CONSTRUCTION PHASE
ECOLOGICAL MONITORING PROGRAM

MARBLE HILL
NUCLEAR GENERATING STATION
UNITS 1 AND 2

FINAL REPORT
FEBRUARY - NOVEMBER 1978

VOLUME 1

FEBRUARY 1979

APPLIED BIOLOGY, INC.
ATLANTA, GEORGIA

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INTRODUCTION

Applied Biology, Inc., was contracted by Public Service Company of Indiana, Inc. (PSI), to conduct a construction phase ecological monitoring program at the proposed Marble Hill Nuclear Generating Station - Units 1 and 2, located near Madison, Indiana. This report presents the results of that monitoring program and analyses of all ecological data collected between 21 March and 16 November 1978.

According to Specification Y-2961, the objectives of this program were to: (a) "ascertain and document the existing ecological conditions in the immediate vicinity of the Marble Hill Nuclear Generating Station," and (b) "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 April 15, 1976. During 1978, the mammal, plankton, periphyton, macroinvertebrate, fish and larval fish communities, as well as chemical and physical parameters, were sampled at seven aquatic or terrestrial sampling stations.

AQUATIC MONITORING PROGRAM

The six aquatic sampling stations (Stations 1, 3, 5, 6, 8, and 14; Figure 1) were sampled in March, May, August, and November 1978. Originally, sampling was scheduled for February but was delayed until March by unfavorable weather. Station 1, located in the Ohio River 200 yards 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 impact would most likely take place. 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 which drain the northern and eastern margins, respectively, of the plant site. Stations 1, 3, 5, and 6 were established at locations previously sampled in a baseline study conducted during 1974-75. Station 8 was added in 1977 to study erosion from construction activities. Station 14, located three miles 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 were consistent with those used in the baseline study.

TERRESTRIAL MONITORING PROGRAM

One terrestrial sampling station (Station 13; Figure 1) was located in the wooded area on the east-facing slope. This station, composed of five separate observation posts, was established during the baseline study and was surveyed for the abundance of squirrels in March and November 1978. In addition, rabbit counts were conducted in May 1978 on the roads which approximate the site boundaries.

1978 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 1978 monitoring program was essentially a repeat of monitoring conducted during 1977. Although considered as a construction phase sampling program, sampling in 1977 was more than three-quarters complete before construction actually began.

Figure 1. Locations of sampling stations. Marble Hill Plant site, 1978.

TABLE 1

FIELD WORK AT MARBLE HILL PLANT
FEBRUARY - NOVEMBER 1978

Date	Purpose of Field Trip	ABI Personnel
February 28	Placing of periphyton and macroinvertebrate samplers	W. Rhodes W. Courtis
March 21-23	1st quarterly sampling 1st fish eggs and larvae collection	W. Rhodes S. Dupont W. Howard J. O'Hara H. Kania
April 7	2nd fish eggs and larvae collection	W. Rhodes W. Courtis
April 21	3rd fish eggs and larvae collection	W. Courtis G. Glover
May 5	4th fish eggs and larvae collection	W. Courtis G. Glover
May 17	5th fish eggs and larvae collection	W. Courtis J. Downing
May 22-25	2nd quarterly sampling	W. Rhodes D. Herrema R. Comegys H. Kania
May 30	6th fish eggs and larvae collection	W. Courtis G. Glover
June 6	7th fish eggs and larvae collection	W. Courtis G. Glover
June 13	8th fish eggs and larvae collection	W. Courtis G. Glover
June 19	9th fish eggs and larvae collection	W. Courtis G. Glover

TABLE 1
(continued)
FIELD WORK AT MARBLE HILL PLANT
FEBRUARY - NOVEMBER 1978

Date	Purpose of Field Trip	ABI Personnel
June 26	10th fish eggs and larvae collection	W. Courtis G. Glover
July 6	11th fish eggs and larvae collection	W. Rhodes J. Russell
July 13	12th fish eggs and larvae collection	J. Russell M. Soule-Hinds
July 20	13th fish eggs and larvae collection	M. Soule-Hinds D. Webster
July 27	14th fish eggs and larvae collection	D. Webster R. Comegys
August 3	15th fish eggs and larvae collection	J. Russell M. Soule-Hinds
August 10	16th fish eggs and larvae collection	J. Russell R. Comegys
August 16-18	3rd quarterly sampling 17th fish eggs and larvae collection	W. Rhodes W. Howard M. Soule-Hinds H. Kania
October 23	Placing of periphyton and macroinvertebrate samplers	J. Russell M. Smith
November 14-16	4th quarterly sampling	W. Rhodes J. Russell M. Smith H. Kania

A. CHEMICAL AND PHYSICAL PARAMETERS

INTRODUCTION

This study was designed to monitor the physical and chemical parameters of the aquatic habitat at locations near the Marble Hill Plant site. Chemical and physical parameters are especially important to the biological community in aquatic environments because of possible effects on the entire food chain.

MATERIALS AND METHODS

Duplicate sub-surface water samples were collected at Stations 1, 3, 5 and 6 with a non-metallic 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 shown 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 (SCT) meter. Temperature was measured electronically with the oxygen and conductivity meters. Turbidity was determined in the laboratory with a Hach Model 2100 A nephelometric turbidimeter. All meters were calibrated in the laboratory before each field use.

RESULTS OF WATER CHEMISTRY ANALYSIS

The results from the chemical analysis of water samples collected quarterly at Stations 1, 3, 5 and 6 during 1978 are tabulated in Appendix Tables A-2 through A-5. Both replicate values and their average are shown 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 (PSI, 1976) and, where available, with Ohio River Valley Water Sanitation Commission (ORSANCO) data. Average monthly values from the closest ORSANCO sampling stations upstream (Mile Post 528.1 at Neville, Ohio) and downstream (Mile Post 600.6 at Louisville, Kentucky) of the Marble Hill Plant site (Mile Post 570) were used for these comparisons.

Water chemistry data for the Ohio River stations in 1978 generally varied considerably between seasons, but only slightly between stations. Chemical parameter values measured in 1978 were similar to those of the baseline study and 1978 ORSANCO values.

Little Saluda Creek (Station 6) water chemistry data obtained by Applied Biology, Inc. in 1978 were compared to baseline (PSI, 1976) and 1977 construction phase monitoring results (ABI, 1978) (Table A-1). Minimum and maximum values of each chemical parameter are presented for comparison.

Dissolved Oxygen

Dissolved oxygen values were similar at all the Ohio River stations within a sampling period but varied seasonally (Figure A-1). Dissolved oxygen values were highest in the fall and lowest in the summer. Little Saluda Creek dissolved oxygen values were similar to those in the Ohio River in March and November, but during May and August the creek values were appreciably higher. Regardless of the season, dissolved oxygen values for all stations remained above 5.0 mg/liter, which is higher than the 4.0 mg/l average value per calendar day recommended by the 1977 State of Indiana Water Quality Standards (SPC 1R-4).

pH and Alkalinity

The pH values measured at the Marble Hill Plant site during the 1978 quarterly sampling program ranged from 6.8 to 7.6 in the Ohio River and from 7.3 to 8.0 in Little Saluda Creek (Figure A-2). These are well within the 6.0 to 9.0 range recommended by the Indiana Water Quality Standards.

Alkalinity, the measure of the carbonate and bicarbonate buffering capacity of water, ranged from 54.5 to 78.8 mg/liter in the Ohio River (Figure A-3). The EPA (1976) recommended 20 mg/liter as a minimum total alkalinity necessary to support fresh-water aquatic life. Levels up to approximately 400 mg/liter are not considered a problem to human health (National Academy of Sciences, 1974). Little Saluda Creek, which had alkalinity values between 193 and 243 mg/liter, was also well above this minimum acceptance value. The higher alkalinity of the creek is probably a result of water leaching through the surrounding limestone cliffs.

Conductivity, Total Dissolved Solids, and 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 170 and 388 μmhos/cm for the Ohio River and between 168 and 478 μmhos/cm for Little Saluda Creek (Figure A-4). The TDS values varied between 159 and 279 mg/liter for the Ohio River and between 248 and 351 mg/liter for Little Saluda Creek (Figure A-5). For Station 8 TDS values ranged from 207 to 447 mg/liter.

Suspended solids are insoluble particles suspended in the water column which increase turbidity and reduce light penetration. Suspended solids values varied between 11 and 242 mg/liter for the Ohio River, the highest values were recorded in March when runoff was high (Figure A-6). Suspended solids values for Little Saluda Creek were between 39 and 132 mg/liter which is higher than values recorded during the 1977 construction period when the range was 5 to 39 mg/liter.

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 which can be oxidized by a chemically defined dichromate solution. Both these tests, as well as total organic carbon (TOC) values, indicate the concentration of organic waste material present in water. BOD values for Ohio River stations ranged from 2.2 to 4.6 mg/liter (Figure A-7), COD values ranged from 4.0 to 29.0 mg/liter (Figure A-8), and TOC ranged from 5.41 to 12.24 mg/liter (Figure A-9). BOD values in Little Saluda Creek ranged from $<$1.0 to 4.2 mg/liter, COD ranged from 3.2 to 10.4 mg/liter, and TOC ranged from 3.50 to

13.43 mg/liter. When 1978 values for these parameters were compared with baseline and 1977 construction phase data, a large increase in the range for BOD, COD and TOC in Little Saluda Creek was apparent. These increases parallel increased bacterial populations of the creek (see Section B) but are not related to increased periphyton populations (see Section D). Also, values for these parameters in Little Saluda Creek were often higher than in the Ohio River which was not usually the case during 1977.

Nitrogen and Phosphorous

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

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 maximum value for total phosphorous was repeatedly exceeded at Stations 3 and 5 in the Ohio River during 1978. These high total phosphorous values were not caused by construction at Marble Hill site because Control Station 1 exceeded recommended values also. No blooms were noticed during 1978. Concentrations of total phosphorous in Little Saluda Creek remained below 0.10

mg/liter except in November. Total phosphorous values for the Ohio River stations ranged from 0.02 to 0.39 mg/liter (Figure A-10), and orthophosphate values ranged from <0.01 to 0.07 mg/liter (Figure A-11). In Little Saluda Creek, total phosphorous ranged from <0.01 to 0.24 mg/liter and orthophosphate values ranged from <0.01 to 0.09 mg/liter.

Nitrate nitrogen values for stations in the Ohio River and Little Saluda Creek were relatively constant (0.75-1.97 mg/liter) during the year (Figure A-12), and both exceeded the 0.1 mg/liter minimum concentrations necessary to limit growth of algae and plants (MacKenthum, 1969). Nitrate values for all stations were, however, much less than EPA (1976) maximum recommended level of 10.0 mg/liter.

Ammonia nitrogen values ranged from <0.01 to 0.30 mg/liter at the Ohio River stations and from <0.01 to 0.11 mg/liter in Little Saluda Creek (Figure A-13). These values correspond to less than 0.02 mg/liter of unionized ammonia which is the maximum recommended value for freshwater aquatic life (EPA, 1976).

Organic nitrogen values ranged from 0.24 to 0.75 mg/liter at the Ohio River stations and from 0.13 to 0.69 mg/liter in Little Saluda Creek (Figure A-14).

Other Chemical Parameters

Quarterly values for silica, chloride, calcium, magnesium and sodium were similar at the three Ohio River stations (Figures A-15 through A-20), but differed substantially between the Ohio River and Little Saluda Creek. The Ohio River had a higher concentration of sodium and chlorides than Little Saluda Creek, while the reverse was true of silica, calcium and magnesium. The high concentrations of calcium, magnesium, and silica are probably derived from minerals dissolving along the flow of Little Saluda Creek. The high levels of sodium and chloride in the Ohio River are probably due to municipal wastes. The highest values of sulfate (Figure A-20) and chloride measured during 1978 (113 and 42 mg/liter) were well below the Indiana Water Quality Standards recommended maximum of 250 mg/l. There was no difference in sulfate values between Ohio River stations. Sulfate values for the Ohio River were only slightly lower than in Little Saluda Creek.

Residual free chlorine and chloramines values in the Ohio River and in Little Saluda Creek were both less than 0.01 mg/liter during each quarter of 1978.

Hexane soluble material levels were similar in the Ohio River and Little Saluda Creek, with ranges of 4.0 to 14.2 for Little Saluda Creek and 4.2 to 13.0 for the Ohio River (Figure A-21). Phenol levels varied between <0.002 and 0.009 mg/liter at both the Ohio River and Little Saluda Creek stations, but were consistently lower in Little Saluda Creek (Figure A-22). These phenol values were below ORSANCO's maximum recommended criteria for the mainstream of the Ohio River of 0.010 mg/liter. Indiana Water Quality Standards list no standard for phenol.

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 Stationa 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 5.7 to 27.9°C for Ohio River stations and from 5.8 to 21.3°C for Little Saluda Creek. The maximum temperature rise at Stations 3 and 5 never exceeded values at control Station 1 more than 0.3°C. Indiana Water Quality Standards recommends a maximum increase of 2.8°C in streams.

Current velocity ranged from 20 to 250 cm/sec for Ohio River stations and from <10 to 115 cm for Little Saluda Creek. Secchi depth ranged from 10 to 115 cm for Ohio River stations and from 10 to 50 cm for Little Saluda Creek. Water depth ranged from 4.4 to 7.3 m for Ohio River stations and from 0.5 to 1.5 m for Little Saluda Creek. Turbidity at Station 8 ranged from 55 to 220 NTU.

SEDIMENTATION STUDIES

Sedimentation studies were conducted at Stations 6 and 8, which are located in streams which drain the plant site. This study was designed to estimate erosion by measuring sediment accumulations 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 flood plain of the Ohio River. Both upstream and downstream sedimentation study rods at Station 6 were located upstream 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 August and November 1977, 14.9 cm of sediment accumulated at the upstream study rod at Station 8 (ABI, 1978) A small settling pond was constructed in late 1977 at the top of the east-facing slope to combat erosion in the Station 8 stream. This pond appears to have been effective during 1978 and, combined with erosion control and grass planting on the site, has reduced new sediment accumulation to a total of 3 cm. At the downstream study rod at Station 8, road and pipe construction has contributed an estimated 10 cm of new sediment accumulation on top of the 2.6 cm found in November 1977 (ABI, 1978). Extensive grass plantings in this area will probably reduce future sedimentation particularly now that most of the pipe construction on the east-facing slope has been completed.

Sedimentation in Little Saluda Creek has not been heavy during 1978 primarily because there is always some flow in the creek to flush out sediment accumulations. No sediment accumulation was found at the upstream study rod during 1978. At the downstream study rod, accumulations up to 4 cm deep were noted through August, but most of this had been washed away by November. Sedimentation at Station 6 cannot be compared to the pre-construction condition of the stream since no sedimentation study was conducted in 1977. A total accumulation of 3 to 5 cm since construction began has been estimated visually. Combined with other types of construction impact, this amount of sedimentation could have impacted the macroinvertebrate community of the primarily riffle habitats of Little Saluda Creek (see Section E). However, it is possible that this sedimentation could be flushed out and the creek returned to normal after several good rains.

CONCLUSIONS

Chemical and physical parameter values were similar at all the Ohio River stations during each of the quarterly sampling periods in 1978. They were similar to the values recorded during baseline and construction period studies. Therefore, the Marble Hill Plant site construction seems to have a negligible effect at this time upon 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 which indicate decreased water quality are higher in the Ohio River than in Little Saluda Creek. This decreased water quality seems to be due to municipal discharges upstream from the Marble Hill Plant site. Chemical and physical parameter values are in general within water quality standards for the State of Indiana.

Sediment accumulations at Stations 6 and 8 during 1978 were generally smaller than reported during the last quarter of 1977. Minor accumulations continue to take place, however. At Station 6, sediment accumulations have probably contributed to construction impact on the stream. After cessation of construction; however, it is probable that Little Saluda Creek will return to its pre-construction form.

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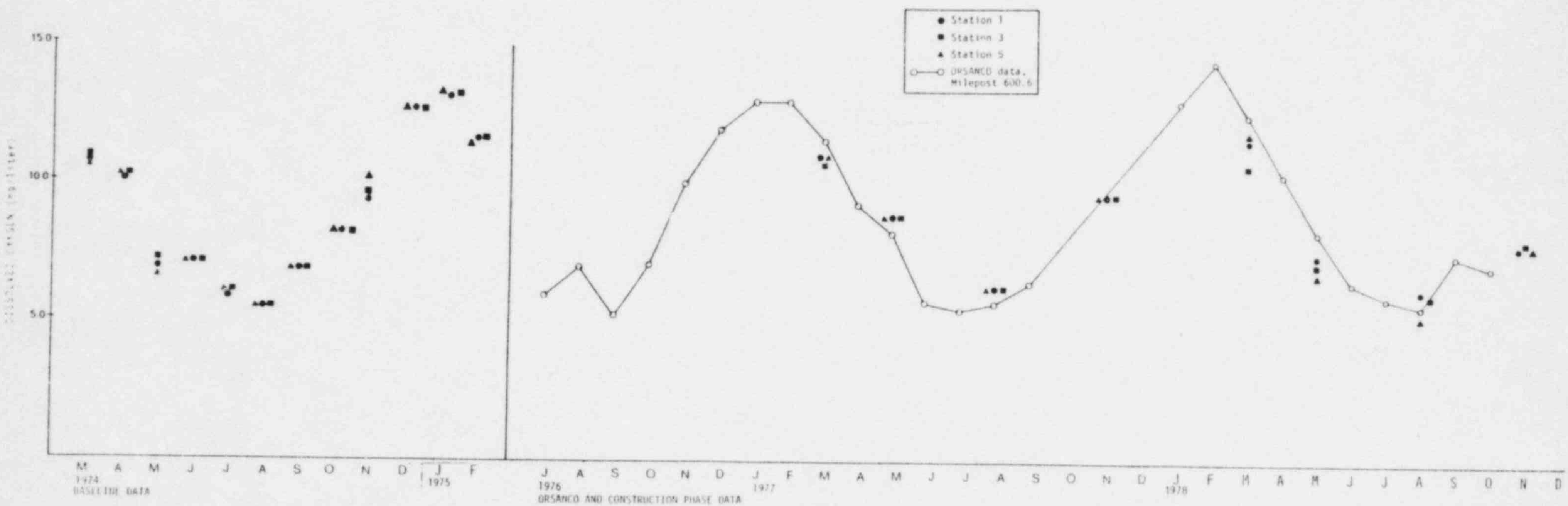

Figure A-1. Comparison of baseline, ORSANCO, and ABI dissolved oxygen (average values) taken in the Ohio River near the Marble Hill Plant site.

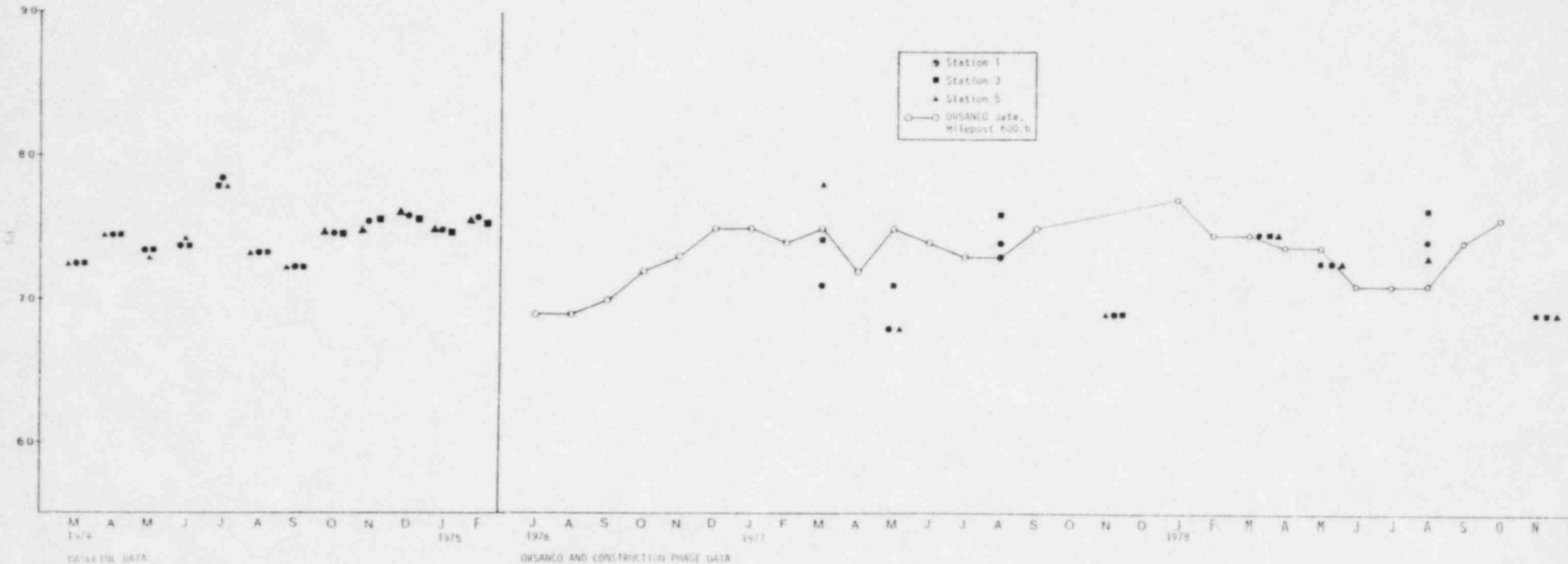

Figure A-2. Comparison of baseline, ORSANCO, and ABI pH data (average values) taken in the Ohio River near the Marble Hill Plant site.

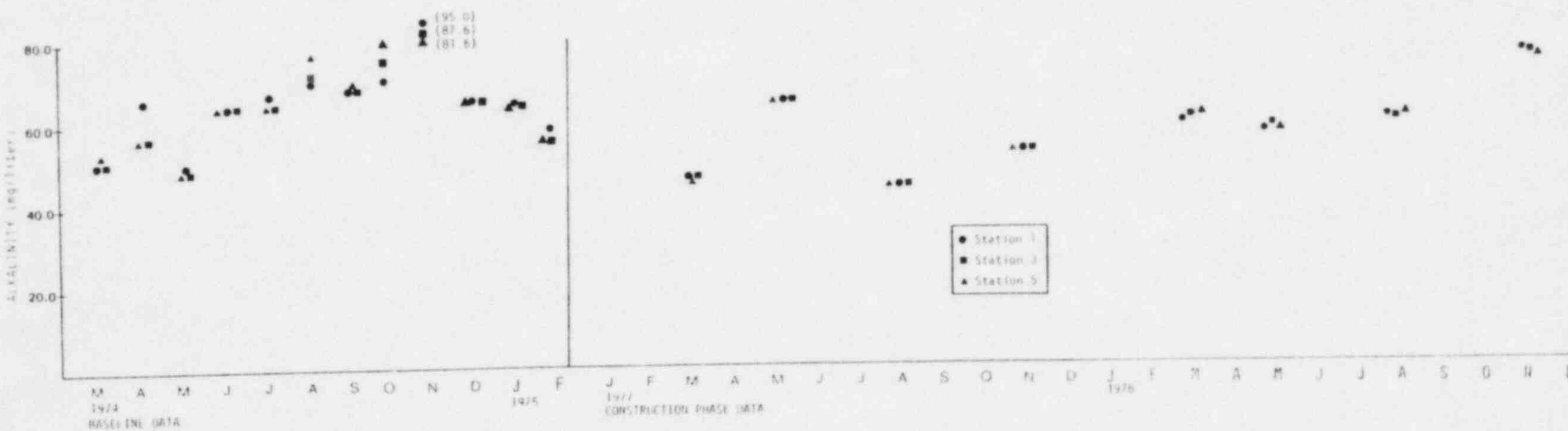

Figure A-3. Comparison of baseline and ABI alkalinity data (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

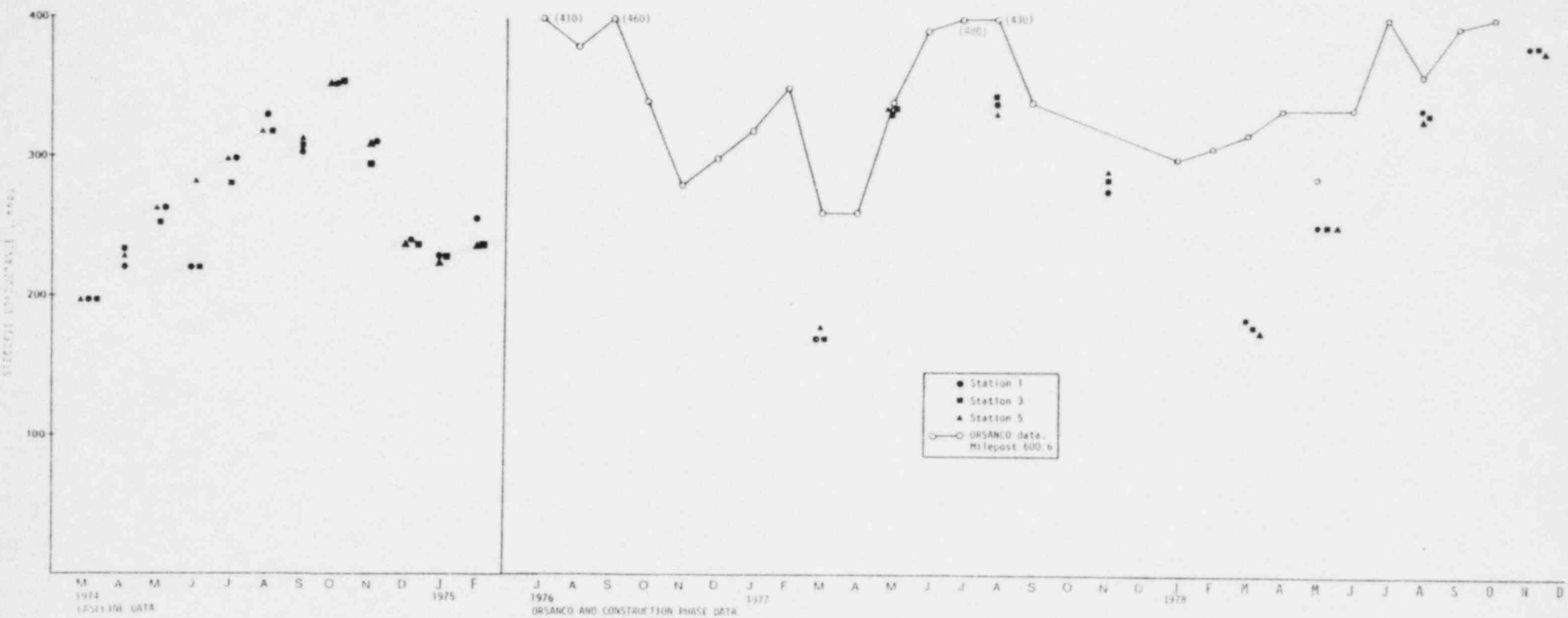

Figure A-4. Comparison of baseline, ORSANCO, and ABI specific conductance data (average values) taken in the Ohio River near the Marble Hill Plant site.

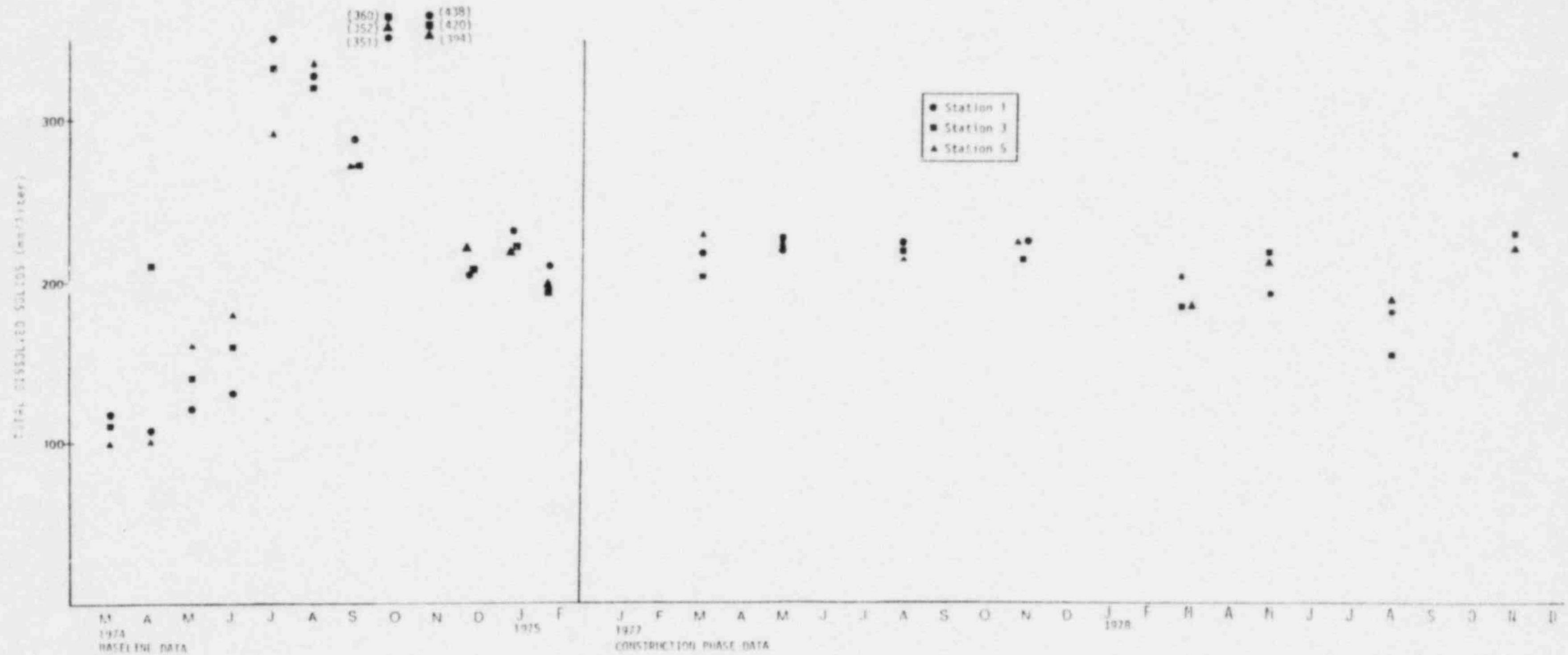

Figure A-5. Comparison of baseline and ABI dissolved solids (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

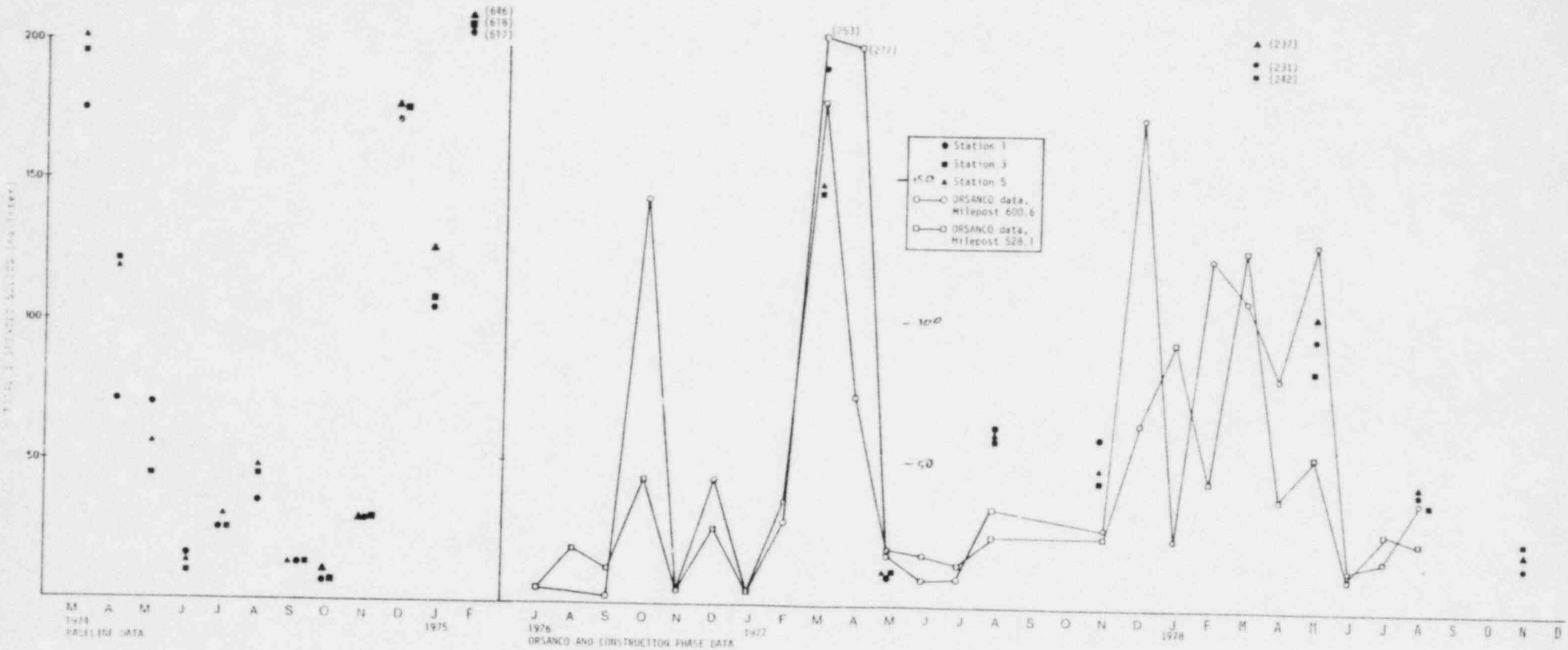

Figure A-6. Comparison of baseline, ORSANCO, and ABI total suspended solids data (average values) taken in the Ohio River near the Marble Hill Plant site.

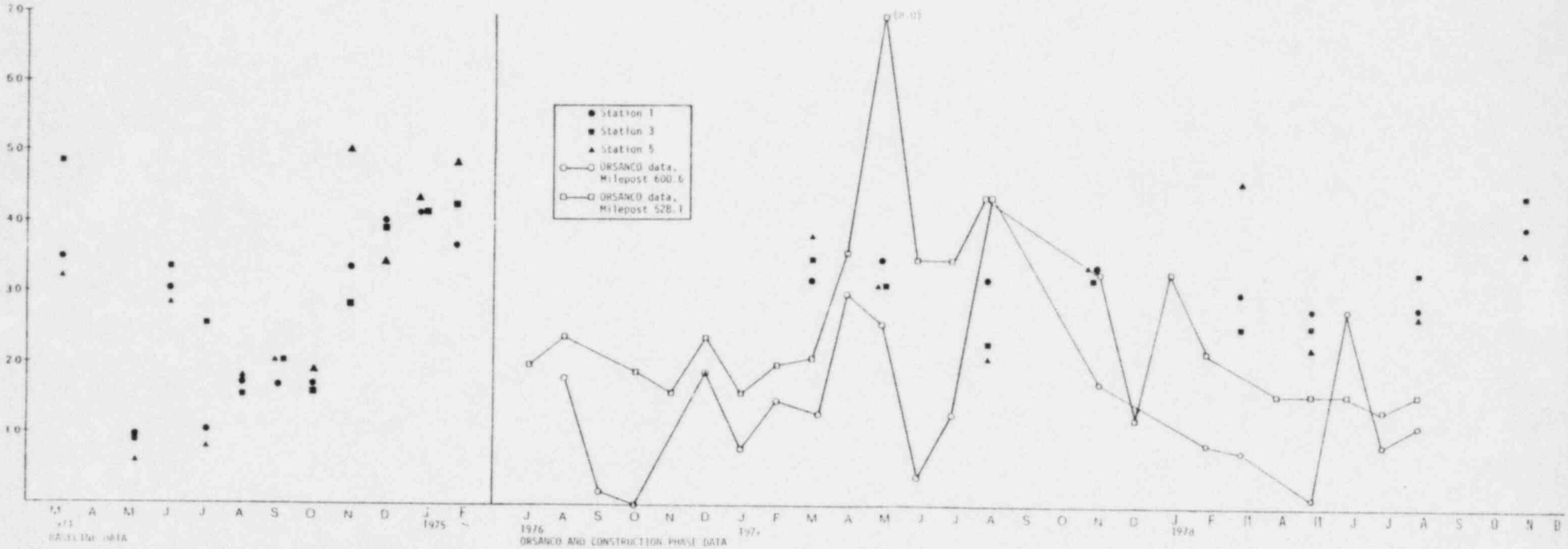

Figure A-7. Comparison of baseline, ORSANCO, and ABI biochemical oxygen demand data (average values) taken in the Ohio River near the Marble Hill Plant site.

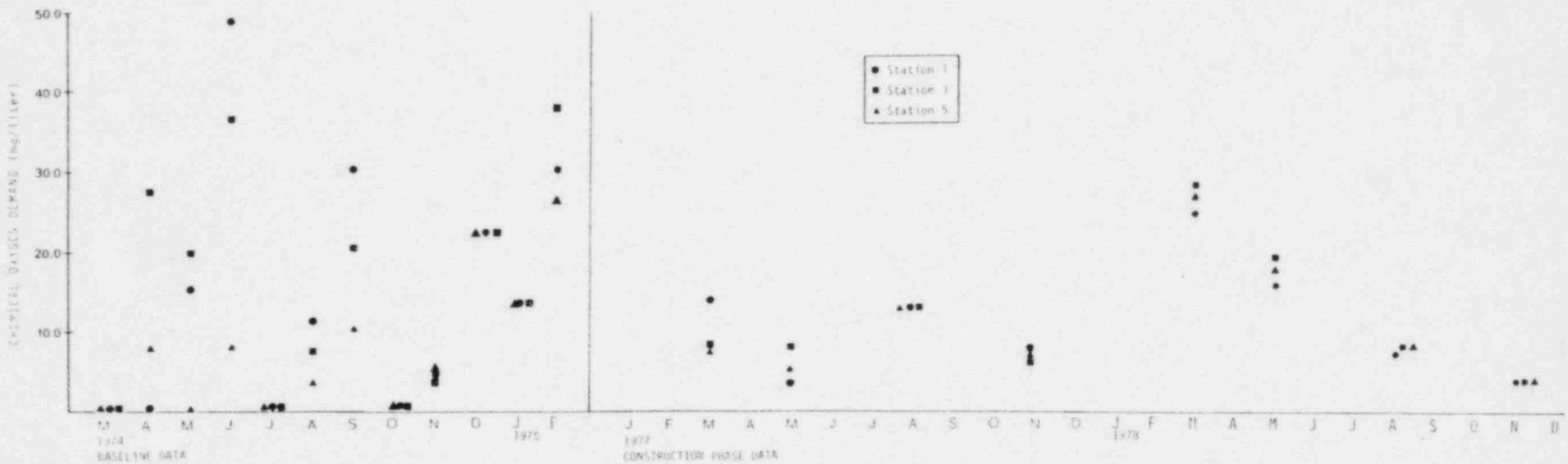

Figure A-8. Comparison of baseline and ABI chemical oxygen demand (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

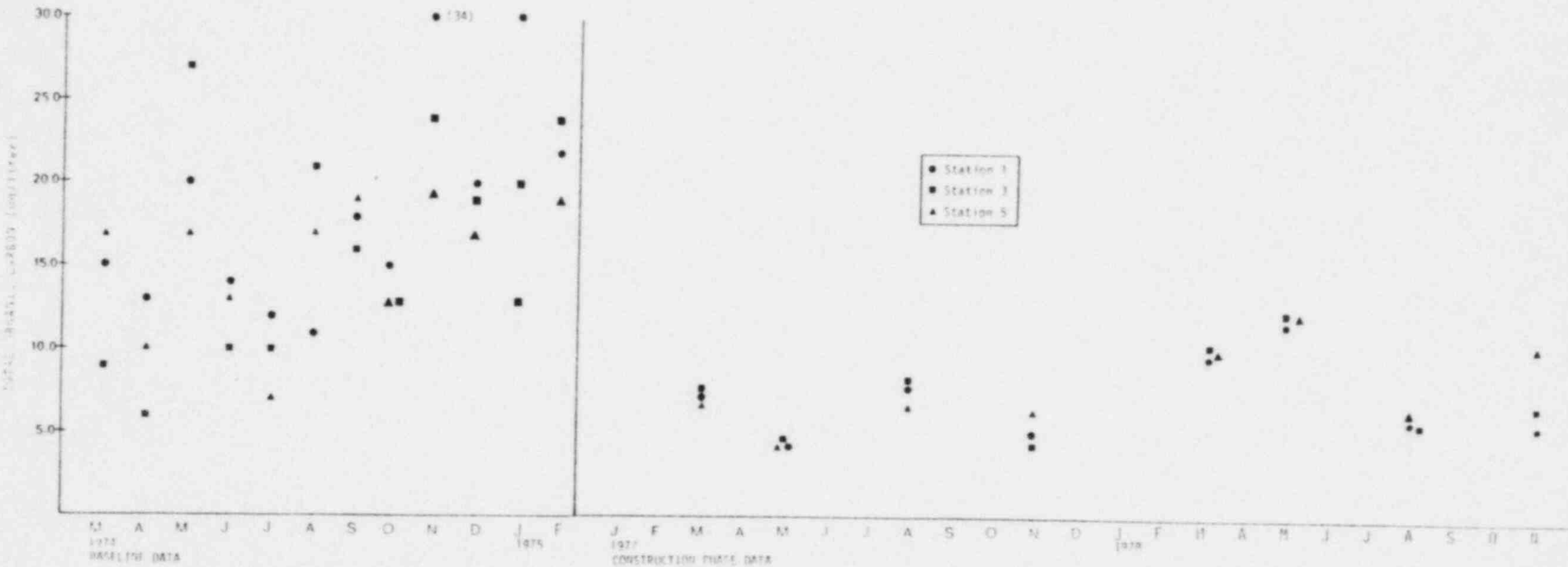

Figure A-9. Comparison of baseline and ABI total organic carbon (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

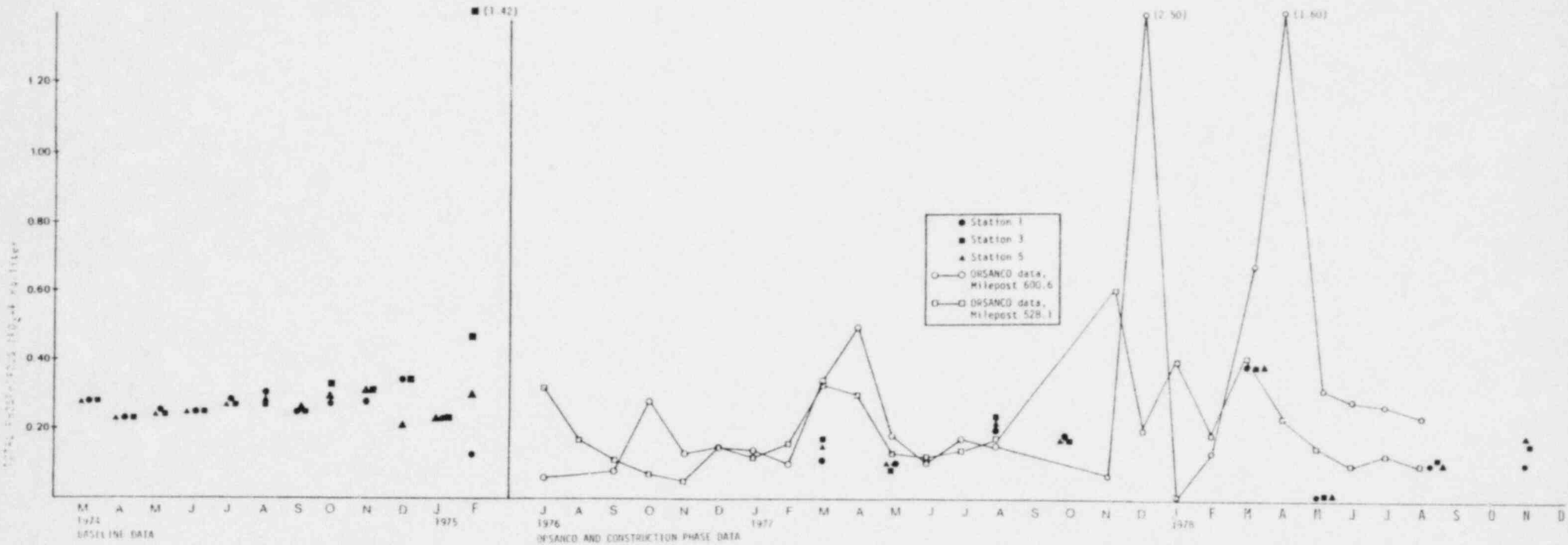

Figure A-10. Comparison of baseline, ORSANCO, and ABI total phosphorous data (average values) taken in the Ohio River near the Marble Hill Plant site.

