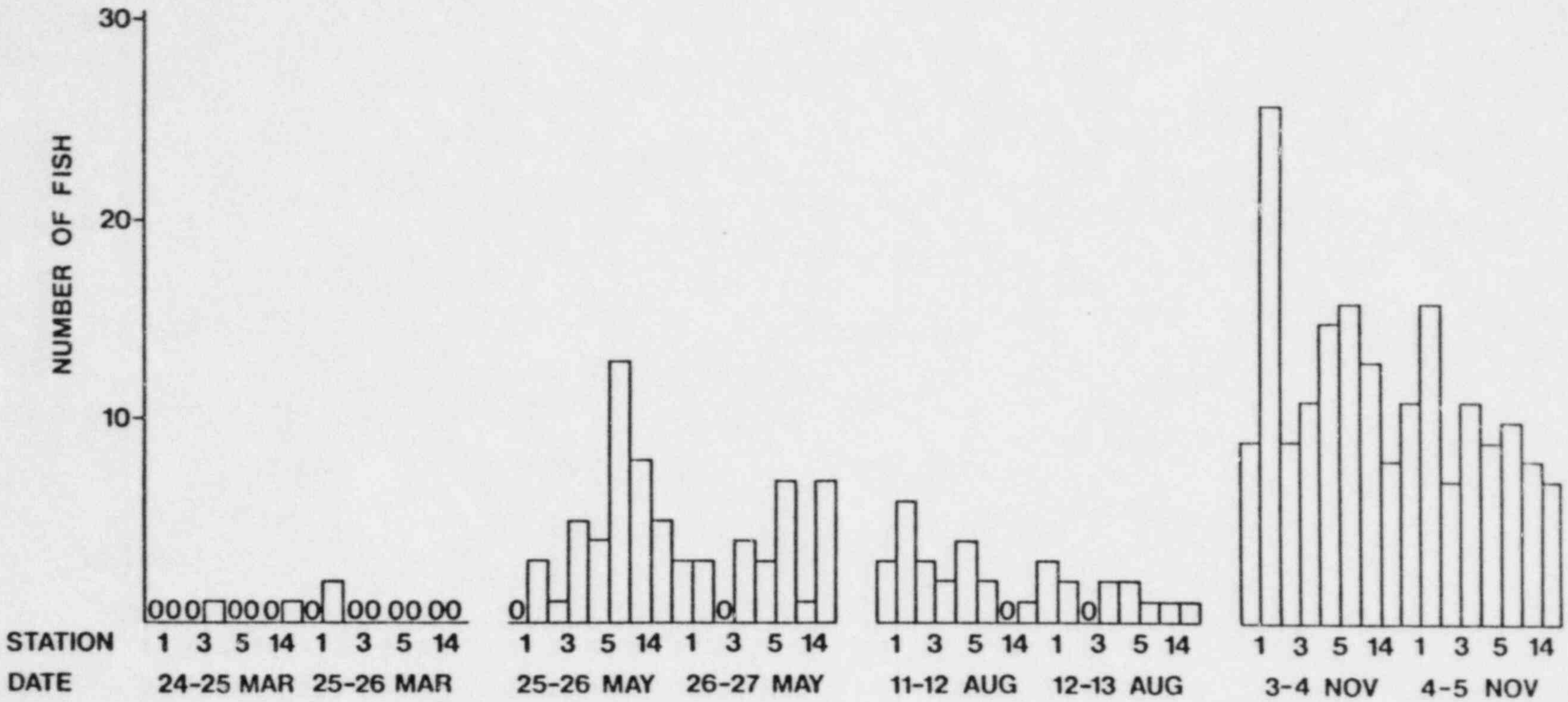

Figure F-1. Number of fish collected per gill net per 24 hours at each of two replicates per station, Marble Hill Plant site, 1980.

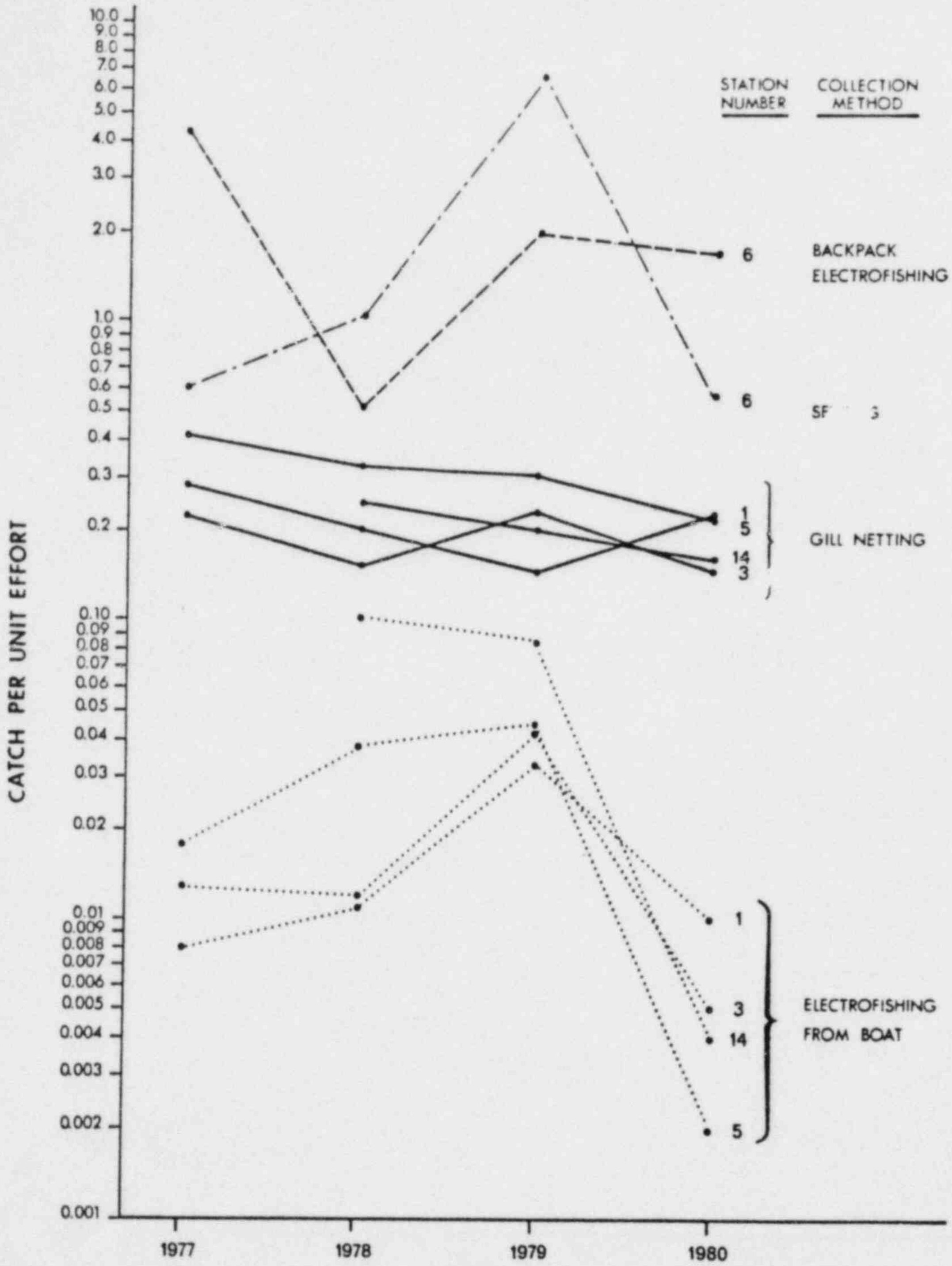

Figure F-2. Annual catch per unit effort by station for fishes collected in the vicinity of the Marble Hill Plant site, 1977-1980.