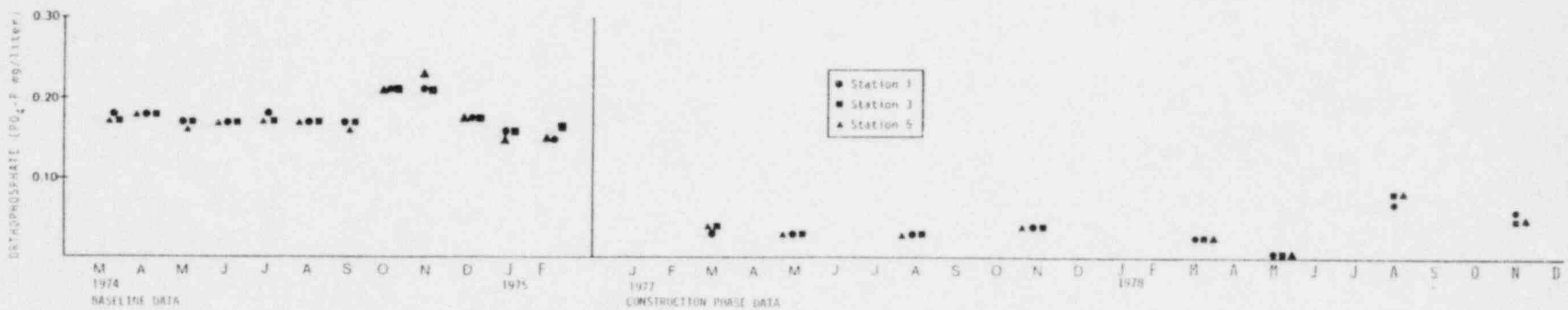

Figure A-11. Comparison of baseline and ABI orthophosphate (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

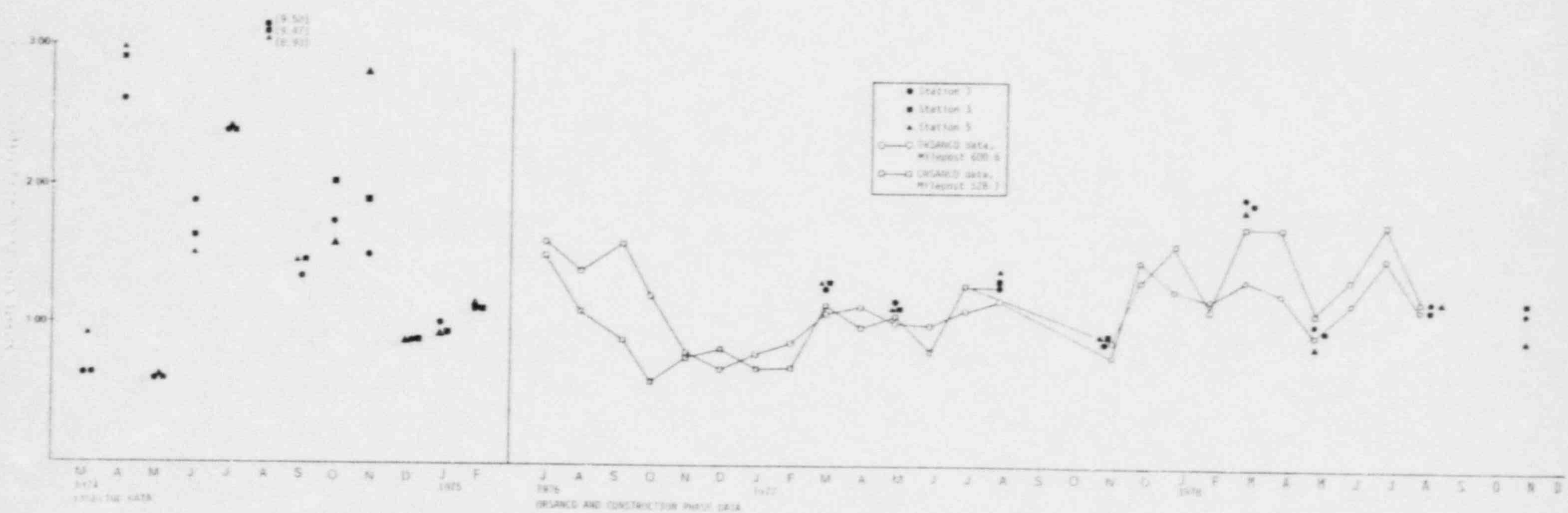

Figure A-12. Comparison of baseline, ORSANCO, and ABI nitrate nitrogen data (average values) taken in the Ohio River near the Marble Hill Plant site.

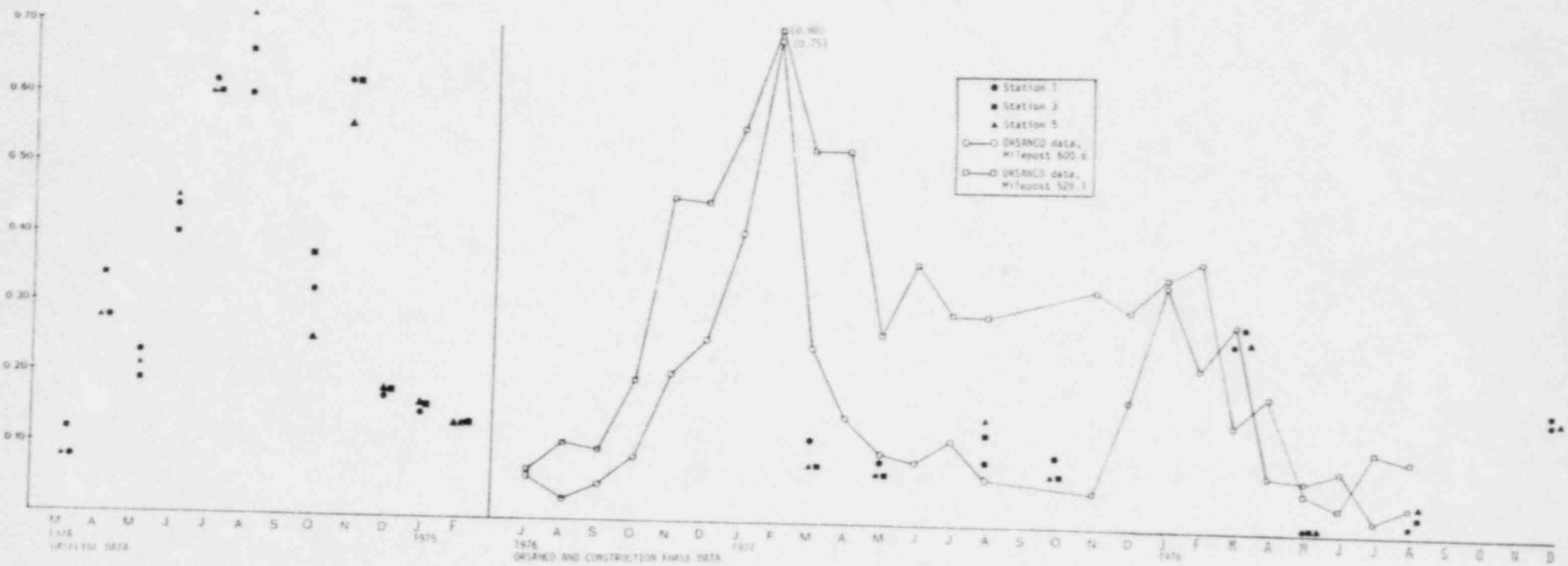

Figure A-13. Comparison of baseline, ORSANCO, and ABI ammonia nitrogen data (average values) taken in the Ohio River near the Marble Hill Plant site.

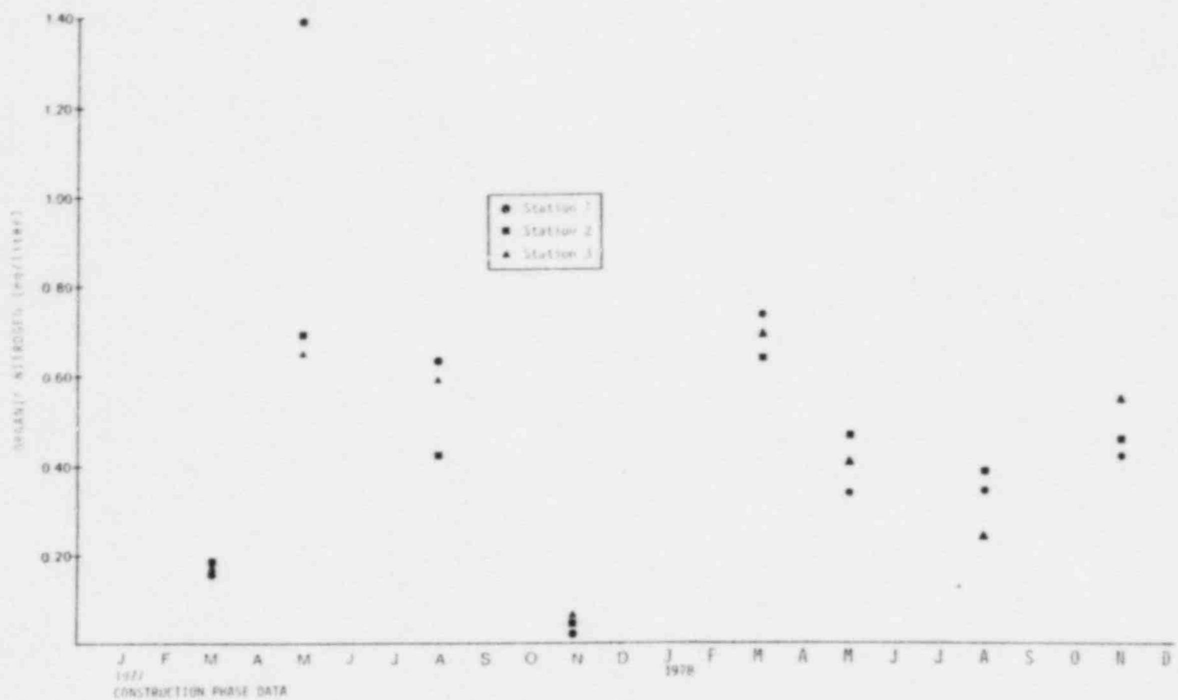

Figure A-14. ABI quarterly organic nitrogen data from samples taken in the Ohio River near the Marble Hill Plant site.

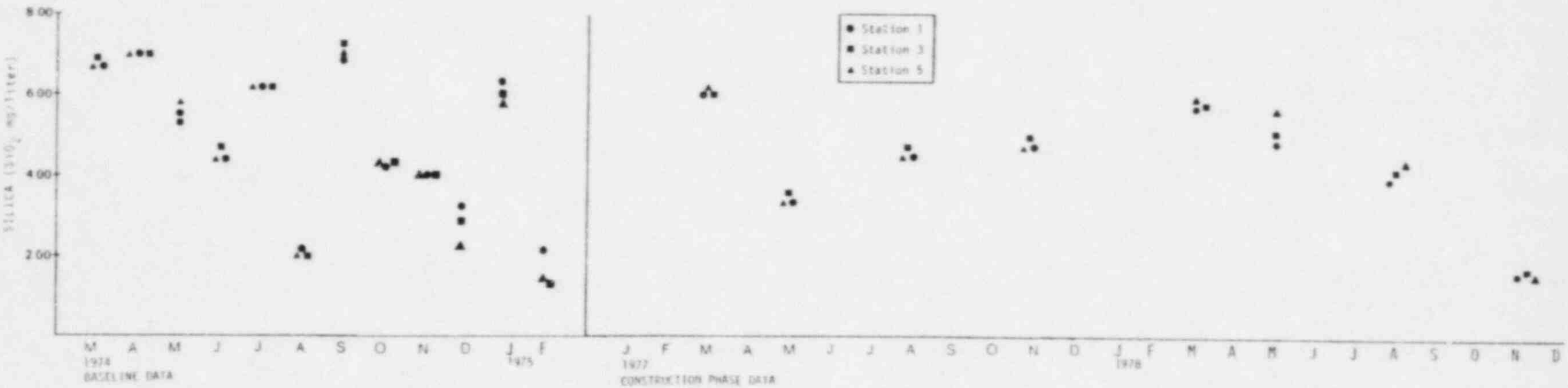

Figure A-15. Comparison of baseline and ABI silica (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

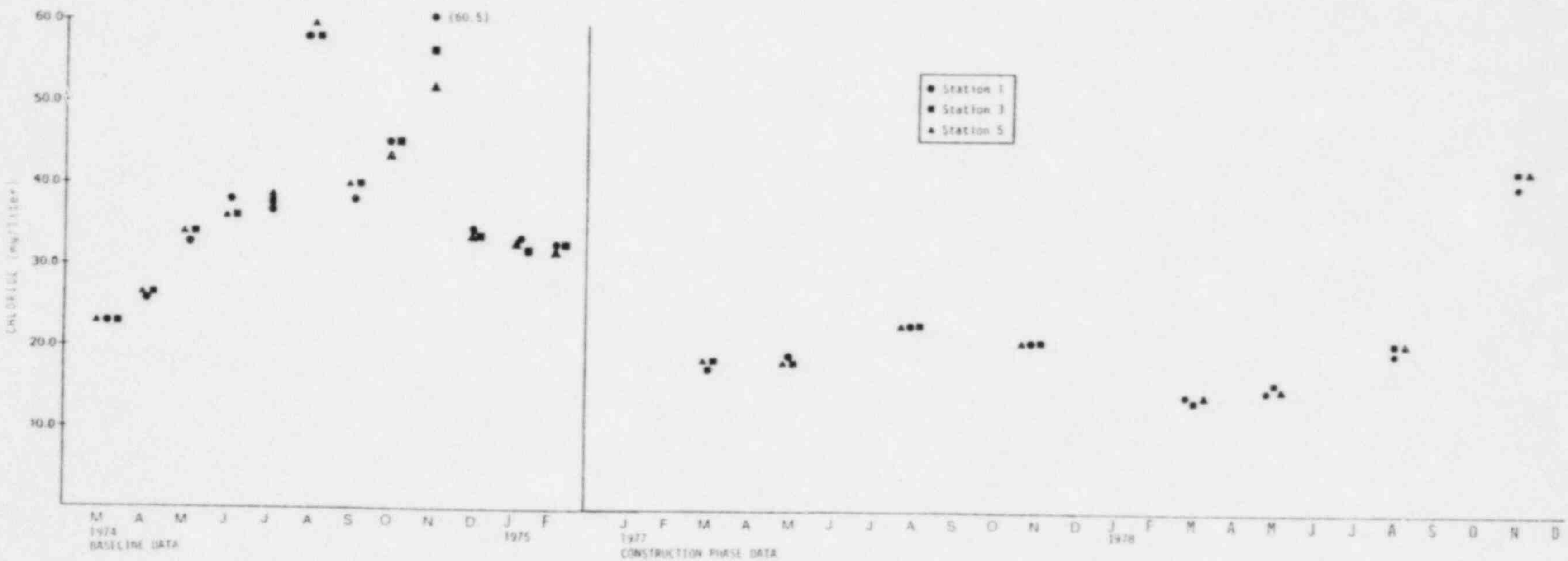

Figure A-16. Comparison of baseline and ABI chloride (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

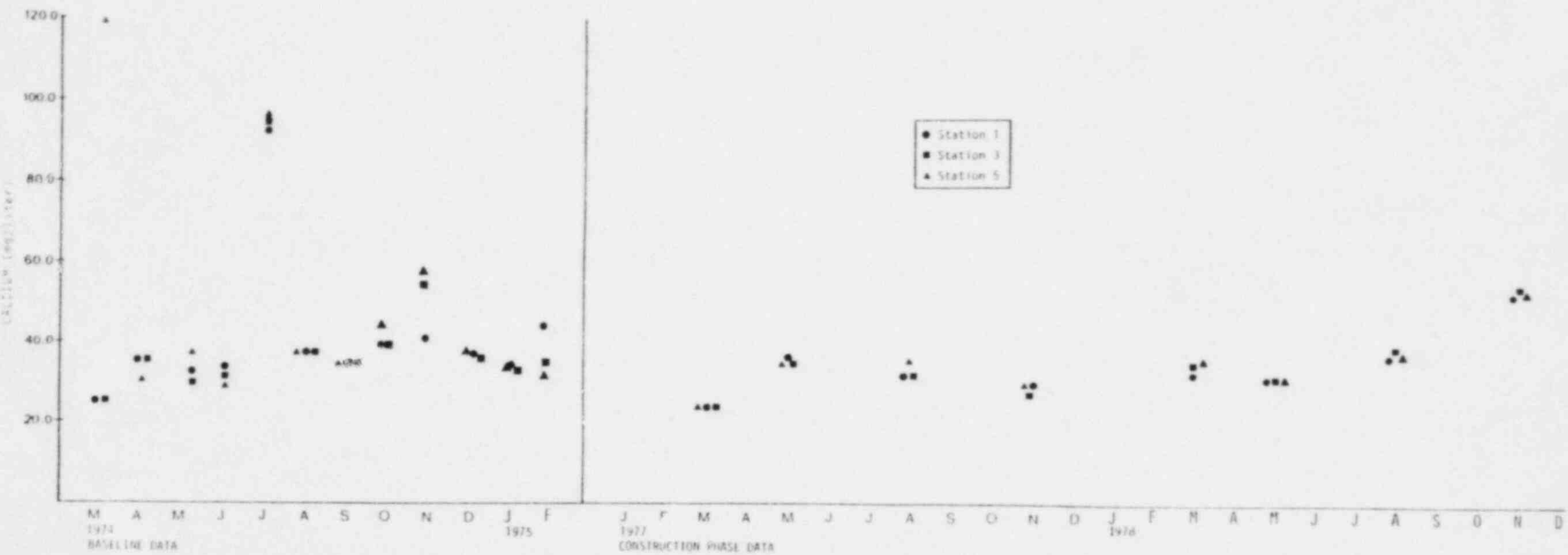

Figure A-17. Comparison of baseline and ABI calcium (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

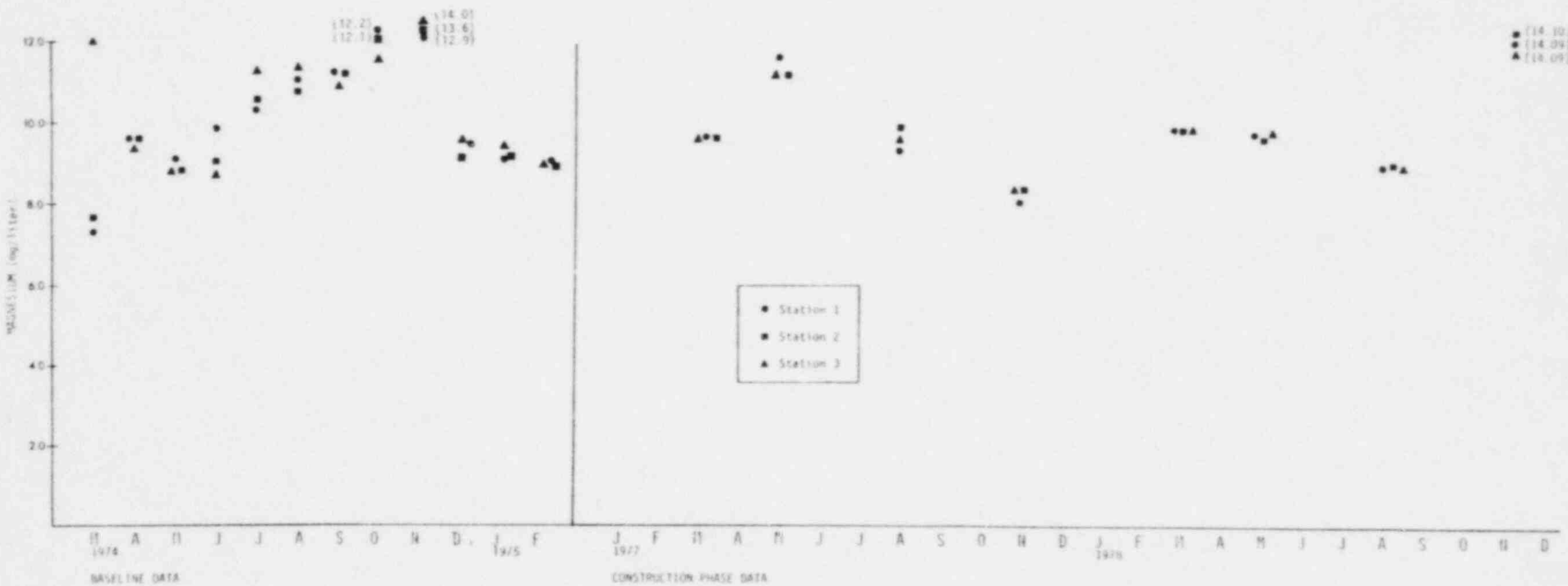

Figure A-18. Comparison of baseline and ABI magnesium (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

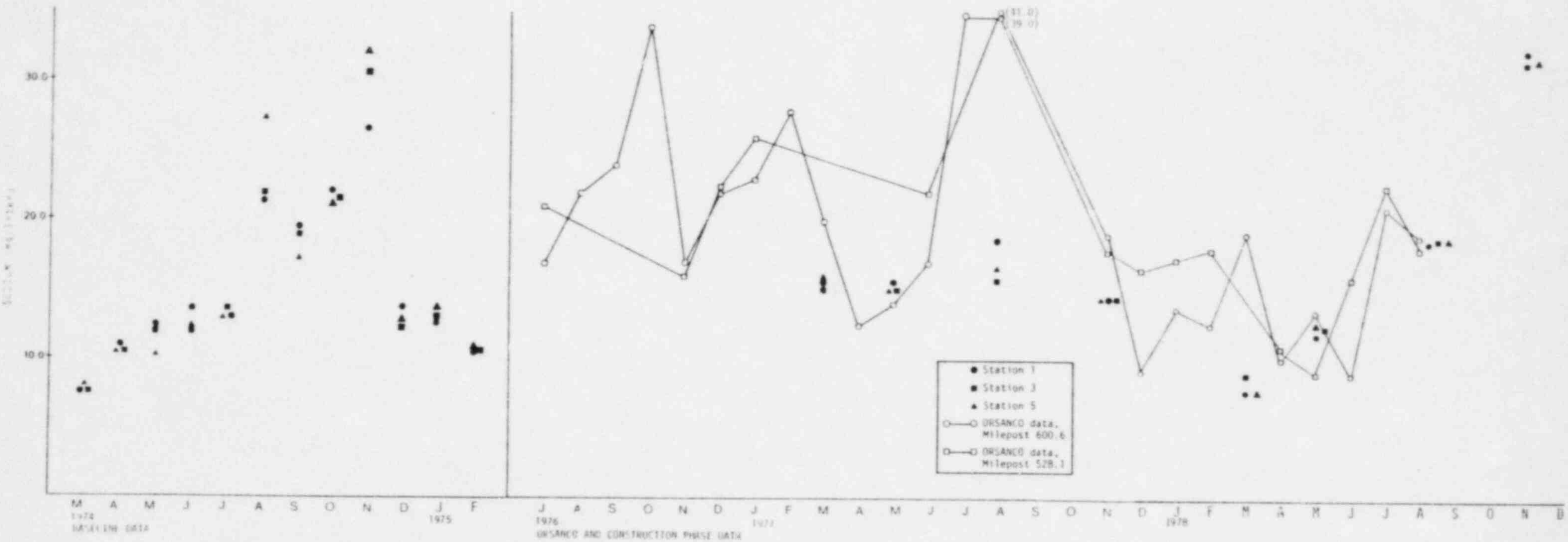

Figure A-19. Comparison of baseline, ORSANCO, and ABI sodium data (average values) taken in the Ohio River near the Marble Hill Plant site.

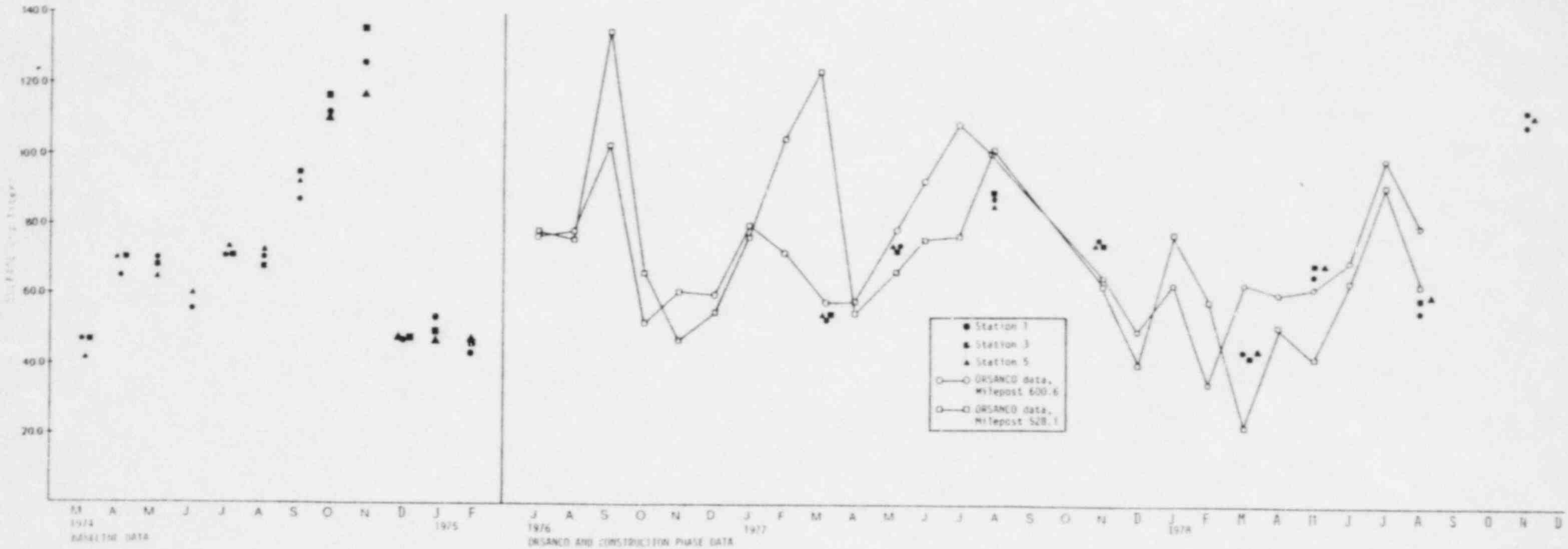

Figure A-20. Comparison of baseline, ORSANCO, and ABI sulfate data (average values) taken in the Ohio River near the Marble Hill Plant site.

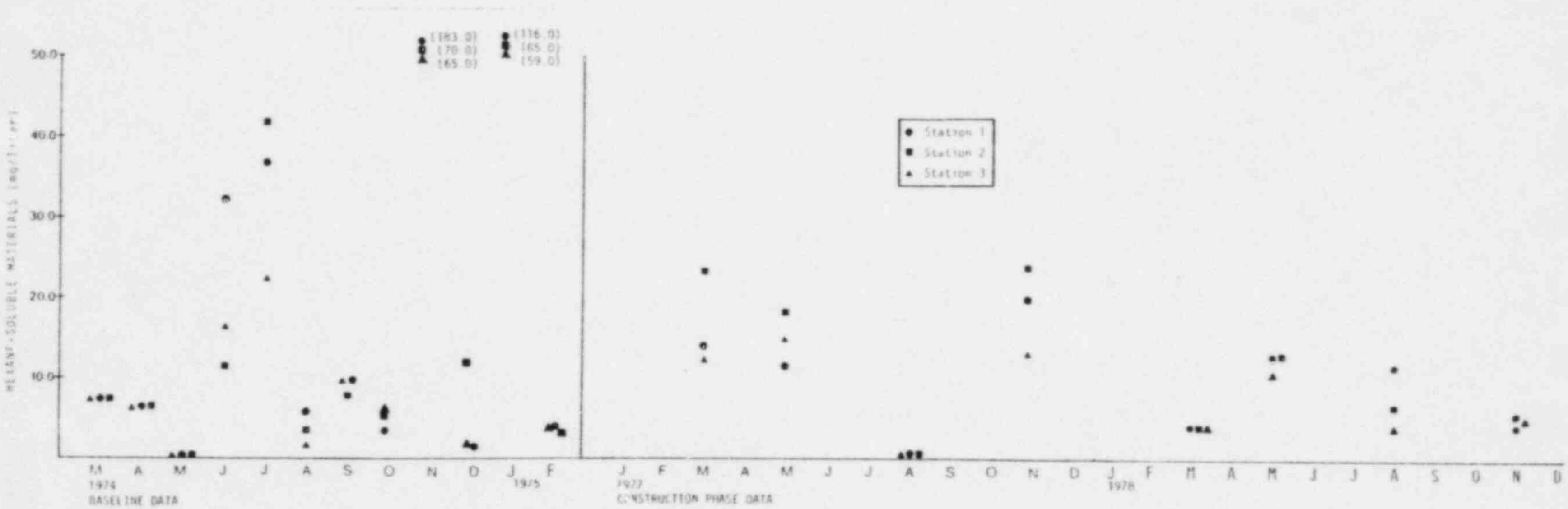

Figure A-21. Comparison of baseline and ABI hexane-soluble materials (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

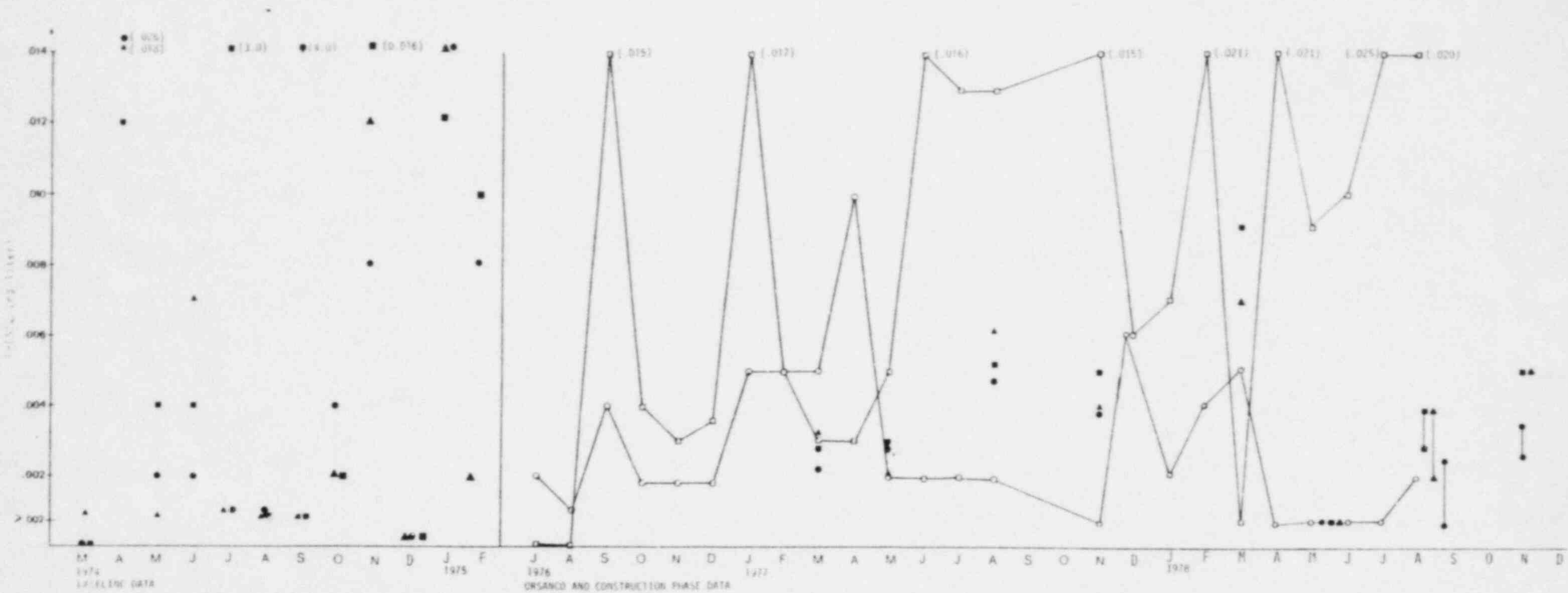

Figure A-22. Comparison of baseline, ORSANCO, and ABI phenol data (average values) taken in the Ohio River near the Marble Hill Plant site.

Figure A-23. Upstream sedimentation study rod at Station 8; 21 March 1978. Heavy runoff, water 10 cm deep. Sediment accumulation was 1 cm less than in November 1977.

Figure A-24. Upstream sedimentation study rod at Station 8; 23 May 1978. Small amount of water in stream. Approximately 1 cm sediment accumulation since March.

Figure A-25. Upstream sedimentation study rod at Station 8; 16 August 1978. New rod put in place. Approximately 2 cm sediment accumulation since May.

NO PHOTOGRAPH AVAILABLE

Figure A-26. Upstream sedimentation study rod at Station 8; 14 November 1978. No additional sediment accumulation noted. Total accumulation for the year was 3 cm.

Figure A-27. Downstream sedimentation study rod at Station 8; 21 March 1978. Water 25 - 35 cm deep with heavy runoff. Rod underwater.

Figure A-28. Downstream sedimentation study rod site at Station 8; 23 May 1978. Sediment accumulations up to 8 cm deep were noted in areas which were bare rock in March. Study rod was missing.

Figure A-29. Downstream sedimentation study rod at Station 8; 16 August 1978. New rod in place.

NO PHOTOGRAPH AVAILABLE

Figure A-30. Downstream sedimentation study rod at Station 8; 14 November 1978. No new significant sediment accumulation was noted. Total accumulation for the year was estimated at 10 cm.

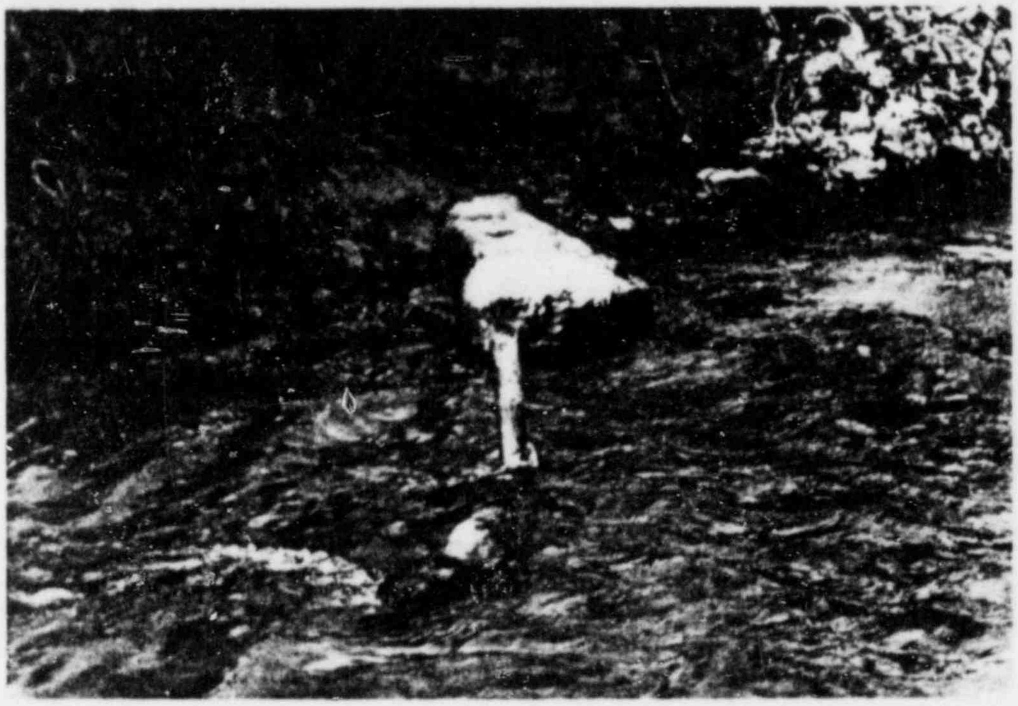

Figure A-31. Upstream sedimentation study rod at Station 6; 21 March 1978. Water 28 cm deep.

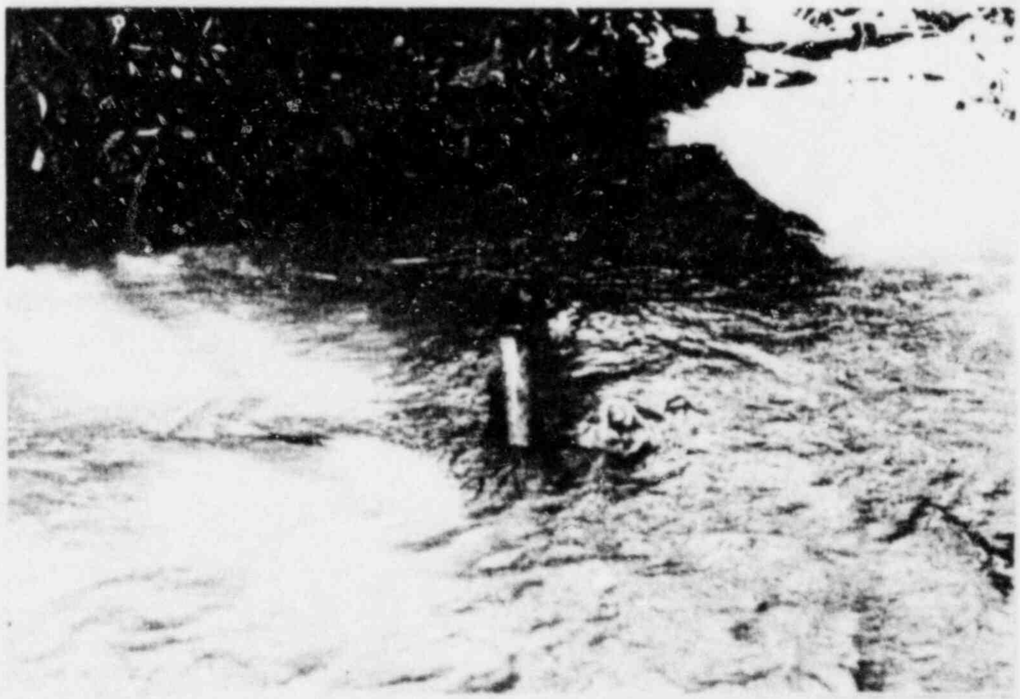

Figure A-32. Upstream sedimentation study rod at Station 6; 23 May 1978. Water 33 cm deep. No sediment accumulation noted.

Figure A-33. Upstream sedimentation study rod at Station 6; 16 August 1978. No sediment accumulation noted.

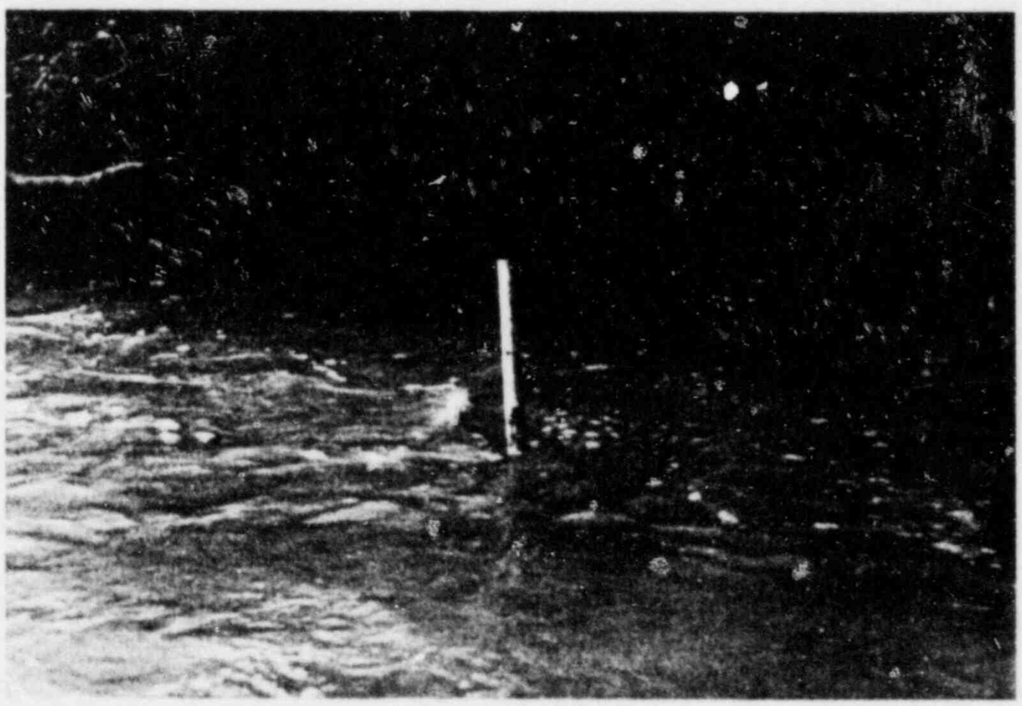

Figure A-34. Upstream sedimentation study rod at Station 6; 14 November 1978. No sediment accumulation noted.

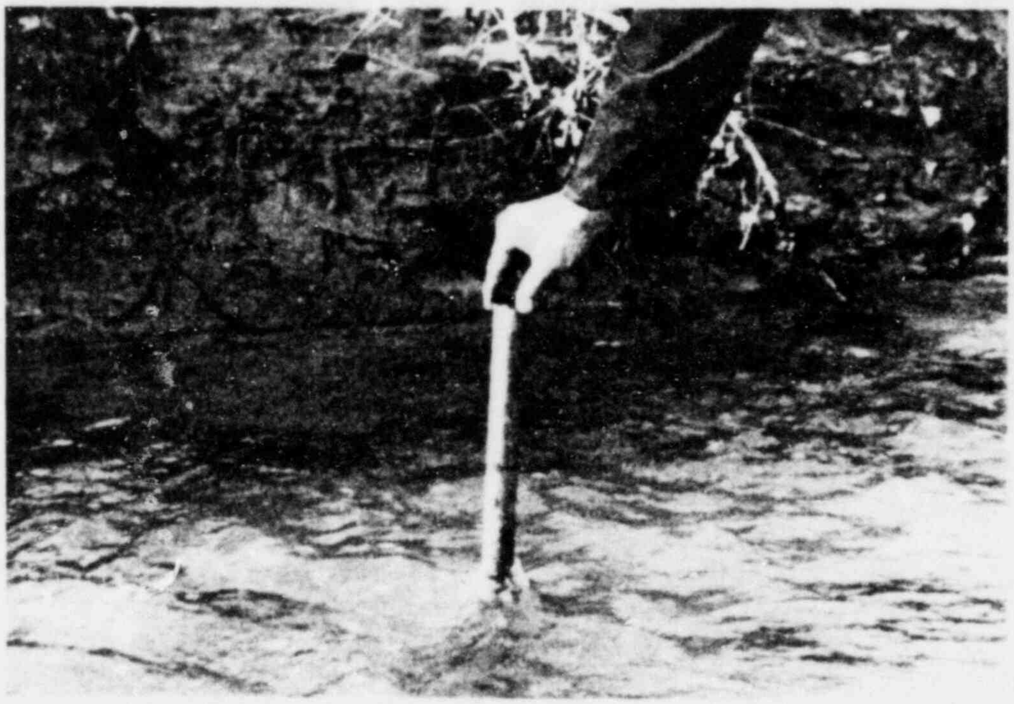

Figure A-35. Downstream sedimentation study rod at Station 6; 21 March 1978. Water 31 cm deep.

Figure A-36. Downstream sedimentation study rod at Station 6; 23 May 1978. Water 36 cm deep. Approximately 2 cm accumulation was noted.

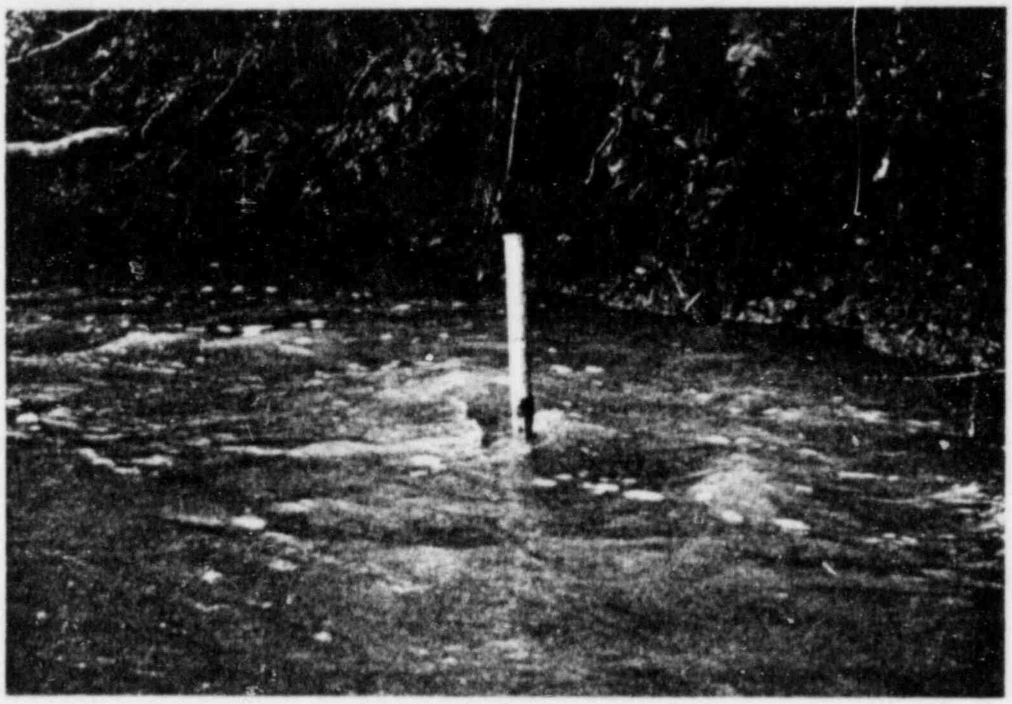

Figure A-37. Downstream sedimentation study rod at Station 6; 16 August 1978. Water 35 cm deep. Approximately 2 cm accumulation was noted since May.

Figure A-38. Downstream sedimentation study rod at Station 6; 14 November 1978. Water 26 cm deep. Approximately 3 cm less sediment accumulation since August. Total accumulation for the year was 1 cm.

TABLE A-1

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

Chemical parameter	Results from Environmental Report (PSI, 1976) March - February 1975[b]	Results from 1977 Quarterly Sampling, Applied Biology, Inc.[b]	Results from 1978 Quarterly Sampling, Applied Biology, Inc.[b]
Dissolved oxygen	7.0 - 13.0	9.2 - 13.2	8.9 - 11.7
Biochemical oxygen demand	0.65 - 8.05	1.0 - 2.9	<1.0 - 4.2
Chemical oxygen demand	<0.1 - 11.4	2.6 - 5.3	3.2 - 10.4
pH (standard units)	7.54 - 8.80	7.5 - 8.0	7.3 - 8.0
Alkalinity	184.0 - 275.2	192.4 - 245.0	111.2 - 196.3
Specific conductance (μmho)	311 - 429	218 - 445	168 - 478
Silica (SiO_2)	1.50 - 9.8	6.50 - 9.14	3.7 - 6.7
Chlorides	18.1 - 22.0	4.4 - 13.8	7.2 - 25.7
Sulfate	23.2 - 38.4	33.0 - 64.0	43.2 - 121.0
Orthophosphates (PO_4-P)	0.15 - 0.19	<0.01 - 0.02	<0.01 - 0.09
Total phosphorous (PO_4-P)	0.20 - 0.28	0.02 - 0.09	<0.01 - 0.24
Total organic carbon	7 - 50	1.71 - 5.33	3.50 - 13.43
Ammonia nitrogen	0.03 - 0.06	<0.02 - 0.08	<0.01 - 0.11
Total suspended solids	2 - 74	5 - 39	39 - 132
Nitrate nitrogen	0.05 - 1.85	0.66 - 1.52	1.39 - 1.97
Calcium	42.3 - 138.8	59.0 - 71.7	53.75 - 65.50
Magnesium	21.9 - 29.7	26.7 - 31.0	23.05 - 30.32
Sodium	2.5 - 30.8	1.4 - 6.9	3.47 - 14.11
Phenols	<0.001- 0.20	<0.003- 0.006	<0.002- 0.009
Hexane-soluble material	<1.0 - 69	1.4 - 17.3	3.8 - 14.2
Free residual chlorine	Not determined	<0.01	<0.01
Chloramines	<0.01	<0.01	<0.01

TABLE A-1
(continued)
RESULTS OF WATER CHEMISTRY ANALYSIS AT LITTLE SALUDA CREEK STATION 6[a]
MARBLE HILL PLANT SITE

Chemical parameter	Results from Environmental Report (PSI, 1976) March - February 1975[b]	Results from 1977 Quarterly Sampling, Applied Biology, Inc.[b]	Results from 1978 Quarterly Sampling, Applied Biology, Inc.[b]
Total dissolved solids	170 - 354	248 - 359	248 - 351
Organic nitrogen	Not determined	<0.03 - 1.00	0.13 - 0.69

[a]Results are in mg/l except when noted.

[b]Results are reported in mg/liter as a minimum to maximum range.

B. BACTERIA

INTRODUCTION

This study was conducted to monitor bacterial populations indicative of the sanitary quality of waters near the Marble Hill Plant site. Sincc certain coliforms and streptococcal bacteria are normally found in the intestinal tract of man and other warm-blooded animals, these bacteria make good indicators of fecal contamination. Quantification of these fecal contaminants can be used to evaluate the disease-producing potential of the water.

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, placed immediately in an iced cooler, and shipped to the laboratory for analysis. The analyses were begun approximately six to ten hours after collection of samples.

In the laboratory, the water samples were shaken vigorously to achieve homogeneity and 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 streptocci. The following media, incubation conditions, and colonial appearance criteria were used for these analyses:

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

RESULTS AND DISCUSSION

The results of the 1978 quarterly bacterial analysis conducted at Stations 1, 3, 6, and 8 are tabulated in Appendix Tables B-1 through B-4. Total coliforms, fecal coliforms, and fecal streptococci are reported as counts per 100 ml of sample. Total and fecal coliform results from Station 1 and 3 were graphically compared to baseline data (PSI, 1976) and current ORSANCO data (Figures B-1 and B-2). Fecal streptococci results were compared only to baseline data (Figure B-3) since ORSANCO does not report counts for these organisms.

Total and Fecal Coliform

Coliforms are a diverse group of bacteria, the natural habitat of which includes human and animal feces, soil, water, and vegetation. 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.

Counts for total coliforms did not vary appreciably between Ohio River Stations 1 and 3 for any sampling period except August (Figure B-1). Values were of the same order of magnitude as in ORSANCO, 1977 construction phase, and 1974 baseline data. Counts at Station 6 in Little Saluda Creek were lower than those for Ohio River stations in March and May, but were higher in August and November. Also, they were higher than any baseline values in 1974.

Counts for fecal coliforms varied appreciably between Ohio River stations in August and November (Figure B-2), but the values at Station 3 were comparable to ORSANCO and the baseline data. In Little Saluda Creek, fecal coliform values were lower or equal to values of the Ohio River stations except in November. Even this value was in the wide range found during the baseline study.

Station 8, which is located in an intermittent stream near the Marble Hill Plant site, exhibited bacterial counts which were not consistent with values at either Ohio River or Little Saluda Creek stations during the entire 1977 and 1978 sampling period. These variations in bacterial population were probably due to the intermittent nature of the stream and the extreme effects which heavy rainfall and subsequent runoff have on its components.

Indiana Stream Pollution Control Board (SPC 1R-4) 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 count shall not exceed 2000 per 100 ml. Fecal coliforms exceeded the permissible maximum limit for all Ohio River stations during May and August of 1978. For Station 6 in Little Saluda Creek fecal coliform count was higher than recommended values only in May.

Fecal Streptococcus

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 four times as many fecal coliforms as fecal streptococci, while fecal streptococci dominate in the excrement of animals. A ratio of fecal coliforms to fecal streptococci (FC/FS) 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.

Fecal streptococcus values did not vary between Ohio River Stations 1 and 3 during the 1978 monitoring program (Figure B-3) and were within the same range as the 1977 data. Fecal streptococcus counts were much higher in August and November in Little Saluda Creek than at the Ohio River stations, but counts were still within the range found during the baseline study.

FC/FS ratios for Ohio River Stations 1 and 3 greatly exceeded 4.0 during May, but ranged from 0.82 to 5.0 during March, August and November. FC/FS ratios for Little Saluda Creek were less than 0.6 except in May when the ratio was 2.49. These data suggest that domestic sewage is the principal bacterial pollutant in the Ohio River, while bacterial contamination in Little Saluda Creek is derived from the feces of warm-blooded animals other than man.

FC/FS ratios for Station 8 were less than 0.6:1 in March, August, and November and were comparable to those at Station 6. This fact suggests that the source of bacterial contamination was similar to that in Little Saluda Creek. However, in May the ratio was 6.37 indicating contamination from human wastes.

CONCLUSIONS

Compared to control Station 1, Station 3 exhibited no increase in total coliform, fecal coliform, or fecal streptococci counts attributable to runoff from the plant site. Little Saluda Creek bacterial contamination increased during 1978 when compared with the 1977 and baseline studies. This increase parallels increased TOC values.

LITERATURE CITED

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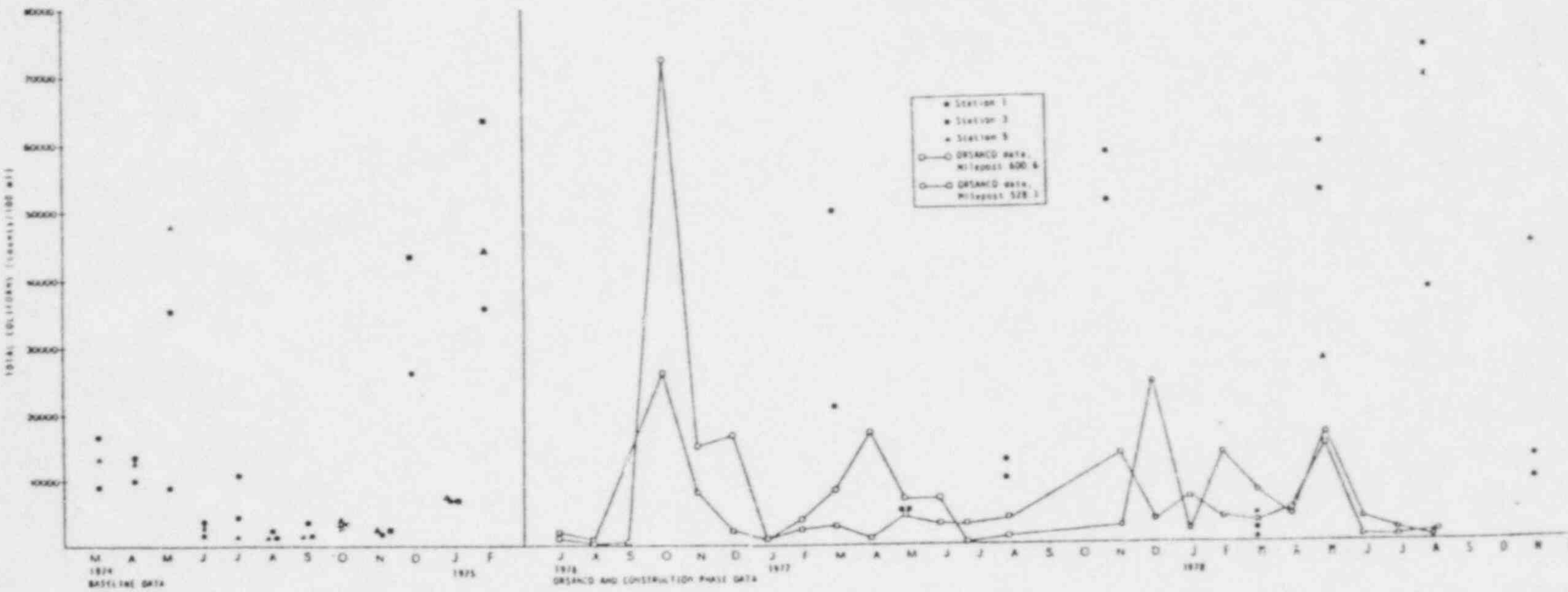

Figure B-1. Comparison of baseline, ORSANCO, and ABI total coliform counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

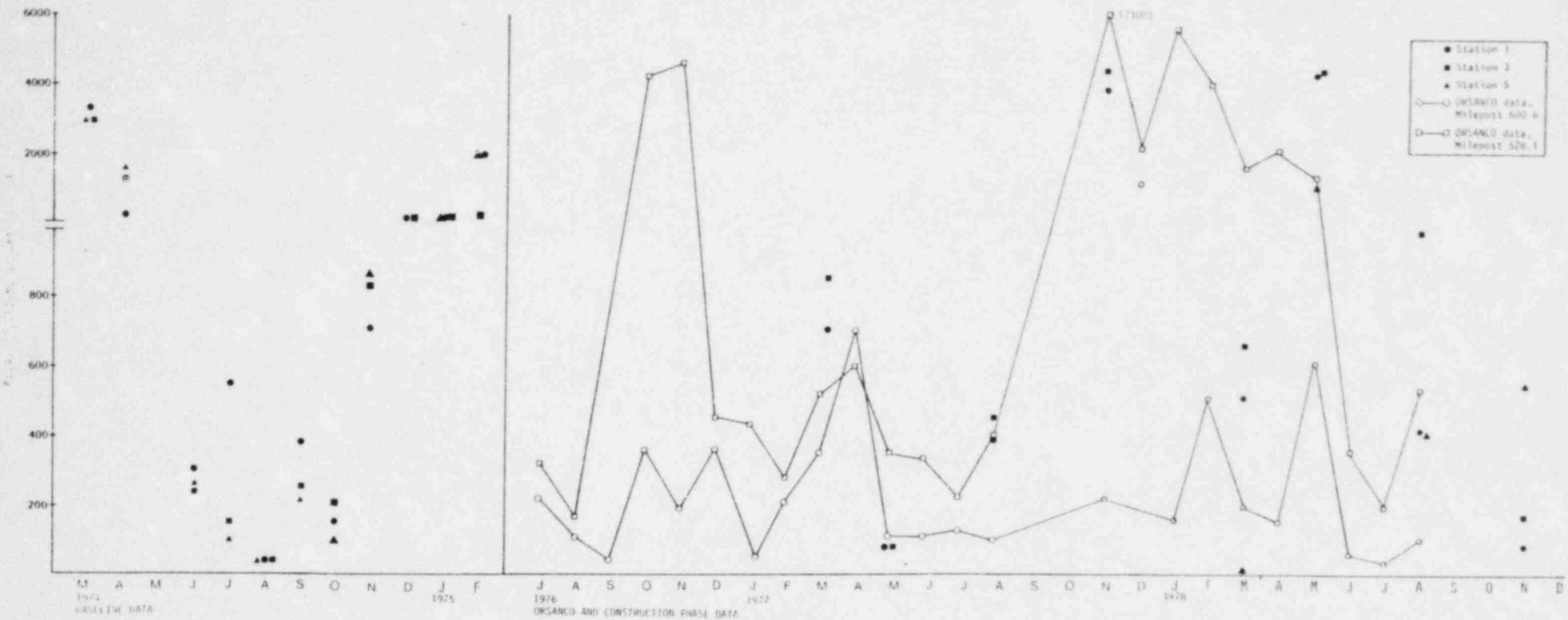

Figure B-2. Comparison of baseline, ORSANCO, and ABI fecal coliform counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

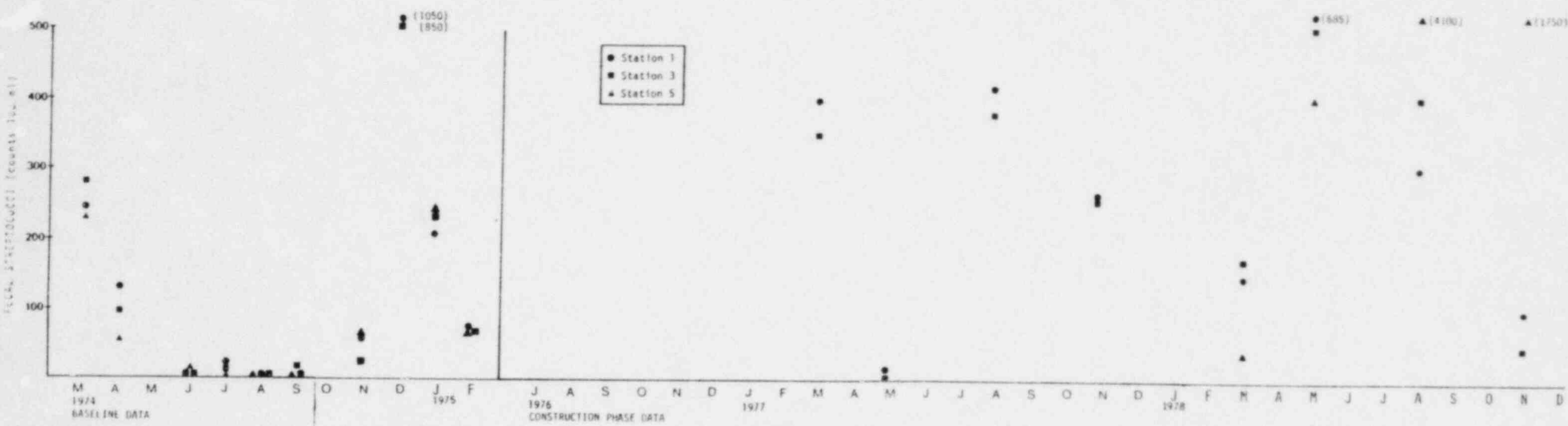

Figure B-3. Comparison of baseline and ABI fecal streptococci counts (average values) from samples taken in the Ohio River near the Marble Hill Plant site.

C. PLANKTON

C.1 PHYTOPLANKTON

Introduction

The purpose of the phytoplankton study at the Marble Hill Plant site was to determine species composition, abundance, and biovolume of phytoplankton in the Ohio River and in Little Saluda Creek during plant construction at the site. Plant construction began after the August 1977 sampling. Data collected during the 1978 monitoring program were compared to 1977 data (ABI, 1978) and to baseline data (PSI, 1976) in an evaluation of plant construction effects on phytoplankton.

Phytoplankton consists of the chlorophyll-bearing algae which passively drift or have limited means of locomotion and are, therefore, largely at the mercy of waves and currents in aquatic environments. Phytoplankters fix solar energy and inorganic nutrients into protoplasm through photosynthesis and form the basis of aquatic food relationships along with macrophytes, which are important contributors only in shallow waters (Reid, 1961). Phytoplankters are consumed by zooplankters and other filter feeders which, in turn, provide food for larger carnivores. Thus, phytoplankton abundance and composition determine, in part, the quantity and quality of all larger organisms which ultimately depend upon phytoplankters for food in any aquatic ecosystem.

Many studies have shown that the drifting algae in small headwater streams are benthic algae, typically diatoms, washed off the stream bottom. However, studies of large rivers have shown that true plankters often predominate and that diatoms are almost always the dominant phytoplankton group (Hynes, 1972). Seasonally, diatoms are joined by true plankters of the green and blue-green algal classes and also by a variety of flagellates. The changing phytoplankton population of large rivers must constantly be replenished from sources such as eddies and backflow areas, resulting from turbulent river flow, and from backwater areas and tributaries joining the river.

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 (0.3 m) water samples were collected with a non-metallic Kemmerer sampling device and preserved in the field with buffered formalin (40 ml concentrated formaldehyde/1000-ml sample).

In the laboratory, each one-liter replicate sample was allowed to settle a minimum of 10 days, after which each sample was concentrated to less than 200 ml by siphoning. Duplicate subsamples (0.15 to 5.0 ml) of each replicate sample concentrate were settled in Utermohl chambers (Utermohl, 1958). The degree of sample concentration and the volume of subsamples were determined by the amount of detritus and number of phytoplankters in the sample. Strip counts of approximately 200 phytoplankters per Utermohl replicate (400 phytoplankters per replicate sample) were made at 560X magnification.

Except for filamentous and colonial greens and blue-greens, all phytoplankters were counted individually. Filamentous green and blue-green species were counted as 100μ 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 per ml was calculated as N by:

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

where: V_c = Volume of sample concentrate (ml)

C = Count

V_e = Subsample volume (ml) x $\frac{\text{area of strips counted (mm}^2\text{)}}{\text{area of Utermohl chamber (mm}^2\text{)}}$

V_s = Volume of sample (ml).

Total diatoms were counted in Utermohl chambers. Species identification 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 vouchers of all samples analyzed were retained as a reference.

Taxonomic references used in the identification of phytoplankton species were: Van Heurck (1896), Walton (1915), Hustedt (1930), Skuja (1948), Smith (1950), Prescott (1962), Patrick and Reimer (1966 and 1975), Weber (1966 and 1970), Drouet (1968), Whitford and Schumacher (1969), Taft and Taft (1971), Sreenivasa and Duthie (1973), Komarek (1974) and Prescott et al. (1975).

Phytoplankton biovolume was estimated from optical measurements. The average volume for each predominant phytoplankter (comprising 5% or more of the total population at any station) was determined by measuring five individuals. The average dimensions were then 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 comprising less than 5% of the total population at any station, at least one biovolume measurement was made. Biovolume was expressed as μ^3/ml and calculated by the following equation:

$$\text{biovolume } (\mu^3/\text{ml}) = (N)\ (V_s)$$

where: N = Density of each species (no./ml)

V_s = Average volume of each species (μ^3)

Results and Discussion

A total of 284 phytoplankton species representing eight major divisions (Table C.1-1) were observed in collections from the Ohio River (Stations 1, 3 and 5) and Little Saluda Creek (Station 6). The major divisions were identical to those observed during 1977 and included 1) Bacillariophyta (diatoms), 2) Chrysophyta (yellow-brown algae), 3) Cryptophyta (cryptophytes), 4) Xanthophyta (xanthophytes), 5) Chlorophyta (greens), 6) Cyanophyta (blue-greens), 7) Euglenophyta (euglenoids) and 8) Pyrrhophyta (dinoflagellates). One additional major group, noted as Others, consisted of unidentified phytoflagellates. The phytoplankton community continued to be dominated by diatoms as in 1977 and baseline monitoring. The more common diatom and green algae species and euglenophytes were observed during all three years of monitoring.

Ohio River Stations

The 1978 total phytoplankton densities at Ohio River stations were slightly lower than 1977, and ranged from a low of 2506 cells/ml at Station 3 in March to a high of 9207 cells/ml at Station 1 in August. The seasonal pattern in density was not as consistent as that observed during the previous year (Figure C.1-1). Phytoplankton density was generally lowest during March, however, the increase in density during May and August was not as great as that observed in 1977 (ABI, 1978). Stations 1 and 3 exhibited similar seasonal density patterns during both years, while the highest density at Station 5 occurred in November. Since these perturbations in phytoplankton density were observed at all river stations, they were considered to be indicative of natural variation and not the result of plant construction. Total biovolume ranged from a low of 11,291x10^2 μ^3/ml at Station 5 in March to a high of 36,879x10^2 μ^3/ml at Station 3 in November (Tables C.1-2 through C.1-5). Biovolume was generally highest in November and lowest in March (Figure C.1-2). Density tended to decrease in November, however, larger diatom species and green algal species and colonies accounted, in part, for the high biovolume observed in the river during this month. Although seasonal patterns in phytoplankton density and biovolume were not as typical as those observed during 1977, they still reflected a normal seasonal cycle of high populations during warm water periods with low populations in early spring following a winter minimum.

Phytoplankton diversity (number of species) was comparable between years. The number of species per station ranged from 51 to 89 and the variation between river stations was greater than during 1977. Stations 3 and 5 were more diverse in May, while Station 1 was most diverse in August (Appendix Tables C.1-1 through C.1-4). The average number of species observed at Station 5 was slightly less than at Stations 1 and 3. Diatoms were most diverse in March and May, while green algae were most diverse in August and November. Blue-green algae were least diverse in November. This generally agreed with the seasonal species distribution observed in 1977 and reflects the typical ecological response of these groups to optimal temperature ranges for growth (Hynes, 1972). Diatoms generally have relatively low temperature tolerance ranges, while green algae tolerances cover a wider temperature range and blue-green algae have more species tolerant of very high temperatures (Patrick, 1973). Thus more diatom species may be expected during cold water temperature periods with increased green and blue-green diversity during and immediately following warm water periods.

Little Saluda Creek

Little Saluda Creek continued to exhibit different physical and chemical characteristics from those observed in the river. These habitat differences were reflected in different phytoplankton density, biovolume and relative abundance. Density and biovolume continued to be much lower than that in the river, although both of these parameters were generally higher than in 1977. Density ranged from 338 to 2709 cells/ml and biovolume from 1419×10^2 to 9173×10^2 μ^3/ml (Tables C.1-2 through C.1-5). Both density and biovolume increased from March to November. In 1978 the seasonal pattern in Little Saluda Creek was more similar to that observed in the river than during the previous year when the higher densities and biovolumes in the creek coincided with the lower values observed in the river.

The number of species in Little Saluda Creek ranged from 35 to 48 and diversity was considerably less than in the river. Diatoms continued to be the most important phytoplankton component during all quarters. Blue-greens and greens were relatively more important in the creek than in the river (Figure C.1-3).

Community Composition

The phytoplankton community in the river (Stations 1 through 5) continued to be dominated throughout the 1978 study by diatoms (Bacillariophyta). Diatoms contributed more than 70% to the total phytoplankton on all sampling dates (Figure C.1-3). This dominance was more pronounced than during the 1977 monitoring when diatoms contributed more than 50% to the total phytoplankton on all sampling dates (ABI, 1978). Diatom relative abundance was lowest during August and November, ranging from 73.3 to 82.3%, and highest during March and May, ranging from 84 to 93.7% (Tables C.1-2 through C.1-5). The pattern of high diatom relative abundance in March was also observed during the 1977 study, however, during that monitoring period, lowest relative abundance was observed in May. This difference in diatom importance may be due to differences in river conditions between May 1977 and May 1978 collections. Seasonal warming appeared to be later during 1978 when May water temperatures were approximately 6°C cooler than the previous year. Cooler water temperatures would be less favorable for the early spring and summer increase in warmer water phytoplankters such as chlorophytes, which seasonally become more abundant as water temperatures increase. Also, current velocity was lowest and Secchi depth highest during May 1977 when diatoms were least important and similar river conditions were observed during August and November 1978 when diatoms were least important.

Diatoms continued to be the dominant phytoplankton group in Little Saluda Creek, ranging from 64.2% of the total phytoplankton in March to 91.9% in May. Diatom relative abundance in Little Saluda Creek was again generally lower than in the river.

The dominant diatom species (contributing 5% or more to the total phytoplankton) were:

**Cyclotella Meneghiniana*
C. pseudostelligera
C. stelligera
**Cyclotella* sp. 1
**Melosira distans*
**M. granulata*
Melosira islandica subsp. *helvetica*
Stephanodiscus astraea
**Achnanthes minutissima*
**Gomphonema parvulum*
**Nitzschia dissipata*
**N. palea*

Those species with an asterisk were also dominant during 1977 and three of the above species, *C. Meneghiniana*, *M. distans* and *M. granulata*, were considered dominant in the baseline study (PSI, 1976). The diatom genera *Cyclotella*, *Melosira* and *Stephanodiscus* are typically dominant in the Ohio River and its tributaries (Williams and Scott, 1962; Weber and Moore, 1967.

C. Meneghiniana, Cyclotella sp. 1 and *S. astraea* were the most important dominant diatoms in terms of density and occurrence. *C. Meneghiniana* was always dominant and *Cyclotella* sp. 1 and *S. astraea* were dominant during most quarters. *C. Meneghiniana* is both periphytic and planktonic in habit (Lowe, 1974) and typically exhibits a fall maximum in density (Palmer, 1974). This species exhibited highest densities in August during both years of monitoring and accounted for more than 26% of the total phytoplankton during August 1978.

C. pseudostelligera, *M. distans*, *M. granulata*, *A. minutissima* and *N. palea* were also numerically important. *A. minutissima*, *G. parvulum*, *N. dissipata* and *N. palea* were most important during spring and early summer (March and May), while *C. stelligera*, *M. distans*, *M. granulata* and *M. granulata* subsp. *helvetica* were most important during late summer and fall (August and November). *M. granulata* is a summer form (Palmer, 1974) and was most important during May and August 1977. *Melosira* as well as many of the other dominant diatom species are considered to be characteristic for waters with high nutrient levels and many of these species have generally been reported as periphytic in habit (Holland, 1968; Palmer, 1969; Lowe, 1974).

The dominant diatom species exhibited various distributional patterns. *Cyclotella* sp. 1, *M. distans*, *A. minutissima* and *N. palea* were dominant in both the river and Little Saluda Creek. *C. stelligera*, *G. parvulum* and *N. dissipata* were dominant only in Little Saluda Creek. The remaining dominant diatom species exhibited dominance only in the river (Appendix Tables C.1-5 through C.1-8).

The Chlorophyta (greens), Cyanophyta (blue-greens) and Cryptophyta (cryptophytes) were the remaining important phytoplankton groups. Green algae were second to diatoms in importance during May, August and November. Density and biovolume in the river generally increased from May to a high in August when green algae accounted for 12 to 18% of the total phytoplankton. In Little Saluda Creek, density and biovolume increased from March to a maximum in November. Numerically dominant greens were *Characium* ? sp., *Chlamydomonas* sp. 1, *Chlamydomonas* sp. 3 and *Chlorella* ? sp. The three former species were dominant in Little Saluda Creek in November, while the latter species was dominant in the river at Station 1 in August. *Chlamydomonas* sp. 3 was dominant in the creek and *Chlorella* ? sp. was dominant in the river during May 1977.

Blue green algae were second to diatoms in importance during March when this group represented 5 to 10% of the total phytoplankton in the river and more than 20% in Little Saluda Creek. *Oscillatoria* sp. (1,2) was dominant at Station 1 and in the creek on this date and exhibited dominance in the creek in May and November 1977. Biovolume was generally highest in March, although maximum densities were observed in August. Blue-greens generally exhibited greater relative abundance in Little Saluda Creek than in the river.

Cryptophyte sp. 2 was dominant at Station 5 in November. This same pattern was evident in November 1977. Cryptophytes were generally less abundant than in the previous year.

Interstation Variation and Ecological Relationships

There was a significant difference in phytoplankton density between river stations.[a] Density at Station 5 was significantly less than at Stations 1 and 3 in August and density at Station 1 was significantly less than at Stations 3 and 5 in November (Table C.1-6). These differences were clearly evident (Figure C.1-1), but were not indicative of impact due to plant construction since Station 5 is downstream from the plant and Station 1 is upstream. There was no single pattern of seasonal variation common to all stations. Density at Station 1 during March, May and November was significantly less than in August; at Station 3 density was significantly lower in March than in all other quarters; and at Station 5 density was significantly lower in March than in November (Table C.1-7). High densities in August and low densities in March were observed in 1977.

There were no significant differences in biovolume between stations during the current monitoring program, although Station 3 exhibited significantly higher biovolume during 1977 (Table C.1-8).

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[a]These interstation differences were not significant when $\log_n$-transformed data were analyzed.

Biovolume was significantly greater in November than in March. This was partially attributable to the presence of larger diatom species and green algal species and colonies during November.

Phytoplankton density and biovolume were compared for both years of the current monitoring program. Construction began after August 1977, so the first year's data were essentially pre-construction. There were no significant differences in density or biovolume between stations or between years (Tables C.1-9 and C.1-10).

Density and biovolume exhibited a positive correlation with temperature at Station 1 (Tables C.1-11 and C.1-12). There was a positive correlation between density and temperature at Station 3. Thus density and biovolume increased with seasonally increasing water temperatures. These correlations by stations, utilizing both years of data, did not indicate dissimilar relationships which might be expected as a result of adverse impact due to plant construction.

Conclusions

Trends in phytoplankton density and composition were generally similar to those reported in the baseline study and to the 1977 monitoring prior to plant construction:

1) diatoms were dominant,

2) numerically dominant diatoms were similar as were seasonal patterns of some diatom species,

3) many of the more common species of green algae were similar,

4) green and blue-green algae increased seasonally, during the warmer months,

5) Little Saluda Creek exhibited reduced phytoplankton density and different community composition from that observed at river stations.

Although interstation variability was greater in 1978 than in 1977 and baseline data and seasonal trends in density and biovolume were less uniform between stations, differences indicative of adverse impact due to plant construction were not apparent.

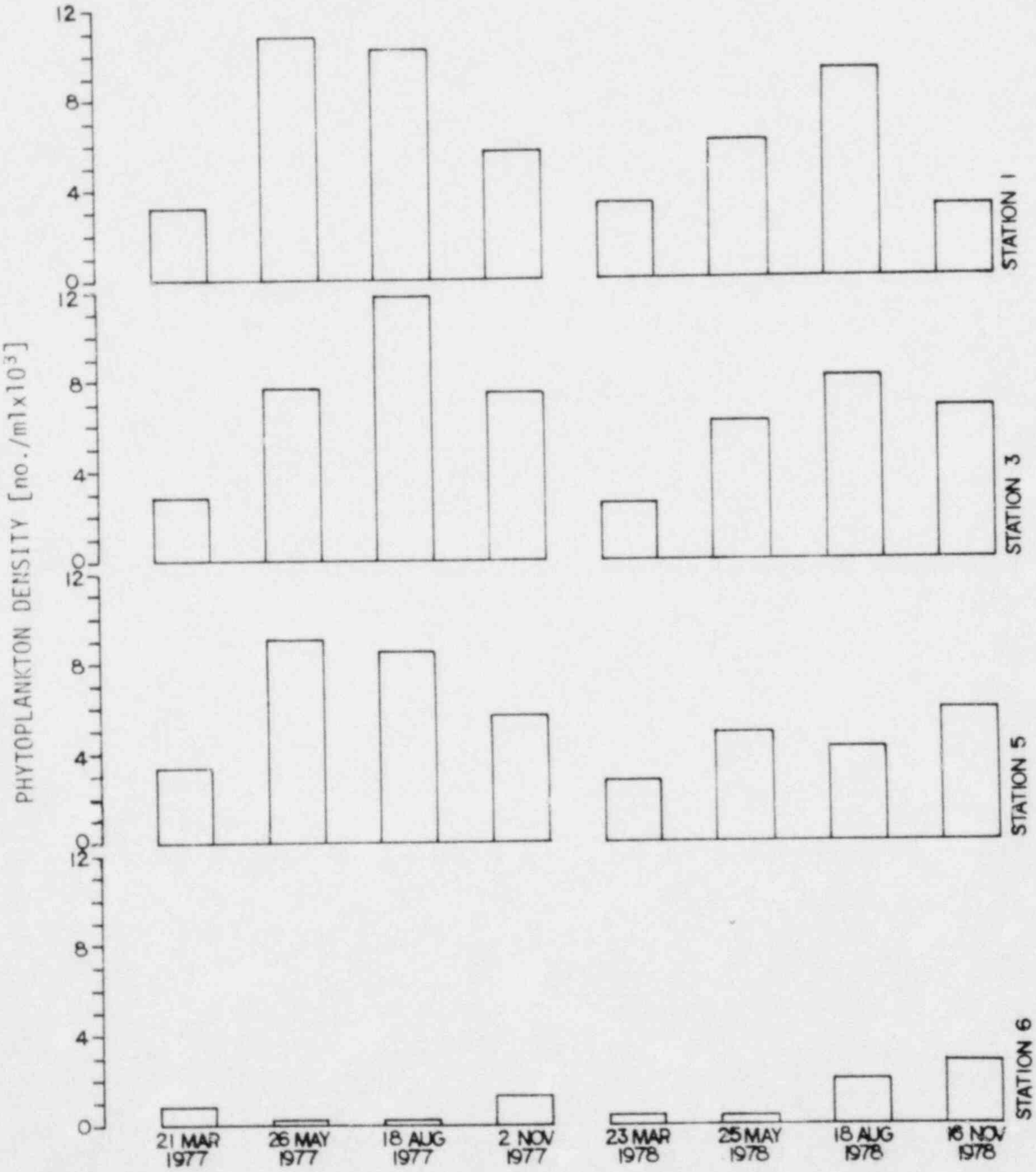

Figure C.1-1. Total phytoplankton density at Stations 1, 3, and 5 in the Ohio River and Little Saluda Creek Station 6, Marble Hill Plant site, March 1977-November 1978.