TABLE F-1

SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
MARBLE HILL PLANT SITE
1980

Lepisosteidae-gars	
Lepisosteus osseus	longnose gar
Clupeidae-herrings	
Alosa chrysochloris	skipjack herring
Dorosoma cepedianum	gizzard shad
Hiodontidae-mooneyes	
Hiodon alosoides	goldeye
H. tergisus	mooneye
Cyprinidae-minnows and carps	
Campostoma anomalum	stoneroller
Carassius auratus	goldfish
Cyprinus carpio	carp
Notropis sp.	shiner
N. atherinoides	emerald shiner
N. volucellus	mimic shiner
Pimephales notatus	bluntnose minnow
Rhinichthys atratulus	blacknose dace
Semotilus atromaculatus	creek chub
Catostomidae-suckers	
Carpiodes cyprinus	quillback
C. velifer	highfin carpsucker
Catostomus commersoni	white sucker
Ictiobus bubalus	smallmouth buffalo
I. niger	black buffalo
Minytrema melanops	spotted sucker
Moxostoma anisurum	silver redhorse
M. erythrurum	golden redhorse
Ictaluridae-freshwater catfishes	
Ictalurus punctatus	channel catfish
I. melas	black bullhead
Pylodictis olivaris	flathead catfish

TABLE F-1
(continued)
SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
MARBLE HILL PLANT SITE
1980

Percichthyidae-temperate basses	
Morone chrysops	white bass
Centrarchidae-sunfishes	
Lepomis macrochirus	bluegill
L. megalotis	longear sunfish
Micropterus salmoides	largemouth bass
Percidae-perches	
Etheostoma flabellare	fantail darter
Stizostedion canadense	sauger
Sciaenidae-drums	
Aplodinotus grunniens	freshwater drum

TABLE F-2

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES
COLLECTED BY GILL NETTING AND ELECTROFISHING
OHIO RIVER STATIONS 1, 3, 5 AND 14
MARBLE HILL PLANT SITE
1980

	Station					
Taxon	1	3	5	14	Total	Relative abundance(%)
longnose gar	11	8	9	8	36	11.5
skipjack herring	9	1	1	1	12	3.8
gizzard shad	27	24	34	21	106	33.8
goldeye	4	3	5	1	13	4.2
mooneye	2	1	-	3	6	1.9
goldfish	1	-	-	-	1	0.3
carp	1	1	4	1	7	2.2
emerald shiner	5	2	-	-	7	2.2
quillback	-	-	2	-	2	0.7
highfin carpsucker	-	-	-	1	1	0.3
smallmouth buffalo	4	1	2	-	7	2.2
black buffalo	-	-	1	-	1	0.3
spotted sucker	1	-	-	-	1	0.3
silver redhorse	1	-	-	-	1	0.3
golden redhorse	7	2	2	1	12	3.8
channel catfish	7	3	8	10	28	8.9
flathead catfish	2	2	3	1	8	2.6
white bass	3	-	5	-	8	2.6
longear sunfish	1	-	-	-	1	0.3
largemouth bass	1	-	-	-	1	0.3
sauger	2	3	4	3	12	3.8
freshwater drum	9	11	8	15	43	13.7
Total	98	62	88	66	314	100.0

TABLE F-3

CATCH PER UNIT EFFORT OF FISH COLLECTED BY GILL NETTING,
ELECTROFISHING AND SEINING
OHIO RIVER STATIONS 1, 3, 5 AND 14 AND
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1980

Sampling method	Station	March	May	August	November	Overall
Gill netting (no. fish/net-hr)	1	0.021	0.094	0.146	0.646	0.227
	3	0.010	0.104	0.073	0.396	0.146
	5	0.000	0.281	0.094	0.521	0.224
	14	0.010	0.219	0.031	0.375	0.159
Electrofishing (no. fish/m)[a]	1	0.003	0.023	0.013	0.000	0.010
	3	0.007	0.000	0.007	0.007	0.005
	5	0.000	0.000	0.000	0.007	0.002
	14	0.010	0.000	0.007	0.000	0.004
	6	1.720	0.150	2.500	0.140	1.128
Seining (no. fish/m)[a]	6	0.010	0.190	0.320	1.640	0.540

[a]Meter of shoreline or stream distance that was electrofished or seined.

TABLE F-4

ANALYSIS OF VARIANCE OF CATCH PER UNIT EFFORT OF FISH
COLLECTED BY GILL NETTING AND ELECTROFISHING
OHIO RIVER STATIONS 1, 3, 5 AND 14
MARBLE HILL PLANT SITE
1980

GILL NETTING BETWEEN STATIONS

Source	Degrees of freedom	Sum of squares	Mean square	F value[a]
Stations	3	0.01193	0.00398	0.13144
Error	12	0.36311	0.03026	
Total	15	0.37504		

ELECTROFISHING BETWEEN STATIONS

Source	Degrees of freedom	Sum of squares	Mean square	F value[a]
Stations	3	0.00013	0.00003	1.12028
Error	12	0.00047	0.00004	
Total	15	0.00060		

[a]Critical $F_{0.05(3,12)} = 3.49$.

TABLE F-5

ANALYSIS OF VARIANCE OF CATCH PER UNIT EFFORT OF FISH
COLLECTED BY GILL NETTING AND ELECTROFISHING
OHIO RIVER STATIONS 1, 3, 5 AND 14
MARBLE HILL PLANT SITE
1977 - 1980

GILL NETTING 1977 - 1980

Source	Degrees of freedom	Sum of squares	Mean square	F value[a]
Years	3	0.07007	0.02336	0.83537
Error	56	1.56568	0.02796	
Total	59	1.63575		

ELECTROFISHING 1977 - 1980

Source	Degrees of freedom	Sum of squares	Mean square	F value[a]
Years	3	0.01882	0.00627	2.46498
Error	56	0.14251	0.00254	
Total	59	0.16133		

[a]Critical $F_{0.05(3,56)} = 3.36$.

TABLE F-6

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED
OHIO RIVER STATIONS 1, 3, 5, AND 14
MARBLE HILL PLANT SITE
1974, 1977-1980

Taxon	1974 Number of fishes	1974 Relative abundance (%)	1977 Number of fishes	1977 Relative abundance (%)	1978 Number of fishes	1978 Relative abundance (%)	1979 Number of fishes	1979 Relative abundance (%)	1980 Number of fishes	1980 Relative abundance (%)
longnose gar	31 (33)[a]	5.7 (2.4)[a]	18	4.7	26	4.7	36	6.2	36	11.5
skipjack herring	14 (29)	2.6 (2.1)	7	1.8	-	-	2	0.4	12	3.8
gizzard shad	272 (499)	50.2 (36.7)	72	18.8	123	22.3	163	28.3	106	33.8
goldeye	4 (8)	0.7 (0.6)	7	1.8	5	0.9	20	3.5	13	4.2
mooneye	1 (1)	0.2 (0.1)	-	-	15	2.7	6	1.0	6	1.9
goldfish	1 (1)	0.2 (0.1)	-	-	-	-	1	0.2	1	0.3
carp	9 (10)	1.7 (0.7)	10	2.6	17	3.1	18	3.1	7	2.2
emerald shiner	65 (599)	12.0 (44.0)	18	4.7	134	24.4	104	18.1	7	2.2
other shiners (Notropis spp.)	7 (7)	1.3 (0.5)	-	-	-	-	-	-	-	-
bluntnose minnow	1 (1)	0.2 (0.1)	-	-	-	-	-	-	-	-
carpsucker (Carpiodes spp.)	26 (27)	4.8 (2.0)	15	3.9	19	3.4	23	4.0	3	1.0
white sucker	3 (3)	0.5 (0.2)	-	-	-	-	2	0.4	-	-
buffalo (Ictiobus spp.)	5 (6)	0.9 (0.4)	3	0.8	1	0.2	8	1.4	8	2.5
spotted sucker	3 (6)	0.5 (0.4)	5	1.3	-	-	4	0.7	1	0.3
redhorse (Moxostoma spp.)	9 (10)	1.7 (0.7)	32	8.4	17	3.1	9	1.6	13	4.1
yellow bullhead	-	-	-	-	2	0.4	-	-	-	-
blue catfish	1 (1)	0.2 (0.1)	-	-	-	-	-	-	-	-
channel catfish	9 (11)	1.7 (0.8)	46	12.0	68	12.4	41	7.1	28	8.9
flathead catfish	1 (1)	0.2 (0.1)	22	5.7	19	3.4	19	3.3	8	2.6
white bass	11 (14)	2.0 (1.0)	29	7.6	23	4.2	20	3.5	8	2.6
rock bass	1 (1)	0.2 (0.1)	1	0.3	1	0.2	-	-	-	-
sunfish (Lepomis spp.)	13 (18)	2.4 (1.3)	6	1.6	2	0.4	8	1.4	1	0.3
smallmouth bass	4 (4)	0.7 (0.3)	3	0.8	2	0.4	-	-	-	-
spotted bass	10 (11)	1.8 (0.8)	5	1.3	-	-	-	-	-	-
largemouth bass	3 (8)	0.6 (0.6)	3	0.8	20	3.6	8	1.4	1	0.3
crappie (Pomoxis spp.)	9 (11)	1.7 (0.8)	-	-	2	0.4	3	0.5	-	-
yellow perch	1 (1)	0.2 (0.1)	-	-	-	-	-	-	-	-
sauger	12 (22)	2.2 (1.6)	53	13.8	34	6.2	45	7.8	12	3.8
walleye	1 (1)	0.2 (0.1)	-	-	-	-	-	-	-	-
freshwater drum	15 (18)	2.7 (1.3)	28	7.3	20	3.6	35	6.1	43	13.7
Total	542 (1362)	100.0 (100.0)	383	100.0	550	100.0	575	100.0	314	100.0

[a]Number of individuals and relative abundance in parentheses includes Station 2 data (located at the mouth of Little Saluda Creek). Station 2 was not sampled in subsequent years.

TABLE F-7

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY ELECTROFISHING AND SEINING
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1980

	Electrofishing		Seining			
Taxon	Number of fishes	Relative abundance(%)	Number of fishes	Relative abundance(%)	Total number of fishes	Overall relative abundance(%)
stoneroller	144	31.9	18	8.3	162	24.3
shiner (Notropis sp.)	2	0.4	-	-	2	0.3
emerald shiner	1	0.2	25	11.6	26	3.9
mimic shiner	2	0.4	25	11.6	27	4.0
bluntnose minnow	10	2.2	30	13.8	40	6.0
blacknose dace	14	3.1	10	4.6	24	3.6
creek chub	260	57.7	105	48.6	365	54.7
white sucker	6	1.4	1	0.5	7	1.0
golden redhorse	-	-	1	0.5	1	0.2
black bullhead	2	0.4	-	-	2	0.3
bluegill	7	1.6	1	0.5	8	1.2
fantail darter	3	0.7	-	-	3	0.5
Total	451	100.0	216	100.0	667	100.0

TABLE F-8

ANALYSIS OF VARIANCE AND TUKEY'S HSD COMPARISON BETWEEN CATCH PER UNIT EFFORT OF FISH COLLECTED BY ELECTROFISHING AND SEINING
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977 - 1980

ELECTROFISHING 1977 - 1980

Source	Degrees of freedom	Sum of squares	Mean square	F value
Years	3	0.16129	0.05376	0.195565[a]
Error	11	3.02409	0.27491	
Total	14	3.18538		

[a]Critical $F_{0.05(3,11)} = 3.59$.

SEINING 1977 - 1980

Source	Degrees of freedom	Sum of squares	Mean square	F value
Years	3	5.40183	1.80061	4.56727[b]
Error	12	4.73091	0.39424	
Total	15	10.13274		

[b]Significant at $P \leq 0.05$; Critical $F_{0.05(3,12)} = 3.49$.

TUKEY'S HSD COMPARISON 1977 - 1980

Year (mean)	1978(0.4633)	1979(1.7496)	1980(0.3581)
1977 (0.4099)	0.0534	1.3397[c]	0.0518
1978 (0.4633)		1.2863	0.1052
1979 (1.7496)			1.3915[c]

[c]Significant at $P \leq 0.05$; HSD = 1.3186.

TABLE F-9

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1974, 1977-1980

Taxon	1974		1977		1978		1979		1980	
	Number of fishes	Relative abundance (%)	Number of fishes	Relative abundance (%)	Number of fishes	Relative abundance (%)	Number of fishes	Relative abundance (%)	Number of fishes	Relative abundance (%)
stoneroller	-	-	3	0.4	42	6.7	77	2.5	162	24.3
emerald shiner	2	1.3	600	88.8	476	75.8	2917	93.1	26	3.9
other shiners (*Notropis* spp.)	14	9.3	7	1.0	15	2.4	8	0.2	29	4.3
blacknose dace	91	60.7	28	4.2	39	6.2	7	0.2	24	3.6
creek chub	3	2.0	28	4.2	22	3.5	88	2.8	365	54.7
other minnows (Cyprinidae spp.)	21	14.0	3	0.4	5	0.8	20	0.6	40	6.0
suckers (Catostomidae spp.)	-	-	1	0.2	4	0.7	4	0.2	8	1.2
mosquitofish	1	0.7	-	-	-	-	-	-	-	-
black bullhead	-	-	2	0.3	2	0.3	-	-	2	0.3
sunfishes (*Lepomis* spp.)	16	10.7	2	0.3	12	1.8	5	0.2	8	1.2
smallmouth bass	-	-	1	0.2	-	-	-	-	-	-
darters (*Etheostoma* spp.)	2	1.3	-	-	11	1.8	6	0.2	3	0.5
Total	150	100.0	675	100.0	628	100.0	3132	100.0	667	100.0

G. FISH EGGS AND LARVAE

INTRODUCTION

Fish eggs and larvae are temporary members of the plankton community and serve an important role in the food chain of the Ohio River and its tributaries. The eggs and larvae of certain fish species also represent an important future contribution to recreational and commercial fisheries.

Changes in the physical and chemical composition of a water body can influence both the spawning success of adult fish and the subsequent survival of their eggs and larvae. The extent of larval survival will determine juvenile recruitment into the population, which will influence future spawning potential.

The purpose of this study was to determine the composition and abundance of fish eggs and larvae in the vicinity of the Marble Hill Plant site during plant construction. Results of this study were compared with those obtained during the 1974 baseline study (PSI, 1976) and the 1977 through 1979 construction phase ecological monitoring programs (ABI, 1978, 1979, 1980). Because construction had not started prior to the completion of the 1977 ichthyoplankton sampling program, both the 1974 and 1977 studies were considered baseline. The comparisons among study years enabled characterization of annual ichthyoplankton fluctuations and determination of possible plant construction effects on ichthyoplankton densities.

MATERIALS AND METHODS

Fish egg and larvae collections were made on 12 occasions between 9 April and 10 July 1980 at Ohio River Stations 1, 3, 5 and 14. Collections were made with 200-cm long bongo nets of 505-μ mesh and 20-cm mouth diameter. During each sampling period, duplicate 10-minute tows were made at sub-surface, middle and near-bottom depths. Tows were made approximately 30 m offshore; this distance is the length of the offshore discharge pipe and intake structure proposed for the Marble Hill Plant.

Nets were towed upstream at approximately 150 cm/sec. A General Oceanics Model 2030 flowmeter was fixed in the mouth of each net to enable the calculation of the volume of water passing through each net. Ichthyoplankton samples were preserved in the field immediately after collection in 5-percent buffered formalin.

In the laboratory, fish eggs and larvae were separated from each sample using a stereo microscope. Fish eggs were counted, examined for viability, and measured to the nearest 0.1 mm diameter. A clear egg was considered viable and an opaque egg nonviable (Bagenal and Braum, 1971). Larval fishes were enumerated, sorted into 5-mm-size classes, and identified to the lowest practical taxon. Taxonomic nomenclature is in accordance with Bailey et al. (1970). Representative specimens were photographed and all ichthyoplankton was retained in 3-percent buffered formalin as reference material.

Data were calculated as eggs and larvae per cubic meter for statistical analysis. Two-way analyses of variance (ANOVAS) were used to determine statistically significant differences in egg and larval densities between stations and depths. Because of unequal error variance, $\log_e$ transformations were made on the egg and larval densities before two-way ANOVAS were employed. To determine significantly different means, multiple range tests at the 0.05 level of significance were performed by the Duncan procedure on the log-transformed data.

RESULTS AND DISSCUSSION

Fish Eggs

Fish eggs were found from 29 May through 10 July 1980 with the exception of the 6 June sampling period (Appendix Tables G-1 through G-12). Mean egg densities for all stations combined ranged from zero in early April through mid-May to $0.05/m^3$ during late June. The highest density of fish eggs ($1.40/m^3$) was found at Station 1 during the 26 June sample collection (Figure G-1). Of all eggs collected, 45.9 percent were considered viable. Although the percentage of viable eggs collected during 1980 was lower than during previous years, egg survival among freshwater fishes is often as low as 0.5 to 3 percent (Dahlberg, 1979).

The mean densities of eggs were not significantly different among stations (Table G-1). Mean egg densities were equal to or slightly greater than $0.01/m^3$ at Stations 1 and 3 and less than 0.01 eggs/m^3 at Stations 5 and 14 (Figure G-2). By depth, mean egg densities were $0.01/m^3$ at the bottom and mid-depth and less than $0.01/m^3$ at the surface (Figure G-2). These slight differences were not significant (Table G-1).

Temporal differences in fish egg occurrence and abundance were apparent among the years studied. Fish eggs were first collected in 1974 on 7 May, in 1977 on 30 April, in 1978 on 5 May, in 1979 on 19 May, and in 1980 on 26 May. The maximum abundance of fish eggs was observed during July in 1974, May in 1977, and June in 1978 through 1980 (Figure G-3 and G-4).

Peak egg densities were considerably lower during 1979 and 1980 than during 1977 and 1978 (Figure G-4). Natural physical variations such as the amount of river flow between years or differences in water temperature resulting from the length of the preceding winter are factors that affect the initiation and duration of spawning in fishes (Lagler et al., 1962). Accordingly, certain species may spawn earlier or later depending on the river conditions during any particular year. In addition, some species produce large quantities of eggs during relatively short periods of time and their peak spawning may have occurred between scheduled sampling periods. Differences in the occurrence and abundance of fish eggs were not attributed to plant construction activities.