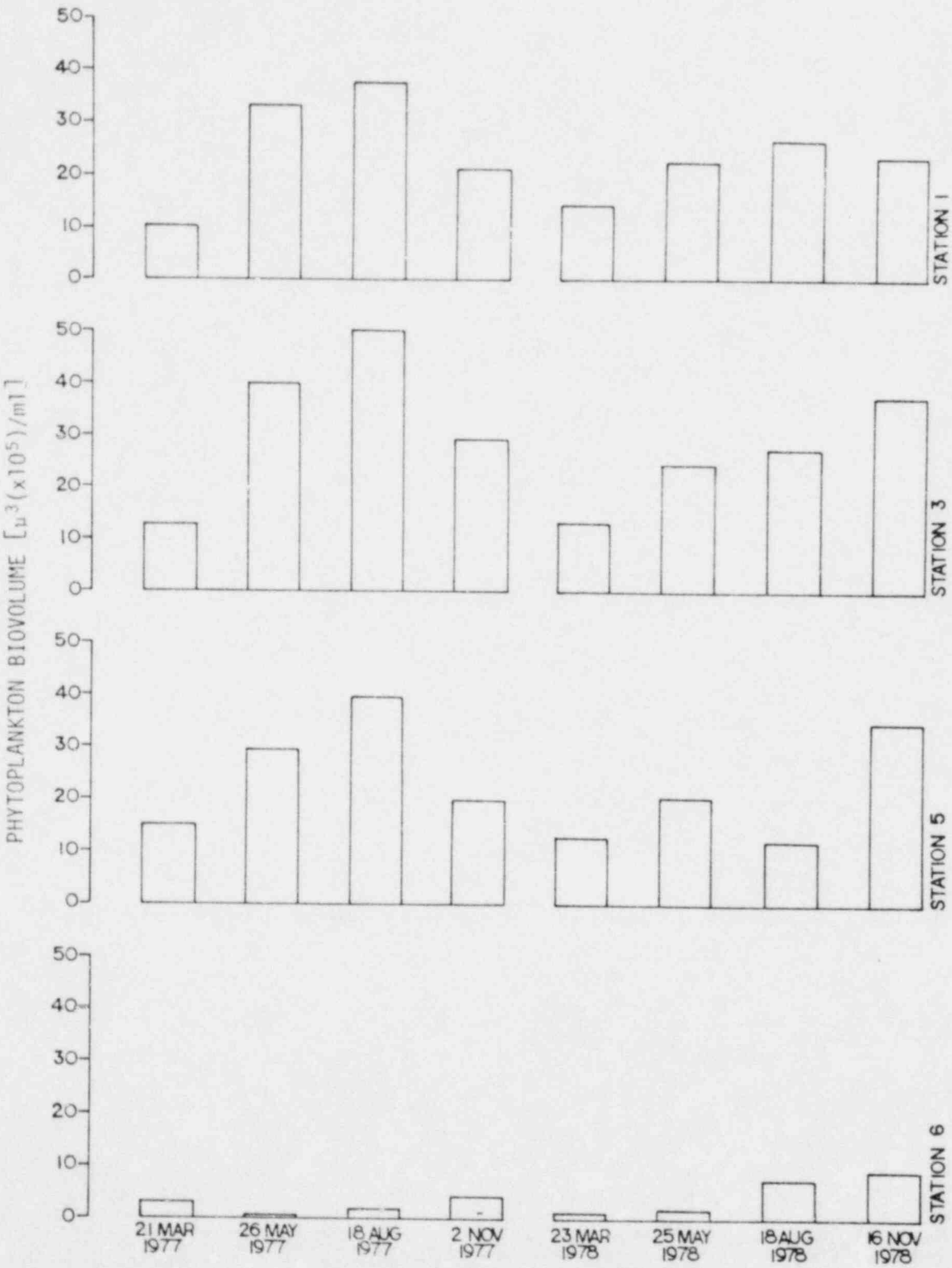

Figure C.1-2. Total phytoplankton biovolume at Stations 1, 3, and 5 in the Ohio River and Little Saluda Creek Station 6. Marble Hill Plant site, March 1977-November 1978.

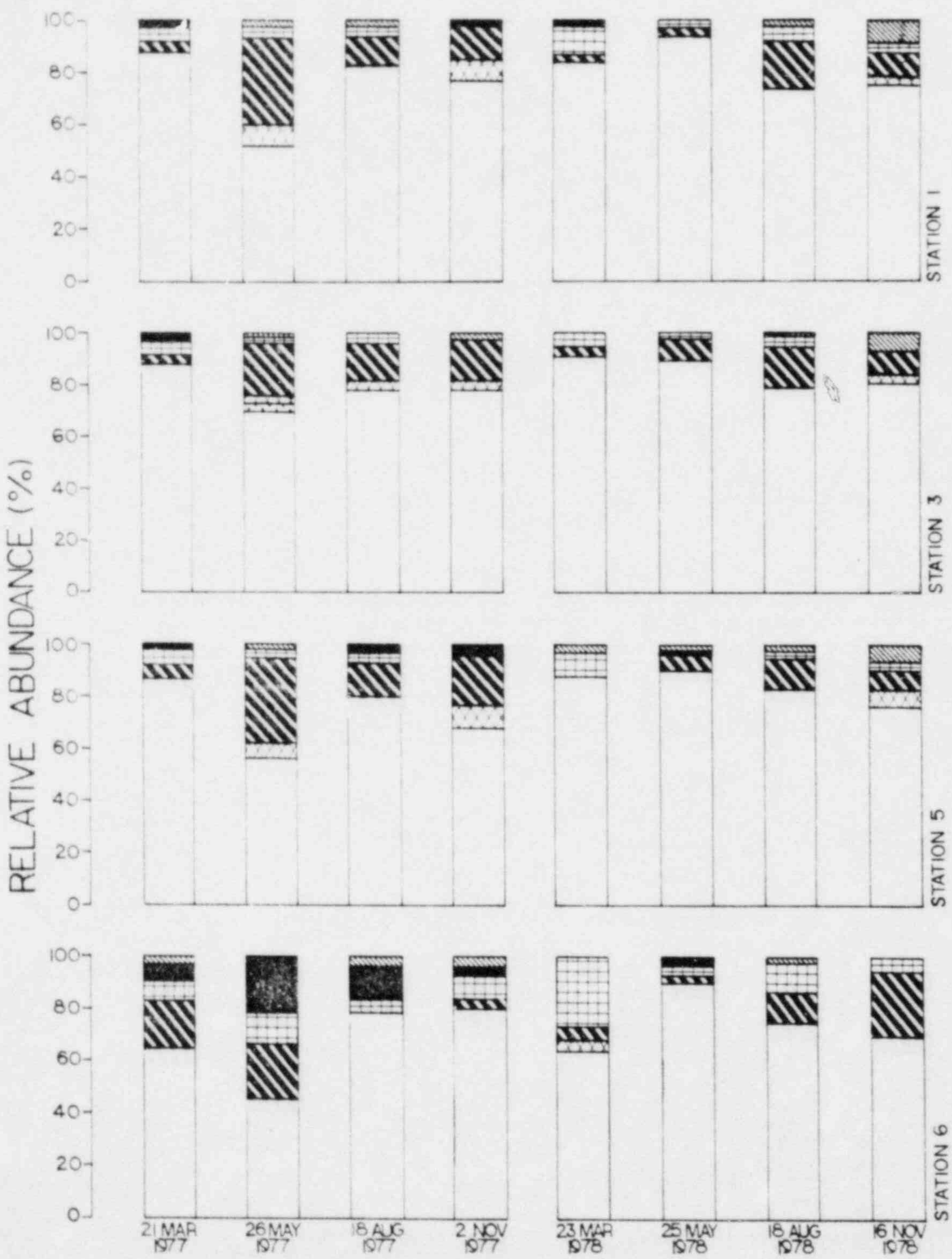

Figure C.1-3. Relative abundance of major phytoplankton groups at Stations 1, 3, and 5 in the Ohio River and Little Saluda Creek Station 6, Marble Hill Plant site, March 1977 - November 1978.

TABLE C.1-1

COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
23 MARCH - 16 NOVEMBER 1978

BACILLARIOPHYTA
Centrales
Coscinodiscus lacustris
Cyclotella bodanica
C. comta
C. glomerata
C. Meneghiniana
C. ocellata
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
Stephanodiscus astraea
Pennales
Achnanthes deflexa
A. fragilarioides
A. lanceolata
A. lanceolata v. dubia
A. minutissima
Achnanthes sp. 1
Achnanthes sp. 2
Achnanthes sp. 3
Amphipleura pellucida
Amphora ovalis v. pediculus
Amphora sp. 1
Asterionella formosa
A. formosa v. gracillima
Cocconeis pediculus
C. placentula
C. placentula v. lineata
Cymbella affinis
C. delicatula
C. minuta
C. minuta v. silesiaca
C. prostrata
C. prostrata v. auerswaldii
C. rupicola
C. tumida
Diatoma hiemale v. mesodon
D. vulgare
D. vulgare v. linearis
Eunotia exigua
Fragilaria capucina
F. crotonensis
Frustulia rhomboides v.
Gomphonema affine
G. angustatum v. obtusatum
G. brasiliense
G. olivaceum
G. parvulum
Gomphonema sp. 1
Gyrosigma acuminatum
G. modiferum
Gyrosigma sp. 1
Hantzschia sp. 1
Meridion circulare
Navicula accomoda
N. bacillum
N. canalis
N. contenta
N. cryptocephala
N. cryptocephala v. veneta
N. exigua v. capitata

BACILLARIOPHYTA (continued)
Pennales (continued)
N. gysingensis
N. hungarica v. capitata
N. mutica
N. rhyncocephala
N. tripunctata
N. viridula v. avenacea
N. viridula v. rostellata
Navicula sp. 1
Navicula sp. 2
Navicula sp. 3
Navicula sp. 4
Navicula sp. 5
Navicula sp. 8
Nitzschia acicularis v. closterioides
N. angustata
N. communis
N. communis v. abbreviata
N. dissipata
N. filiformis
N. ganderscheimiensis
N. palea
N. paradoxa
N. stagnorum
N. subtilis
N. tryblionella v. levidensis
N. tryblionella v. victoriae
Pinnularia abaujensis
P. subcapitata v. paucistriata
Rhoicosphenia curvata
Stauroneis smithii
Stauroneis sp. 1
Surirella angustata
S. ovalis
S. ovata
S. tenera
Synedra acus
S. amphicephala
S. delicatissima
S. radians
S. rumpens
S. rumpens v. familiaris
S. socia
S. tabulata
S. ulna
S. ulna v. aequalis
S. ulna v. contracta
S. ulna v. obtusa
S. ulna v. ramesi
Tabellaria flocculosa
unidentified pennate sp. 2

CHRYSOPHYTA
Botrydiopsis arhiza
Mallomonas ? sp. 1
Ophiocytium sp. 1
Stipitococcus vasiformis
chrysophyte sp. 1

CRYPTOPHYTA
Cryptomonas ovata
cryptophyte sp. 1
cryptophyte sp. 2

XANTHOPHYTA
xanthophyte sp. 1

CHLOROPHYTA
Actinastrum hantzschii

TABLE C.1-1
(continued)
COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
23 MARCH - 16 NOVEMBER 1978

CHLOROPHYTA (continued)
Actinastrum Hantzschii v. fluviatile
Ankistrodesmus Braunii
A. convolutus
A. falcatus
A. falcatus v. acicularis
A. falcatus v. convolutus
A. falcatus v. mirabilis
A. falcatus v. stipitatus
Arthrodesmus sp.
Carteria Klebsii
C. multifilis
Characium ? sp.
Chlamydomonas globosa
C. sphagnicola
Chlamydomonas sp. 1
Chlamydomonas ? sp. 2
Chlamydomonas sp. 3
Chlamydomonas sp. 5
Chlorella ? sp.
Closterium acutum v. variabile
C. moniliferum
C. parvulum v. angustatum
Closterium sp. 1
Closterium sp. 2
Coelastrum sphaericum
Cosmarium sp. 1
Cosmarium sp. 2
Cosmarium sp. 3
Cosmarium sp. 4
Crucigenia apiculata v.
C. fenestrata
C. quadrata
C. tetrapedia
C. truncata
Dictyosphaerium Ehrenbergianum
D. pulchellum
Franceia Droescheri
F. tuberculata
Gloeocystis ampla
G. planctonica
Golenkinia radiata
Kentrosphaera gloeophila
Kirchneriella contorta
K. lunaris
K. lunaris v. Dianae
K. lunaris v. irregularis
K. obesa
K. subsolitaria
Lagerheimia longiseta
L. quadriseta
L. subsalsa
L. wratislawiensis
Micractinium pusillum
M. eriense
M. quadrisetum
Oocystis Borgei
O. pusilla
Pandorina morum
Pediastrum duplex v. clathratum
P. tetras v. tetraodon
Pteromonas angulosa
Quadrigula sp.
Scenedesmus abundans
S. abundans v. longicauda
S. acuminatus
S. arcuatus
S. arcuatus v.
S. bijuga v.
Scenedesmus bijuga v. alternans

CHLOROPHYTA (continued)
Scenedesmus denticulatus
S. dimorphus
S. incrassatulus v. mononae
S. opoliensis
S. quadricauda
Scenedesmus sp. 2
Schroederia setigera
Selenastrum Westii
Selenastrum sp.
Stigeoclonium sp. 1
Tetraedron caudatum
T. minimum
T. muticum
Tetrastrum anomalum
T. elegans
T. glabrum
T. heteracanthum
T. punctatum
T. staurogeniaeforme
T. triacanthum
Treubaria setigerum
Westella botryoides
Westella ? sp.
coccoid green ?
unidentified green 1
unidentified green 2

CYANOPHYTA
Anabaena spiroides
Anabaena sp. 1
Aphanizomenon sp.
Chroococcus dispersus v. minor
C. limneticus
Dactylococcopsis acicularis
D. fascicularis ?
D. Smithii
Gomphosphaeria lacustris
G. lacustris v. compacta
Lyngbya aestuarii
L. contorta
L. Diguetii
L. limnetica
Lyngbya sp.
Marssoniella elegans
Merismopedia tenuissima
Microcoleus lyngbyaceus
Microcystis incerta
Nostoc sp. 1
Oscillatoria amphibia ?
O. lacustris ?
O. tenuis (sp. 4)
Oscillatoria sp. (1, 2)
Oscillatoria sp. 3
Phormidium minnesotense
Rhabdoderma Gorskii
R. irregulare
R. lineare
Spirulina laxissima
coccoid blue-green 1
filamentous blue-green sp. 1

EUGLENOPHYTA
Euglena sp. 1
Euglena sp. 3
Heteronema sp.
Lepocinclis texta
Phacus crenulata
P. helikoides
P. orbicularis

TABLE C.1-1
(continued)
COMPOSITE SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
23 MARCH - 16 NOVEMBER 1978

EUGLENOPHYTA (continued)
- *Phacus* sp. 1
- *Phacus* sp. 2
- *Trachelomonas Playfairii*
- *T. robusta*
- *T. superba* v.
- *T. urceolata*
- *T. volvocina*
- *Trachelomonas* sp. 1
- *Trachelomonas* sp. 2
- *Trachelomonas* sp. 5
- *Trachelomonas* sp. 6
- *Trachelomonas* sp. 7
- *Trachelomonas* sp. 8

EUGLENOPHYTA (continued)
- euglenoid sp. 1
- euglenoid sp. 3

PYRRHOPHYTA
- *Glenodinium pulvisculus*
- *Glenodinium* sp.
- dinoflagellate sp. 1

OTHERS
- phytoflagellate sp. 3
- phytoflagellate sp. 5
- phytoflagellate sp. 6
- phytoflagellate sp. 9
- phytoflagellate sp. 11

TABLE C.1-2

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOVOLUME [$\mu^3(\times10^2)$/ml]
MARBLE HILL PLANT SITE
23 MARCH 1978

	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]
Bacillariophyta	2720.2	84.0	11982.92	2277.2	90.9	12726.15	2398.8	87.5	9783.66	217.0	64.2	1265.65
Chrysophyta	17.0	0.6	18.87	7.4	0.3	4.18	14.9	0.5	8.42	1.0	0.3	4.63
Cryptophyta	8.5	0.3	6.88	0.0	0.0	0.00	14.7	0.5	7.03	12.8	3.8	10.36
Xanthophyta	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyta	105.6	3.1	269.41	66.6	2.7	499.71	37.3	1.4	957.26	15.9	4.7	64.82
Cyanophyta	328.1	10.2	699.25	133.3	5.2	97.41	242.3	8.7	359.55	88.3	26.1	70.83
Euglenophyta	58.0	1.8	1270.60	14.8	0.6	11.54	22.5	0.8	17.55	3.2	0.9	3.36
Pyrrhophyta	0.0	0.0	0.0	7.4	0.3	14.95	0.0	0.0	0.00	0.0	0.0	0.00
Others	0.0	0.0	0.0	0.0	0.0	0.0	14.9	0.6	157.57	0.0	0.0	0.00
Total	3237.4		14247.93	2506.7		13353.94	2745.4		11291.04	338.2		1419.65
std. dev.	±420.6			±312.3			±284.4			±26.4		

TABLE C.1-3

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOVOLUME [$\mu^3(x10^2)$/ml]
MARBLE HILL PLANT SITE
25 MAY 1978

	Station 1			Station 3			Station 5			Station 6		
	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	5664.8	93.7	22332.44	5411.4	88.1	23519.08	4315.5	90.1	20183.16	363.1	91.9	1315.17
Chrysophyta	-	-	-	-	-	-	-	-	-	-	-	-
Cryptophyta	0.0	0.0	0.00	9.3	0.2	5.81	43.6	0.9	37.67	0.0	0.0	0.00
Xanthophyta	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyta	244.3	3.9	543.21	488.0	8.1	817.94	283.7	6.5	450.79	5.9	1.5	9.11
Cyanophyta	101.6	1.6	147.62	141.5	2.3	270.28	67.4	1.5	87.50	19.2	5.0	15.01
Euglenophyta	46.2	0.8	36.04	73.8	1.3	178.79	43.7	1.0	292.37	6.4	1.6	506.01
Pyrrhophyta	-	-	-	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-	-	-	-
Total	6056.9		23059.31	6124.0		24791.90	4753.9		21051.49	394.6		1845.30
std. dev.	±481.6			±1782.7			±939.0			±16.4		

TABLE C.1-4

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOVOLUME [$\mu^3(\times10^2)$/ml]
MARBLE HILL PLANT SITE
18 AUGUST 1978

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]
Bacillariophyta	6814.6	73.3	22057.57	6401.7	78.9	22410.51	3437.5	82.3	9252.77	1468.0	75.1	6626.39
Chrysophyta	14.5	0.2	16.40	6.9	0.1	38.47	0.0	0.0	0.00	0.0	0.0	0.00
Cryptophyta	80.5	0.9	51.28	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
Xanthophyta	-	-	-	-	-	-	-	-	-	-	-	-
Chlorophyta	1614.5	18.1	3257.17	1192.5	14.9	1643.00	504.8	12.4	1275.74	230.2	11.8	127.50
Cyanophyta	588.9	6.3	557.14	324.6	4.1	239.27	120.1	3.0	127.52	223.4	11.5	479.89
Euglenophyta	94.7	1.2	494.34	129.2	1.7	2000.33	75.6	1.8	240.77	25.4	1.3	158.64
Pyrrhophyta	0.0	0.0	0.00	22.9	0.3	1099.15	18.9	0.5	1368.02	0.0	0.0	0.00
Others	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	5.0	0.3	12.33
Total	9207.7		26433.90	8077.8		27430.73	4156.9		12264.82	1952.0		7404.75
std. dev.	±1278.5			±1613.3			±597.3			±250.0		

TABLE C-1.5

SUMMARY OF PHYTOPLANKTON DENSITY (no./ml), RELATIVE ABUNDANCE (%), AND BIOVOLUME [$\mu^3(\times10^2)$/ml]
MARBLE HILL PLANT SITE
16 NOVEMBER 1978

Taxon	Station 1			Station 3			Station 5			Station 6		
	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]	Density (no./ml)	Relative abundance (%)	Biovolume [$\mu^3(\times10^2)$/ml]
Bacillariophyta	2368.1	75.5	15572.34	5416.6	80.7	34226.88	4661.2	76.4	33092.97	1879.1	69.5	5505.49
Chrysophyta	12.1	0.4	44.64	29.5	0.4	108.82	8.8	0.2	32.46	0.0	0.0	0.00
Cryptophyta	117.3	3.8	226.62	256.8	3.8	496.14	393.8	6.7	671.36	0.0	0.0	0.00
Xanthophyta	6.0	0.2	120.76	8.4	0.1	169.07	8.8	0.2	177.11	0.0	0.0	0.00
Chlorophyta	273.8	9.0	5277.86	555.9	8.5	1047.38	436.4	7.7	645.44	689.4	25.4	3554.56
Cyanophyta	108.3	3.4	79.15	114.6	1.6	181.87	117.5	2.1	28.83	134.4	4.9	109.59
Euglenophyta	54.1	1.8	1041.50	46.4	0.7	105.08	25.2	0.4	28.50	6.1	0.2	3.99
Pyrrhophyta	-	-	-	-	-	-	-	-	-	-	-	-
Others	183.5	5.9	480.75	277.8	4.2	544.43	184.3	6.3	386.20	0.0	0.0	0.00
Total	3123.2		22843.62	6706.0		36879.67	5836.0		35062.87	2709.0		9173.63
std. dev.	±336.6			±438.8			±1099.2			±211.7		

TABLE C.1-6

ANALYSIS OF VARIANCE AND TUKEY'S TEST FOR PHYTOPLANKTON DENSITY
AT OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH-NOVEMBER 1978

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	F value
Stations (S)	2	8921660.55	4460830.28	4.32*
Months (M)	3	62528800.07	20842933.36	20.17*
Station x month Interaction (I)	6	35610893.39	5935148.90	5.74*
Error	12	12399912.89	1033326.07	
Total	23	119461266.90		

*Significant at α=.05. N = 24; critical $F_{.05[2,12]}$ =3.89; critical $F_{.05[3,12]}$ = 3.49; critical $F_{.05[6,12]}$ = 3.00

TUKEY'S TEST

Station Comparison For August

Station (mean)	3 (8077.8)	5 (4156.9)
1 (9207.7)	1129.9	5050.8*
3 (8077.8)		3920.9*

Station Comparison For November

Station (mean)	3 (6706.0)	5 (5836.0)
1 (3123.2)	3582.8*	2712.8*
3 (6706.0)		870.0

*Significant at α=.05, critical HSD = 2709.9

TABLE C.1-7

TUKEY'S HSD COMPARISON OF PHYTOPLANKTON DENSITY BY QUARTERS
AT OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH-NOVEMBER 1978

Quarterly Comparison For Station 1

Month (mean)	May (6056.9)	August (9207.7)	November (3123.2)
March (3237.4)	2819.5	5970.3*	114.2
May (6056.9)		3150.8*	2933.7
August (9207.7)			6084.5*

Quarterly Comparison For Station 3

Month (mean)	May (6124.0)	August (8077.8)	November (6706.0)
March (2506.7)	3617.3*	5571.1*	4199.3*
May (6124.0)		1953.8	582.0
August (8077.8)			1371.8

Quarterly Comparison For Station 5

Month (mean)	May (4753.9)	August (4156.9)	November (5836.0)
March (2745.4)	2008.5	1411.5	3090.6*
May (4753.9)		597.0	1082.1
August (4156.9)			1679.1

*Significant at α=.05, critical HSD = 3018.9

TABLE C.1-8

ANALYSIS OF VARIANCE AND TUKEY'S TEST FOR PHYTOPLANKTON BIOVOLUME
AT OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH-NOVEMBER 1978

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	F value
Stations (S)	2	68243120.69	34121560.35	1.00
Months (M)	3	522110287.30	174036762.43	5.12*
Error	6	203825114.61	33970852.43	
Total	11	794178522.60		

*Significant at α=.05. N = 12; critical $F_{.05[2,6]}$ = 5.14; critical $F_{.05[3,6]}$ = 4.76

TUKEY'S TEST

Quarterly Comparison

Month (mean)	May (22967.57)	August (22043.15)	November (31595.39)
March (12964.30)	10003.27	9078.85	18631.09*
May (22967.57)		924.29	8627.82

*Significant at α=.05, critical HSD = 16488.8

TABLE C.1-9

ANALYSIS OF VARIANCE FOR PHYTOPLANKTON DENSITY
AT OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH 1977-NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean square	F value[a]
Stations (S)	2	6210105.24	3105052.62	0.37
Years (Y)	1	23229682.37	23229682.37	2.78
Station x year Interaction (I)	2	394209.03	197104.52	0.02
Error	18	150590971.80	8366165.10	
Total	23	180424968.40		

[a] $F_{.05[2,18]} = 3.57$; $F_{.05[1,18]} = 4.43$

TABLE C.1-10

ANALYSIS OF VARIANCE FOR PHYTOPLANKTON BIOVOLUME
AT OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH 1977-NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean square	F value[a]
Stations (S)	2	200694675.60	100347337.80	0.77
Years (Y)	1	187281156.70	187281156.70	1.44
Station x year Interaction (I)	2	10516225.35	5258112.68	
Error	18	2349025105.00	130501394.70	0.04
Total	23	2747517162.00		

[a] $F_{.05[2,18]} = 3.57$; $F_{.05[1,18]} = 4.43$

TABLE C.1-11

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON DENSITY AND SELECTED PHYSICAL AND CHEMICAL PARAMETERS MARBLE HILL PLANT SITE MARCH 1977-NOVEMBER 1978

	Ohio River Stations (N=8)			Little Saluda Creek (N=8)
Parameter	1	3	5	6
Temperature	0.923*	0.819*	0.694	-0.135
Current	-0.351	-0.425	-0.527	-
Secchi depth	0.071	0.271	0.536	-
Nitrate nitrogen	-0.230	-0.450	-0.268	0.237
Ammonia nitrogen	-0.566	-0.343	-0.165	0.411
Orthophosphate	0.127	0.199	-0.356	0.639
Dissolved silica	-0.163	-0.403	-0.521	-0.700

*Significant at α=.05; critical r=0.707.

TABLE C.1-12

SIMPLE CORRELATION COEFFICIENTS (r) FOR PHYTOPLANKTON BIOVOLUME
AND SELECTED PHYSICAL AND CHEMICAL PARAMETERS
MARBLE HILL PLANT SITE
MARCH 1977-NOVEMBER 1978

	Ohio River Stations (N=8)			Little Saluda Creek (N=8)
Parameter	1	3	5	6
Temperature	0.843*	0.694	0.453	-0.115
Current	-0.452	-0.540	-0.499	-
Secchi depth	0.333	0.534	0.649	-
Nitrate nitrogen	-0.269	-0.344	-0.290	0.245
Ammonia nitrogen	-0.437	-0.158	0.058	0.379
Orthophosphate	0.137	0.069	-0.391	0.681
Dissolved silica	-0.466	-0.609	-0.673	-0.709*

*Significant at α=.05; critical r=0.707.

C.2 ZOOPLANKTON

Introduction

The purpose of this 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. These findings were then compared to the baseline and 1977 data to evaluate the potential impacts of construction at the Marble Hill Plant site.

Zooplankton collectively refers to microscopic and macroscopic aquatic animals that are free-floating or capable of limited self-locomotion. Zooplankton are an important link in the food web of aquatic environments; they are the major consumers of phytoplankton and in turn provide an important food source for larger macroinvertebrates and fishes.

One of the most important agents affecting the distribution of zooplankton in a river is the movement of water. Zooplankton populations of a large river system, such as the Ohio River, are sometimes subjected to rapid changes in river morphometry, from turbulent waters and eddies to slow-moving pools. Zooplankton populations of a river community are therefore likely to vary considerably along the river's length in both space and time (Hynes, 1972).

Materials and Methods

Duplicate zooplankton samples were collected 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 the spatial distribution of zooplankton. A plastic funnel was attached to the end of the weighted intake hose to minimize the effect of selective catches due to avoidance by stronger swimming zooplankters (Welch, 1948). Thirty-two liters of water from each depth at river Stations 1, 3 and 5 was filtered through an 80μ-mesh Wisconsin net suspended over a volumetric container. Concentrated samples from all three depths at each river station were consolidated into a 250-ml polyethylene bottle. Because water levels were low in Little Saluda Creek, 96 liters of water was filtered from mid-depth only. Zooplankton samples were preserved immediately after collection in a five percent formalin solution buffered to pH 7-8 with sodium borate.

In the laboratory, the samples were allowed to settle for a minimum of 48 hours. The settled samples were concentrated to a volume of approximately 20 ml by siphoning and placed in vials for analysis. The final concentrate volume of the sample was based on the amount of detritus and density of zooplankters in the sample.

Zooplankton identifications and counts were made by placing a well-mixed aliquot of concentrate into a 1-ml Sedgwick-Rafter counting chamber. Entire Sedgwick-Rafter chambers were enumerated at 100X magnification. When possible, a minimum of 100 organisms were examined from each of four identically prepared chambers per replicate. Organisms to be dissected for species identification were removed from the counting chamber and dissected under a stereoscopic microscope. All zooplankters were identified to the lowest practicable taxon. Taxonomic references used for zooplankton identifications include: Ahlstrom (1940 and 1943), Rylov (1948), Pennak (1953 and 1963), Brooks (1957), Corliss (1959), Ward and Whipple (1959), Harding and Smith (1960), Borror and Delong (1964), Honiberg, et al. (1964), Mackinnon and Hawes (1966), Barnes (1969), Deevey and Deevey (1971), Jahn and Jahn (1971), Kudo (1971), Usinger (1971), Meglitsch (1972), Mordukhai-Boltovskoi and Chirkova (1973), Fryer (1974), Ruttner-Kolisko (1974), McNair (1976), Chengalath, et al. (1978), and Smith and Fernando (1978).

Zooplankters per liter were calculated as N by:

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

where: C = Count

V_s = Volume of sample concentrate (ml)

V_c = Volume of concentrate enumerated (ml)

V_i = Initial volume of sample (liters)

Whole zooplankton samples were retained as vouchers.

Fragmented cladoceran carapaces were frequently observed in the zooplankton samples collected during the 1977 monitoring program. These fragments were enumerated and reported as "damaged cladocera"; however, their densities were not included in the data discussion because of their uncertain origin.

To determine the number of cladocera carapaces present in bottom sediments due to natural molting processes, a Ponar dredge sample was taken near Station 1 during the August 1978 quarterly sampling period. Results of analyses suggested that fragmented carapaces observed in the zooplankton samples most likely result from the resuspension of carapace molts in the water column during periods of high water flow. Damaged categories that appear in Appendix Tables C.2-1 through C.2-4 reflect the enumeration of only those individuals which have undergone recent physical damage from natural or mechanical causes and do not include carapace molts as reported in the 1977 study.

Results and Discussion

The zooplankton species collected during the second year of construction phase ecological monitoring near the Marble Hill Plant site represented four major groups: Protozoa, Rotifera, Cladocera and Copepoda. Incidentally planktonic forms, such as insect larvae and miscellaneous organisms were grouped together and reported under the "Others" category.

A total of 85 taxa were recorded during this study with rotifers accounting for nearly 50% of the species found (Table C.2-1). Zooplankton composition, density and relative abundance by station and date are presented in Appendix Tables C.2-1 through C.2-8.

Although species diversity varied little between collection dates, zooplankton densities were highly variable between seasons (Figure C.2-1). Annual variations of zooplankton densities in temperate climatic regions are highly variable, but generally follow a low winter/early spring production period followed by a sharp increase in densities towards the warmer summer months and a decrease in abundance through winter. Zooplankton densities for the river stations ranged from 6.1 organisms per liter at Stations 1 and 3 in August to 121.3 zooplankters per liter at Station 3 in November (Tables C.2-2 through C.2-5). Zooplankton numbers in Little Saluda Creek

(Station 6) did not exceed 2.7 organisms per liter for the first three collection periods, but averaged over 33 zooplankters per liter in the November samples.

Ohio River Stations

Interstation differences in zooplankton abundance between Ohio River Stations 1, 3 and 5 were not statistically significant during 1978 collections (Table C.2-6). This is typical for flowing-water environments where turbulence results in a more homogeneous distribution of organisms. Zooplankton densities over short distances (4.83 km) on the Illinois River were found to vary from the mean by no more than 10% (Kofoid, 1903). Temporal changes in zooplankton composition and abundance near the Marble Hill Plant site were characteristic of those found in large rivers that are influenced by physical and climatic changes in light, temperature, water levels, turbulence, silt, and the availability of food (PSI, 1976; ABI, 1975, 1977 and 1978).

Mean zooplankton densities in March ranged from 32.6 zooplankters per liter at Station 3 to 44.2 organisms per liter at Station 1 (Table C.2-2). The numerically dominant taxonomic group was protozoa (Figure C.2-2), which comprised 83.9 to 88.5% of the total zooplankton collected at the river stations for this date (Figure C.2-3). *Centropyxis* spp. was the dominant taxon found with other typical larger river protozoan genera, such as *Difflugia* and *Arcella* recorded. The sessile protozoans, *Carchesium*, *Vorticella* and *Zoothamnium* were also collected on this date. Freshwater protozoa occupy diverse habitats. The thecate forms, including *Centropyxis* and *Difflugia*, and sessile groups like *Carchesium* prefer living among vegetation, on floating or submerged debris, or on the bottom in shallow and slow moving waters. Most freshwater protozoa are considered to be epibenthic, that is, living on or just above the substrata.

High water levels on 21 March along with heavy silt loads and associated rapid currents most likely produced a scouring effect in the river and were responsible for the increased occurrence of these epibenthic forms. Rotifers, cladocerans and copepods were also present in the March collections, but had comparatively low relative abundance values (8.9% or less of the total zooplankton) for this date (Figure C.2-3). Rotifer and cladoceran densities both had a significant negative correlation with current velocities and a significant positive relationship to Secchi disc measurements (Table C.2-7). Zooplankton data from the 1977 monitoring program suggested that suspended silt reduced the numbers of rotifers in the water column during periods of high stream flow. Many cladocera may also be eliminated by silt when turbulent water prevents selective feeding, resulting in the ingestion of sand and silt materials (Hynes, 1972).

Although total zooplankton densities in May were similar to those found in March, the number of taxa present, particularly rotifers, increased. Rotifers contributed 39.4 to 45.5% to the total zooplankters collected (Table C.2-3), with *Keratella cochlearis* and *Brachionus calyciflorus* the two dominant rotifer species recorded. *K. cochlearis* was the most widely distributed and abundant rotifer collected in a study of 128 sampling stations on the major rivers and Great Lakes of the United States (Williams, 1966). The reproduction rate in rotifers is temperature dependent. In *K. cochlearis*, this effect is most marked with optimal temperatures at 17 to 18°C. Water temperatures on 24 May averaged 18.2°C at the river stations, providing suitable reproductive conditions for *K. cochlearis* and other rotifer species with similar optimal temperatures.

The second major contributor to the total zooplankton assemblage in May was protozoans (mostly *Centropyxis* spp.), followed by copepods, (specifically naupliar and copepodite developmental stages), with average densities of 11.6 and 8.8 organisms per liter, respectively.

Total cladoceran densities on this date were less than one individual per liter, and thus showed little increase in abundance from the March collections.

Zooplankton densities in August were significantly reduced from the March and May densities (Table C.2-6). Total zooplankton densities ranged from 6.1 zooplankters per liter at Stations 1 and 3 to 7.6 organisms per liter at Station 5 (Table C.2-4). Protozoan, cladoceran and copepod groups each exhibited total densities of less than one organism per liter for this date. Rotifers, although present in low densities, represented a comparatively large percentage of the total zooplankton populations. *Brachionus calyciflorus* and *B. havanaensis* were the two dominant rotifer species.

Reduced densities in August were most likely the result of high water temperatures. Increasing temperatures affect the composition of the zooplankton community through the progressive exclusion of less temperature tolerant species. Hodgkinson (1970) suggested that temperatures may be the primary factor in determining seasonal succession in rotifers. Most rotifer species are considered as being eurythermal, having a wide range of temperature tolerances. This serves to adapt these species to the seasonal fluctuations that occur in temperate climates such as in the vicinity of the Marble Hill Plant site.

Water temperatures in August at the river stations averaged over 27°C, exceeding the optimal temperature ranges of most zooplankton species. First year construction phase monitoring program at the Marble Hill Plant site also demonstrated low zooplankton densities in the month of August.

Zooplankton densities on 14 November were significantly higher than on any previous sampling date (Table C.2-6). Zooplankton densities were 94.2 zooplankters per liter at Station 1, 121.3 at Station 3 and 74.3 at Station 5. Rotifers were the numerically dominant group and accounted for 43.3 to 51.9% of the total zooplankton population.

Of the 19 rotifer species collected in November, *Brachionus calyciflorus* and *Keratella cochlearis* were the dominant forms. Although more than one rotifer genus often dominates in a single sample, each genus tends to have only one major species represented (Williams, 1966). This may be a simple trophic effect where interspecific competition limits the co-dominance of two similar species or it may be that conditions favor both types of organisms. Other major contributors to zooplankton composition and abundance on this date were the cladoceran, *Bosmina longirostris* and the colonial protozoan, *Epistylis* sp. Crustaceans, which are important in the lenitic plankton of lakes, are rarely numerous in the open waters of rivers. However, the small size and round shape of *B. longirostris* favors its survival in flowing environments. *B. longirostris* densities ranged from 24.3 per liter at Station 1 to 48.4 per liter at Station 5.

Hynes (1972) suggested that zooplankton of large river systems originate in still or gently flowing areas. Beach (1960) and Williams (1966) supported this concept and concluded that rotifer populations of flowing environments are not qualitatively different from those of lakes and impoundments. Numerous small streams and pools empty into the Ohio River. These areas of slow water replacement allow concentration of nutrients and may provide suitable sites for zooplankton recruitment. These areas may thus provide the river with its initial source of zooplankton during periods of high productivity. The November increase in total zooplankton densities, and rotifer abundance in particular, is attributed to a wide variety of physical and chemical parameters that are highly variable along the course of the river.

Little Saluda Creek

Zo. lankton densities in Little Saluda Creek reflected the unstable habitat of small streams of intermittent flow and varying size. Zooplankton abundance averaged 1.3 organisms per liter in

March, 2.1 per liter in May, 2.7 per liter in August and 33.9 zooplankters per liter in November. Generally, zooplankton composition in Little Saluda Creek was similar to that of the river stations, however, zooplankton densities at the river stations were consistently higher than those in Little Saluda Creek. The increase in zooplankton densities at Station 6 in November reflected the seasonal pulse of zooplankters observed at the river stations, but showed a disproportionate number of protozoans in the sample. Protozoans accounted for 45.6% of the total zooplankters collected in Little Saluda Creek on this date. *Centropyxis* sp., a thecate, epibenthic form normally associated with bottom substrates, was dominant. The increased occurrence of protozoans at Station 6 was attributed to the high stream flow observed during November collections.

Data Comparison Between Years

Although zooplankton densities varied considerably between years and months (Figure C.2-4), no significant statistical differences were found between 1977 and 1978 zooplankton densities (Table C.2-8). However, general trends indicate reduced total zooplankton densities in 1978 compared to 1977 and baseline data. This most likely is attributable to natural annual variation rather than the effects of construction at the Marble Hill Plant site. No statistically significant relationships between zooplankton density and physical parameters over the two year monitoring period were observed (Table C.2-9).

Seasonal zooplankton composition between the four months considered (March, May, August and November) showed similar species diversities and relative abundance values over the three years of study. The seasonal pattern of protozoan dominance in early spring collections when river flow was high, was followed by increasing rotifer densities that oscillated throughout the late spring and autumn collection periods. During the baseline and construction phase monitoring programs the co-dominance of the rotifers *Brachionus calyciflorus* and *Keratella cochlearis* was common during the months of May and November when water temperatures were near optimal for these species. Changes in zooplankton composition and abundance appear to be related to natural environmental variations and seasonal changes in water movement, temperature and food availability and are not influenced by construction activity at the Marble Hill Plant site.

Conclusions

Zooplankton densities at the river stations were generally lowest in August and highest in November. No significant differences in zooplankton abundance between river stations were found.

Zooplankton populations in Little Saluda Creek were lowest in March and highest in November. Zooplankton composition in

Little Saluda Creek and at the river stations was qualitatively similar; however, zooplankton densities at the river stations were consistently higher than those in Little Saluda Creek on all sampling dates.

Although not statistically significant reduced zooplankton densities as compared to baseline and early construction phase monitoring were evident in 1978. However, these differences probably reflect natural annual variability rather than variations due to plant effect. Zooplankton abundance and species diversity in the Ohio River in the vicinity of the Marble Hill Plant site were consistent with those reported during previous studies.

A significant negative correlation between current velocity and total cladocera and rotifer densities may be attributable to increased silt loads during periods of high stream flow. Temperature has a direct ecological effect on the composition and abundance of zooplankters found in the Ohio River, and is particularly important in the seasonal succession of rotifers. No apparent perturbations to the zooplankton community were attributable to impact from construction activities near the Marble Hill Plant site.

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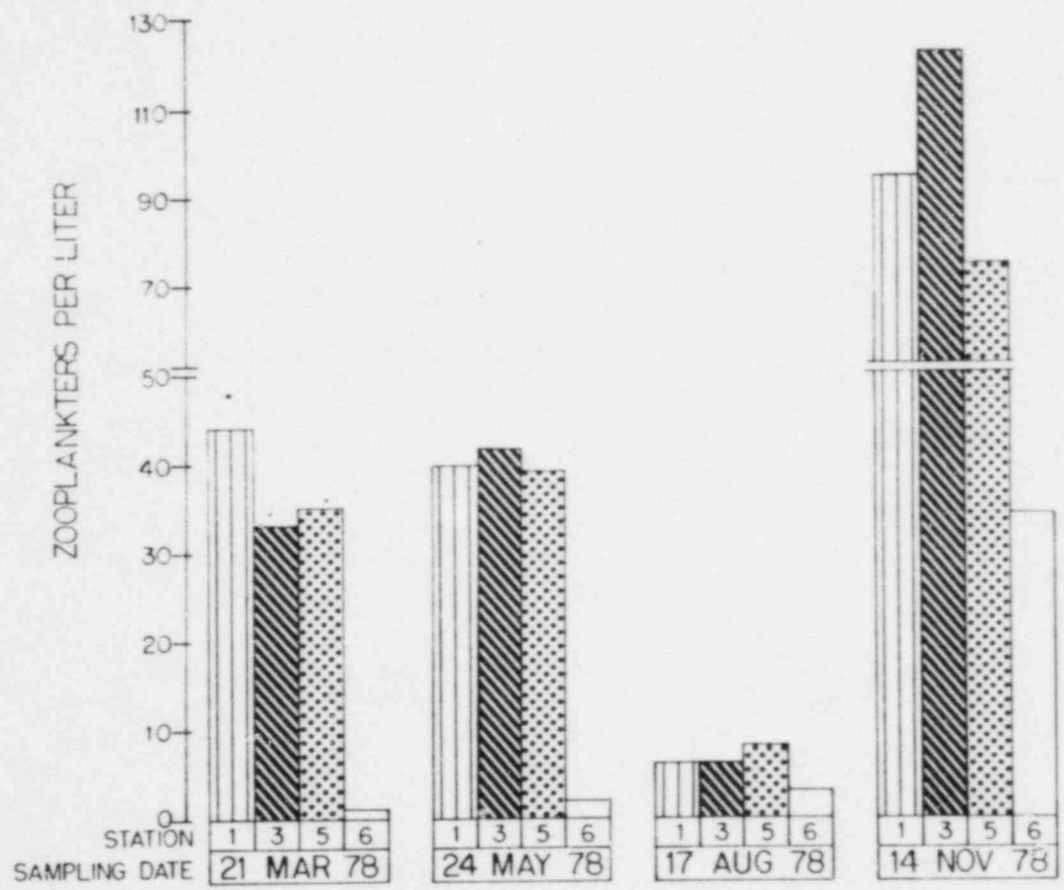

Figure C.2-1. Total zooplankton densities at Stations 1, 3 and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, 21 March - 14 November 1978.

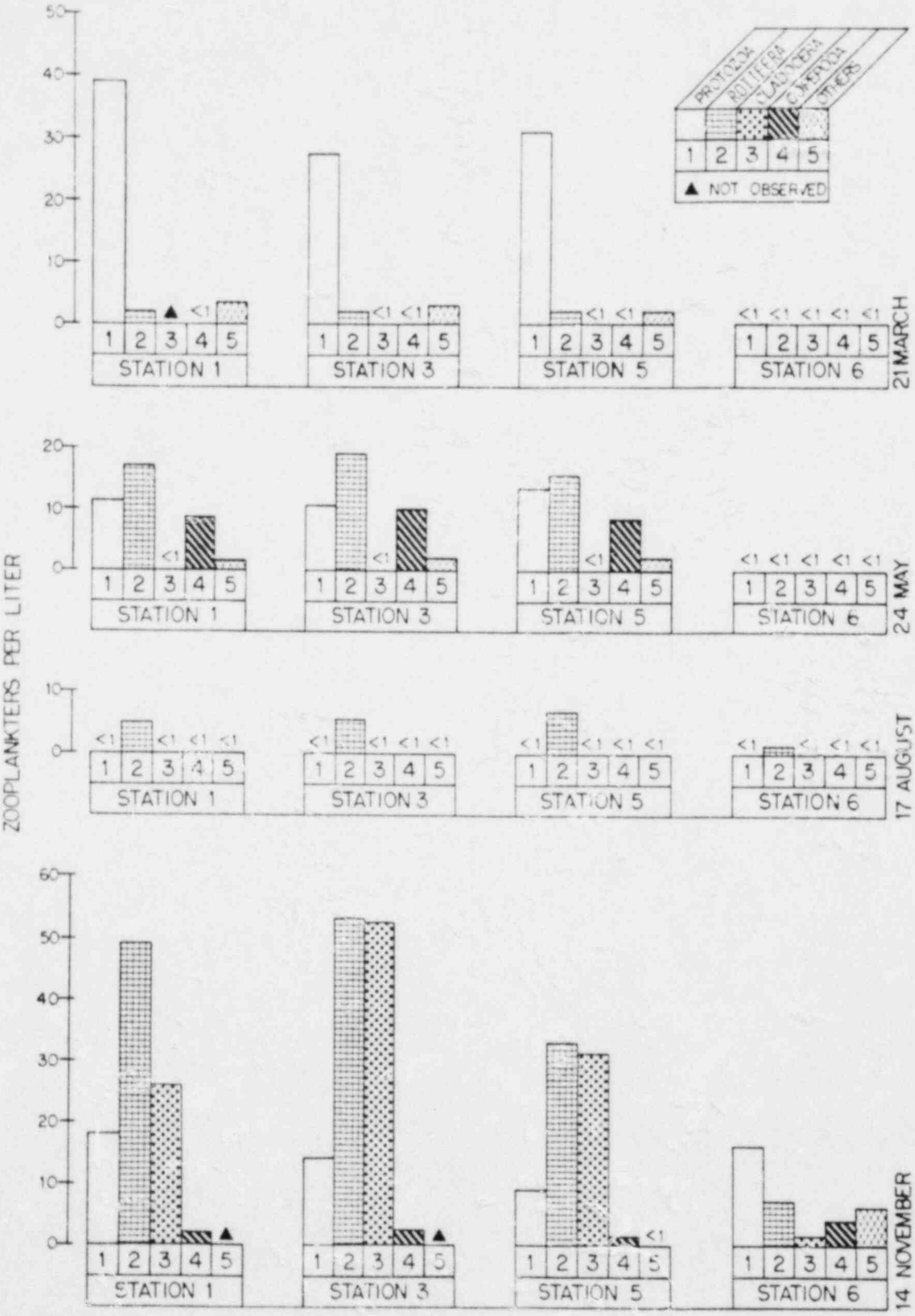

Figure C.2-2. Total densities of the major zooplankton groups at the Marble Hill Plant site, 21 March - 14 November 1978.

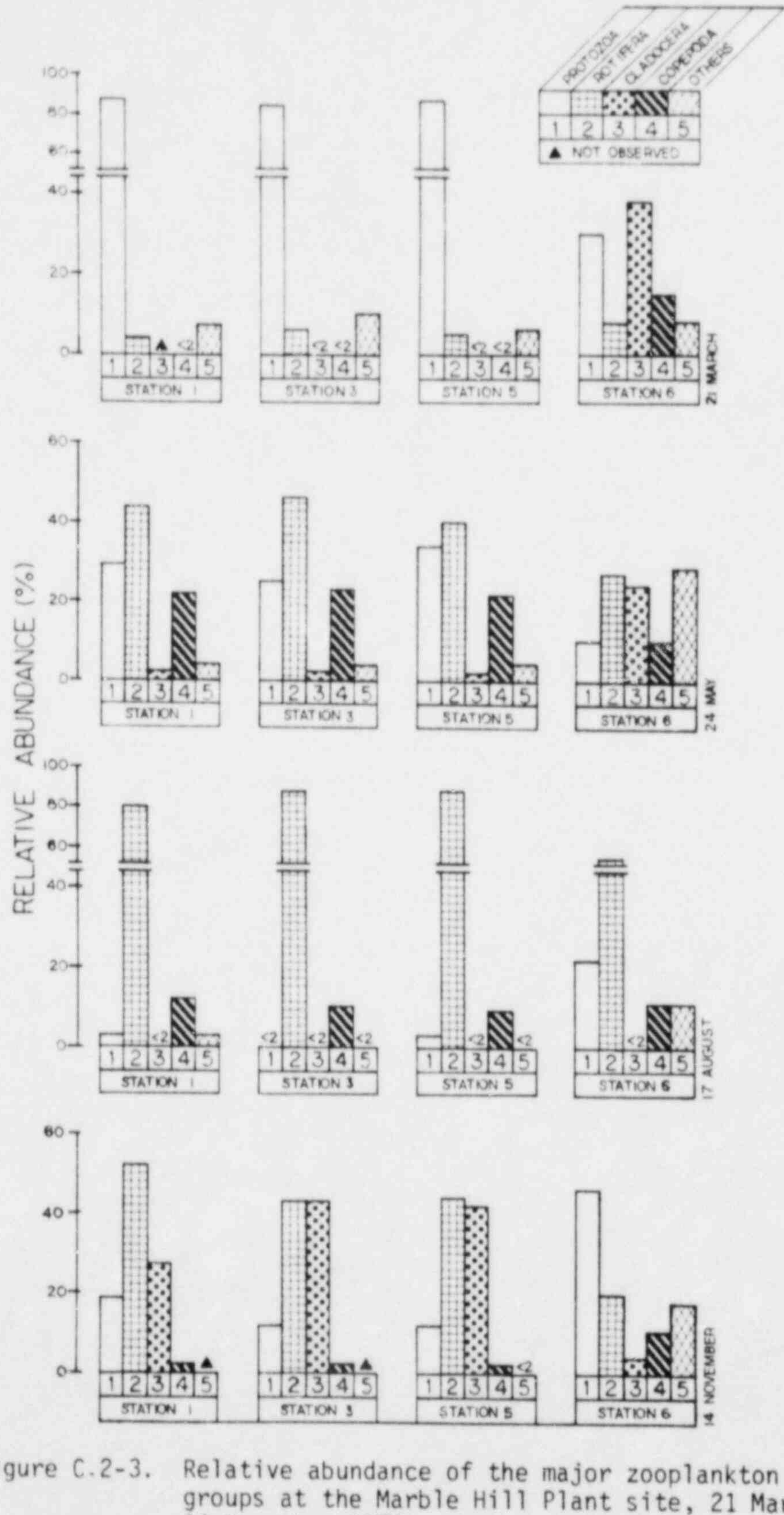

Figure C.2-3. Relative abundance of the major zooplankton groups at the Marble Hill Plant site, 21 March - 14 November 1978.

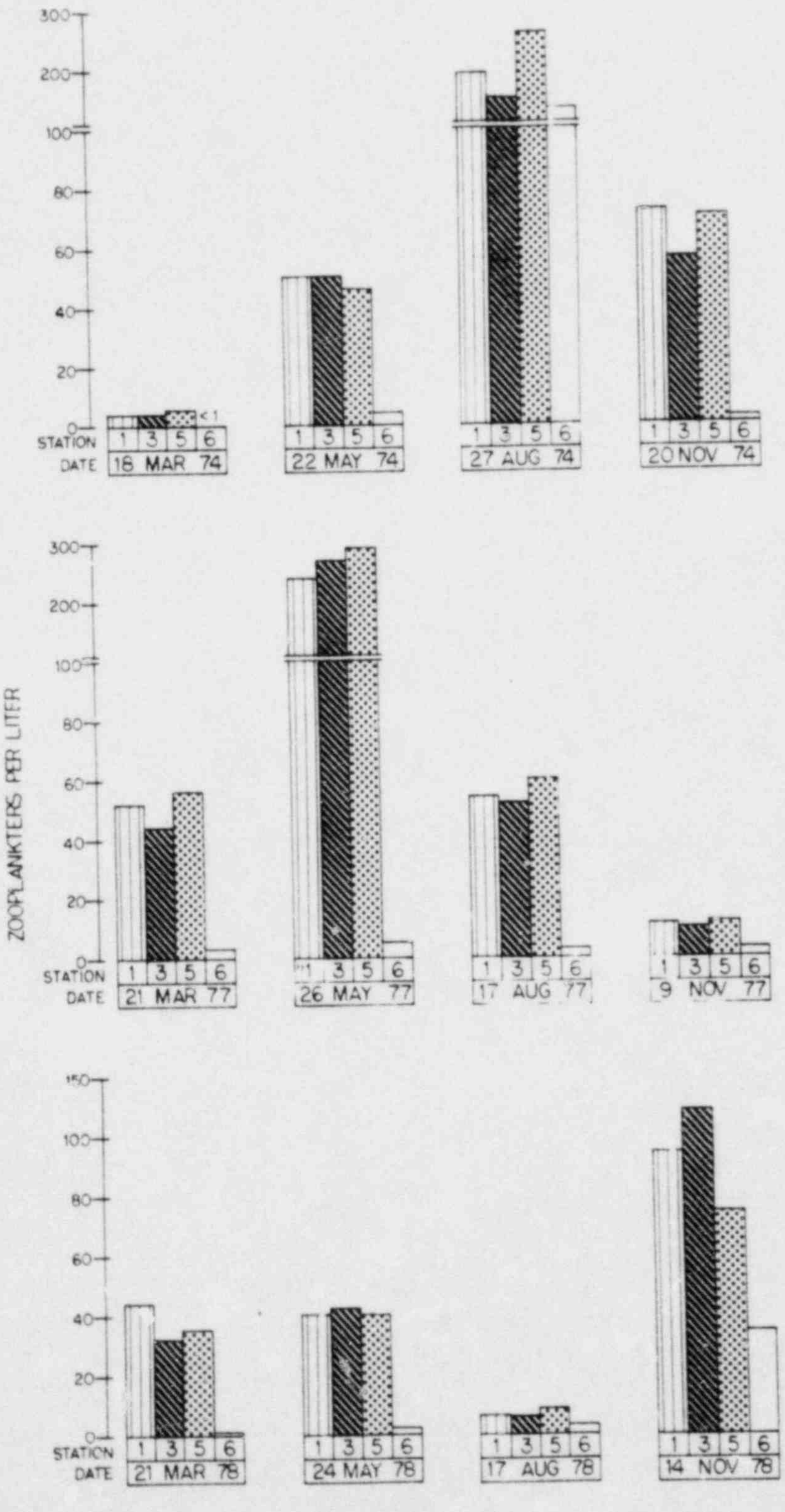

Figure C.2-4. Total zooplankton densities at Stations 1, 3 and 5 in the Ohio River and Station 6 in Little Saluda Creek, Marble Hill Plant site, 1974, 1977 and 1978.

TABLE C.2-1

COMPOSITE SPECIES LIST OF ZOOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
MARCH-NOVEMBER 1978

PROTOZOA
- *Acineta* sp.
- *Arcella* spp.
- *Carchesium* sp.
- *Centropyxis* spp.
- *Difflugia* spp.
- *Epistylis* sp.
- *Squalorophrya* sp.
- *Vorticella* sp.
- *Zoothamnium* sp.

ROTIFERA
- *Asplanchna* sp.
- *Brachionus* spp.
- *B. angularis*
- *B. bidentata*
- *B. budapestinensis*
- *B. calyciflorus*
- *B. caudatus*
- *B. havanaensis*
- *B. quadridentata*
- *Colurella* sp.
- *Conochilus* sp.
- *Epiphanes* sp.
- *Filinia* sp.
- *Gastropus* sp.
- *Kellicottia bostoniensis*
- *K. longispina*
- *Keratella* spp.
- *K. cochlearis*
- *K.quadrata*
- *K. valga*
- *Lecane* sp.
- *L. luna*
- *Monostyia bulla*
- *M. lunaris*
- *Notholca* sp.
- *Platyias patulus*
- *P. quadricornis*

ROTIFERA (cont.)
- *Polyarthra* sp.
- *Rotaria* sp.
- *Trichocerca* sp.
- *Trichotria* sp.
- unidentified *Bdelloidea*

CLADOCERA
- *Alona* sp.
- *Bosmina longirostris*
- *Chydorus sphaericus*
- *Daphnia* sp.
- *D. ambigua*
- *Diaphanosoma brachyurum*
- *D. leuchtenbergianum*
- *Eubosmina* sp.
- *E. coregoni*
- *Pleuroxus* sp.
- *P. denticulatus*
- *Scapholeberis kingi*
- immature Cladocera

COPEPODA
- Calanoida
  - *Diaptomus* sp.
  - *D. pallidus*
  - *D. sicilis*
- Cyclopoida
  - *Cyclops* sp.
  - *C. bicuspidatus thomasi*
  - *C. vernalis*
  - *Eucyclops speratus*
  - *Macrocyclops albidus*
  - *Tropocyclops prasinus*
- Harpacticoida
  - *Attheyella* sp.
  - *A. illinoisensis*
- Copepodites
- Naupii

TABLE C.2-1
(continued)
COMPOSITE SPECIES LIST OF ZOOPLANKTON COLLECTED IN THE OHIO RIVER AND IN LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
MARCH-NOVEMBER 1978

OTHERS
- Nematoda
  - *Criconema* sp.
- Ectoprocta statoblasts
- Tardigrada
- Oligochaeta
- Ostracoda
- Araneae
- Hydracarina adults
- Hydracarina immatures
- Oribatoidae adults
- Diptera larvae
- Chironomidae larvae
- *Chaoborus* sp. larvae
- Hemiptera immatures
- Hydropsychidae larvae
- Psocoptera adults
- Thysanoptera adults

TABLE C.2-2

SUMMARY OF ZOOPLANKTON DENSITY (no./liter) AND RELATIVE ABUNDANCE(%)
MARBLE HILL PLANT SITE
21 MARCH 1978

Taxon	Station 1 Density (no./l)	Station 1 Relative abundance(%)	Station 3 Density (no./l)	Station 3 Relative abundance(%)	Station 5 Density (no./l)	Station 5 Relative abundance(%)	Station 6 Density (no./l)	Station 6 Relative abundance(%)
Protozoa	38.6	87.3	27.4	83.9	30.9	88.5	0.5	30.6
Rotifera	1.9	4.3	1.9	5.8	1.8	4.6	0.1	8.1
Cladocera	0.0	0.0	0.1	0.2	<0.1	0.2	0.5	37.9
Copepoda	0.4	1.1	0.4	1.2	0.3	0.9	0.2	15.0
Others	3.3	7.3	2.8	8.9	2.0	5.8	<0.1	8.4
Total	44.2		32.6		35.0		1.3	

TABLE C.2-3

SUMMARY OF ZOOPLANKTON DENSITY (no./liter) AND RELATIVE ABUNDANCE(%)
MARBLE HILL PLANT SITE
24 MAY 1978

Taxon	Station 1		Station 3		Station 5		Station 6	
	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	11.3	28.5	10.4	25.1	13.2	33.4	0.2	10.3
Rotifera	17.0	43.6	18.8	45.5	15.4	39.4	0.5	27.2
Cladocera	0.9	2.3	0.9	2.2	0.8	2.0	0.5	23.8
Copepoda	8.6	21.6	9.5	22.9	8.4	21.3	0.3	10.9
Others	1.6	4.0	1.8	4.3	1.5	3.9	0.6	27.8
Total	39.4		41.4		39.3		2.1	

TABLE C. 2-4

SUMMARY OF ZOOPLANKTON DENSITY (no./liter) AND RELATIVE ABUNDANCE(%)
MARBLE HILL PLANT SITE
17 AUGUST 1978

Taxon	Station 1		Station 3		Station 5		Station 6	
	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	0.2	3.2	0.1	1.6	0.2	2.6	0.6	22.2
Rotifera	5.0	82.1	5.3	87.0	6.7	88.2	1.5	55.6
Cladocera	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copepoda	0.7	11.5	0.6	9.8	0.7	9.2	0.3	11.1
Others	0.2	3.2	0.1	1.6	<0.1	<0.1	0.3	11.1
Total	6.1		6.1		7.6		2.7	

TABLE C. 2-5

SUMMARY OF ZOOPLANKTON DENSITY (no./liter) AND RELATIVE ABUNDANCE(%)
MARBLE HILL PLANT SITE
[illegible] NOVEMBER 19[illegible]

Taxon	Station 1		Station 3		Station 5		Station [illegible]	
	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)	Density (no./l)	Relative abundance(%)
Protozoa	17.6	18.5	14.1	11.7	9.2	12.3	15.5	45.6
Rotifera	48.8	51.9	52.6	43.4	32.6	44.0	7.2	21.4
Cladocera	25.8	27.4	52.3	43.0	31.0	41.8	1.4	4.1
Copepoda	2.0	2.1	2.3	1.9	1.4	1.8	3.6	10.6
Others	0.0	0.0	0.0	0.0	0.1	0.1	6.2	18.3
Total	94.2		121.3		74.3		33.9	

TABLE C.2-6

ANALYSIS OF VARIANCE AND TUKEY'S TEST FOR DIFFERENCES BETWEEN MEANS FOR ZOOPLANKTON DENSITY[a]
MARBLE HILL PLANT SITE
MARCH - NOVEMBER 1978

Analysis of Variance
Ohio River Stations 1, 3 and 5

Source	Degrees of freedom	Sum of squares	Mean squares	F value
Stations	2	0.0274	0.0137	0.0711
Months	3	25.0103	8.3367	43.1780*
Station x month interaction	6	0.3838	0.0639	0.3313
Error	12	2.3169	0.1930	
Total	23	27.7384		

[a]Data log transformed
*Significant at $\alpha = .05$; critical $F_{05(3,12)} = 3.49$.

Tukey's Test

Month (mean)	March (3.6179)	May (3.6896)	August (1.8870)	November (4.5700)
March (3.1679)	0	0.0717	1.7309*	0.9521*
May (3.6896)		0	1.8026*	0.8804*
August (1.8870)			0	2.6830*

*Significant at $\alpha = .05$; HSD = 0.1545.

TABLE C.2-7

SIMPLE CORRELATION COEFFICIENTS (r) FOR SELECTED ZOOPLANKTON DENSITIES[a] AND PHYSICAL - CHEMICAL PARAMETERS FOR OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH - NOVEMBER 1978

Densities (no./l)	Temperature (°C)	Dissolved oxygen (ppm)	Current Velocity (cm/sec)	Secchi (cm)
Total zooplankton	-0.712*	0.454	-0.004	0.595*
Total protozoa	-0.942*	0.798*	0.501	0.098
Total rotifera	0.165	-0.444	-0.664*	0.821*
Total cladocera	-0.179	-0.035	-0.659*	0.981*
Total copepoda	0.170	-0.434	0.111	0.061

[a]Data log transformed
*Significant at α=.05; critical r value = 0.576.

TABLE C.2-8

ANALYSIS OF VARIANCE BETWEEN TOTAL ZOOPLANKTON DENSITIES[a] AT
OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
MARCH 1977 - NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean squares	F value[b]
Year	1	1.7636	1.7636	1.1924
Station	2	0.0053	0.0026	0.0017
Year x station interaction	2	0.0437	0.0218	0.0147
Error	18	26.6233	1.4790	
Total	23	28.4359		

[a]Data log transformed.

[b]Critical $F_{.05(1,18)} = 4.41$, critical $F_{.05(2,18)} = 3.55$

TABLE C.2-9

SIMPLE CORRELATION COEFFICIENTS (r) FOR TOTAL ZOOPLANKTON DENSITIES[a] AND SELECTED PHYSICAL - CHEMICAL PARAMETERS FOR OHIO RIVER STATIONS 1, 3 AND 5
MARBLE HILL PLANT SITE
1977 AND 1978

Station	Physical/chemical parameter	Calculated[b] $r(\alpha=.05)$
1	Temperature (°C)	0.264
3		0.337
5		0.265
1	Dissolved oxygen (ppm)	0.136
3		0.129
5		0.095
1	Current velocity (cm/sec)	-0.149
3		-0.314
5		-0.400
1	Secchi (cm)	0.199
3		0.231
5		0.179

[a]Data log transformed.

[b]Critical r value at $\alpha=.05$ = 0.707.

D. PERIPHYTON

INTRODUCTION

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 the 1977 construction phase monitoring data (ABI, 1978), as well as, interstation comparisons of 1978 data allowed assessment of possible construction-related effects on periphyton.

The term periphyton is used to describe all those organisms that attach to submerged substrates but do not penetrate into them (APHA, 1976). In current usage, periphyton includes all organisms which, 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 bryozoa. Plants and certain parasitic organisms which have roots or otherwise penetrate the substrate are not included in the periphyton community.

In addition, periphyton includes free-living organisms (i.e., rotifers, worms, larvae) inhabiting the mat of attached forms. Because of the wide variety of plants and animals included in the periphyton community, and a similarly varied range of specialized adaptations, virtually all submerged substrates (living and non-living) may be colonized. Such colonization is common in temperate and near-temperate 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 and competition for available substrate space is intense. Any natural or man-induced change in habitat parameters may therefore result in rapid qualitative and quantitative alterations in the periphyton community.

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 (2.5 x 7.6 cm) microscope slides. Six slides were harvested from each station after a 3-week exposure period. For biomass determinations, three slides per station were preserved individually in jars containing approximately 100 ml of five percent buffered formalin solution. Two slides per station were similarly preserved for species identifications and counts. An additional slide was preserved to replace any sample slide broken during transit to the laboratory. Diatometers and slides were lost at Stations 1, 3, and 5 prior to the 22 March and 24 May sampling dates due to high river flow conditions. Samples were collected on 26 June to replace those not collected on 24 May.

At Station 6 (Little Saluda Creek), measured areas of natural substrate (approximately 100 cm^2) were scraped clean of periphyton. Unglazed quarry tiles were scraped, as available, to improve sampling precision. For species identification, counts, and biomass determinations, two replicate scrapings were washed separately into bottles of five percent buffered formalin solution. Natural substrate composition and habitat types were noted and included in the data. The November samples were exceptionally high in detrital content and could not be analyzed due to insufficient addition of preservative.

In the laboratory, natural substrate and tile substrate samples were concentrated by siphoning to approximately 30 ml after at least 24 hours settling. Sampling suspensions used for species identification and counts were transferred to graduated test tubes, allowed to resettle for at least 24 hours, and concentrated to a known volume by further siphoning.

The inverted microscope technique (Utermohl, 1958) was used for species identifications and counts. Periphyton species other than diatoms were identified to the lowest possible taxon in 25-ml settling chambers. Total diatom and non-diatom species were enumerated by random strip counts at 400X magnification in two identically prepared chambers per sample replicate. A minimum of 400 individuals per replicate were routinely counted. 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). Taxonomic references used in species identification included: Van Heurck (1896), Walton (1915), Hustedt (1927-1966, 1930), Skuja (1948), Smith (1950), Edmondson (1959), Prescott (1962), Patrick and Reimer (1966, 1975), Weber (1966), Tiffany and Britton (1971), Taft and Taft (1971), Bick (1972), Sreenivasa and Duthie (1973), and Prescott, et. al. (1975).

All algal species, excluding certain greens and blue-greens, were counted as individual cells. Filamentous green and blue-green species were measured in 100μ lengths with each length representing one counting unit. Colonial forms exclusive of diatoms were counted as naturally occurring colonies, unless otherwise noted. Non-algal species were counted as individual organisms. Periphyton density per 10 cm^2 was calculated as N by:

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

where:

V_c = Volume of sample concentrate (ml)

C = Count

V_e = Volume of sample concentrate examined (ml)

A_s = Area of substrate sampled (10 cm^2 units).

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

Ash-free dry weights (biomass) were determined for three replicate artificial substrate samples per station at Stations 1, 3 and 5 and for quarry tile or rock substrate scrapings at Station 6 (APHA, 1976). Ash-free dry weight values were calculated as mg/10 cm^2.

Species diversity was calculated as 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.

RESULTS AND DISCUSSION

As in the baseline and 1977 construction phase monitoring studies (ABI, 1978), periphyton at the Marble Hill Plant site in 1978 (Appendix Tables D-1 through D-8) consisted predominantly of diatoms. Of a total of 129 taxa observed, 82 (64%) were Bacillariophyta (diatoms) (Table D-1). Other major taxa included Chlorphyta (green algae) and Cyanophyta (blue-green algae) which included 22% and 9%, respectively, of all species observed.

Bacillariophyta (diatoms)

Diatoms were dominant in all samples collected in 1978 (Figure D-1). Diatom percentage composition (Table D-2) ranged from 77% to 99% which represented a higher, and less variable range than that observed in 1977 (21% to 99%).

Diatom representation was similar at all Ohio River stations on each sampling date. A seasonal reduction in diatom percentages at the Ohio River stations in August was similar to reductions observed in both the 1977 and 1974-1975 studies. The comparability of annual and seasonal changes in diatom representation at all Ohio River stations indicated an absence of plant construction related effects. Diatom representation at Little Saluda Creek (Station 6) appeared to be greater in 1978 than in 1977. However, only the second and third quarterly samples were available for direct comparison between years. Increased diatom representation at Station 6 was attributable to natural, annual variation.

Differences in numbers of diatom species observed in 1974-75, 1977 and 1978 (75, 91 and 82, respectively) were small. Species which, in 1978 were encountered most frequently and were often in comparatively high densities (2% or more of total periphyton counts) included:

Ohio River Stations

Melosira varians
Cocconeis placentula v. *euglypta*
Gomphonema angustatum
G. olivaceum
G. parvulum
Navicula graciloides
Synedra fasciculata v. *truncata*

Little Saluda Creek Station

Achnanthes minutissima
Gomphonema angustatum
G. olivaceum
Nitzschia amphibia
N. palea
Surirella ovata

As in 1977, natural environmental conditions at the Marble Hill Plant site area were compatible with the known environmental requirements of the predominant diatoms (Table D-3). Wide-range temperature tolerance, preference for somewhat alkaline conditions, ability to grow in either standing or flowing water, and tolerance of nutrient enrichment are factors which characterize most of these species and should promote their growth in the Ohio River.

The growth of certain diatom species at Stations 1, 3, and 5 was seasonally influenced. *Cocconeis placentula* v. *euglypta* was a summer (August) dominant, whereas the highest densities of most other major diatom species were observed in May or November. The similarity of seasonal variations at all of the Ohio River stations indicated that there were no effects of plant construction. Differences in major diatom species composition between the Ohio River stations and Little Saluda Creek were attributable to natural differences between these two habitats.

Chlorophyta (green algae)

Although present in most samples, green algae never became a dominant periphyton taxon in 1978. Percentage composition ranged from 0% to 9% which reflected a general decrease relative to 1977 data. Decreases occurred at all Ohio River stations and were probably attributable to natural, annual variation. Although green algal species were diverse, *Characium ambiguum* was the only species with a relative percentage of 2% or greater. This occurrred only in August at Station 5. The relative percentages (and densities) of green algae were somewhat lower at Station

3 than at Stations 1 and 5 on all 1978 sampling dates. These reductions were not associated with any consistent differences in physical or chemical parameters at Station 3, however, and therefore could not be attributed to possible plant construction effects. The low relative percentages of green algae observed at all Ohio River stations indicated that any localized modification of green algal growth or diversity at Station 3 would have, at most, a limited effect on total periphyton production.

Cyanophyta (blue-green algae)

Blue-green algae were second to diatoms with respect to percentage representation during 1978. Relative percentages of blue-green algae ranged from less than 1% to 13%, which reflected a substantial reduction in comparison with 1977 data. Reductions were similar at all the Ohio River stations, and therefore were probably attributable to natural, annual variation.

A total of 11 blue-green taxa were observed. *Lyngbya* sp. 2 was the only major blue-green species (2% or more of the total periphyton) and it occurred in maximum density at Stations 1, 3 and 5 in August. The greatest number of blue-green species occurred in May, but relative percentages (as well as densities) of blue-green algae were highest in August. The similarity of blue-green algal increases at all Ohio River Stations in August indicated that these increases were seasonally influenced, as in the 1977 monitoring and 1974-75 baseline studies, and were not associated with any plant construction related effect.

Reductions in blue-green algal percentage composition at Station 6 throughout March, May, and August, 1978 were also within a range of variation that is attributable to natural causes. Unlike the Ohio River stations, however, no seasonal blue-green algal increase was observed at Station 6 in August. As indicated in the 1977 monitoring study, periphyton composition in Little Saluda Creek may be expected to vary from that observed in the Ohio River since very different environmental conditions exist in the creek.

Community Similarity

Morisita's community similarity index was applied to Ohio River Station data to compare the degree of species overlap between stations per quarter. All index values of 0.50 or greater indicate that the compared communities were similar. Results of this test (Table D-4) indicated that river stations were more similar in species composition in 1978 than during 1974-75 and 1977 and this similarity was more consistent between quarters during 1978. Similarity of species composition at Stations 1, 3 and 5 showed that the predominantly diatomaceous periphyton communities upstream and downstream of the Marble Hill Plant site were not qualitatively affected by construction activies. Index comparisons were not made between Little Saluda Creek and Ohio River communities due to the difference in habitats.

Total Periphyton Density

In 1978 total periphyton densities ranged from 14,210.3 x $10^3/10\ cm^2$ to 2295.7 x $10^3/10\ cm^2$ at Ohio River stations and from 9302.1 x $10^3/10\ cm^2$ to 1021.3 x $10^3/10\ cm^2$ in Little Saluda Creek. Extensive seasonal and interstation variability was similar to that observed in the 1974-75 and 1977 studies (Figure D-2).

There were significant interstation and seasonal differences in periphyton densities between river stations in 1978 (Table D-5)[a]. As in 1977, significant interaction of station and season effects precluded any generalizations concerning overall interstation or seasonal differences. Interstation differences varied between quarters, and seasonal differences varied between stations. Differences in density were therefore examined comparing interstation differences by months, and seasonal differences by stations (Table D-6).

Significant interstation differences occurred only in November when Station 3 densities were significantly higher than those

[a]Differences between log transformed data, as well as between untransformed data, were significant.

at Stations 1 and 5. Regarding seasonal difference, total periphyton densities at Station 3 were significantly higher in November than in June or August, and densities at Station 5 were significantly higher in June than in August. The limited occurrence of significant interstation differences did not provide evidence of plant construction related effects in the Ohio River. Although significant seasonal differences were also limited, examination of both Ohio River and Little Saluda Creek data (Figure D-2) shows that a pattern of reduced summer (August) densities and high late spring or fall densities, prevailed during both years of study. This continuation of a common seasonal trend at all stations further indicated no plant impact.

Ohio River periphyton densities from both 1977 and 1978 were compared. There were no significant differences between stations over the two-year period, or between years (Table D-7). Whereas substantial variation occurred at all stations during the two-year period, there were no chronic reductions which could be attributed to Marble Hill Plant construction effects. Station 6 densities were also comparable with densities observed in 1977, and did not provide evidence of plant related effects.

Species Diversity

Species diversity ($\bar{d}$) and species evenness values (e) were similar at Ohio River stations in June and November (Table D-8).

In August, values were somewhat reduced at Station 5 due to greater dominance of the diatom *Cocconeis placentula* v. *euglypta* and to the exclusion of certain other diatom and green algal species which were observed at Stations 1 and 3. Interstation differences in species diversity and evenness were otherwise small and did not indicate plant construction related effects.

Similar ranges of Ohio River species diversity and evenness values were observed in the 1974-1975 baseline, and 1977 and 1978 monitoring programs.

Study	Diversity Index Range	Equitability Range
present study	1.8021 - 3.4999	0.22 - 0.52
ABI, 1978	1.6500 - 4.5482	0.17 - 0.97
PSI, 1976	0.5036 - 3.4149	0.18 - 0.59

The period of seasonally high diversity values varied from year to year, however decreased values were always observed during warmer months. Generally consistent ranges of seasonal variation in species diversity and evenness at all Ohio River stations in 1977 and 1978 further indicated that plant construction has not affected these parameters. Higher species diversity and evenness values at Little Saluda Creek (Station 6) in 1978 were within the overall range of variation observed in the preceding studies and therefore were attributable to natural effects.

Periphyton Biomass

Comparison of Figures D-2 and D-3 shows similar variations in biomass and total periphyton densities. Biomass values ranged from 4.2 mg/10 cm^2 to 1.3 mg/10 cm^2 at the Ohio River stations. Seasonal differences in biomass during 1978 and interaction of station and seasonal effects were significant (Table D-9). At Station 3, biomass was significantly higher in November than in June or August and at Station 5, biomass was significantly higher in June and November than in August (Table D-10). The absence of significant differences between stations indicated no plant construction effect on periphyton biomass at Ohio River stations. The degree of variation in biomass in Little Saluda Creek (Station 6) was comparable to that observed in 1977.

Periphyton biomass data from both 1977 and 1978 showed no significant differences between river stations or between years over the two-year period (Table D-11). Therefore, neither long-term interstation differences nor significant annual differences, which might be related to over-all plant construction effects, were indicated.

CONCLUSIONS

The 1978 periphyton composition was similar to that observed in the 1974-75 baseline and 1977 monitoring programs. Diatoms were dominant in all studies. Green algae and blue-green algae were never dominant, but were present in all Ohio River samples, and in all but the May sample from Little Saluda Creek.

The relative percentages of diatoms and blue-green algae were similar at Ohio River stations. Consistent, although moderate, reductions in relative percentages and densities of green algae were observed at Station 3. However, these reductions were not associated with differences in physical or chemical parameters and did not indicate plant effect. Moristia's community similarity index values demonstrated a high degree of periphyton species over-lap between Ohio River stations. Differences in periphyton composition between Ohio River stations and the Little Saluda Creek station reflected natural environmental differences.

No significant interstation differences in total periphyton densities or biomass which reflected plant construction related effects were observed during 1978. Consistent reductions in species diversity or species evenness at any of the Ohio River stations were also lacking.

Variations in all periphyton community parameters observed during 1978 were within the range of variation observed in preceding studies. With the possible exception of reduced green algal percentage composition and diversity at Station 3, all of the interstation and seasonal differences described in this report were attributable to natural variation rather than to impact from plant construction.

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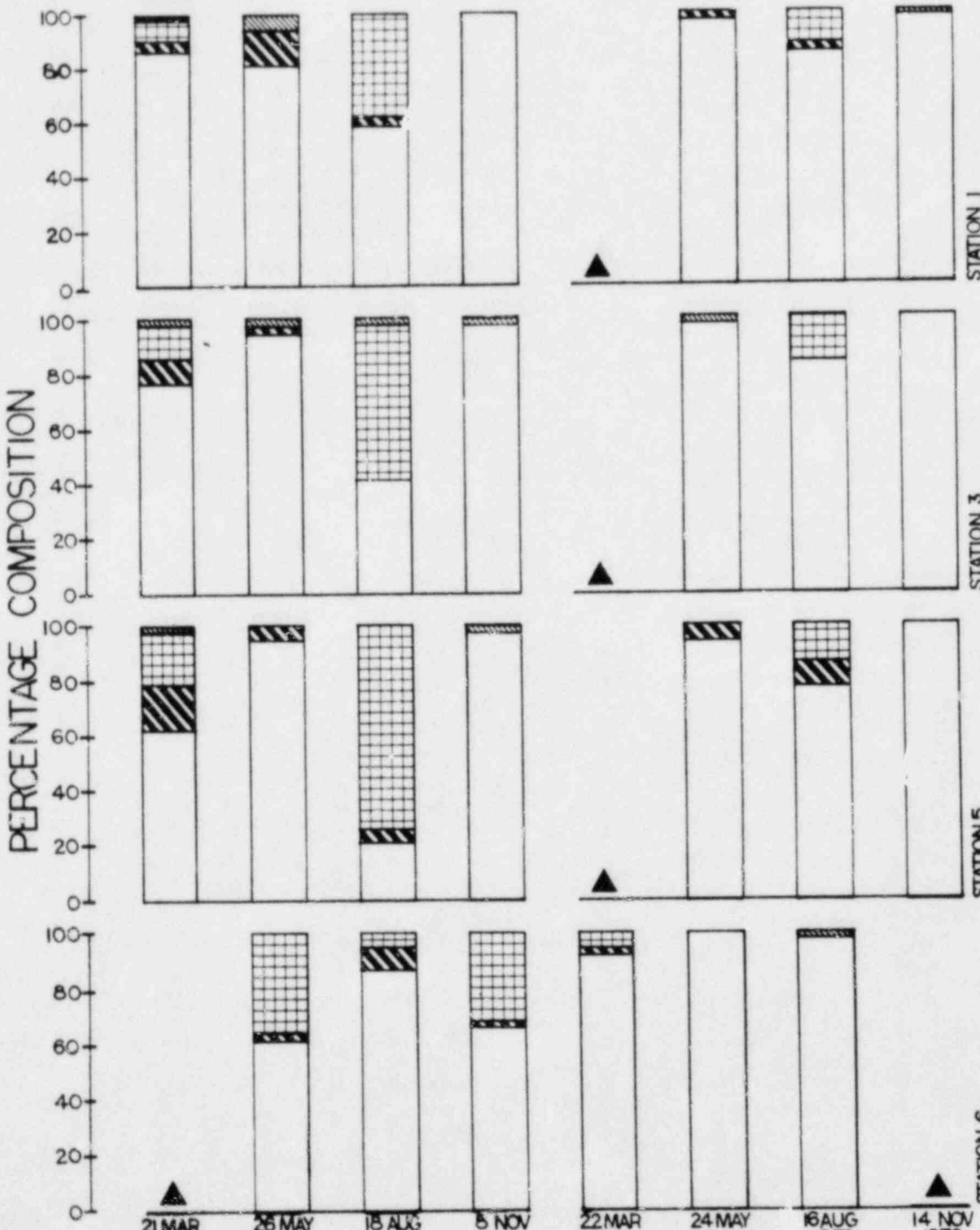

Figure D-1. Percentage composition of major periphyton taxa at Ohio River Stations 1, 3, and 5 and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1978.