Fish Larvae

Fish larvae were found from 23 April through 10 July 1980 (Appendix Tables G-1 through G-12). Larval densities fluctuated throughout the spawning season; mean densities for all stations combined ranged from zero on 9 April to $1.98/m^3$ on 26 May (Figure G-5). The highest density of fish larvae ($3.10/m^3$) was found at Station 14 during the 26 May sampling period (Figure G-6).

No statistically significant differences in larval fish densities were found among stations (Table G-2). Mean larval density was $0.44/m^3$ at Station 1, $0.54/m^3$ at Station 3 and $0.62/m^3$ at Stations 5 and 14 (Figure G-2).

Larval densities were significantly higher near the surface than at mid-depth or near the bottom (Table G-3). Mean larval densities were $0.88/m^3$ near the surface and $0.41/m^3$ at middle and bottom depths (Figure G-2). Herrings, freshwater drum and smallmouth buffalo larvae are known to orient themselves to the surface (Wrenn and Grinstead, 1968; Nelson and Cole, 1975; Tuberville, 1979). These species account for most of the higher larval densities observed at the surface.

During all the study years, fish larvae were first observed between 20 and 30 April. Definite peaks in larval fish abundance were observed during each year (Figures G-3, G-5, G-6, G-7); the first peak usually occurred in mid-to-late May and a second between mid-June and early July. During 1977, however, the highest density was recorded on 30 April, the first sampling date. Maximum densities varied among years but, in general, higher peak densities were observed during the last two years of plant construction than during previous years (Figure G-7).

Differences in the occurrence and abundance of fish larvae is attributed to natural variations in the environment and in the spawning success of resident fishes. Lagler et al. (1962) reported that environmental factors including temperature, current and photoperiod have an effect on the reproduction of fishes. Construction activity had no apparent effect on fish larvae at the Marble Hill Plant site.

Herrings

Of the larval fishes collected from the Ohio River during 1980, the herring family was dominant and accounted for 37.8 percent of the larval fishes found (35.6 percent herrings and 2.2 percent gizzard shad; Table G-4). Larval herrings were also the most abundant group collected during 1979. During the preceeding studies, however, the percentage of herrings was considerably lower (Table G-5). Based on the abundance and fecundity of adult fishes (Section F. Fish), the majority of the larvae identified as herrings were probably gizzard shad. Additionally, Preston and White (1978) reported that gizzard shad was the most abundant species in the Ohio River by weight and only emerald shiner was more abundant in number. No statistically significant differences were found in the density of herrings among stations. Significantly more herrings were collected at the surface than at mid-depth or the bottom (Tables G-6 and G-7). As previously mentioned, this was because of the tendency of larval herring to orient to the surface, especially during the daytime (Tuberville, 1979).

Suckers

Suckers were the second most abundant family of larval fishes collected. This taxa accounted for 30.4 percent of the total larval fishes found (23.4 percent suckers, 6.8 percent carpsuckers and 0.2 percent buffalos; Table G-4). No significant differences were found in sucker densities among stations or depths (Table G-8). Most of the larvae identified as suckers were either carpsuckers or buffalo. Because of the similarities between these genera and the lack of available literature, identifications could not be accurately made below the family level.

The percentage abundance of suckers has fluctuated greatly among study years. Suckers were the most abundant taxa collected during 1977 and 1978, accounting for 70.0 and 40.1 percent of the total larvae collected, respectively (Table G-5). During 1974 and 1979, they comprised only 2.0 and 16.0 percent of the total, respectively.

Minnows and Carp

The minnows and carp family was the third most abundant family of larval fishes collected. This group was primarily composed of carp, which accounted for 22.0 percent of the total larval fishes collected (Table G-4). No significant differences in larval carp densities were found among stations or depths (Table G-9). Carp spawn in shallow areas and have an extended spawning season starting in the spring and possibly continuing to early fall (Scott and Crossman, 1973; Clay, 1975; Pflieger, 1975). During the present study year, carp were found from 14 May through the remainder of the study. The percentage abundance of carp has gradually increased from a low of 2.8 percent during 1974 to a high of 22.0 percent during the present study year (Table G-5). It is not known whether this trend of increasing carp abundance is a coincidence or if it represents a real population shift.

The remaining members of the minnows and carp family collected were shiner, emerald shiner and "other" minnows. These species accounted for 0.3, 0.1 and 1.5 percent, respectively, of the total larval fishes collected (Table G-4). Only minor fluctuations have been observed in the percentage of minnows other than carp among studies.

Drums

The freshwater drum is the only member of the drum family that is indigenous to fresh water. This species accounted for 5.1 percent of the total larval fishes collected in 1980 (Table G-4). Densities of freshwater drum were not significantly different among stations. However, densities were significantly greater at the surface than at mid-depth and near the bottom (Tables G-10 and G-11) because of the buoyancy of early drum larvae (Nelson and Cole, 1975). Freshwater drum spawn between May and August with peaks in June or July (Scott and Crossman, 1973; Pflieger, 1975; Smith, 1979). Freshwater drum larvae were first found on 6 June in 1980 and continued to appear throughout the remainder of the study.

The freshwater drum was the most abundant taxa collected during 1974 and accounted for 82.5 percent of the total larvae collected. During subsequent years, the percentage abundance of freshwater drum was considerably lower, ranging between 3.8 percent in 1977 to 14.5 percent in 1979 (Table G-5).

Other Taxa

All other taxa combined made up 2.8 percent of the total larval fishes collected during 1980. These larvae were longnose gar, mooneye, temperate bass (including white bass), sunfish (including smallmouth bass and white crappie), perch (including sauger) and unidentifiable, damaged larvae (Table G-4).

Differences in species composition may have resulted from variations in the spawning success of different species and, in some cases, may have been related to sampling frequencies and the chance occurrence of larvae. For example, during 1974, 83 percent of the larvae (primarily freshwater drum) were taken on one date, and during 1977, 68 percent of the larvae were collected on one date.

Interstation comparisons indicated that all stations were generally similar with regard to the ichthyoplankton present. Differences were observed in the relative abundance between stations of certain taxa during one year or another, however, no consistent dissimilarities were observed among the years studied. In general, the ichthyoplankton communities at the four samplings stations were found to be typical of that found at the other Ohio River Stations.

CONCLUSIONS

Fish egg and larvae collections were made on 12 occasions on the Ohio River from 9 April through 10 July 1980. Fish eggs were first found on 29 May and the highest density was observed on 26 June. No significant differences were found in mean egg densities between stations or depths.

Fish larvae first appeared on 23 April and the highest densities were recorded on 26 May. No significant differences were found among stations. Significantly more larvae were collected at the surface than at middle or bottom depths. This was attributed to the surface orientation characteristic of the larvae of fishes in many of the abundant taxa.

Nine families of larval fishes were collected during 1980. Members of the herring family were the most abundant taxa, followed in abundance by suckers, carp and minnows, and freshwater drum.

Ichthyoplankton occurrence, abundance and species composition differed among study years. These differences were attributed to natural physical variations in the Ohio River among years, the chance occurrence of large numbers of eggs or larvae on particular occasions, variations in sampling frequencies, and annual variations in spawning success of different species. Differences could not be attributed to plant construction activities.