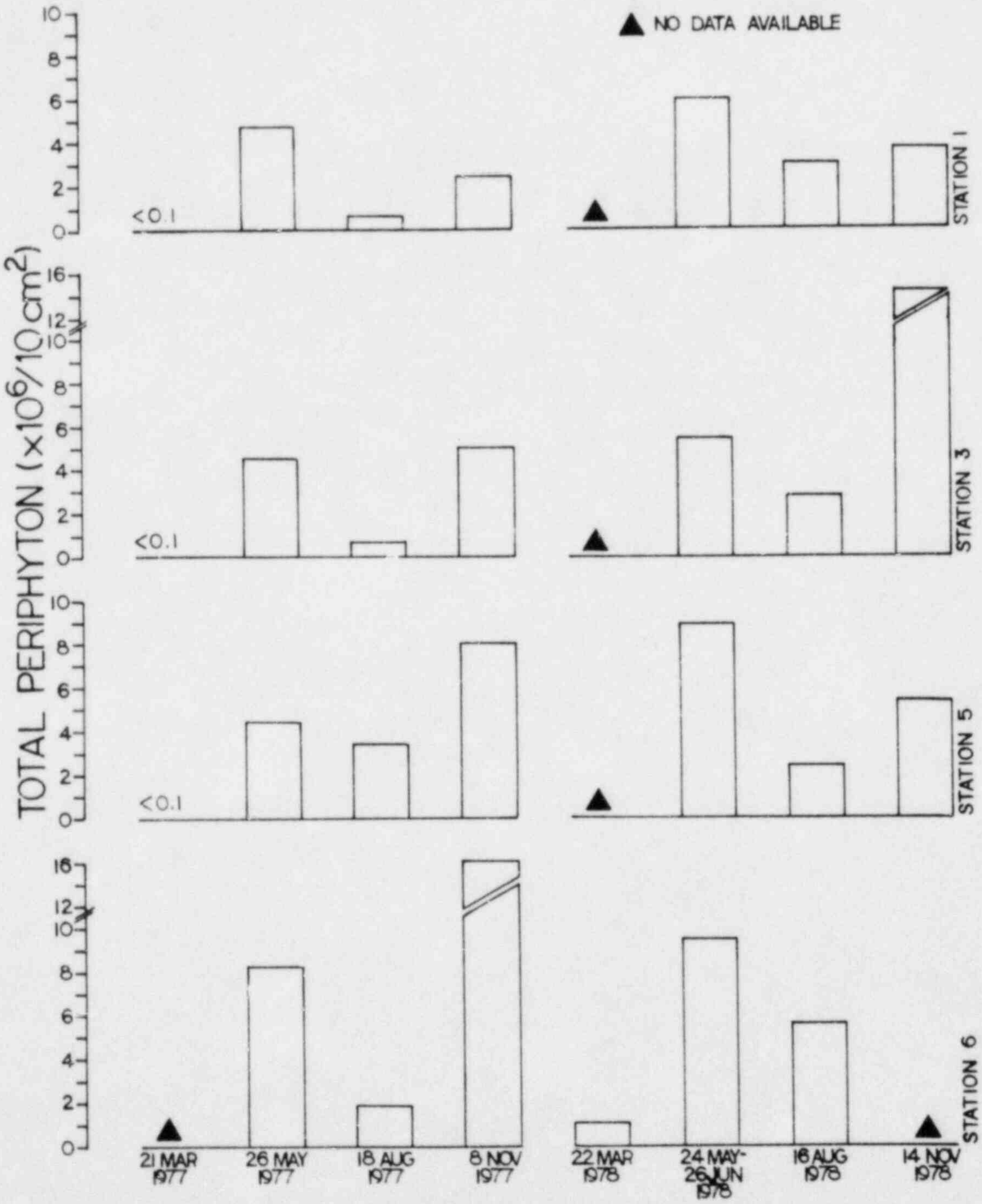

Figure D-2. Seasonal variation in total periphyton density at Stations 1, 3, and 5 in the Ohio River and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1978.

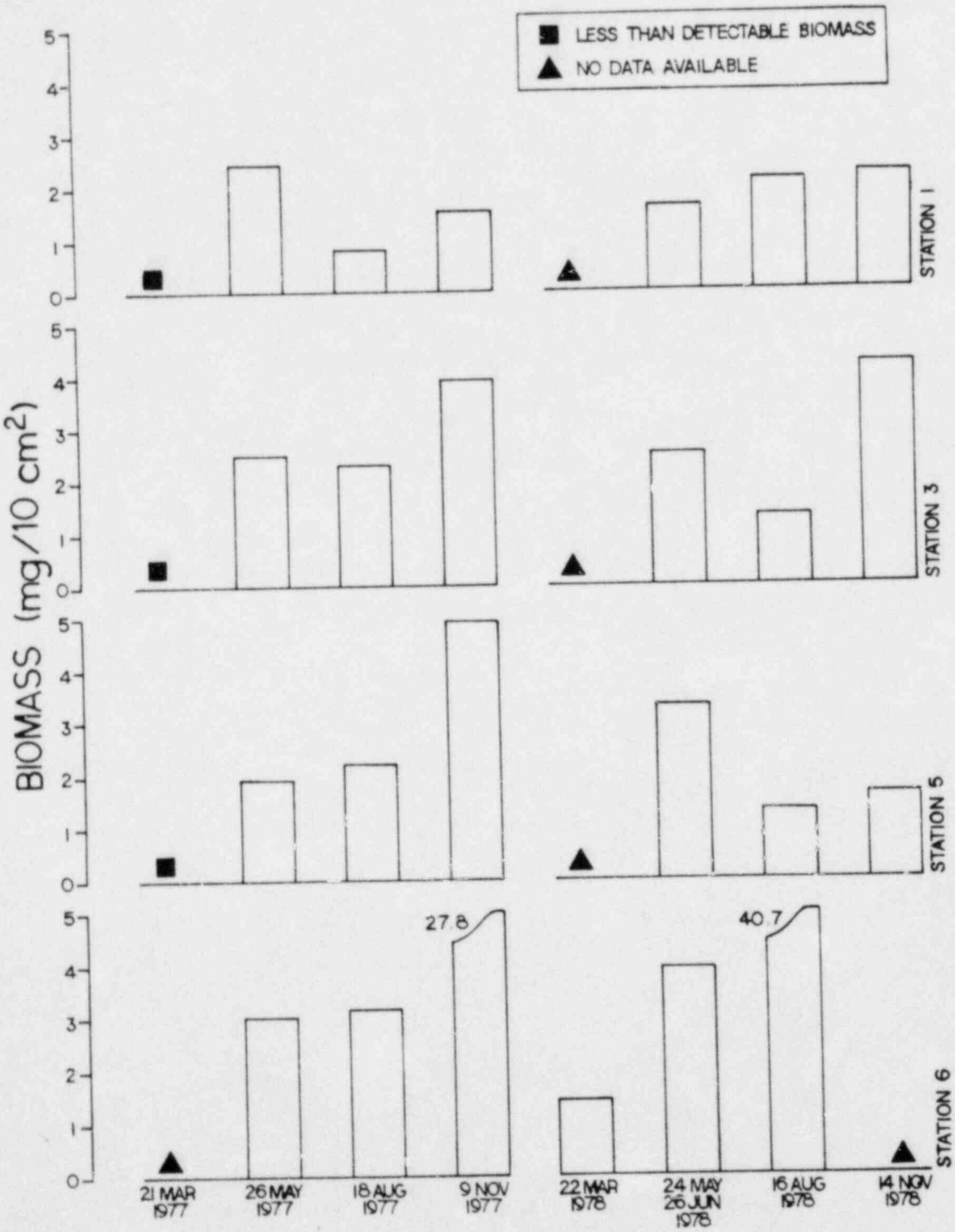

Figure D-3. Periphyton biomass at Stations 1, 3, and 5 in the Ohio River and Little Saluda Creek Station 6, Marble Hill Plant site, 1977-1978.

TABLE D-1

COMPOSITE SPECIES LIST OF PERIPHYTON COLLECTED IN THE OHIO RIVER AND LITTLE SALUDA CREEK
MARBLE HILL PLANT SITE
22 MARCH - 14 NOVEMBER 1978

BACILLARIOPHYTA
- Centrales
  - *Cyclotella [illegible]*
  - *C. glomerata*
  - *C. kutzingiana*
  - *C. kutzingiana v. [illegible]*
  - *C. meneghiniana*
  - *C. pseudostelligera*
  - *C. stelligera*
  - *Melosira ambigua*
  - *M. distans*
  - *M. granulata*
  - *M. varians*
  - *Skeletonema potamos*
  - *Stephanodiscus [illegible]*
- Pennales
  - *Achnanthes [illegible]*
  - *A. [illegible]*
  - *A. lanceolata*
  - *A. linearis f. [illegible]*
  - *A. minutissima*
  - *[illegible]*
  - *Amphora [illegible]*
  - *A. [illegible]*
  - *Asterionella formosa*
  - *Cocconeis pediculus*
  - *C. placentula v. euglypta*
  - *C. placentula v. lineata*
  - *Cymbella [illegible]*
  - *C. minuta v. silesiaca*
  - *C. prostrata v. [illegible]*
  - *C. tumida*
  - *Diatoma tenue v. elongatum*
  - *D. vulgare*
  - *Fragilaria [illegible]*
  - *F. crotonensis*
  - *F. vaucheriae*
  - *F. virescens*
  - *Gomphonema angustatum*
  - *G. angustatum v. [illegible]*
  - *G. gracile*
  - *G. olivaceum*
  - *G. parvulum*
  - *Gyrosigma [illegible]*
  - *G. [illegible]*
  - *Meridion circulare*
  - *Navicula [illegible]*
  - *N. [illegible]*
  - *N. cryptocephala v. [illegible]*
  - *N. [illegible]*
  - *N. minima*
  - *N. [illegible]*
  - *N. rhynchocephala*
  - *N. [illegible]*
  - *N. viridula v. [illegible]*
  - *N. [illegible]*
  - *Nitzschia acicularis*
  - *N. amphibia*
  - *N. communis*
  - *N. communis v. abbreviata*
  - *N. dissipata*
  - *N. gracilis*
  - *N. hungarica*
  - *N. linearis*
  - *N. palea*
  - *N. paradoxa*
  - *N. parvula*
  - *N. tryblionella v. debilis*
  - *N. tryblionella v. levidensis*
  - *N. tryblionella v. victoriae*
  - *Peronia erinacea* (?)

BACILLARIOPHYTA (continued)
- Pennales (continued)
  - *Pinnularia brebissonii v. diminuta*
  - *Pinnularia* sp. 1
  - *Rhoicosphenia curvata*
  - *Stauroneis smithii*
  - *Surirella linearis*
  - *S. ovata*
  - *Synedra delicatissima*
  - *S. fasciculata v. truncata*
  - *S. rumpens v. familiaris*
  - *S. rumpens v. meneghiniana*
  - *S. ulna*
  - *S. ulna v. [illegible]*
  - *S. ulna v. oxyrhynchus* f. *mediocontracta*

CHLOROPHYTA
- *Actinastrum hantzschii*
- *Ankistrodesmus falcatus*
- *Characium ambiguum*
- *Characium* sp.
- *Chlamydomonas globosa*
- *Chlamydomonas* sp.
- *Closterium moniliferum*
- *Closterium* sp.
- *Coelastrum* sp.
- *Dictyosphaerium pulchellum*
- *Kirchneriella obesa v. aperta*
- *Micractinium pusillum*
- *Oocystis pusilla*
- *Pediastrum duplex v. clathratum*
- *P. obtusum*
- *P. tetras v. tetraodon*
- *Pseudulvella americana*
- *Scenedesmus abundans v. brevicauda*
- *S. dimorphus*
- *S. opoliensis*
- *S. quadricauda*
- *Scenedesmus* sp.
- *Stigeoclonium* sp.
- *Tetraedron caudatum*
- *T. caudatum v. longispinum*
- *T. minimum*
- *Tetrastrum heteracanthum*
- unidentified coccoid sp. (4-5µ diam.)
- unidentified coccoid sp. (6-7µ diam.)

CYANOPHYTA
- *Chamaesiphon* ? sp.
- *Chroococcus* sp.
- *Lyngbya [illegible]*
- *Lyngbya* sp. 2
- *Merismopedia tenuissima*
- *Oscillatoria nigra*
- *O. tenuis*
- *Oscillatoria* sp. 1
- *Oscillatoria* sp. 3
- *Phormidium minnesotense*
- *Spirulina major*

EUGLENOPHYTA
- *Euglena* sp.
- *Phacus acuminatus*
- *Trachelomonas* sp.
- unidentified euglenoid sp. 2

PROTOZOA
- *Difflugia* sp.
- unidentified ciliated protozoan

OTHERS
- unidentified flagellate

TABLE D-2

PERIPHYTON DENSITY AND RELATIVE ABUNDANCE DATA SUMMARY
FOR OHIO RIVER STATIONS 1, 3, AND 5 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
22 MARCH - 14 NOVEMBER 1978

	22 March			24 May							
	Stations 1, 3 and 5[a]	Station 6		Station 1[b]		Station 3[b]		Station 5[b]		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 (%)	Density (no.x10^3/10 cm^2)	Relative abundance (%)
Bacillariophyta		939.84	92.03	5696.08	97.37	5159.35	98.01	8347.23	93.98	9240.11	99.33
Chlorophyta		19.53	1.91	110.06	1.87	63.50	1.19	408.23	4.60	0.00	0.00
Cyanophyta		61.30	6.00	36.38	0.62	37.96	0.73	103.42	1.16	61.98	0.67
Euglenophyta		0.58	0.06	8.68	0.14	3.72	0.07	23.05	0.26	0.00	0.00
Protozoa		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Others		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total		1021.25		5851.20		5264.53		8881.93		9302.09	

	16 August								14 November						
	Station 1		Station 3		Station 5		Station 6		Station 1		Station 3		Station 5		Station 6[c]
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 (%)	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	2526.46	84.92	2259.93	84.88	1772.05	77.19	5405.77	98.20	3596.64	98.18	14021.76	98.67	5328.74	98.50	
Chlorophyta	78.26	2.65	38.02	1.44	210.94	9.19	4.24	0.08	28.88	0.77	19.54	0.14	31.92	0.58	
Cyanophyta	365.98	12.29	364.20	13.68	312.66	13.62	74.17	1.34	17.49	0.48	169.00	1.19	36.49	0.68	
Euglenophyta	2.08	0.07	0.00	0.00	0.00	0.00	18.16	0.33	4.56	0.12	0.00	0.00	4.56	0.08	
Protozoa	2.08	0.07	0.00	0.00	0.00	0.00	2.72	0.05	1.52	0.04	0.00	0.00	9.12	0.16	
Others	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.20	0.41	0.00	0.00	0.00	0.00	
Total	2974.86		2662.15		2295.65		5505.06		3664.29		14210.30		5410.83		

[a]Samples were lost from Stations 1, 3, and 5 due to high water conditions.

[b]Samples collected on June 26 after resetting diatometers to replace samples scheduled for 24 May collection

[c]Station 6 samples could not be analyzed due to insufficient addition of preservative.

TABLE D-3

ENVIRONMENTAL REQUIREMENTS OF MAJOR DIATOM SPECIES
IDENTIFIED IN PERIPHYTON SAMPLES[a]
MARBLE HILL PLANT SITE
23 MARCH - 14 NOVEMBER 1978

Species	Occurrence: Ohio River	Occurrence: Little Saluda Creek	Temperature	pH	Current	Nutrients
Melosira varians	✓		eurythermal and oligothermal to mesothermal	6.4 to 9.0 8.5 optimum	indifferent	eutrophic
Achnanthes minutissima		✓	eurythermal	indifferent 7.5 - 7.8 optimum	indifferent	–
Cocconeis placentula v. *euglypta*	✓		euthermal	6.2 - 9.0	indifferent to rheophilis	–
Gomphonema angustatum	✓		eurythermal to metathermal and oligothermal to mesothermal	6.0 - 9.0 7.5 - 7.7 optimum	indifferent	eutrophic; oligotrophic and mesotrophic
G. olivaceum	✓		eurythermal to oligothermal to mesothermal	6.4 - 9.0	indifferent to rheophilis	eutrophic
G. parvulum	✓		mesothermal to stenothermal	indifferent 4.2 - 9.0 7.8 - 8.2 optimum	rheophilis	nutrient enrichment, especially by sanitary or farm wastes
Navicula graciloides	✓		–	–	–	–
Nitzschia amphibia		✓	eurythermal, oligothermal to mesothermal	4.0 - 9.3 8.5+ optimum	indifferent	eutrophic
N. palea		✓	eurythermal 0° to 30°C	indifferent 4.2 to 9.0 8.4 ca. optimum	indifferent	eutrophic
Surirella ovata		✓	oligothermal, eurythermal	6.4 - 8.2 7.5 - 8 optimum	rheophilis	–
Synedra fasciculata v. *truncata*		✓	–	–	–	–

[a]Adapted from Lowe (1974).

TABLE D-4

MORISITA'S COMMUNITY SIMILARITY INDEX VALUES FOR PERIPHYTON SAMPLES COLLECTED FROM OHIO RIVER STATIONS 1, 3, AND 5[a]
MARBLE HILL PLANT SITE
26 JUNE - 14 NOVEMBER 1978

Comparison	Sampling date		
	26 June	16 August	14 November
Sta. 1 x Sta. 3	0.93	0.99	0.87
Sta. 1 x Sta. 5	0.93	0.97	0.94
Sta. 3 x Sta. 5	0.97	0.95	0.95

[a]Index values ≥ 0.50 indicate paired communities similar.

TABLE D-5

ANALYSIS OF VARIANCE OF TOTAL PERIPHYTON
DENSITIES AT OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
26 JUNE - 14 NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean square	F value
Subgroups	8	0.2304689×10^9	0.2880861×10^8	
Stations	(2)	0.3125288×10^8	0.1562644×10^8	7.81*
Months	(2)	0.8712801×10^8	0.4356401×10^8	21.79*
Interaction (stations x months)	(4)	0.1120880×10^9	0.2802200×10^8	14.01*
Error	9	0.1799716×10^8	0.1999684×10^7	
Total	17	0.2484660×10^9		

*Significant at $\alpha = 0.05$. $F_{.05[2,9]} = 4.26$; $F_{.05[4,9]} = 3.63$

TABLE D-6

TUKEY'S HSD COMPARISON OF TOTAL PERIPHYTON DENSITIES AT OHIO RIVER STATIONS 1, 3, AND 5 BY STATIONS AND SAMPLING DA[illegible]
MARBLE HILL PLANT SITE
26 JUNE - 14 NOVEMBER 1978

BY STATIONS ON 14 NOVEMBER

Station (mean)	3 (14210.27)	5 (5410.73)
1 (3664.23)	10546.04*	1746.50
3 (14210.27)		8799.54*

HSD = 3949.69

BY SAMPLING DATES AT STATION 3

Sampling dates (mean)	16 Aug (2662.12)	14 Nov (14210.27)
26 Jun (5264.42)	2602.30	8945.85*
16 Aug (2662.12)		11548.15*

HSD = 3949.69

BY SAMPLING DATES AT STATION 5

Sampling dates (mean)	16 Aug (2295.45)	14 Nov (5410.73)
26 Jun (8881.91)	6586.46*	3471.18
16 Aug (2295.45)		3115.28

HSD = 3949.69

[a]Only comparisons which contain significant differences are shown.

*Significant at $\alpha = 0.05$.

TABLE D-7

ANALYSIS OF VARIANCE OF TOTAL PERIPHYTON DENSITIES
AT OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
26 MAY-9 NOVEMBER 1977 and 26 JUNE-14 NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Subgroups	5	0.4432852×10^{8}	0.8865704×10^{7}	
Stations	(2)	0.1617545×10^{8}	0.8087725×10^{7}	0.74
Years	(1)	0.1696914×10^{8}	0.1696914×10^{8}	1.56
Interaction (Stations x years)	(2)	0.1118393×10^{8}	0.5591965×10^{7}	0.51
Error	12	0.1307233×10^{9}	0.1089361×10^{8}	
Total	17	0.1750518×10^{9}		

$F_{.05[2,12]} = 3.89$; $F_{.05[1,12]} = 4.75$

TABLE D-8

PERIPHYTON SPECIES DIVERSITY INDEX AND SPECIES EVENESS VALUES[a]
MARBLE HILL PLANT SITE
22 MARCH - 14 NOVEMBER 1978

	22 March			24 May[b]		
Station	S	$\bar{d}$	e	S	$\bar{d}$	e
1	(Ohio River Stations 1, 3 and 5 samples lost due to high water conditions)			39	2.8942	0.27
3				38	2.7340	0.24
5				42	2.7501	0.22
6	30	3.2213	0.44	25	2.6426	0.35

	16 August			14 November		
Station	S	$\bar{d}$	e	S	$\bar{d}$	e
1	36	2.5176	0.22	44	3.3439	0.35
3	36	2.7463	0.26	38	3.0522	0.31
5	21	1.8021	0.22	43	3.3148	0.33
6	31	3.4999	0.52	(Station 6 samples could not be analyzed due to insufficient preservation)		

[a]S = Number of species.

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

e = Equitability

[b]Ohio River samples (Stations 1, 3 and 5) were collected on 26 June to replace samples lost due to high water conditions.

TABLE D-9

ANALYSIS OF VARIANCE OF PERIPHYTON
BIOMASS AT OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
26 JUNE - 14 NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Subgroups	8	0.2221630×10^2	0.2777038×10	
Stations	(2)	0.2527407×10	0.1263704×10	2.50
Months	(2)	0.5871852×10	0.2935926×10	5.80*
Interaction (stations x months)	(4)	0.1381704×10^2	0.3454260	6.83*
Error	18	0.9106667×10	0.5059259	
Total	26	0.3132296×10^2		

*Significant at $\alpha = 0.05$. $F_{.05(2,18)} = 3.57$; $F_{.05(4,18)} = 2.95$

TABLE D-10

TUKEY'S HSD COMPARISON OF MEAN PERIPHYTON BIOMASS AT OHIO RIVER STATIONS 1, 3, AND 5 BY SAMPLING DATES[a]
MARBLE HILL PLANT SITE
26 JUNE - 14 NOVEMBER 1978

BY SAMPLING DATES AT STATION 3

Sampling dates (mean)	16 Aug (1.3)	14 Nov (4.2)
26 Jun (2.5)	1.2	1.7*
16 Aug (1.3)		2.9*

HSD = 1.5

BY SAMPLING DATES AT STATION 5

Sampling dates (mean)	16 Aug (1.3)	14 Nov (1.6)
26 Jun (3.3)	2.0*	1.7*
16 Aug (1.3)		0.3

HSD = 1.5

[a]Only comparisons which contain significant differences are shown.

*Significant at $\alpha = 0.05$.

TABLE D-11

ANALYSIS OF VARIANCE OF PERIPHYTON BIOMASS
IN OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
26 MAY-9 NOVEMBER 1977 and 26 JUNE-14 NOVEMBER 1978

Source	Degrees of freedom	Sum of squares	Mean square	Calculated F
Subgroups	5	0.4996111x10	0.9992222	
Stations	(2)	0.3367778x10	0.1683889x10	1.34
Years	(1)	0.2938889	0.2938889	0.23
Interaction (Stations x years)	(2)	0.1334444x10	0.6672220	0.53
Error	12	0.1504667×10^2	0.1253889x10	
Total	17	0.2004278×10^2		

$F_{.05[2,12]} = 3.89$; $F_{.05[1,12]} = 4.75$

E. BENTHIC AND DRIFT MACROINVERTEBRATES

INTRODUCTION

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) to determine the effects of plant construction.

Macroinvertebrates are animals large enough to be seen by the unaided eye and can be 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 available substrata in a body of water.

The major taxonomic groups of freshwater macroinvertebrates are insects, oligochaete worms, molluscs, flatworms, and crustaceans. Macroinvertebrates may occupy a diverse variety of microhabitats and substrata in a freshwater ecosystem (sand, mud, vascular plants, logs, debris, etc.).

Macroinvertebrates may also occupy virtually all levels of the trophic structure of an ecosystem and include omnivorous, herbivorous, and carnivorous species. They may be deposit or detritus feeders, parasites, scavengers, grazers, or predators. As important members of the food web, their well-being is reflected in the well-being of higher forms such as fish (EPA, 1973).

A community of macroinvertebrates in an aquatic system is sensitive to external stress. Because of their limited mobility and relatively long life span, their community characteristics are a function of environmental conditions during the recent past. Thus they serve as useful indicators of environmental perturbation (EPA, 1973). Macroinvertebrate communities have been shown to reflect the influence of temperature, salinity, depth, current, substratum, and chemical and organic pollutants.

MATERIALS AND METHODS

Benthos

Benthic macroinvertebrates were collected and analyzed in accordance with methods recommended by APHA (1975), EPA (1973), and NESP (1975). Two replicate samples were taken at each station. Additional replicates were taken and analyzed for quality assurance purposes.

Benthic sampling at Stations 1, 3, and 5 in the Ohio River was performed with a Ponar grab (Figure E-1). Two replicate Ponar samples each were taken at inshore (10 feet from shore) and offshore locations (100 yards offshore). The Ponar grab is well suited for use in hard sediments (Flannagan, 1970) like those encountered in the Ohio River. Samples taken with the grab were 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 of five percent formalin (Williams, 1974). These stains color animal tissue red and enable faster, more accurate hand sorting of benthic samples. Preserved samples were placed in labeled containers and taken to the laboratory where they were hand-sorted and the macroinvertebrates identified to the lowest practical taxon.

Taxonomic references used in identification included Johannsen (1934-37), Frison (1935), Ross (1944), Burks (1953), Pennak (1953), Needham and Westfall (1955), Usinger (1956), Eddy and Hodson (1961), Brinkhurst (1964 and 1965), Brinkhurst and Cook (1966), Mason (1971), Starrett (1971), Brown (1972), Burch (1972 and 1973), Holsinger (1972), Parrish (1975), Hobbs (1976), Williams (1976) and Wiggins (1977).

At Station 6, benthic sampling was conducted with a Surber square-foot sampler (Figure E-2). Both riffle and pool habitats of Little Saluda Creek were sampled. Surber samples were preserved and analyzed in the same manner as the Ponar samples.

Drift Macroinvertebrates

Those macroinvertebrates which voluntarily or involuntarily leave the bottom substrate and drift with the current were quantitatively sampled at all stations.

Drift sampling at the three Ohio River stations (1, 3, and 5) was conducted using a pair of 20-cm diameter, 505μ-mesh bongo nets towed from a boat (Figure E-3). Samples were taken in conjunction with fish egg and larvae collections, which were made on 17 occasions between 22 March and 16 August 1978. 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 which was fixed in the mouth of the net. No portion of Little Saluda Creek was suitable for the use of this apparatus; therefore qualitative samples were taken in conjunction with the larval fish trap program (see Section G).

Long-term drift community analysis was conducted using multiple-plate artificial substrate samplers (Hester and Dendy, 1962; Fullner, 1971) (Figure E-4). At Stations 1, 3 and 5, the samplers were suspended approximately one meter 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 a three-week period. Two replicate samplers were then retrieved from each station and scraped clean. The colonizing organisms were preserved and analyzed using the same method previously outlined for benthic samples.

Benthos/Macroinvertebrate Analysis

Biomass analyses were conducted on all samples. The biomass of each major macroinvertebrate group constituting the sample was obtained by drying for four hours at 105°C, then weighing to the nearest 0.001 g on a Mettler H32 analytical balance (EPA, 1973). Data were reported as biomass per replicate and also as biomass per square meter.

Biomass per square meter, as well as density of individuals per square meter, was calculated by multiplying the total per replicate by the appropriate conversion figure (one square meter equals the area sampled by 19.1 Ponar, 10.76 Surber, or 6.15 Hester-Dendy samples).

Volume of water filtered through the bongo nets was calculated by:

$$\text{Volume } (m^3) = A\ V\ T\ (0.000001)$$

where: A = Area of the mouth of the net (cm^2)

V = Velocity of current (cm/sec)

T = Time (sec)

The Shannon-Weaver index of diversity and the equitability component were applied to the density data. The Shannon-Weaver Index of diversity ($\bar{d}$) (Lloyd, et al., 1968) is used as a measure of the effect of induced stress on the structure of a community. It is calculated by:

$$\bar{d} = \frac{C}{N} (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where: C = 3.321928 (converts base 10 log to base 2)

N = Total number of individuals

n_i = Total number of individuals of the i^{th} species.

Mean diversity is affected by both the number of species and the distribution of individuals among the species present and may range from 0 to 3.321928 log N.

Equitability is a measure of the distribution of the individuals among the species in a sample only. Equitability values usually range from zero to one. Equitability is computed by:

$$e = \frac{s'}{s}$$

where: s = Number of taxa in the sample

s' = Hypothetical maximum number of taxa in the sample based on a table devised by Lloyd and Ghelardi (1964).

Data from EPA biologists have shown that diversity indices for macroinvertebrates in unpolluted water generally range from 3.0 to 4.0 and are usually below 1.0 in polluted waters. Equitability levels below 0.5 have not been encountered in waters known to be free of oxygen-demanding wastes. In such waters, equitability usually ranges from 0.6 to 0.8, while equitability in polluted waters is generally 0.0 to 0.3.

RESULTS AND DISCUSSION

The macroinvertebrate fauna collected during construction phase ecological monitoring near the Marble Hill Plant site was composed of oligochaete worms, molluscs, small crustaceans, immature insects, flatworms, and mites. No endangered or commercially valuable species were present. Complete collection data are given in Appendix Tables E-1 through E-42.

A total of 4009 individuals of 61 benthic and drift macroinvertebrate species was collected (Table E-1). Although seasonal differences were apparent, no statistically significant between-station differences were found in temperature, pH, conductivity, current velocity, or dissolved oxygen concentration data collected at the three Ohio River stations (Table E-2). Each of these chemical/physical factors has been demonstrated to influence macroinvertebrate species distribution under given circumstances. Chemical/physical data from Little Saluda Creek (Station 6) were frequently quite different from the data collected in the Ohio River because the habitat at Station 6 was entirely different from that at Stations 1, 3, and 5. Data from the two different habitats were therefore not comparable. In general, Station 6 was cooler, more alkaline, more conductive, and had lower current velocity and greater dissolved oxygen concentration. Complete physical/chemical data can be found in Appendix Tables A-1 through A-9.

The bottom of the Ohio River was very similar at Stations 1, 3 and 5 near the proposed Marble Hill Plant site. At deeper water stations the substrate was generally composed of mud with small stones and unoccupied *Corbicula* shells. Stones and shells were least abundant at Station 1, while Station 3 had mainly *Corbicula* shells and some stones. Station 5 had mostly stones and some shell. Shallow water substrates were generally composed of mud and a few stones. Stones were most abundant at Station 5 and least abundant at Station 1. Station 6 was a shallow stream with a rocky bottom. Small pools in the stream were generally only 1/3 meter deep and had the same rocky substrate.

Benthos - Stations 1, 3, and 5

The benthic fauna of the Ohio River was generally sparse and patchy in distribution. Density of individuals ranged from 38 to 3499/m^2 in deep water and from 53 to 1644/m^2 in shallow water (Figure E-5). Densities were comparable with those reported in previous Ohio River studies:

Study	Mile Post	Density Range
Construction monitoring, 1978	570	38-3499/m^2
Construction monitoring, 1977	570	10-2782/m^2
PSI, 1976	570	10-2865/m^2
Anderson & Mason, 1968	462 approx.	650-2218/m^2
Mason, et al., 1971	600.5	226-3950/m^2
Mason, et al., 1971	462.8	280-2196/m^2
Corps of Engineers, 1977	511	10-4403/m^2

Substrate differences probably account for most of the differences in density among the above sampling locations. Density near the proposed Marble Hill Plant was highest in May or August (summer) and lowest in March (late winter). This pattern is typical of freshwater systems (Hynes, 1972).

Biomass values were low as a result of the low density and ranged from 0.038 to 1.948 g/m^2 (Figure E-6). The higher biomass values were caused by the occasional capture of a large, heavy-bodied animal such as a mussel or crayfish. Biomass values were generally between 0.1 and 0.3 g/m^2.

Biomass values from the baseline study (PSI, 1976) were usually higher due to the more frequent appearance of molluscan species, particularly *Corbicula manilensis* (Asiatic clam), which sometimes occurred in considerable number. Although large numbers of unoccupied *Corbicula* shells were found (500-600/m^2 at Station 3), only a few living juveniles of this clam were found during the present study and those only in August and November. Because an ✓ individual mollusc generally contributes a greater proportion of the total biomass than does an individual of any other group, *Corbicula* comprised a large portion of the biomass reported in the baseline study. *Corbicula* have been common and numerous in the Ohio River since their first appearance in 1957 (Sinclair, 1963); and, as is generally the case with imported species, *Corbicula* population declines have been noted following periods of explosive population growth (Horning and Keup, 1964).

Diversity values ranged from 0.93 (Station 5, May) to 3.20 (Station 1, November). As with the number of species, diversity was generally higher in the second half of the year (Figure E-7). While diversity indices at the river stations could be regarded as generally low, they were comparable with indices calculated from data collected in previous studies:

Study	Mile Post	Diversity Index Range
Construction monitoring, 1978	570	0.93 - 3.20
Construction monitoring, 1977	570	0.0 - 2.83
PSI. 1976	570	0.0 - 2.69
Mason, et al., 1971	600.5	0.52 - 2.84
Mason, et al., 1971	462.8	0.32 - 2.85
Corps of Engineers, 1977	511	0.0 - 2.00

With some exceptions, oligochaete worms dominated the fauna at each of the river stations (Tables E-3 and E-4). The dominant worms were *Limnodrilus*, although many unidentifiable juvenile tubificid worms, *Branchiura sowerbyi*, *Peloscolex* sp., *Naidium* sp., and *Tubifex* sp. were also present. The crustacean fauna at the river stations was composed primarily of the amphipod *Gammarus pseudolimnaeus*. The insect fauna was composed of several immature species of flies, mayflies, and caddis flies. Representatives of the mollusc, crustacean, and insect groups were usually far less abundant than the oligochaete worms.

As previously mentioned, molluscs did not appear in the samples until August. This repeated a pattern noted during 1977 monitoring. Molluscs were primarily the snail *Somatogyrus* and the Asiatic clam *Corbicula manilensis*.

With one meaningful exception, no significant between-station differences were found in density, biomass, or diversity of the three

Ohio River stations.[a] This was true for both shallow-and deep-water samples (Tables E-5 and E-6, Part I). The one exception was the density of shallow-water samples: density at Station 5 was found to be significantly larger than the density at Stations 1 or 3. The reason for the reduced density probably lies in the greater number of micro-habitats offered by the presence of stones and shells at Station 5. This finding was substantially the same as observed during 1977.

In general, variation in density, biomass, and diversity did not correlate with variation in temperature, pH, dissolved oxygen concentration, current velocity, or conductance (Tables E-5 and E-6, Part II). Minor correlation of conductance with diversity at deep-water stations and current velocity with diversity at shallow water stations was noted.

When 1977 and 1978 data were compared, 1978 data usually had lower mean values. Only two values were significantly different. First, biomass at Station 5 in 1978 was significantly lower than in 1977. This probably does not have any biological significance as the molluscan population at Station 5 was larger in 1977 and thus contributed more biomass. Density at Station 3 was also observed to be significantly lower in 1978 than in 1977. This difference is probably best explained by the generally higher current velocities

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[a]In this and all subsequent statistical testing, all data was log transformed before analysis.

observed during 1978. Because Station 3 has the muddiest substrate, it may have been most affected by higher current velocities.

Within each station, the density, biomass, number of species, and diversity of the deep-water samples did not differ significantly from those of the shallow-water samples (Table E-7).

Drift Macroinvertebrates - Stations 1, 3, and 5

The drift macroinvertebrate fauna of the three Ohio River stations was generally less dense than the benthic fauna. Overall density was highest in August and lowest in March and ranged from 114 to 1233 individuals/m^2 (Figure E-8). The number of individuals per sampler ranged from 0 to 125 during the baseline study, from 1 to 272 during 1977, and from 13 to 207 during 1978.

Biomass followed the same pattern of variation as the density of individuals in that overall biomass was highest in August and lowest in March (Figure E-9). August biomass ranged from 1.433 to 1.525 g/m^2 and was significantly higher than the biomass found in other months, when values ranged from 0.031 to 0.123 g/m^2. Biomass of the macroinvertebrate fauna collected in the baseline study ranged from 0.0 to 1.241 g/m^2. August biomass values were larger due to the appearance of numerous caddis flies. This appearance is an annual occurrence well documented in previous Ohio River studies (Mason, et al., 1971; PSI, 1976; and ABI, 1978).

Despite the increased numbers of caddis flies, August diversity indices did not decline sharply as would be expected during such mass accumulations of animals of one type. Values ranged from 2.01 to 3.04 and were generally higher than in 1977 (0.81 to 2.80) or the baseline study (0.0 to 2.69)(Figure E-10).

As is usual in drifting macroinvertebrate studies, insects dominated the fauna at every station in every month of sampling (Table E-8). The degree of dominance ranged from 50.0 to 100% of the fauna. Crustaceans, primarily amphipods, were of secondary importance, while worms and molluscs appeared in the samples on only one occasion each.

Statistical analysis of the macroinvertebrate collection data revealed no significant between-station differences in density, biomass, or diversity (Table E-9). Seasonal differences in these parameters were apparent and expected. Correlations of increased density and biomass with increased temperature and decreased dissolved oxygen concentration, and increased conductance were noted. Other correlations involved increased diversity with increased current velocity and decreased conductance. These correlations were a function of seasonal influences and were not related to the construction of the Marble Hill Plant. Comparison of 1977 and 1978 macroinvertebrate data revealed no significant differences at any station.

Benthos - Station 6

Density of the benthos in Little Saluda Creek was usually higher in riffle habitats than in pool habitats. Benthic density in riffles was usually higher than benthic density at the river stations as well. Highest density at Station 6 occurred in May (Table E-10). Biomass was also usually higher in the creek than at the river stations and always higher in riffles than in pools. Biomass values were highest in May and lowest in August and ranged from 0.075 to 1.571 g/m^2.

The number of species was always higher in riffles than in pools, and diversity indices ranged from 1.27 (May) to 3.23 (November). Diversity indices were generally much higher in 1978 than in 1977 due to the fact that the isopod *Lirceus fontinalis* was much less abundant during 1978 except during May. Insects dominated the fauna during other months (Table E-11).

Following is a brief comparison of data from the baseline study and construciton phase monitoring:

Parameter	Location	Range per sample: Baseline	1977	1978
Density	riffle	0-4469/m^2	1646-3658/m^2	108-1727/m^2
	pool	0-3762/m^2	145-603/m^2	65-1587/m^2
Biomass	riffle	0.0-26.969 g/m^2	1.786-6.209 g/m^2	0.054-1.571 g/m^2
	pool	0.0-33.922 g/m^2	0.172-0.516 g/m^2	0.049-0.732 g/m^2
Diversity	riffle	0- 2.12	0.40 -1.65	1.27 -3.23
	pool	0- 2.85	0.47 -1.65	1.68 -2.69

Generally, the baseline data varied over a much wider range and showed less difference between riffle and pool habitats than did the 1977 or 1978 monitoring programs. Compared to 1977, riffle habitat density and biomass during 1978 were significantly reduced and diversity was significantly increased (Table E-12). The lower density pool habitats were not significantly affected, but Little Saluda Creek is comprised primarily of riffle habitats.[a] The increase in diversity was a result of the reduction of the *Lirceus fontinalis* population which in baseline and 1977 studies was the dominant creek species. These statistical differences are attributed to plant construction impact through substantial alteration of the stream substrate by runoff from the top of Marble Hill and mainly from driving construction vehicles through the stream on occasions between early July and mid-August. In August, this impact was reported to Public Service Co. of Indiana which then erected barricades to keep construction vehicles out of the creek.

[a]Conversely, 1978 data showed larger fish populations in Little Saluda Creek, i.e., no impact was apparent upon the upper trophic levels of the creek.

Macroinvertebrates - Station 6

Macroinvertebrate density in Little Saluda Creek ranged from 18 to 311 individuals/m^2 in March and May, respectively (Table E-13), repeating the minimum/maximum pattern noted in 1977. Biomass followed the same pattern of variation as density in that lowest values occurred in March and highest values occurred in May. No data was collected in August as the samplers were destroyed by construction activities. Macroinvertebrate diversity in the creek was lowest in May and highest in November. In general, patterns of variation in the macroinvertebrate community of Little Saluda Creek bore little relationship to patterns of variation in the macroinvertebrate community of the Ohio River.

As with the benthic fauna of Little Saluda Creek, crustaceans dominated the macrcinvertebrate fauna to a great extent (Table E-14). Again, the bulk of the dominant crustaceans was composed of *Lirceus fontinalis*. Insects were of secondary importance except in November.

Following is a brief comparison of data from the baseline study and construction phase monitoring:

	Range per sample		
Parameter	Baseline	1977	1978
Individuals	0-125	0-264	2-66
Biomass	0-1.241g	0-0.463g	0.006-0.140g
Diversity	0-2.22	0.60-2.39	0.24-2.29

Drift Macroinvertebrates - Stations 1, 3 and 5

A total of 42,757 drift macroinvertebrates were taken in conjunction with fish egg and larva sampling (Table E-15). Of this total, 89.6% of the individuals from the three river stations were composed of several species of cladocerans and copepods which are more usually considered zooplanktonic forms. The remainder was composed of small worms, crustaceans, insects, and hydroids. Eight species were found in drift samples only. Complete collection data may be found in Appendix Tables E-25 through E-41.

When sampling began in late March, density was between 0.2 and 1.6 individuals/m^3. Peak density occurred in mid-June when up to 142.6 individuals/m^3 were taken. After mid-June, density returned to values similar to those found in March. Greatest densities were usually encountered at bottom depths.