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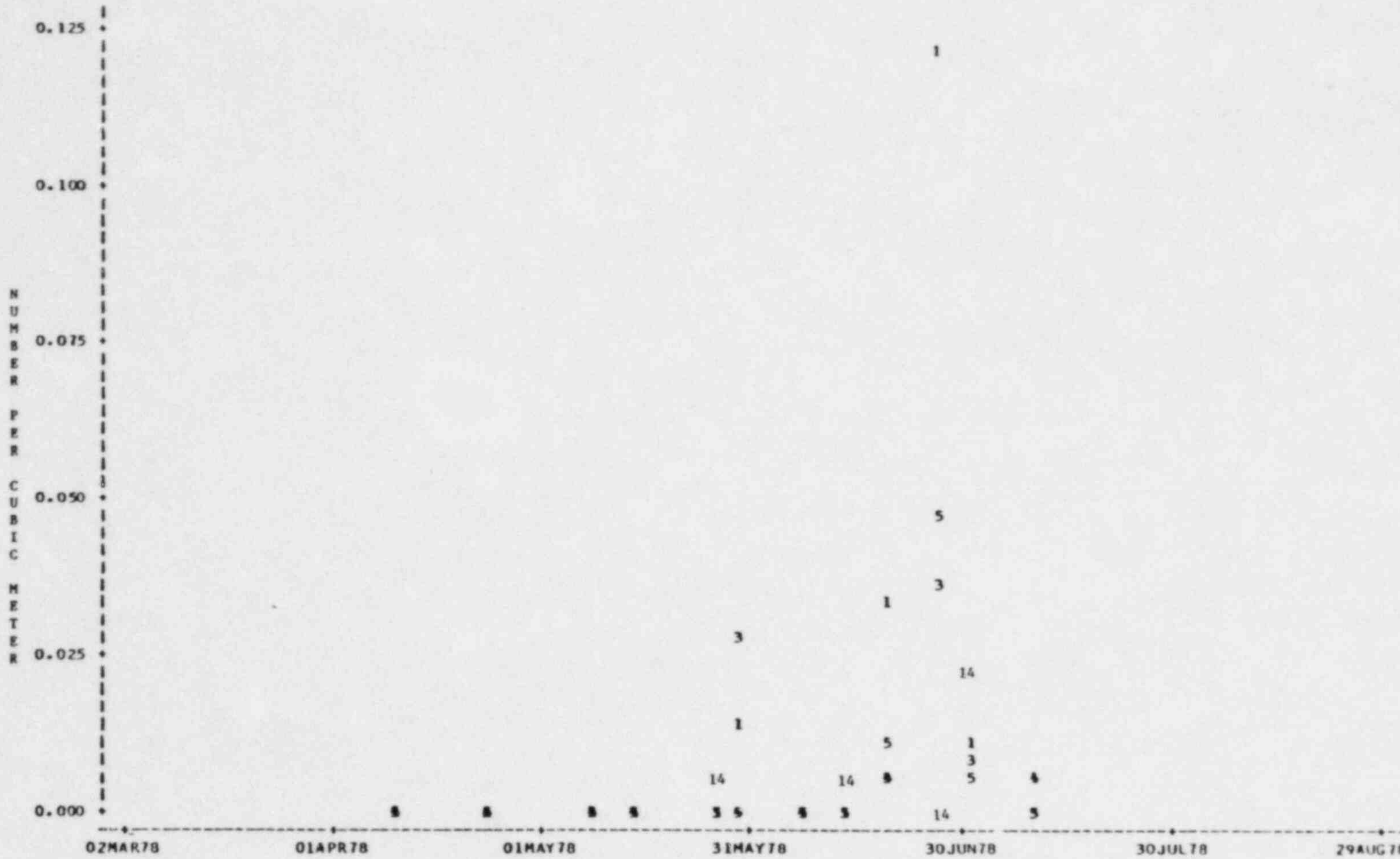

Figure G-1. Mean densities of fish eggs collected by station, Marble Hill Plant site, 1980.

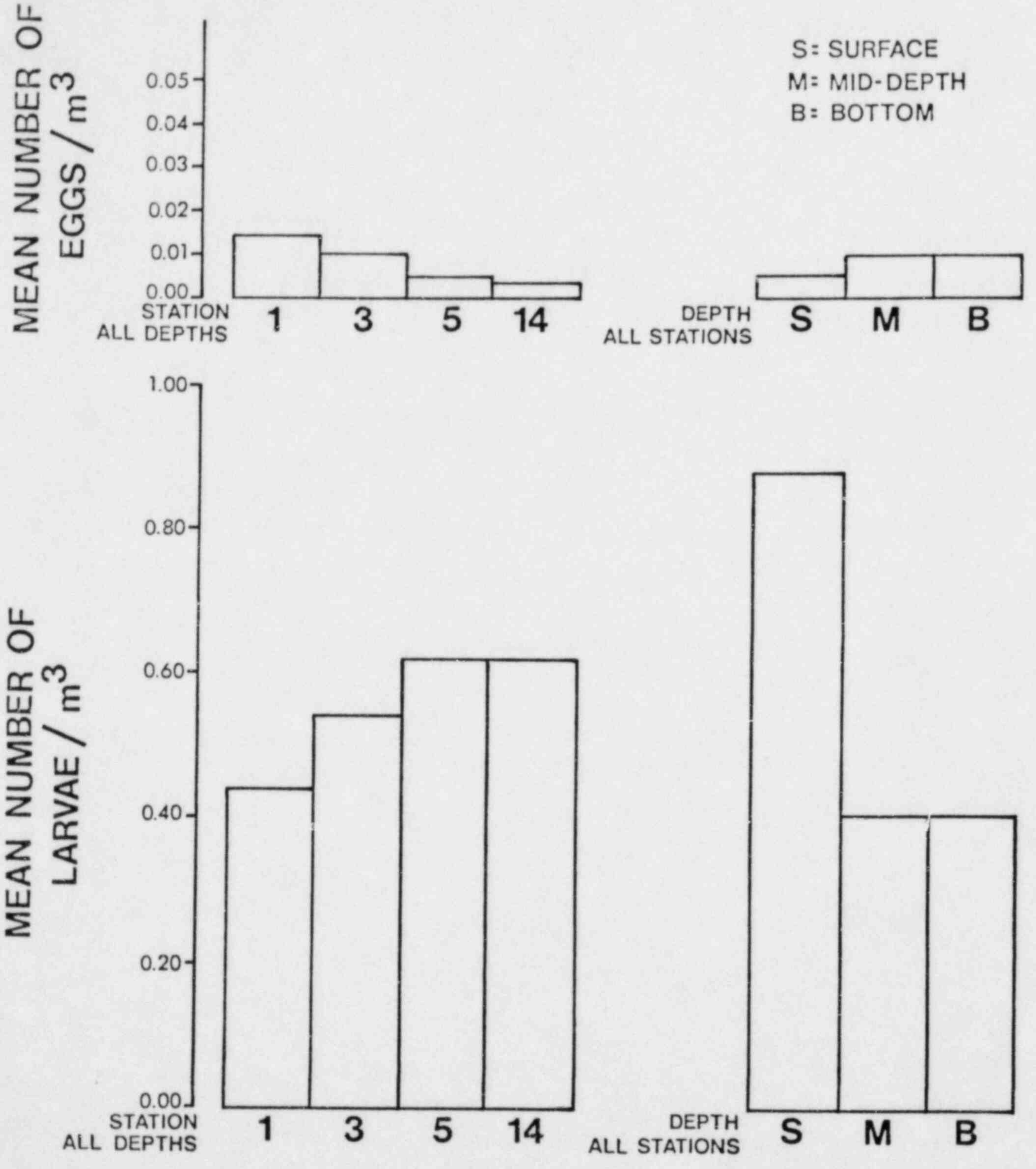

Figure G-2. Mean densities of fish eggs and larvae collected by station and depth from the Ohio River, Marble Hill Plant site, 1980.

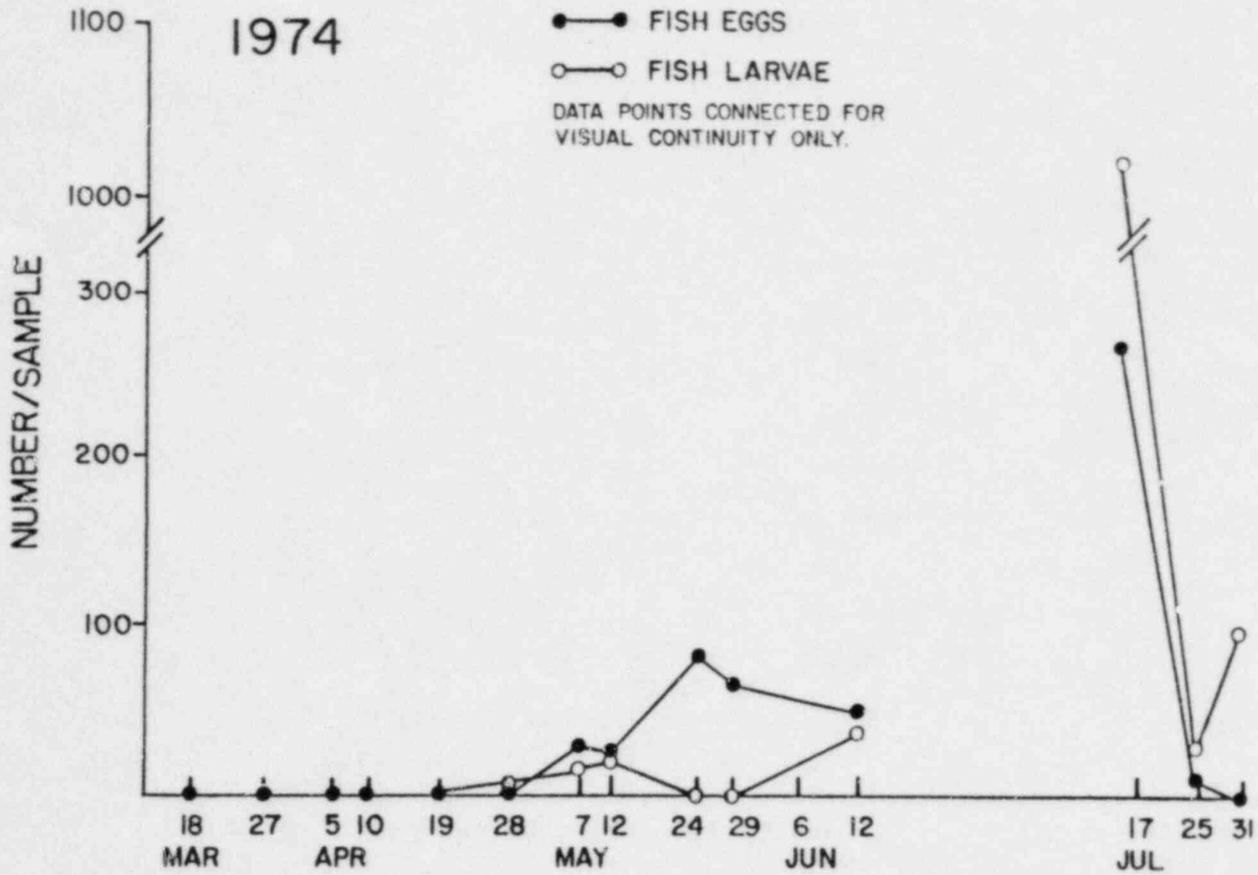

Figure G-3. Fish eggs and larvae collected by 15-minute drift net sets for baseline study (PSI, 1976), Marble Hill Plant site, 18 March - 31 July 1974.

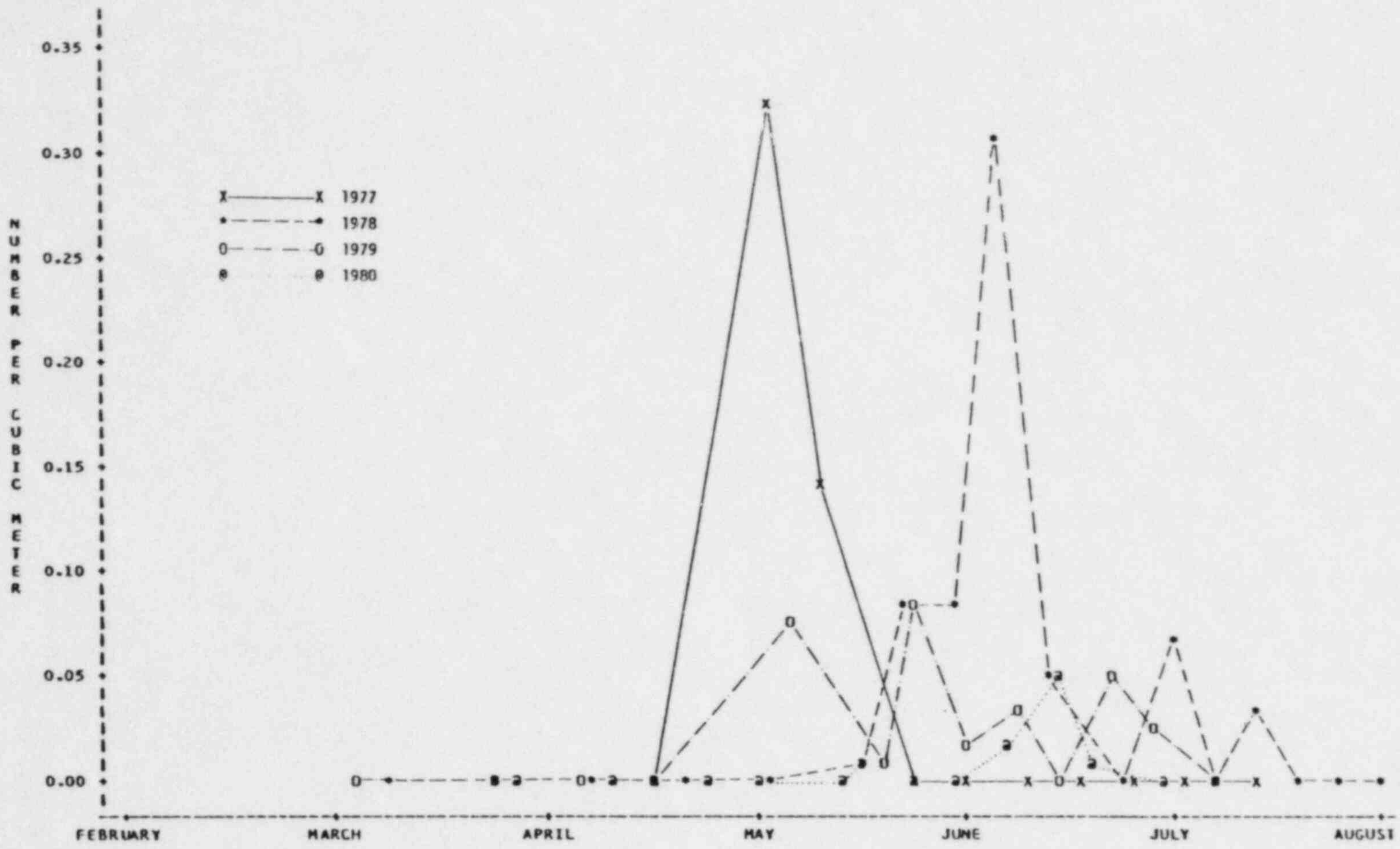

Figure G-4. Mean densities of fish eggs collected by 10-minute metered bongo-net tows, Marble Hill Plant site, 1977 - 1980.

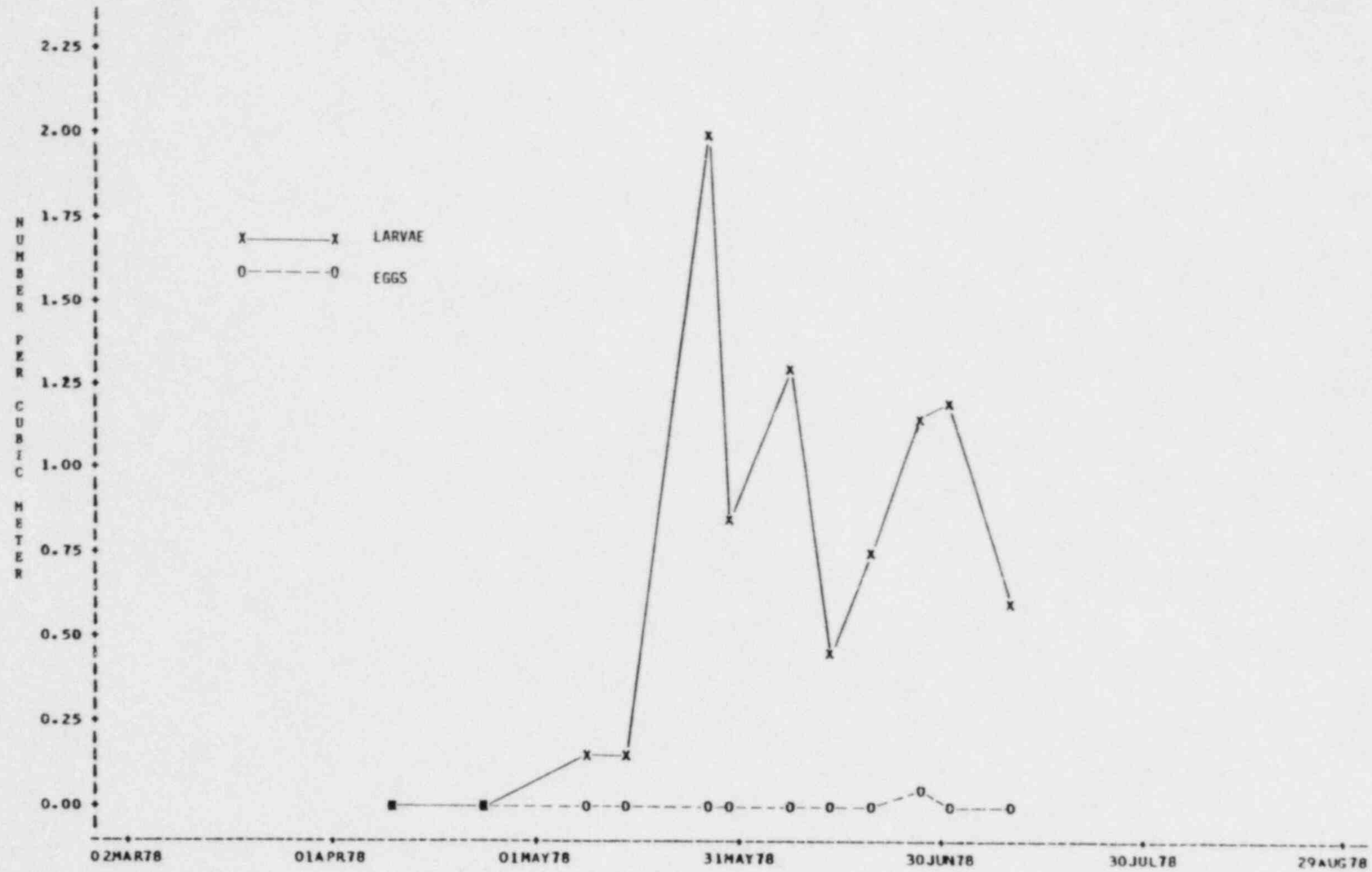

Figure G-5. Mean densities of fish eggs and larvae collected by date, Marble Hill Plant site, 1980.