Statistical analysis of the density data by two-way analysis of variance showed significant variation in drift macroinvertebrate density with sampling date (Table E-16). This effect was expected because cladoceran populations, which comprised the bulk of the community, are known to vary appreciably over the course of the year (Pennak, 1953).

Two-way analysis of variance revealed no significant differences among the density of individuals at Stations 1, 3, and 5 regardless of depth. At all stations, surface collections were significantly smaller than either mid-depth or bottom collections. Surface populations were probably smaller because current velocities are generally greatest at the surface of a river (Hynes, 1972). Further statistical tests revealed no differences in the densities of the 1977 and 1978 drift macroinvertebrate collections despite the 1978 collection being much smaller in total number of organisms (Table E-16 and E-17). The 1978 collections had nearly three times the number of species, however. With a few exceptions, the drift macroinvertebrate fauna was very similar to the benthic fauna (Tables E-1 and E-15).

Cladocerans, the bulk of the drift community, are small crustaceans between 0.2 and 3.0 mm long. Most species feed on phytoplankton, but some (e.g., *Leptodora kindti*) feed on zooplankters. The importance of cladocerans in the aquatic food chain is as food for young fish. Various studies of young fish stomach contents show up to 95% cladocerans by volume. Few studies show less than 10%. Many cladoceran species are cosmopolitan and are frequently tolerant of a wide range of temperatures, pH, and dissolved oxygen concentrations (Pennak, 1953). As found in the present study, cladocerans are most abundant in spring and virtually absent from a habitat in summer and winter. Species vary greatly from one another in their seasonal abundance, and a single species may have quite different population abundance curves in two adjacent bodies of water. Furthermore, relative abundance and specific time of maximum and minimum populations may vary considerably within a single species in the same river from one year to the next (Pennak, 1953). This was particularly evident when 1977 and 1978 cladoceran collections were compared.

Drift Macroinvertebrates - Station 6

A total of 20 species were collected by larval fish traps placed at Station 6 (Appendix Table E-42). All but one of these species (*Heterocleon* sp.) were found in other collections made at Station 6. Only a qualitative survey was made. As is usual in drift macroinvertebrate studies, most of these organisms were insects although the isopod *Lirceus fontinalis* was the most abundant species. Most of the organisms collected are not known as drifting type organisms but are substrate dwellers thus reflecting the shallowness of Little Saluda Creek.

CONCLUSIONS

The benthic and macroinvertebrate fauna of the Ohio River were generally of low density, biomass and diversity. Data collected during the 1978 construction phase ecological monitoring program usually showed somewhat lower density, biomass, and diversity than was found at the Marble Hill Plant site during baseline or 1977 monitoring programs. Data were still generally comparable, however. Changes in the benthic and macroinvertebrate fauna of the Ohio River were found to be determined by seasonal changes in the environment and not by construction activity at the Marble Hill Plant site.

Significant density, biomass, and diversity changes were noted in Little Saluda Creek. Density and biomass were much lower in 1978 than in 1977 while diversity was much higher as a result of the reduction of the isopod population. Isopods were previously the dominant organism in the creek. The above changes all came about as a direct result of construction activity. Subsequent mitigative procedures were initiated that are expected to reduce observed impacts.

Drift macroinvertebrate collections had lower density in 1978 than in 1977 yet no statistical differences were found. The drift community is sparsely populated by benthic invertebrates and numerically dominated by zooplanktonic forms. Construction at the Marble Hill Plant site does not appear to influence or inhibit the drift macroinvertebrate community.

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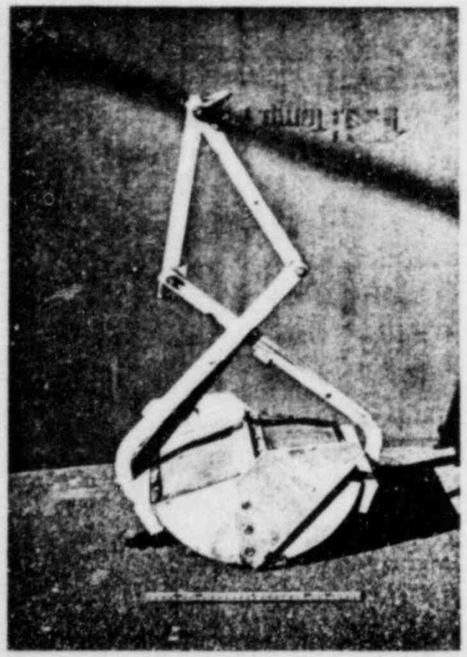

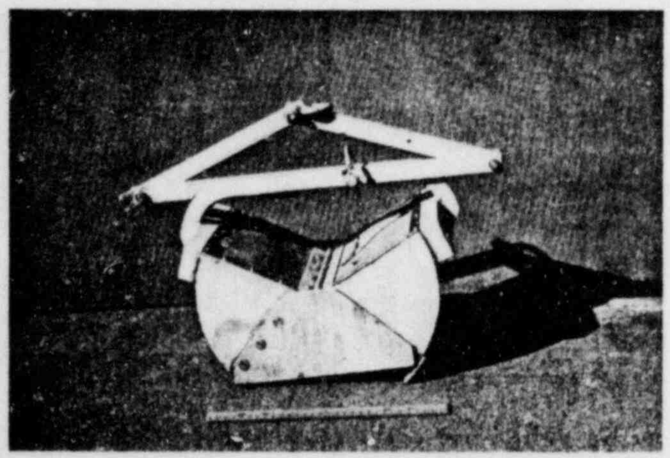

Figure E-1

Ponar grab in closed(upper) and open (lower) positions.

Figure E-2

Surber square-foot sampler in operation.

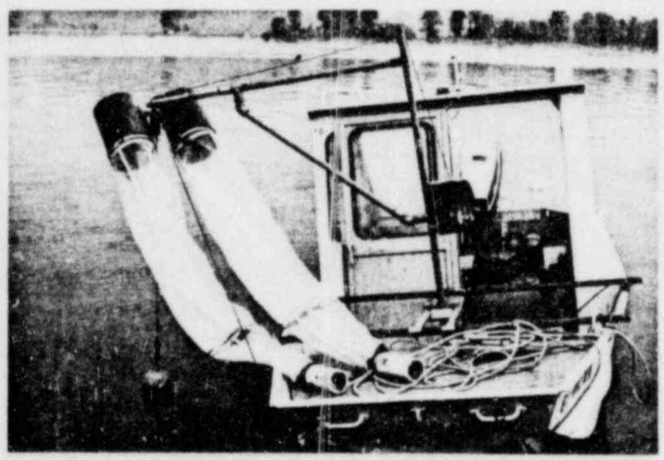

Figure E-3

Bongo Nets.

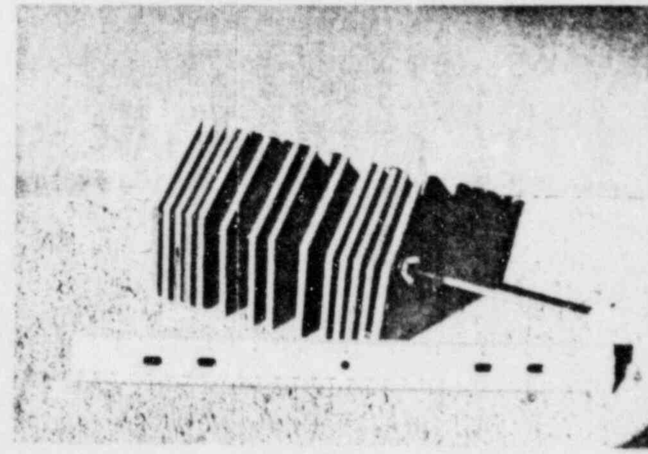

Figure E-4

Multiple-plate artificial substrate sampler of the type used in this study.

MARBLE HILL NUCLEAR GENERATING STATION UNITS 1 & 2

SAMPLING EQUIPMENT

APPLIED BIOLOGY, INC.

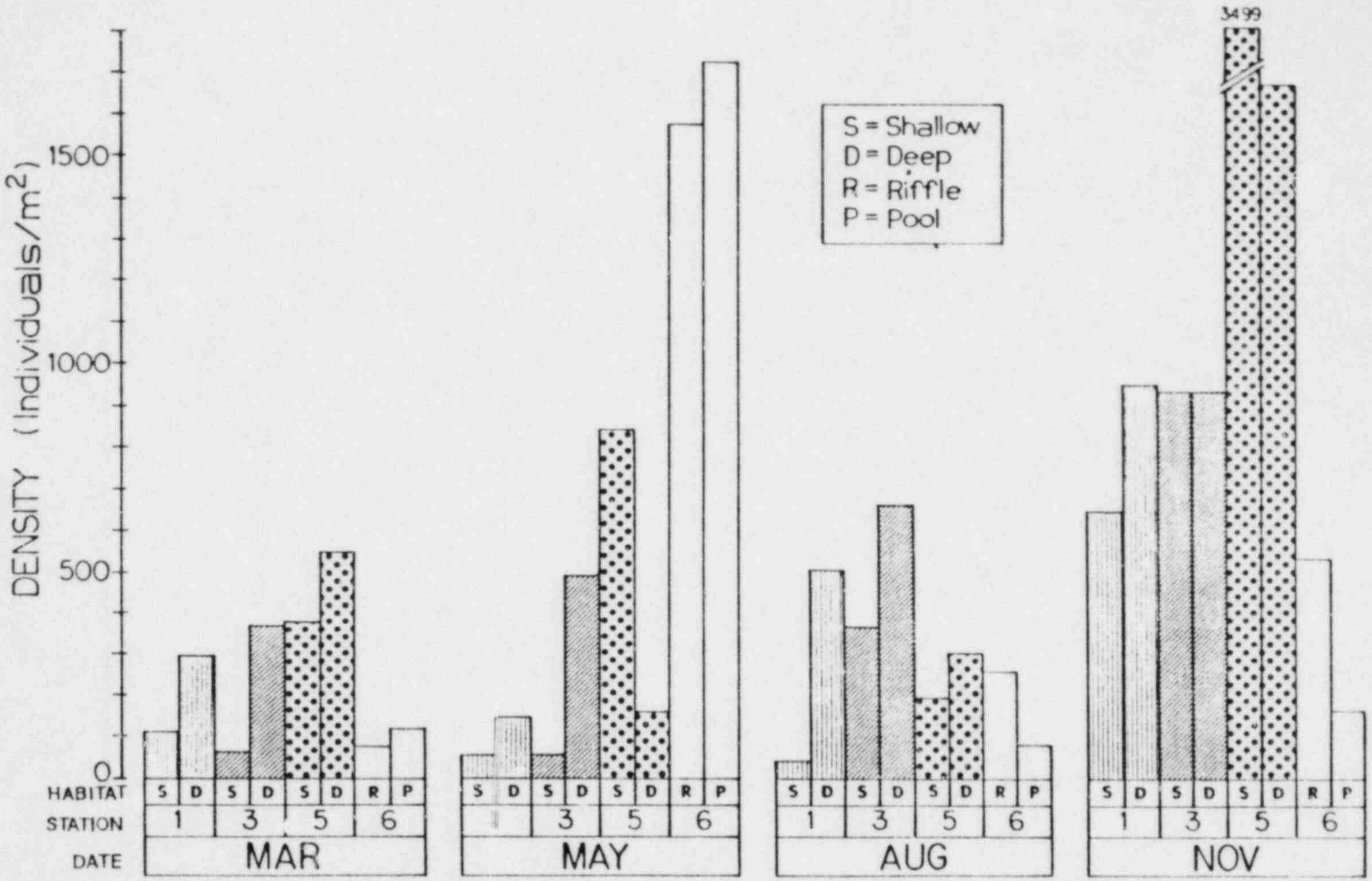

Figure E-5. Density of benthic macroinvertebrates, Marble Hill Plant site, 1978.

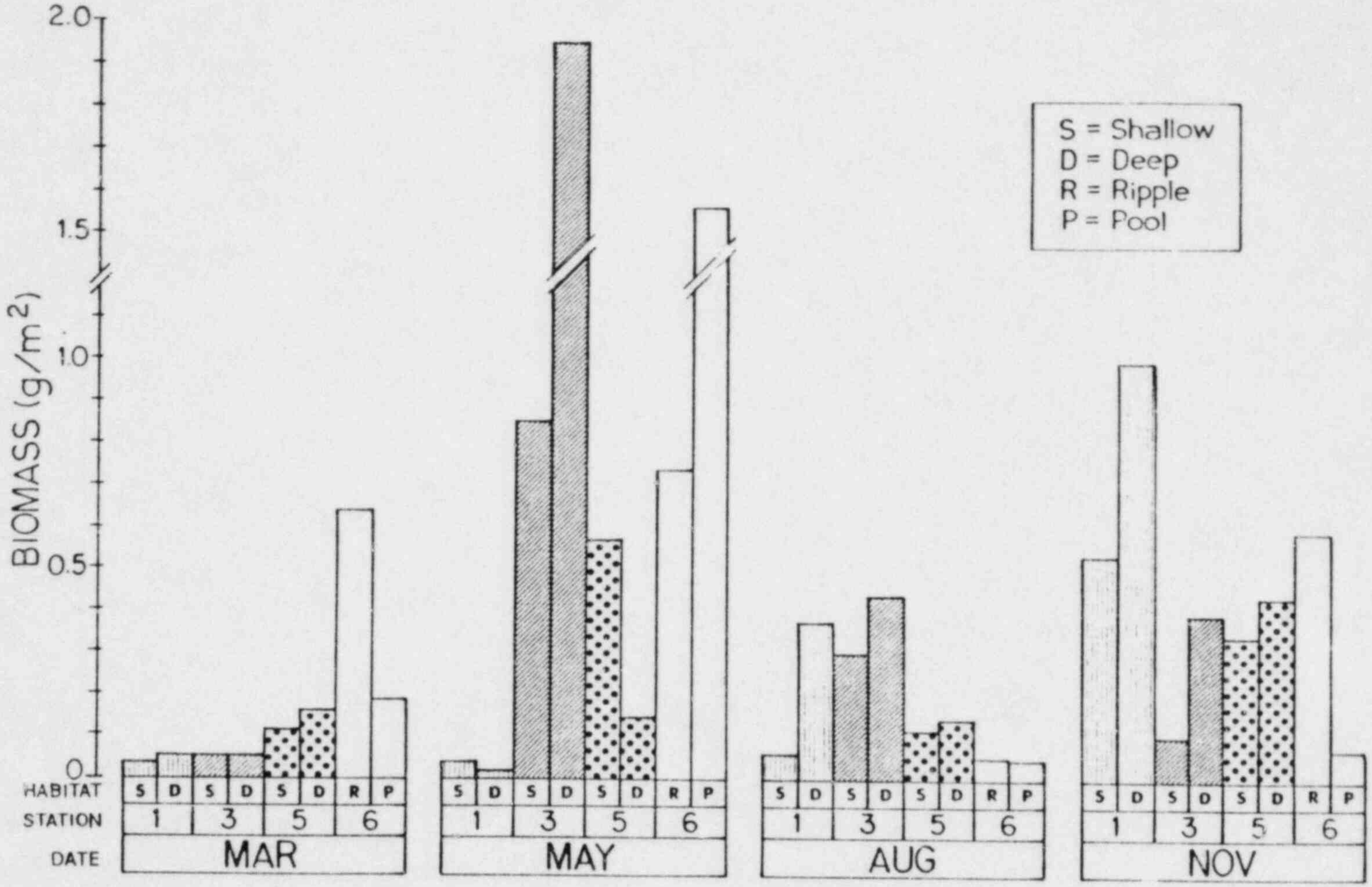

Figure E-6. Biomass of benthic macroinvertebrates, Marble Hill Plant site, 1978.

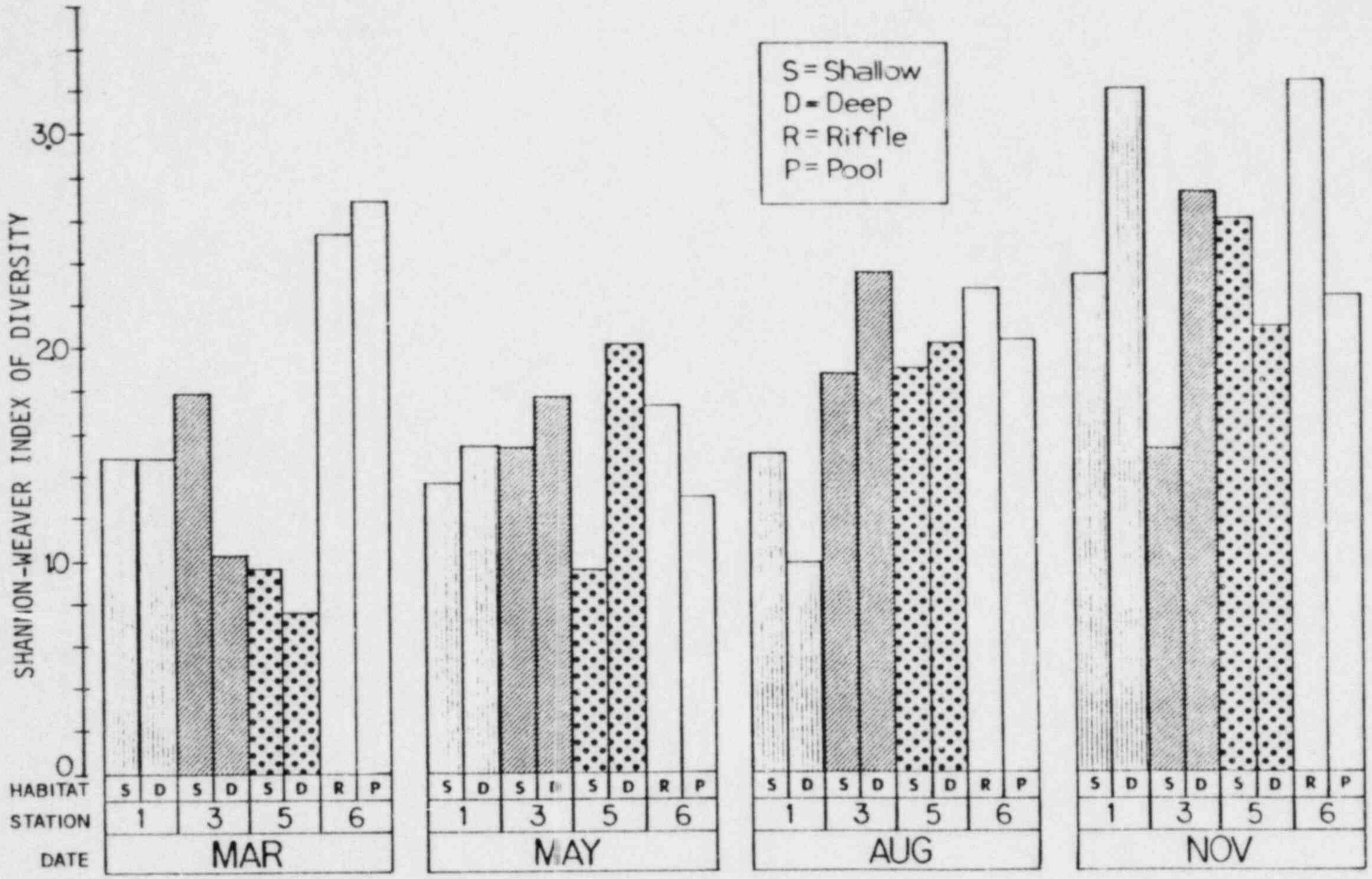

Figure E-7. Diversity of benthic macroinvertebrates, Marble Hill Plant site, 1978.

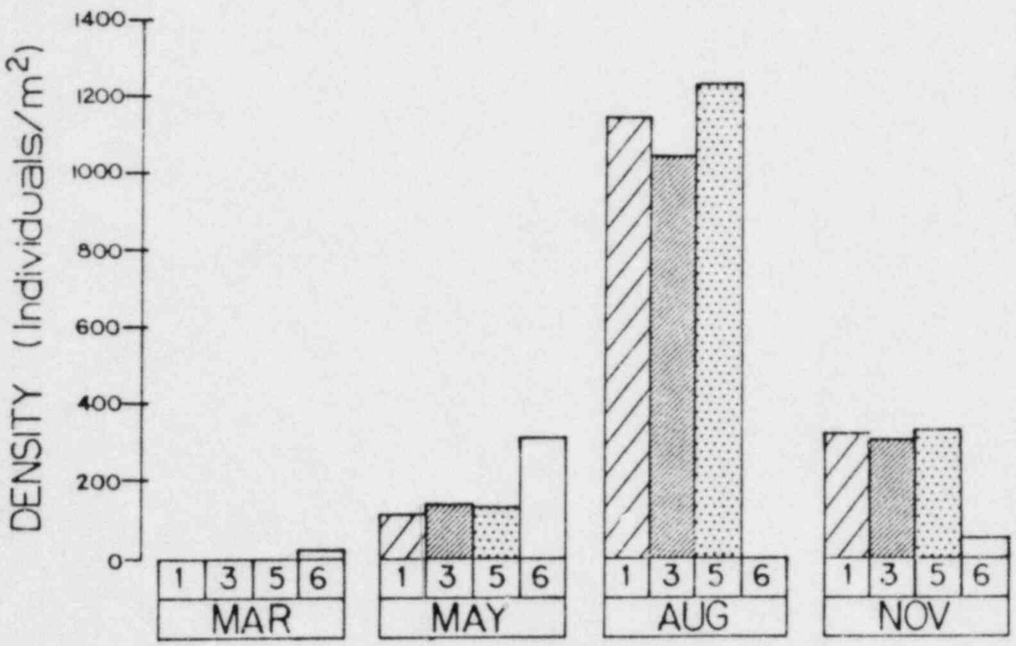

Figure E-8. Density of drift macroinvertebrates, Marble Hill Plant site, 1978.

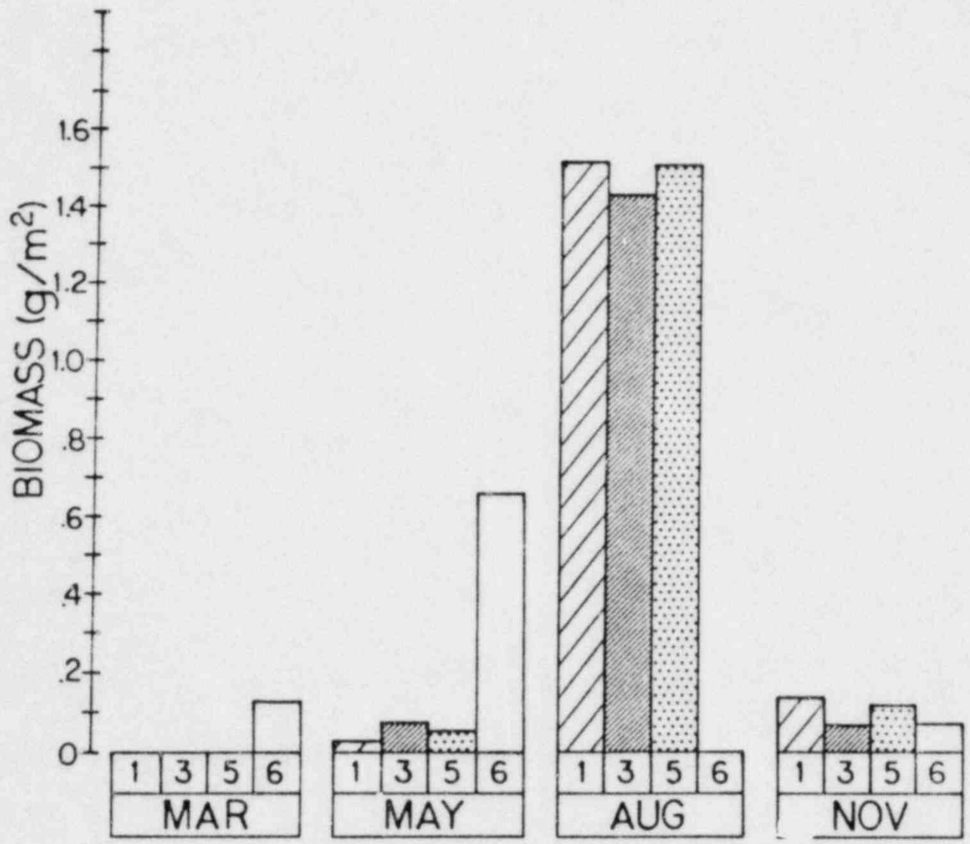

Figure E-9. Biomass of drift macroinvertebrates, Marble Hill Plant site, 1978.

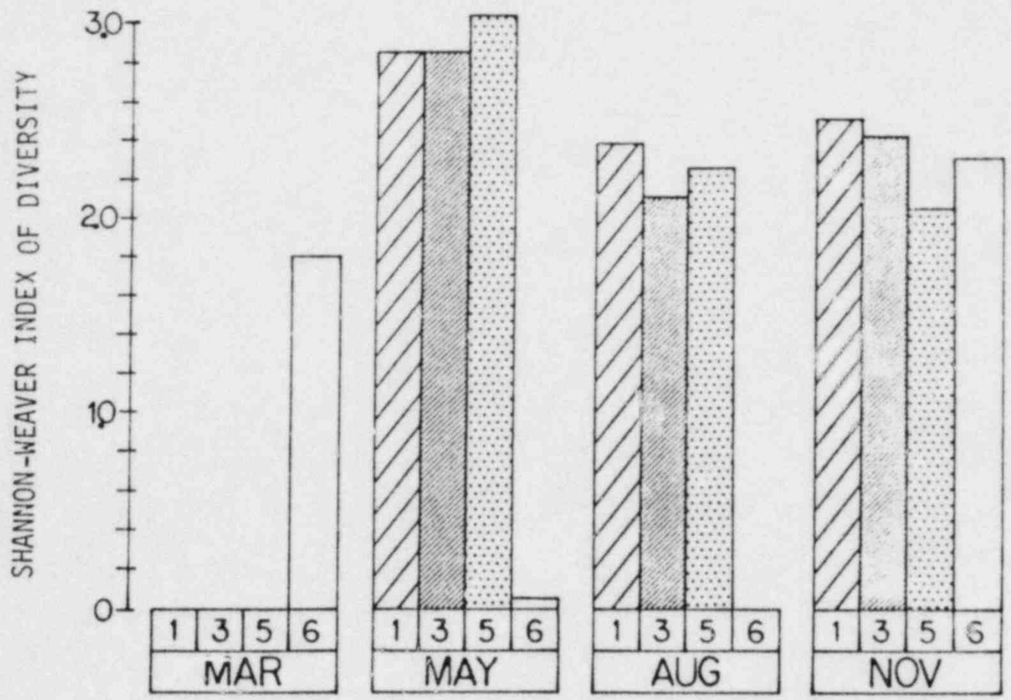

Figure E-10. Diversity of drift macroinvertebrates, Marble Hill Plant site, 1978.

TABLE E-1

OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1978

Species	Station 1	3	5	6
Class Oligochaeta				
worms *Branchiura sowerbyi*	✓	✓	✓	
Limnodrilus hoffmeisteri	✓	✓	✓	
L. maumeensis				✓
Naidium sp.	✓	✓		
Peloscolex sp.	✓	✓	✓	
Tubifex tubifex			✓	
immature tubificids	✓	✓	✓	✓
Class Hirudinea				
leeches *Helobdella fusco*	✓			
Class Turbellaria				
flatworms *Phagocata velata*	✓	✓	✓	✓
Class Arachnida				
mites unidentified		✓		
Class Crustacea				
isopods *Lirceus fontinalis*		✓		✓
amphipods *Gammarus pseudolimnaeus*	✓	✓	✓	
Class Insecta				
Order Diptera				
midges *Ablabesmyia mallochi*	✓	✓	✓	
Chaoborus punctipennis		✓	✓	
Cardiocladius sp.				✓
Cricotopus sp.	✓	✓	✓	✓
Cryptochironomus fulvus	✓	✓	✓	✓
Coelotanypus sp.	✓	✓	✓	✓
Chironomus attenuatus	✓		✓	✓
Dicrotendipes modestus	✓	✓	✓	✓
Eukiefferiella sp.	✓	✓	✓	
Micropsectra sp.	✓	✓	✓	✓
Orthoctadius sp.				✓
Phaenopsectra sp.	✓		✓	
Polypedilum halterale	✓	✓	✓	✓
Probezzia sp.				✓

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1978

Species	Station 1	3	5	6
Order Diptera (continued)				
Procladius sp.	✓	✓	✓	
Stenochironomus sp.			✓	✓
crane flies *Tipula* sp.				✓
black flies *Simulium* sp.				✓
marsh flies *Tetanocera* sp.				✓
horse flies *Tabanus* sp.			✓	✓
Chrysops sp.				✓
Order Ephemeroptera				
mayflies *Baetis* sp.	✓		✓	✓
Caenus sp.	✓			
Hexagenia limbata	✓		✓	
Stenonema heterotarsale	✓			
S. interpunctatum	✓	✓	✓	✓
Stenonema sp.	✓			
Order Plecoptera				
stonefiles *Isoperla clio*				✓
Peltoperla sp.	✓	✓	✓	
Order Trichoptera				
caddis flies *Agraylea* sp.		✓	✓	
Cheumatopsyche sp.				✓
Cyrnellus fraternus				✓
Hydropsyche orris	✓	✓	✓	✓
Neureclipsis crepuscularis		✓	✓	
Potamyia flava	✓	✓	✓	✓
Order Odonata				
damsel flies *Calopteryx* sp.				✓
dragonflies *Macromia illinoiensis*		✓	✓	
Order Coleoptera				
beetles *Dubiraphia* sp.				✓
Ectopria sp.				✓
Hydroporus sp.				✓
Psephenus herricki				✓
Rhizelmis sp.				✓
Stenelmis (sexlineata?)				✓
Order Collembola				
springtails *Isotomurus palustris*				✓

TABLE E-1
(continued)
OCCURRENCE OF BENTHIC AND MACROINVERTEBRATE SPECIES
MARBLE HILL PLANT SITE
1978

Species	Station 1	3	5	6
Class Gastropoda				
snails *Somatohyrus* sp.	✓	✓	✓	
Class Pelecypoda				
bivales *Corbicula manilensis*	✓	✓	✓	
Lampsilis sp.		✓		
Megalonais gigantea		✓		
Sphaerium sp.	✓	✓	✓	
Species/station	31	31	33	35
Total species: 61				
Individuals/station	800	875	1340	994
Total individuals: 4009				

TABLE E-2

TWO-WAY ANALYSIS OF VARIANCE OF CHEMICAL/PHYSICAL PARAMETERS MEASURED IN CONJUNCTION WITH BIOTIC SAMPLING
OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
1978

Parameter	Comparison	Critical F value (α=.05)	Calculated F value (α=.05)
Temperature	among seasons	4.76	2047.678*
	among stations	5.14	0.219
pH	among seasons	4.76	47.890*
	among stations	5.14	0.999
Specific conductance	among seasons	4.76	3567.702*
	among stations	5.14	2.182
Current velocity	among seasons	4.76	69.053*
	among stations	5.14	2.060
Dissolved oxygen	among seasons	4.76	110.240*
	among stations	5.14	1.283

*Significant at α=.05.

TABLE E-3

STRUCTURE OF THE DEEP-WATER BENTHIC COMMUNITY
OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
1978

Month	Station	Number of individuals (% composition)				
		Worms	Molluscs	Crustaceans	Insects	Others
March	1	31 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	3	38 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	5	57 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
May	1	7 (43.8)	0 (0.0)	4 (25.0)	5 (31.2)	0 (0.0)
	3	7 (13.5)	1 (1.9)	4 (7.7)	39 (75.0)	1 (1.9)
	5	11 (25.6)	2 (4.7)	2 (4.7)	28 (65.0)	0 (0.0)
August	1	54 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	3	54 (79.4)	1 (1.5)	1 (1.5)	12 (17.6)	0 (0.0)
	5	21 (65.6)	0 (0.0)	0 (0.0)	11 (34.4)	0 (0.0)
November	1	41 (41.0)	15 (15.0)	11 (11.0)	18 (18.0)	15 (15.0)
	3	30 (30.9)	11 (11.3)	17 (17.5)	34 (35.1)	5 (5.2)
	5	48 (27.9)	13 (7.6)	13 (7.6)	93 (54.0)	5 (2.9)

TABLE E-4

STRUCTURE OF THE SHALLOW-WATER BENTHIC COMMUNITY
OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
1978

		Number of individuals (% composition)				
Month	Station	Worms	Molluscs	Crustaceans	Insects	Others
March	1	3 (27.3)	0 (0.0)	0 (0.0)	8 (76.7)	0 (0.0)
	3	4 (80.0)	0 (0.0)	0 (0.0)	1 (20.0)	0 (0.0)
	5	38 (97.4)	0 (0.0)	0 (0.0)	1 (2.6)	0 (0.0)
May	1	1 (20.0)	0 (0.0)	3 (60.0)	1 (20.0)	0 (0.0)
	3	2 (40.0)	0 (0.0)	2 (40.0)	1 (20.0)	0 (0.0)
	5	80 (90.9)	0 (0.0)	0 (0.0)	8 (9.1)	0 (0.0)
August	1	3 (75.0)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)
	3	35 (92.1)	0 (0.0)	0 (0.0)	3 (7.9)	0 (0.0)
	5	16 (76.2)	0 (0.0)	0 (0.0)	5 (23.8)	0 (0.0)
November	1	24 (35.3)	3 (4.4)	2 (2.9)	39 (57.4)	0 (0.0)
	3	74 (76.3)	1 (1.0)	3 (3.1)	19 (19.6)	0 (0.0)
	5	163 (44.5)	7 (1.9)	19 (5.2)	177 (48.4)	0 (0.0)

TABLE E-5

STATISTICAL ANALYSIS OF DEEP-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT SITE
1978

I. TWO-WAY ANOVA

Community parameter	Comparison	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
Density	among seasons	2.76	6.46*
	among stations	3.74	2.11
Biomass	among seasons	2.76	0.66
	among stations	3.74	1.29
Diversity	among seasons	4.76	3.44
	among stations	5.14	0.19

II. CORRELATION

Comparison		
Community parameter	Physical/chemical parameter	Calculated $r(\alpha=.05)$[a]
Density with	temperature	-0.109
	pH	-0.662
	dissolved oxygen	0.026
	current velocity	0.630
	conductance	0.665
Biomass with	temperature	0.149
	pH	-0.293
	dissolved oxygen	-0.269
	current velocity	-0.149
	conductance	0.249
Diversity with	temperature	0.205
	pH	-0.654
	dissolved oxygen	-0.404
	current velocity	-0.652
	conductance	0.754*

TABLE E-5
(continued)
STATISTICAL ANALYSIS OF DEEP-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT SITE
1978

III. 1977-1978 DATA COMPARISON

Station	Parameter	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
1	density	4.60	0.01
	biomass	4.60	0.39
	diversity	7.71	0.29
3	density	4.60	0.07
	biomass	4.60	0.33
	diversity	7.71	2.98
5	density	4.60	0.68
	biomass	4.60	9.87*
	diversity	7.71	0.43

*Significant at $\alpha=.05$.

[a]Critical r value for all correlation calculations was 0.671.

TABLE E-6

STATISTICAL ANALYSIS OF SHALLOW-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT SITE
1978

I. TWO-WAY ANOVA

Community parameter	Comparison	Critical F(α=.05)	Calculated F(α=.05)
Density	among seasons	2.76	5.30*
	among stations	3.74	11.38*
Biomass	among seasons	2.76	0.89
	among stations	3.74	0.36
Diversity	among seasons	4.76	2.11
	among stations	5.14	0.31

II. CORRELATION

Comparison		
Community parameter	Physical/chemical parameter	Calculated r(α=.05)[a]
Density with	temperature	-0.116
	pH	-0.628
	dissolved oxygen	-0.018
	current velocity	-0.411
	conductance	0.499
Biomass with	temperature	0.132
	pH	-0.336
	dissolved oxygen	-0.324
	current velocity	0.042
	conductance	0.176
Diversity with	temperature	0.090
	pH	-0.471
	dissolved oxygen	-0.159
	current velocity	-0.677*
	conductance	0.621

TABLE E-6
(continued)
STATISTICAL ANALYSIS OF SHALLOW-WATER BENTHOS COLLECTION DATA
MARBLE HILL PLANT SITE
1978

III. 1977-1978 DATA COMPARISON

Station	Parameter	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
1	density	4.96	3.45
	biomass	4.96	1.41
	diversity	7.71	7.24
3	density	4.96	6.23*
	biomass	4.96	3.07
	diversity	7.71	0.14
5	density	4.96	1.07
	biomass	4.96	4.67
	diversity	7.71	0.12

*Significant at $\alpha=.05$.

[a]Critical r value for all correlation calculations was 0.671.

TABLE E-7

STATISTICAL COMPARISON OF SHALLOW AND
DEEP-WATER SAMPLING STATIONS
MARBLE HILL PLANT SITE
1978

Community parameter	Depth	Mean replicate value	Calculated $F(\alpha=.05)$[a]
Biomass	deep	0.022 g	1.166
	shallow	0.014 g	
Abundance	deep	30.54	0.003
	shallow	31.17	
Diversity	deep	1.74	0.497
	shallow	1.65	

[a]Critical F value was 4.07.

TABLE E-8

STRUCTURE OF THE MACROINVERTEBRATE COMMUNITY
OHIO RIVER STATIONS 1, 3, AND 5
MARBLE HILL PLANT SITE
1978

		Number of individuals (% composition)				
Month	Station	Worms	Molluscs	Crustaceans	Insects	Others
March	1	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	0 (0.0)
	3	0 (0.0)	0 (0.0)	0 (0.0)	6 (100.0)	0 (0.0)
	5	0 (0.0)	0 (0.0)	0 (0.0)	9 (100.0)	0 (0.0)
May	1	0 (0.0)	0 (0.0)	81 (26.9)	222 (73.1)	0 (0.0)
	3	0 (0.0)	0 (0.0)	54 (26.7)	148 (73.3)	0 (0.0)
	5	0 (0.0)	0 (0.0)	109 (28.5)	273 (71.5)	0 (0.0)
August	1	0 (0.0)	0 (0.0)	1 (0.4)	274 (99.6)	0 (0.0)
	3	0 (0.0)	0 (0.0)	0 (0.0)	333 (100.0)	0 (0.0)
	5	0 (0.0)	0 (0.0)	0 (0.0)	401 (100.0)	0 (0.0)
November	1	0 (0.0)	1 (1.0)	40 (40.0)	59 (59.0)	0 (0.0)
	3	1 (1.0)	0 (0.0)	47 (47.0)	50 (50.0)	0 (0.0)
	5	0 (0.0)	0 (0.0)	61 (58.1)	44 (41.9)	0 (0.0)

TABLE E-9

STATISTICAL ANALYSIS OF MACROINVERTEBRATE (ARTIFICIAL SUBSTRATE) COLLECTION DATA MARBLE HILL PLANT SITE 1978

I. TWO-WAY ANOVA

Community parameter	Comparison	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
Density	among seasons	3.33	69.29*
	among stations	4.10	0.55
Biomass	among seasons	3.33	627.42*
	among stations	4.10	0.61
Diversity	among seasons	6.94	8.76*
	among stations	6.94	0.50

II. CORRELATION

Comparison		
Community parameter	Physical/chemical parameter	Calculated $r(\alpha=.05)$[a]
Density with	temperature	0.860*
	pH	0.604
	dissolved oxygen	-0.687*
	current velocity	-0.288
	conductance	0.226
Biomass with	temperature	0.929*
	pH	0.726
	dissolved oxygen	-0.766
	current velocity	-0.256
	conductance	0.091
Diversity with	temperature	-0.219
	pH	0.039
	dissolved oxygen	-0.032
	current velocity	0.790*
	conductance	-0.765*

TABLE E-9
(continued)
STATISTICAL ANALYSIS OF MACROINVERTEBRATE
(ARTIFICIAL SUBSTRATE) COLLECTION DATA
MARBLE HILL PLANT SITE
1978

III. 1977-1978 DATA COMPARISON

Station	Parameter	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
1	density	4.96	4.66
	biomass	4.96	0.42
	diversity	7.71	0.42
3	density	5.12	3.66
	biomass	5.12	1.36
	diversity	7.71	0.23
5	density	4.96	2.62
	biomass	4.96	0.01
	diversity	7.71	0.54

*Significant at α=.05.

[a]Critical r value for all correlation calculations was 0.671.