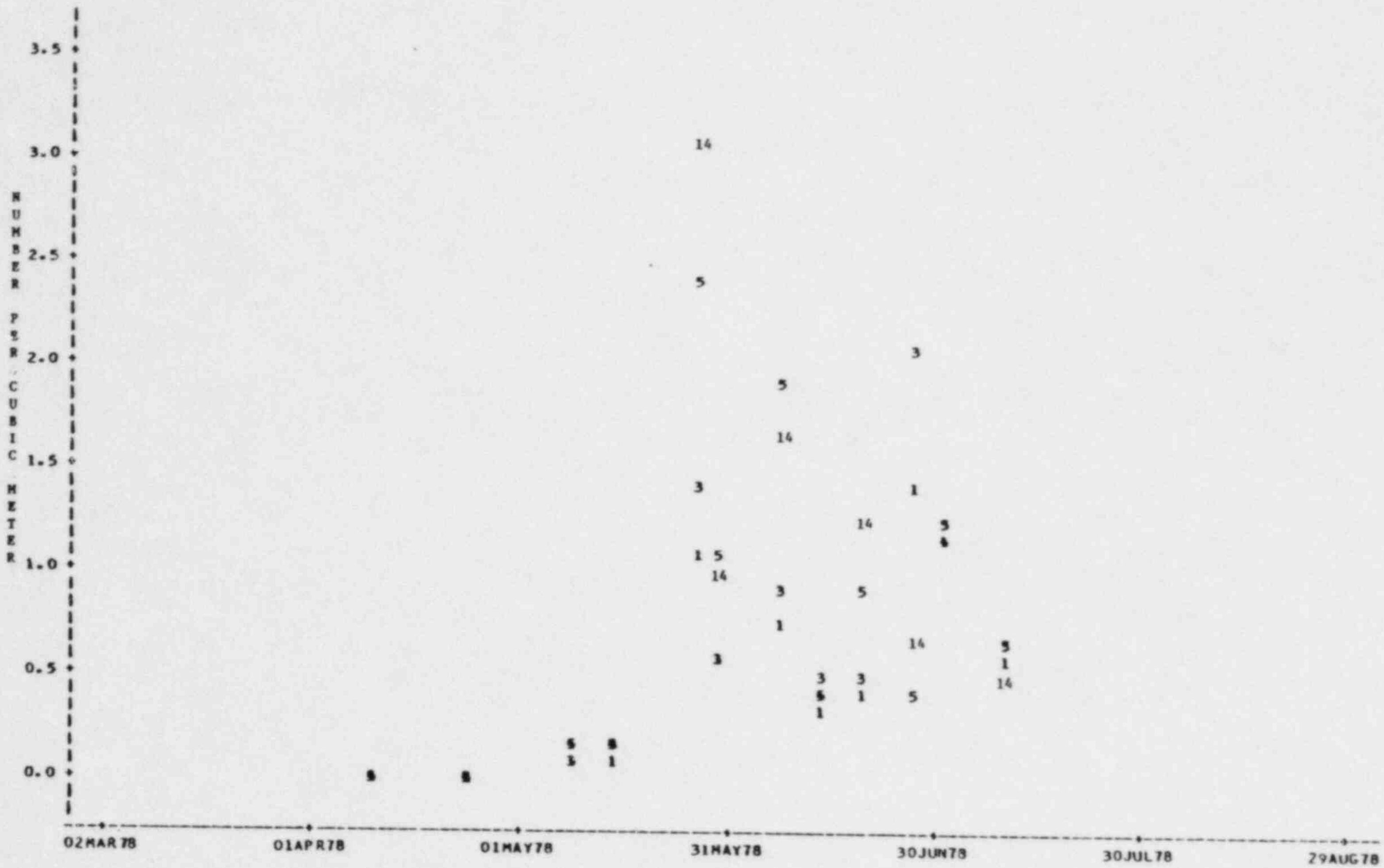

Figure G-6. Mean densities of fish larvae collected by station, Marble Hill Plant site, 1980.

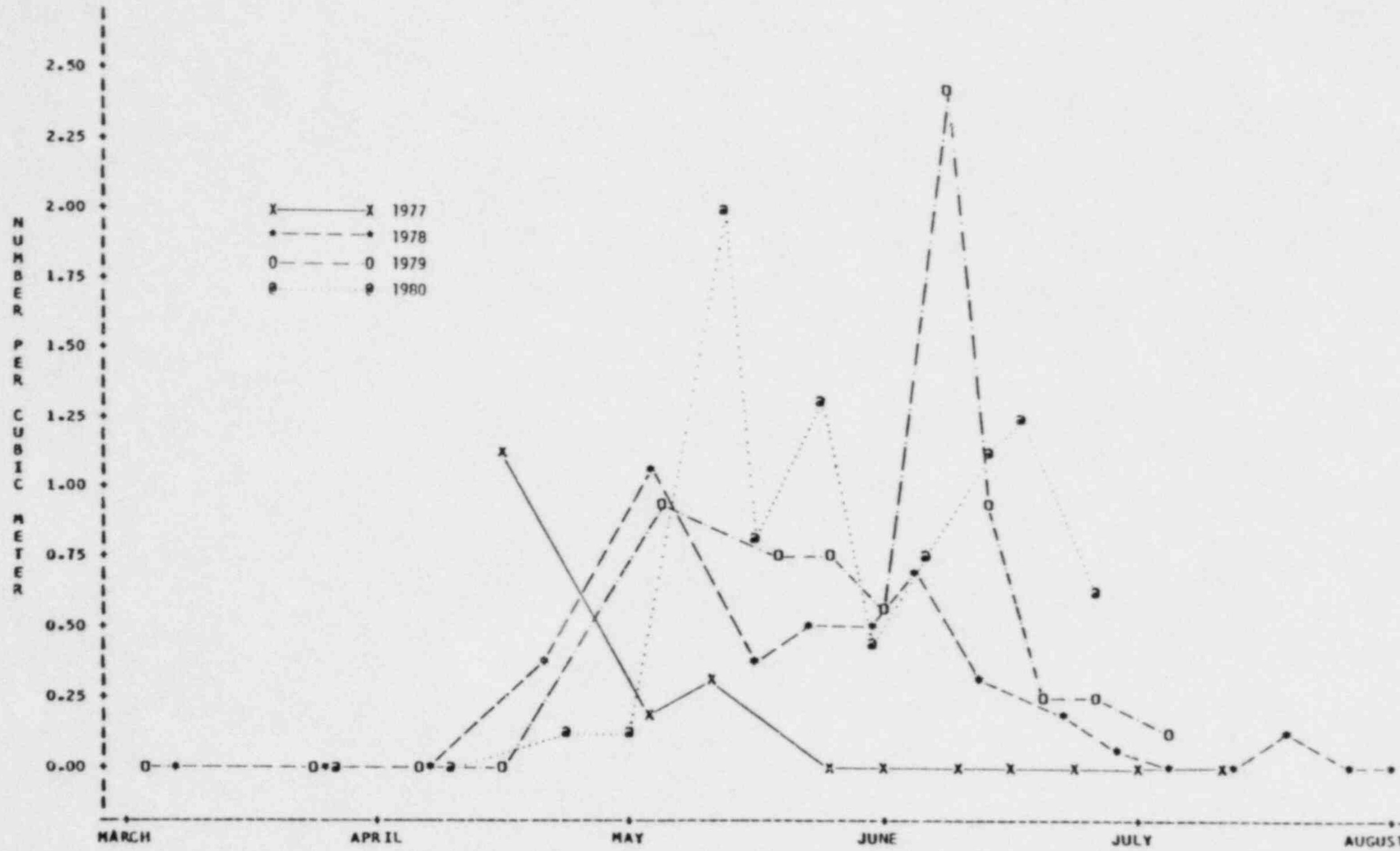

Figure G-7. Mean densities of fish larvae collected by 10-minute metered bongo-net tows, Marble Hill Plant site, 1977 - 1980.

TABLE G-1

TWO-WAY ANOVA FOR STATION AND DEPTH EFFECTS FOR FISH EGGS
MARBLE HILL PLANT SITE
1980

DEPENDENT VARIABLE: EGGS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE
Model	11	0.00849182	0.00077198	1.14	0.3268	0.043597
Error	276	0.18628809	0.00067496			
Corrected total	287	0.19477992				

STANDARD DEVIATION	MEAN
0.02597993	LOG 0.00719167
	GEOMETRIC 0.01/m^3

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
Station	3	0.00480335	2.37	0.0694
Depth	2	0.00060894	0.45	0.6374
Station x depth	6	0.00307953	0.76	0.6016

TABLE G-2

TWO-WAY ANOVA FOR STATION AND DEPTH EFFECTS FOR FISH LARVAE
MARBLE HILL PLANT SITE
1980

DEPENDENT VARIABLE: LARVAE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE
Model	11	6.21321688	0.56483790	3.55	0.0001	0.123970
Error	276	43.90551854	0.15907797	STANDARD DEVIATION		MEAN
Corrected total	287	50.11873542		0.39884579		LOG 0.43903780
						GEOMETRIC 0.55/m^3

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
Station	3	0.67687048	1.42	0.2364
Depth	2	5.25090232	16.50	0.0001*
Station x depth	6	0.28544408	0.30	0.9370

*Significant at $P \leq 0.05$.

TABLE G-3

DUNCAN'S MULTIPLE RANGE TEST FOR DIFFERENCES IN FISH LARVAL DENSITY
BY DEPTH
MARBLE HILL PLANT SITE
1980

Depth	Mean densities (larvae/m^3)	Number	Grouping
Surface	0.88	96	A[a]
Middle	0.41	96	B
Bottom	0.41	96	B

[a]Means with the same letter are not significantly different.
$P \leq 0.05$, Degrees of freedom = 276, Mean square = 0.159078.

TABLE G-4

COMMON NAME, SCIENTIFIC NAME AND PERCENTAGE COMPOSITION OF LARVAL FISH TAXA
OHIO RIVER STATIONS 1, 3, 5 AND 14
MARBLE HILL PLANT SITE
1980

Common name	Scientific name	Percentage composition by station 1	3	5	14	Overall percentage composition
longnose gar	Lepisosteus osseus	0.0	0.0	0.1	0.0	<0.1
herring	Clupeidae spp.	31.0	48.9	34.1	28.9	35.6
gizzard shad	Dorosoma cepedianum	2.2	1.5	1.6	3.4	2.2
mooneye	Hiodon tergisus	0.0	0.1	0.2	0.2	0.1
carp	Cyprinus carpio	29.4	19.2	21.2	20.5	22.0
shiner	Notropis spp.	0.1	0.2	0.1	0.7	0.3
emerald shiner	Notropis atherinoides	0.1	0.1	0.0	0.1	0.1
other minnows	Cyprinidae spp.	1.4	1.8	1.2	1.5	1.5
sucker	Catostomidae spp.	20.1	15.4	23.6	31.9	23.4
carpsucker	Carpiodes spp.	8.3	5.9	8.0	5.4	6.8
buffalo	Ictiobus spp.	0.0	0.0	0.6	0.0	0.2
temperate bass	Morone spp.	0.0	0.0	0.0	<0.1	<0.1
white bass	Morone chrysops	0.3	0.2	0.5	0.4	0.4
sunfish	Centrarchidae spp.	0.0	0.2	0.2	0.1	0.1
smallmouth bass	Micropterus dolomieui	0.0	0.0	0.0	<0.1	<0.1
white crappie	Pomoxis annularis	0.2	0.0	0.0	0.0	<0.1
perch	Percidae spp.	0.1	0.0	0.0	0.1	<0.1
sauger	Stizostedion canadense	0.3	0.9	1.0	1.0	0.8
freshwater drum	Aplodinotus grunniens	4.9	3.7	6.8	4.6	5.1
unidentifiable (damaged) larvae		1.6	1.9	0.8	1.1	1.3

TABLE G-5

RELATIVE PERCENTAGE ABUNDANCE OF LARVAL FISH
MARBLE HILL PLANT SITE
1974, 1977-1980

Taxon	1974	1977	1978	1979	1980
herrings	6.5	7.7	15.0	39.6	37.8
carp	2.8	13.6	10.8	20.2	22.0
minnows other than carp	5.0	0.0	9.5	6.0	1.9
suckers	2.0	70.0	40.1	16.0	30.4
freshwater drum	82.5	3.8	12.3	14.5	5.1
all others	1.2	4.9	12.3	3.7	2.8

TABLE G-6

TWO-WAY ANOVA FOR STATION AND DEPTH EFFECTS FOR HERRING LARVAE
MARBLE HILL PLANT SITE
1980

DEPENDENT VARIABLE: HERRINGS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	
Model	5	6.75819489	1.35163898	21.92	0.0001	0.279852	
Error	282	17.39096665	0.06167009		STANDARD DEVIATION		MEAN
Corrected total	287	24.14916154			0.24833464		LOG 0.17581077
							GEOMETRIC $0.19/m^3$

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
Station	3	0.25085146	1.36	0.2555
Depth	2	6.50734343	52.76	0.0001*

*Significant at $P \leq 0.05$.

TABLE G-7

DUNCAN'S MULTIPLE RANGE TEST FOR DIFFERENCES IN HERRING LARVAL DENSITY BY DEPTH
MARBLE HILL PLANT SITE
1980

Depth	Mean densities (larvae/m^3)	Number	Grouping
Surface	0.47	96	A[a]
Middle	0.08	96	B
Bottom	0.07	96	B

[a]Means with the same letter are not significantly different. $P \leq 0.05$, Degrees of freedom = 282, Mean square = 0.0616701.

TABLE G-8

TWO-WAY ANOVA FOR STATION AND DEPTH EFFECTS FOR SUCKER LARVAE
MARBLE HILL PLANT SITE
1980

DEPENDENT VARIABLE: SUCKERS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	
Model	5	0.58666284	0.11733257	2.23	0.0508	0.038067	
Error	282	14.82478889	0.05257017	STANDARD DEVIATION			MEAN
Corrected total	287	15.41145173		0.22928186			LOG 0.16741561
							GEOMETRIC 0.18

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
Station	3	0.35130230	2.23	0.0838
Depth	2	0.23536054	2.24	0.1085

TABLE G-9

TWO-WAY ANOVA FOR STATION AND DEPTH EFFECTS FOR CARP LARVAE
MARBLE HILL PLANT SITE
1980

DEPENDENT VARIABLE: CARP

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE
Model	5	0.08945705	0.01789141	0.48	0.7908	0.008494
Error	282	10.44257310	0.03703040			
Corrected total	287	10.53203015				

STANDARD DEVIATION	MEAN
0.19243285	LOG 0.12905682
	GEOMETRIC 0.14

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
Station	3	0.03472936	0.31	0.8181
Depth	2	0.05472769	0.74	0.4785

TABLE G-10

TWO-WAY ANOVA FOR STATION AND DEPTH EFFECTS FOR FRESHWATER DRUM LARVAE
MARBLE HILL PLANT SITE
1980

DEPENDENT VARIABLE: FRESHWATER DRUM

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	
Model	5	0.12041049	0.02408210	3.04	0.0110	0.051119	
Error	282	2.23509538	0.00792587	STANDARD DEVIATION			MEAN
Corrected total	287	2.35550587		0.08902736			LOG 0.02994227
							GEOMETRIC 0.03/m^3

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
Station	3	0.01324584	0.56	0.6480
Depth	2	0.10716466	6.76	0.0014*

*Significant at $P \leq 0.05$.

TABLE G-11

DUNCAN'S MULTIPLE RANGE TEST FOR DIFFERENCES IN FRESHWATER DRUM LARVAL DENSITY BY DEPTH
MARBLE HILL PLANT SITE
1980

Depth	Mean densities ($larvae/m^3$)	Number	Grouping
Surface	0.06	96	A[a]
Middle	0.02	96	B
Bottom	0.01	96	B

[a]Means with the same letter are not significantly different.
$P \leq 0.05$, Degrees of freedom = 282, Mean square = 0.0079259.

This package contains:

Reference Question	Item
290.5	U. S. EPA 1978 Draft Environmental Report Impact Statement, Trimble County Generating Plant, Volumes I and II and Technical Appendix.
291.2	Environmental monitoring reports prepared by Applied Biology, Inc. and Normandeau Associates, Inc. (formerly Texas Instruments) for the years 1977 through 1981.
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