TABLE E-10

SUMMARY OF BENTHIC COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Community parameter	Habitat	March	May	August	November
Density (no./m^2)	riffle	108	1727	253	549
	pool	65	1587	97	151
Biomass (g/m^2)	riffle	0.646	1.571	0.054	0.581
	pool	0.194	0.732	0.049	0.075
Diversity	riffle	2.56	1.27	2.23	3.23
	pool	2.69	1.68	2.06	2.22

TABLE E-11

STRUCTURE OF THE BENTHIC COMMUNITY
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

		Number of individuals (% composition)				
Month	Habitat	Worms	Molluscs	Crustaceans	Insects	Others
March	riffle	7 (43.8)	0 (0.0)	5 (31.2)	7 (43.8)	1 (6.2)
	pool	2 (16.7)	0 (0.0)	3 (25.0)	7 (58.3)	0 (0.0)
May	riffle	6 (1.9)	0 (0.0)	251 (78.2)	24 (7.5)	40 (12.4)
	pool	0 (0.0)	0 (0.0)	211 (71.5)	68 (23.1)	16 (5.4)
August	riffle	27 (3.7)	0 (0.0)	19 (14.5)	83 (63.3)	2 (1.5)
	pool	13 (43.3)	0 (0.0)	2 (6.7)	15 (50.0)	0 (0.0)
November	riffle	14 (29.8)	0 (0.0)	1 (2.1)	32 (68.1)	0 (0.0)
	pool	11 (61.1)	1 (5.6)	0 (0.0)	6 (33.3)	0 (0.0)

TABLE E-12

STATISTICAL COMPARISON OF BENTHOS COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1977-1978

Sample type	Parameter	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
Benthos Riffle habitat	density	4.60	18.58*
	biomass	4.60	9.17*
	diversity	5.99	13.06
Benthos Pool habitat	density	5.99	4.45
	biomass	5.99	2.18
	diversity	18.50	2.78
Macroinvertebrate Artificial Substrate	density	4.96	0.78
	biomass	4.96	1.35
	diversity	7.71	0.01

*Significant at $\alpha=.05$

TABLE E-13

SUMMARY OF MACROINVERTEBRATE COLLECTION DATA
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Community parameter	March	May	August	November
Density (no./m^2)	18	311	-	46
Biomass (g/m^2)	0.129	0.664	-	0.080
Diversity	1.79	0.24	-	2.29

TABLE E-14

STRUCTURE OF THE MACROINVERTEBRATE COMMUNITY
LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Date	Worms	Molluscs	Crustaceans	Insects	Others
March	0 (0.0)	0 (0.0)	3 (50.0)	2 (33.3)	1 (16.7)
May	0 (0.0)	0 (0.0)	98 (97.0)	2 (2.0)	1 (1.0)
August	-	-	-	-	-
November	0 (0.0)	0 (0.0)	6 (40.0)	9 (60.0)	0 (0.0)

TABLE E-15

LIST OF DRIFT MACROINVERTEBRATE SPECIES COLLECTED IN CONJUNCTION WITH FISH EGGS AND LARVAE SAMPLING
MARBLE HILL PLANT SITE
1978

Class Hydrozoa
Hydra sp.

Class Oligochaeta
Branchiura sowerbyi
Limnodrilus hoffmeisteri
immature tubificids

Class Gastropoda
Physa sp.

Class Arachnida
Hydrachna sp.

Class Crustacea
copepods[a]
cladocerans[a]
ostracods[a]
Gammarus pseudolimnaeus
Lirceus fontinalis

Class Insecta
Order Diptera
Ablabesmyia rhamphe[a]
Chaoborus punctipennis
Chironomus attenuatus
Cricotopus sp.
Cryptochironamus sp.
Dicrotendipes modestus
Euriefferiella sp.
Orthocladius sp.
Parachironomus sp.
Pericoma sp.[a]
Polypedilum halterale
Probezzia sp.
Procladius sp.
Stratiomyia sp.[a]
Tanypus sp.
Order Trichoptera
Cyrnellus fraternus[a]
Cheumatopsyche sp.
Hydropsyche orris
Neureclipsis crepuscularis
Potamyia flava
Order Ephemeroptera
Baetis intercalaris
Callibaetis sp.[a]
Caenis sp.
Hexagenia limbata
Stenanema interpunetatum
Order Coleoptera
Helodidae[a]
Order Collembola
Isotamurus palustris

[a]These species were found only in drift samples and not in benthic or macroinvertebrate samples.

TABLE E-16

STATISTICAL ANALYSIS OF DRIFT
MACROINVERTEBRATE COLLECTION DATA
MARBLE HILL PLANT SITE
1978

I. TWO-WAY ANOVA

Depth	Comparison	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
Surface	among seasons	1.98	9.38*
	among stations	3.30	0.09
Mid-depth	among seasons	1.98	36.52*
	among stations	3.30	0.33
Bottom	among seasons	1.98	47.76*
	among stations	3.30	0.78
All	Station 1	3.30	4.83*
	Station 3	3.30	7.91*
	Station 5	3.30	5.82*

II. 1977-1978 DATA COMPARISON

Station	Depth	Critical $F(\alpha=.05)$	Calculated $F(\alpha=.05)$
1	surface	4.41	0.75
	mid-depth	4.41	2.07
	bottom	4.41	1.22
3	surface	4.41	0.62
	mid-depth	4.41	1.92
	bottom	4.41	0.55
5	surface	4.41	0.27
	mid-depth	4.41	0.14
	bottom	4.41	0.15

*Significant at $\alpha=.05$

TABLE E-17

COMPARISON OF DENSITY OF MACROINVERTEBRATES IN BONGO-NET SAMPLES
MARBLE HILL PLANT SITE
1977-1978

BOTTOM

Date	Mar 22	Apr 6	21	May 5	17	30	Jun 6	13	19	26	Jul 6	13	20	27	Aug 3	10	17
Station 1 Bottom (individuals/m³)																	
1978	0.4	0.2	0.3	0.0	0.3	0.4	21.1	7.5	81.1	53.1	9.1	0.6	0.4	1.7	8.4	2.1	0.6
1977	-	-	-	1.7	71.8	489.1	890.1	107.4	125.4	2.4	0.0	0.6	-	0.0	-	-	-
Station 3 Bottom (individuals/m³)																	
1978	0.4	0.2	0.8	0.5	0.3	0.4	17.1	7.2	114.7	39.4	9.3	0.4	0.7	5.4	8.0	0.8	0.6
1977	-	-	-	0.9	148.3	254.6	621.3	199.7	12.9	1.0	0.0	0.0	-	0.0	-	-	-
Station 5 Bottom (individuals/m³)																	
1978	1.6	0.1	0.3	0.5	0.3	0.1	5.7	9.3	134.5	106.4	9.2	1.4	3.2	1.3	6.3	4.6	0.5
1977	-	-	-	5.6	12.2	165.7	394.0	6.0	4.9	7.7	0.0	0.0	-	0.6	-	-	-

MID-DEPTH

Date	Mar 22	Apr 8	21	May 5	17	30	Jun 6	13	19	26	Jul 6	13	20	27	Aug 3	10	17
Station 1 Mid-Depth (individuals/m³)																	
1978	0.3	0.2	0.1	0.1	0.6	0.5	6.2	6.2	53.7	13.5	5.8	0.9	0.1	1.8	6.0	1.3	0.7
1977	-	-	-	0.4	33.7	454.1	1176.2	66.8	185.5	0.5	0.0	1.1	-	1.6	-	-	-
Station 3 Mid-Depth (individuals/m³)																	
1978	1.2	0.1	0.2	3.0	0.4	0.1	7.8	4.7	37.5	23.2	6.0	0.5	0.1	0.8	5.7	1.8	0.5
1977	-	-	-	1.8	37.6	494.7	726.7	57.0	25.2	3.0	0.6	0.9	-	0.0	-	-	-
Station 5 Mid-Depth (individuals/m³)																	
1978	0.3	0.1	0.2	2.4	0.2	0.6	4.4	4.4	32.8	55.3	4.9	0.2	0.4	2.6	4.8	2.2	1.2
1977	-	-	-	1.2	13.5	93.3	281.7	8.2	1.8	2.0	0.0	0.0	-	1.1	-	-	-

SURFACE

Date	Mar 22	Apr 8	21	May 5	17	30	Jun 6	13	19	26	Jul 6	13	20	27	Aug 3	10	17
Station 1 Surface (individuals/m³)																	
1978	0.2	0.0	0.0	0.3	0.8	0.1	8.8	0.4	9.4	0.7	5.5	0.4	0.1	5.4	2.3	1.4	0.2
1977	-	-	-	0.4	3.9	460.9	1241.8	1.4	2.3	0.5	0.0	0.6	-	0.0	-	-	-
Station 3 Surface (individuals/m³)																	
1978	0.3	0.0	0.0	0.3	0.8	0.1	2.3	1.9	7.7	7.9	5.3	0.5	0.4	1.8	1.1	1.0	0.5
1977	-	-	-	0.0	4.1	166.7	13.0	5.2	72.0	0.0	0.5	0.0	-	0.0	-	-	-
Station 5 Surface (individuals/m³)																	
1978	1.4	0.0	0.0	0.5	0.5	0.1	6.6	0.3	11.9	4.8	6.5	0.2	3.4	1.0	0.3	1.1	0.3
1977	-	-	-	0.0	6.2	122.2	41.9	5.4	2.5	0.0	0.0	0.0	-	0.0	-	-	-

F. FISH

INTRODUCTION

The purpose of this study was to determine the species composition and abundance of fishes 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 construction phase ecological monitoring program which was completed before construction began (ABI, 1978).

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 in length by 1.8 m in depth (100 x 6 ft). The nets were constructed of three 10.2-m panels of 25.4-, 38.1- and 50.8-mm^2 mesh (1-, 1.5-, and 2-in^2) sewn end-to-end. The nets were submerged and held perpendicular to the shore from nearshore shallows to depths of about 3 m (10 ft). The nets were fished for two consecutive 24-hour periods, and the fishes were removed from the nets and analyzed after each period. Two nets were fished at each station. Results were expressed as number of fish per net-hour.

Electrofishing

Collections were made by electrofishing during each quarterly sampling period at night at Ohio River Stations 1, 3, 5 and 14 and during the day at Little Saluda Creek Station 6. River stations were sampled with a DC shocking assembly (Smith-Root Model VI-A) powered by a Winco 2400-watt, 230-volt, single-phase generator connected to two electrodes suspended approximately 2 m (6 ft) 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 and water depth would allow. The Little Saluda Creek station was electrofished with a Smith-Root Model VII backpack shocker which produced a 500-volt DC current 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: 150 m (164 yd) at Ohio River stations and 100 m (109 yd) in Little Saluda Creek. Two replicate samples were taken 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 in length by 1.2 m in depth (30 x 4 ft) and of 3-mm^2 (0.12-in^2) mesh. Two replicate seine hauls were each made over a distance of 50 m (55 yd) during each sampling period. Results were expressed as number of fish per meter of shoreline seined.

Analytical Methods

Fishes were identified to species, counted, measured, weighed, and examined for ectoparasitic infestations. Live fishes were released after sampling unless needed for taxonomic verification.

Literature sources used for fish identification included Trautman (1957), Hubbs and Lagler (1958), Moore (1968), Eddy (1969), Becker and Johnson (1970), Scott and Crossman (1973), Eddy and Underhill (1974), Clay (1975), and Pflieger (1975). Taxonomic nomenclature was in accordance with the American Fisheries Society's *List of Common and Scientific Names of Fishes* (Bailey, et al., 1970). The total length (TL) of each fish was measured to the nearest millimeter. Weight was measured to the nearest gram. Fishes were individually analyzed, with the exception of small (<50 mm TL) species such as shiners. The range of total lengths and the combined weight were recorded for individuals of each of these small species.

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

$$K = \frac{W \cdot 10^5}{L^3}$$

where: W = Weight in grams

L = Length in millimeters

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

To test for possible significant differences in catch per unit effort (CPUE) and condition factors (K) between stations, one-way analysis of variance was applied to these data.

RESULTS AND DISCUSSION

A total of 33 species of fishes in 10 families was collected during the 1978 monitoring program (Table F-1). Of the 1178 individuals collected by all sampling methods combined, emerald shiners were the most abundant fish found (Table F-2).

Gill Netting

Three hundred fifty-seven (357) fishes representing 22 species were collected by gill netting (Table F-3; Appendix Tables F-1A through F-4B). The fewest number of fishes were collected during March and only a few more were found in May (Figure F-1). High water levels and current velocities carried considerable debris downstream during these two sampling periods. This debris accumulated in the nets, making them more visible and easily avoided by fish. Additionally, fishes may have congregated in less turbulent areas near the bottom offshore and, thus, would not have encountered the nets set nearshore. Considerably more fishes were found during August when water levels were down and water velocity was comparatively low, and the largest number of fishes were found in November when the current was least (Figure F-1).

Catch per unit effort (CPUE) ranged from 0.000 to 0.729 fish per net-hour (Table F-4). The annual CPUE was 0.201 fish per net-hour at Station 1, 0.151 at Station 3, 0.328 at Station 5, and 0.250 at Station 14. On an annual basis, these interstation differences were not statistically significant (α=0.05) due to wide variations in the CPUE at each station during the different sampling periods. Nevertheless, the total number of fishes collected at Station 3, in the vicinity of the plant, was lower than the numbers collected at the other stations. The reasons for fewer fishes being found at Station 3 are obscure, but could be related to the fortiutous occurrence of the highly mobile fishes captured by this method; interstation differences in shoreline, depth configurations or downstream obstructions which could affect fish movements; differences in bottom types which could affect distribution of certain species because of feeding preferences; other factors or a combination of factors. Since the number of fishes found at Station 3 during 1977, prior to plant construction, was also lower than those at the other river stations, the fewer fishes collected at this locality is probably not the result of any construction-related activity.

Gizzard shad and channel catfish were the two most common species, although numbers found (74 and 66 individuals, respectively) were not considered disproportionately high relative to the total number of fishes collected (Table F-3). Gizzard shad are abundant schooling fishes which feed primarily on plankton (Table F-5). They are of no sport or commercial value, although juveniles are important as forage for larger fishes. Gizzard shad were found during the August and November sampling periods and comprised 20.7% of the total number of fishes taken during gill netting (Table F-3). The average condition factors (K)[a] for gizzard shad were 1.09 at Station 1, 0.86 at Station 3, 1.19 at Station 5 and 1.22 at Station 14. The significantly (α=0.05) lower average K value at Station 3, in the vicinity of the plant, resulted primarily from the collection in November of three long ($\geq$350 mm TL) individuals with very low (0.40-0.63) K values. Why these three individuals were found at Station 3 is not known but is probably coincidental. Plant construction related effects being responsible for the lower average K value at Station 3 can be neither eliminated from consideration nor established at this time.

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[a]Condition factors may vary seasonally, with age or length of the fish and, in this study, were based on relatively few (<30) individuals. Condition values in this discussion should not be overemphasized in assessing impact.

Channel catfish were second in abundance in the gill net collections with 18.5% of the total fishes found (Table F-3). The channel catfish is an omnivorous species of both sport and commercial[a] importance (Table F-5) and was found during each sampling period. Condition factors for channel catfish ranged from 0.25 to 1.35 and were not significantly (α=0.05) different between stations.

All other species each comprised less than 9% of the total number of fishes collected by gill netting (Table F-3). Sauger, a prediatory species at the top of the aquatic food chain and an important game species, accounted for 8.7% (31 individuals) of the total number of fishes collected. Sauger were found during every quarter sampled and, at one time or another, at every sampling station.

Twenty-six longnose gar represented 7.3% of the total number of fishes collected and the sunfishes (six species) an additional 7.3% (Table F-3). Other species found were white bass (a total of 21 individuals collected during the year), freshwater drum and flathead catfish (19 each), carp and golden redhorse (17 each), mooneye (15), highfin carpsucker (9), river carpsucker (8), goldeye (5), yellow bullhead (2), quillback and buffalo (1 each).

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[a]Catfishes, carp, buffalo and freshwater drum are the predominant fishes caught commercially in the area. Commercial fishing in the area has been reduced substantially in recent years because of low monetary return and high effort involved, relative to other lines of employment. Landings statistics, as regards biomass and value of the catch, are not known to be available.

Electrofishing

At Ohio River Stations 1, 3, 5, and 14, 193 fishes were collected by electrofishing (Table F-6; Appendix Tables F-5 through F-8). At Little Saluda Creek Station 6, 210 fishes were taken by electrofishing (Table F-7; Appendix Tables F-9 through F-12). Emerald shiner and gizzard shad were the dominant fishes collected at the Ohio River stations and emerald shiner were dominant in Little Saluda Creek.

Ohio River

Eight species of fishes were collected by electrofishing at Ohio River Stations 1, 3, 5 and 14 (Table F-6). Emerald shiners comprised 69.5% of the total number of fishes collected and gizzard shad 25.4%. The other fishes found were three saugers, two of each channel catfish and white bass, and one each of river carpsucker, green sunfish, and freshwater drum. These other fishes together comprised 5.1% of the total fishes collected.

Catch per unit effort (CPUE) ranged from 0.000 to 0.390 fish per meter of shoreline fished (Table F-4). The annual CPUE was 0.011 fish per meter at Station 1, 0.012 at Station 3, 0.038 at Station 5, and 0.101 at Station 14. On an annual basis there was no statistically significant difference (α=0.05) between stations due to wide variations in CPUE at each station between the different sampling periods. Fishes were collected during all sampling periods except March, when water levels and velocities were very high. At this time, the effectiveness of electrofishing may have been limited by the high water turbidity and fishes were probably more dispersed between inshore and offshore areas rather than concentrated along shore where the electrofishing sampling was conducted.

Condition factors were calculated for fishes collected during electrofishing, but not enough individuals within similar size ranges were available for meaningful interstation comparisons.

Little Saluda Creek

Twelve taxa of fishes were collected by electrofishing at Little Saluda Creek Station 6 (Table F-7). The emerald shiner was the dominant species and comprised 41.9% of the 210 fishes found. The stoneroller represented 19.5% of the total and blacknose dace 15.7%. All other taxa together comprised 22.9% of the total fishes, and no single taxa was represented by more than 15 individuals during the year.

Catch per unit effort ranged from 0.015 to 0.455 fish per meter of stream distance fished (Table F-4). Small numbers of fishes were collected during March and May and larger numbers were collected during the August and November sampling periods. The smaller catches in March and May probably resulted from high water levels and velocities, which may have forced many of the fishes into calmer water downstream, and from the natural decrease in fish populations following winter. The larger catches in August and November probably resulted from fishes moving back up into the stream and the natural population increase following spawning.

Seining

Nine species of fishes were collected by seining at Little Saluda Creek (Table F-7). Of the 418 individuals found (Appendix Tables F-13 through F-16), the emerald shiner was the most abundant and comprised 92.8% of the total number of fishes collected by this method. Seven creek chub were captured and six each of striped shiner, blacknose dace, and bluegill. Stoneroller, redhorse and fantail darter were each represented by one individual.

Catch per unit effort ranged from 0.020 fish per meter of stream distance in May to 3.900 in November (Table F-4). The annual CPUE for all sampling dates was 1.045. CPUE differences probably resulted from differences in stream water flow or natural annual population fluctuations, as discussed in the previous section of this report.

Study Comparisons

The baseline (Construction Permit Stage) study on fish at the Marble Hill Plant site was conducted from March 1974 through January 1975 (PSI, 1976), and the construction phase ecological monitoring from

March through November 1977 (ABI, 1978) and March through November 1978.

The total numbers of fishes collected were similar during each of the three study periods (Table F-8). There were 1512 fishes collected during the baseline study, 1058 during 1977 and 1178 during 1978. The larger number of fishes collected during the baseline study resulted from sampling at the mouth of Little Saluda Creek, which was not sampled in subsequent years. About 54% of the total fishes found during the baseline study were from this one location and fish abundance there was attributed to an influx of food at the creek's mouth and/or protection from high water velocities in the river (PSI, 1976).

The several fish taxa collected, and their abundance relative to each other, were also similar during each of the three study periods (Table F-8). The emerald shiner was the dominant species in each study, based on relative abundance by number of individuals collected; gizzard shad were second in abundance. No rare or endangered species were found during any of the three studies.

The largest difference in the relative abundance of species was that gizzard shad were more abundant (33.0% of the catch) during the baseline study than in the two subsequent study years

(6.8 and 10.4%). Other changes in relative abundance (some species increasing and others decreasing in numbers found from one year to the next) are also evident in Table F-8. These differences are not considered unusual and may be due to natural yearly variations in fish populations, the fortuitous occurrence of schooling species, such as gizzard shad, or to differences in sampling locations or methodologies. No differences between the baseline study and construction phase monitoring could be attributed to plant construction activity.

CONCLUSIONS

Fishes were collected quarterly at four Ohio River stations and one Little Saluda Creek station by gill netting, electrofishing and/or seining. A total of 1178 fishes comprising 33 species was collected by these methods. The emerald shiner was the most abundant species. No rare or endangered fishes were found.

The total number of fishes collected and the relative abundance of species were similar during the baseline study and subsequent construction phase monitoring. Differences in the results obtained during these studies were not considered unusual and could not be attributed to plant construction activity.

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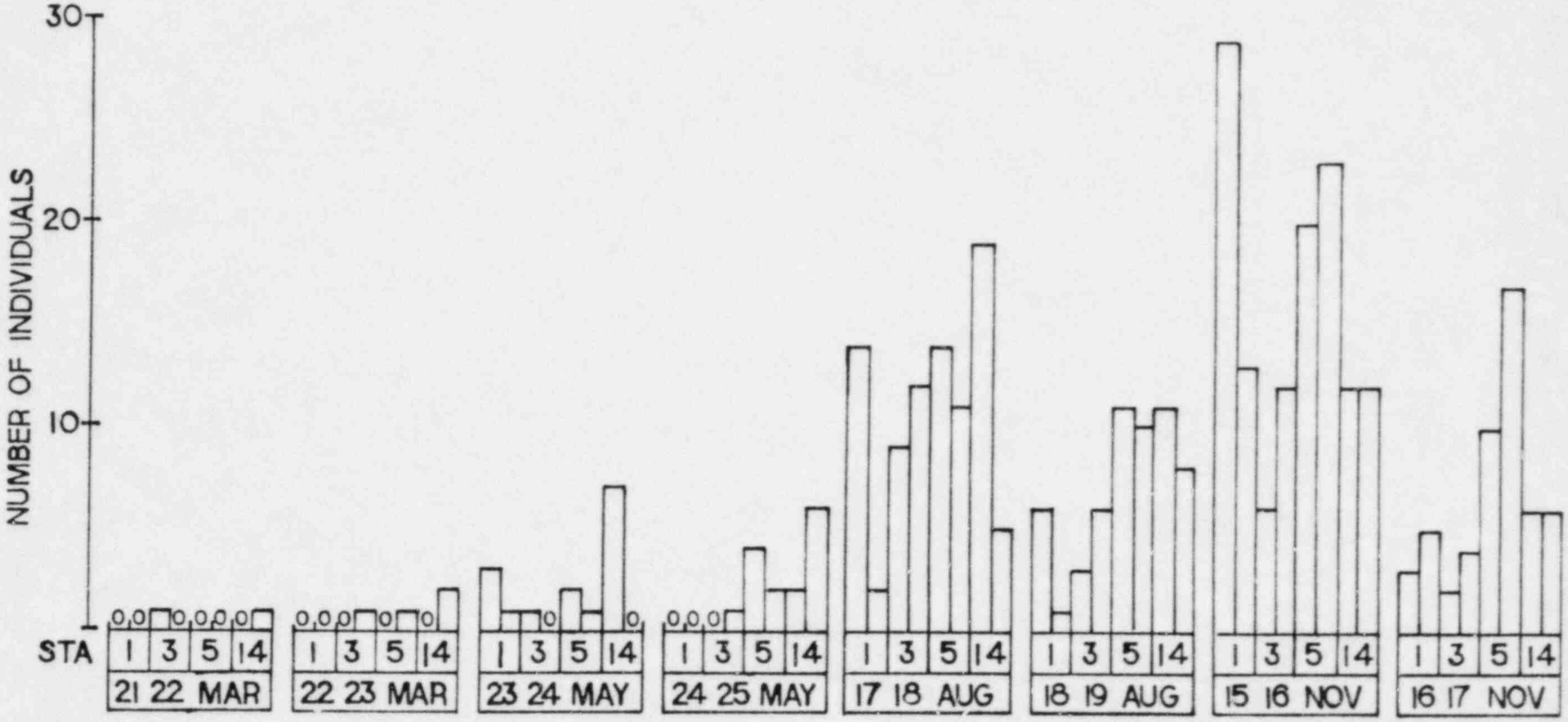

Figure F-1. Number of individuals collected per gill net per 24 hours at each of two replicates per station, Marble Hill Plant site, 1978.

TABLE F-1

SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
IN THE VICINITY OF THE
MARBLE HILL PLANT SITE
1978

Lepisosteidae-gars	
Lepisosteus osseus	longnose gar
Clupeidae-herrings	
Dorosoma cepedianum	gizzard shad
Hiodontidae-mooneyes	
Hiodon alosoides	goldeye
Hiodon tergisus	mooneye
Cyprinidae-minnows and carps	
Campostoma anomalum	stoneroller
Cyprinus carpio	carp
Notropis atherinoides	emerald shiner
Notropis chrysocephalus	striped shiner
Notropis rubellus	rosyface shiner
Notropis volucellus	mimic shiner
Rhinichthys atratulus	blacknose dace
Semotilus atromaculatus	creek chub
Catostomidae-suckers	
Carpiodes carpio	river carpsucker
Carpiodes cyprinus	quillback
Carpiodes velifer	highfin carpsucker
Catostomus commersoni	white sucker
Ictiobus sp.	buffalo
Moxostoma erythrurum	golden redhorse
Ictaluridae-freshwater catfishes	
Ictalurus melas	black bullhead
Ictalurus natalus	yellow bullhead
Ictalurus punctatus	channel catfish
Pylodictis olivaris	flathead catfish
Percichthyidae-temperate basses	
Morone chrysops	white bass

TABLE F-1
(continued)
SCIENTIFIC AND COMMON NAMES OF FISHES
COLLECTED BY ALL METHODS
IN THE VICINITY OF THE
MARBLE HILL PLANT SITE
1978

	Centrarchidae-sunfishes	
Ambloplites rupestris		rock bass
Lepomis cyanellus		green sunfish
Lepomis macrochirus		bluegill
Micropterus dolomieui		smallmouth bass
Micropterus salmoides		largemouth bass
Pomoxis annularis		white crappie
Pomoxis nigromaculatus		black crappie
	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, ELECTROFISHING, AND SEINING FROM OHIO RIVER STATIONS 1, 3, 5, AND 14 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Taxon	Station 1	Station 3	Station 5	Station 14	Station 6	Total	Relative abundance (%)
longnose gar	3	-	7	9	-	26	2.2
gizzard shad	26	16	48	33	-	123	10.4
goldeye	1	3	1	-	-	5	0.4
mooneye	1	4	8	2	-	15	1.3
stoneroller	-	-	-	-	42	42	3.6
carp	1	3	9	4	-	17	1.4
emerald shiner	2	3	22	107	476	610	51.8
striped shiner	-	-	-	-	6	6	0.5
rosyface shiner	-	-	-	-	1	1	0.1
mimic shiner	-	-	-	-	1	1	0.1
blacknose dace	-	-	-	-	39	39	3.3
creek chub	-	-	-	-	22	22	1.9
shiner	-	-	-	-	7	7	0.6
minnow	-	-	-	-	5	5	0.4

TABLE F-2
(continued)
TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY
GILL NETTING, ELECTROFISHING, AND SEINING FROM
OHIO RIVER STATIONS 1, 3, 5, AND 14 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Taxon	Station 1	Station 3	Station 5	Station 14	Station 6	Total	Relative abundance (%)
river carpsucker	3	4	1	1	-	9	0.8
quillback	-	-	1	-	-	1	0.1
highfin carpsucker	1	3	4	1	-	9	0.8
white sucker	-	-	-	-	3	3	0.2
buffalo	-	-	-	1	-	1	0.1
golden redhorse	10	1	4	2	-	17	1.4
redhorse	-	-	-	-	1	1	0.1
black bullhead	-	-	-	-	2	2	0.2
yellow bullhead	-	-	-	2	-	2	0.2
channel catfish	18	3	27	20	-	68	5.8
flathead catfish	4	2	8	5	-	19	1.6
white bass	7	3	10	3	-	23	1.9
rock bass	-	-	1	-	-	1	0.1

TABLE F-2
(continued)
TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY
GILL NETTING, ELECTROFISHING, AND SEINING FROM
OHIO RIVER STATIONS 1, 3, 5, AND 14 AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Taxon	Station 1	3	5	14	6	Total	Relative abundance (%)
green sunfish	-	-	-	1	2	3	0.2
bluegill	-	-	-	1	6	7	0.6
smallmouth bass	1	-	-	1	-	2	0.2
largemouth bass	3	9	4	4	-	20	1.7
white crappie	1	-	-	-	-	1	0.1
black crappie	-	1	-	-	-	1	0.1
sunfish	-	-	-	-	4	4	0.3
fantail darter	-	-	-	-	11	11	0.9
sauger	7	8	12	7	-	34	2.9
freshwater drum	1	2	4	13	-	20	1.7
Totals	90	72	171	217	628	1178	100.0

TABLE F-3

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY GILL NETTING FROM OHIO RIVER STATIONS 1, 3, 5, AND 14
MARBLE HILL PLANT SITE
1978

Taxon	Station 1	Station 3	Station 5	Station 14	Total	Relative abundance (%)
longnose gar	3	7	7	9	26	7.3
gizzard shad	15	9	29	21	74	20.7
goldeye	1	3	1	-	5	1.4
mooneye	1	4	8	2	15	4.2
carp	1	3	9	4	17	4.7
river carpsucker	3	3	1	1	8	2.2
quillback	-	-	1	-	1	0.3
highfin carpsucker	1	3	4	1	9	2.5
buffalo	-	-	-	1	1	0.3
golden redhorse	10	1	4	2	17	4.7
yellow bullhead	-	-	-	2	2	0.6
channel catfish	18	1	27	20	66	18.5
flathead catfish	4	2	8	5	19	5.3
white bass	7	3	9	2	21	5.9

TABLE F-3
(continued)
TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY
GILL NETTING FROM OHIO RIVER STATIONS 1. 3, 5, AND 14
MARBLE HILL PLANT SITE
1978

Taxon	Station 1	Station 3	Station 5	Station 14	Total	Relative abundance (%)
rock bass	-	-	1	-	1	0.3
bluegill	-	-	-	1	1	0.3
smallmouth bass	1	-	-	1	2	0.6
largemouth bass	3	9	4	4	20	5.6
white crappie	1	-	-	-	1	0.3
black crappie	-	1	-	-	1	0.3
sauger	7	8	9	7	31	8.7
freshwater drum	1	1	4	13	19	5.3
Totals	77	58	126	96	357	100.0

TABLE F-4

CATCH PER UNIT EFFORT OF FISHES COLLECTED BY
GILL NETTING, ELECTROFISHING AND SEINING FROM
OHIO RIVER STATIONS 1, 3, 5 AND 14
AND LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Sampling method	Station	March	May	August	November	1978[a]
Gill netting (fish/net-hr)	1	0.000	0.042	0.240	0.521	0.201
	3	0.021	0.021	0.313	0.250	0.151
	5	0.010	0.094	0.479	0.729	0.328
	14	0.031	0.156	0.448	0.375	0.250
Electrofishing (fish/m[b])	1	0.000	0.000	0.030	0.013	0.011
	3	0.000	0.013	0.010	0.023	0.012
	5	0.000	0.007	0.097	0.047	0.038
	14	0.000	0.000	0.390	0.013	0.101
	6	0.175	0.015	0.405	0.455	0.263
Seining (fish/m[b])	6	0.110	0.020	0.150	3.900	1.045

[a]Total fish per unit effort for the year.

[b]Shoreline or stream distance.

TABLE F-5

SUMMARY OF THE LIFE HISTORIES[a] OF REPRESENTATIVE FISH SPECIES
COLLECTED IN THE OHIO RIVER NEAR THE
MARBLE HILL PLANT SITE
1978

Species	Economic significance	Trophic classification	Habitat		Food		Spawning						
			Adult	Young	Adult	Young	Time	Water temp(°C)	Migration	Breeding site	Mating	Products	Parental care
Longnose gar	None	Carnivore	Quiet shallows of lakes and large rivers	Protected weedy areas along streams	Frogs, crayfish, crabs, fish	Insects	May to mid-June		Upstream to small, higher gradient streams	Small streams over weedy areas	Gregarious	Demersal adhesive eggs	None
Gizzard shad	None	Herbivore-important forage fish	Fertile reservoirs and large rivers	Shallow areas along shoreline	Phyto- and zooplankton, insect larva	Phyto- and zooplankton	May	17.2-22.8°C	Upstream to low gradient streams	Small streams over sand and gravel	Gregarious	Demersal adhesive eggs	None
Goldeye	None	Omnivore-important forage fish	Open water of large rivers and deep pools of tributary streams	Same	Insects, molluscs, crustaceans, frogs, fish	Micro-crustacnans	April to May	10.0-12.8°C	Upstream to shallow firm bottom areas	Mid-water	Pairs	Pelagic eggs	None
Carp	Sport, commercial	Omnivore	Lakes and reservoirs, rivers and streams	Same	Aquatic insects, plant material	Same	Late March to late June	16-23°C	Not highly migratory	Shallow weedy areas	Gregarious	Demersal eggs	None
Emerald shiner	None	Omnivore	Reservoirs and lakes, large streams	Same	Small crustaceans, aquatic insects	Algae	Late May to early July		None	Shallow water over sand or firm mud	Gregarious	Demersal eggs	None
Smallmouth buffalo	Commercial	Omnivore	Large rivers, tributaries, and reservoirs	Not known	Insect larvae, algae and detritus	Not known	April to May		None	Not known	Not known	Not known	Not known
Golden redhorse	Commercial	Omnivore	Lakes or streams with gravelly or rocky bottoms	Not known	Insects	Not known	April	11.1°C	From larger bodies of water into smaller rivers or streams	Gravelly riffles	Gregarious	Demersal eggs	None
Channel catfish	Sport, commercial	Omnivore	Large streams with low gradients	Riffles or shallow parts of pools	Fish, insects, crayfish, molluscs, plant material	Small insects	May to July	23.5°-29.5°C	None	Holes, undercut banks, log jams, rocks	Pairs	Demersal eggs	Nest built by male; male protects young until they leave nest
White bass	Sport	Carnivore	Deep pools of streams and open water of lakes and reservoirs	Not known	Fish, insects	Small crustaceans and insects	March to June	18.4°-21.1°C	Upstream into tributary streams	Mid-water over gravelly and rocky bottoms	Gregarious	Demersal adhesive eggs	None
Bluegill	Sport	Omnivore	Pools and backwaters of streams, lakes and reservoirs	Protected shallow weedy areas	Insects, crustaceans, plant material, small fish	Small crustaceans	May to August	19.4°-26.6°C	None	Shallow areas over any type of substrate	Pairs	Demersal eggs	Nest built by male; male guards eggs until they hatch
Largemouth bass	Sport	Carnivore	Lakes and reservoirs rivers and streams	Shallow areas along shorelines	Fish, crayfish large insects, frogs	Zooplankton, crustaceans, small insects	Mid-April to late May	15.5°-25°	Not highly migratory	Shallow areas along the shoreline	Pairs	Demersal adhesive eggs	Male constructs nest, guards eggs and fry
Sauger	Sport	Carnivore	Large rivers and lakes	Not known	Fish	Small crustaceans and insects	March to April	3.9°-6.1°C	Upstream	Shallow shoals over gravel-rubble substrate	Gregarious	Semibuoyant eggs	None
Freshwater drum	Commercial, sport	Omnivore	Near bottom in large rivers, lakes and reservoirs	Not known, but presumably close to bottom	Fish, crayfish, molluscs, and insects	Zooplankton and insects	May to June	18°-24°C	From larger bodies of water to smaller rivers or streams	Not known	Not known	Pelagic	None

[a] Life history information based on Breder and Rosen (1966), Calhoun (1966), Pflieger (1975), Scott and Crossman (1973), Trautman (1957), and Swedberg and Walburg (1970).

TABLE F-6

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY ELECTROFISHING FROM OHIO RIVER STATIONS 1, 3, 5, AND 14
MARBLE HILL PLANT SITE
1978

Taxon	Station				Total	Relative abundance (%)
	1	3	5	14		
gizzard shad	11	7	19	12	49	25.4
emerald shiner	2	3	22	107	134	69.5
river carpsucker	-	1	-	-	1	0.5
channel catfish	-	2	-	-	2	1.0
white bass	-	-	1	1	2	1.0
green sunfish	-	-	-	1	1	0.5
sauger	-	-	3	-	3	1.6
freshwater drum	-	1	-	-	1	0.5
Totals	13	14	45	121	193	100.0

TABLE F-7

TOTAL NUMBERS AND RELATIVE ABUNDANCE OF FISHES COLLECTED BY ELECTROFISHING AND SEINING FROM LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
1978

Taxon	Electrofishing	Seining	Total	Relative abundance (%)
stoneroller	41	1	42	6.7
emerald shiner	88	388	476	75.8
striped shiner	-	6	6	0.9
rosyface shiner	1	-	1	0.2
mimic shiner	1	-	1	0.2
blacknose dace	33	6	39	6.2
creek chub	15	7	22	3.5
shiner	7	-	7	1.1
minnow	5	-	5	0.8
white sucker	3	-	3	0.5
redhorse	-	1	1	0.2
black bullhead	-	2	2	0.3
green sunfish	2	-	2	0.3
bluegill	-	6	6	0.9
sunfish	4	-	4	0.6
fantail darter	10	1	11	1.8
Totals	210	418	628	100.0

TABLE F-8

NUMBER OF INDIVIDUALS AND RELATIVE ABUNDANCE OF FISHES COLLECTED DURING 1974, 1977 AND 1978 IN THE VICINITY OF THE MARBLE HILL PLANT SITE

	1974		1977		1978	
Taxon	Number of individuals	Relative abundance (%)	Number of individuals	Relative abundance (%)	Number of individuals	Relative abundance (%)
longnose gar	33	2.2	18	1.7	26	2.2
skipjack herring	29	1.9	7	0.7	-	-
gizzard shad	499	33.0	72	6.8	123	10.4
goldeye	8	0.5	7	0.7	5	0.4
mooneye	1	<0.1	-	-	15	1.3
stoneroller	-	-	3	0.3	42	3.6
goldfish	1	<0.1	-	-	-	-
carp	10	0.7	10	0.9	17	1.4
emerald shiner	601	39.9	618	58.4	610	51.8
shiner (*Notropis* spp.)	21	1.4	7	0.7	15	1.3
pugnose minnow	-	-	2	0.2	-	-
bluntnsoe minnow	15	1.0	1	0.1	-	-
bullhead minnow	7	0.5	-	-	-	-
blacknose dace	91	6.0	28	2.6	39	3.3
creek chub	3	0.2	28	2.6	22	1.9
minnow	-	-	-	-	5	0.4
carpsucker (*Carpiodes* spp.)	27	1.8	15	1.4	19	1.6
white sucker	3	0.2	-	-	3	0.2
buffalo (*Ictiobus* spp.)	6	0.4	4	0.4	1	0.1
spotted sucker	6	0.4	5	0.5	-	-
redhorse (*Moxostoma* spp.)	10	0.7	32	3.0	18	1.5

TABLE F-8
(continued)
NUMBER OF INDIVIDUALS AND RELATIVE ABUNDANCE OF FISHES COLLECTED DURING
1974, 1977 AND 1978 IN THE VICINITY OF THE
MARBLE HILL PLANT SITE

	1974		1977		1978	
Taxon	Number of individuals	Relative abundance (%)	Number of individuals	Relative abundance (%)	Number of individuals	Relative abundance (%)
blue catfish	1	<0.1	-	-	-	-
black bullhead	-	-	2	0.2	2	0.2
yellow bullhead	-	-	-	-	2	0.2
channel catfish	11	0.7	46	4.3	68	5.8
flathead catfish	1	<0.1	22	2.1	19	1.6
mosquitofish	1	<0.1	-	-	-	-
white bass	14	0.9	29	2.7	23	1.9
rock bass	1	<0.1	-	-	1	0.1
sunfishes (*Lepomis* spp.)	34	2.3	9	0.9	14	1.2
smallmouth bass	4	0.3	4	0.4	2	0.2
spotted bass	11	0.7	5	0.5	-	-
largemouth bass	8	0.5	3	0.3	20	1.7
crappie (*Pomoxis* spp.)	11	0.7	-	-	2	0.2
rainbow darter	2	0.1	-	-	-	-
fantail darter	-	-	-	-	11	0.9
yellow perch	1	<0.1	-	-	-	-
sauger	22	1.5	53	5.0	34	2.9
walleye	1	<0.1	-	-	-	-
freshwater drum	18	1.2	28	2.6	20	1.7
Totals	1512	100.0	1058	100.0	1178	100.0

G. FISH EGGS AND LARVAE

INTRODUCTION

Changes in the physical and chemical composition of a water body can influence both the spawning success of fishes and subsequent survival of the eggs and larvae. In turn, 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 construction phase ecological monitoring program (ABI, 1978) to characterize annual ichthyoplankton fluctuations and determine if plant construction activity might have affected ichthyoplankton densities.

MATERIALS AND METHODS

Quantitative collections were made at the Ohio River stations with bongo nets. The bongo nets were of 505μ mesh, 20 cm in mouth diameter, and 200 cm in length (Figure E-3). During each sampling period, duplicate 10-minute tows were made at each station at each of three depths: sub-surface, mid-depth, and near-bottom. The tows were made approximately 80 to 100 feet offshore. This distance was determined by the length of the offshore discharge pipe and intake structure proposed for the Marble Hill Plant.

The nets were towed upstream at approximately 150 cm/sec. General Oceanics Model 2030 flowmeters were placed in the mouth of each net to enable the calculation of the volume of water passing through each net.

Due to the shallowness of the water at Little Saluda Creek Station 6, qualitative larval fish traps, 24"L x 14"H x 14"W constructed of 1/4" plexiglass (Figure G-1) were set and left overnight in pool areas of the creek.

Fish eggs and larvae were preserved in the field in five percent formalin and returned to the laboratory for microscopic and statistical analysis. Fish eggs were counted and the range of diameters were measured to the nearest 0.1 mm. Larval fishes were enumerated and identified to the lowest practicable taxonomic classification by the following systematic method:

a. Larvae were sorted into family groupings.

b. Each family grouping was examined in detail and specimens sorted into developmental series for each species by tracing characteristics backwards from identifiable specimens to the smallest larvae collected.

c. Each developmental series was examined and compared to the taxonomic literature, specifically Fish (1932), May and Gasaway (1967), Bailey, et al. (1970), Scotton, et al. (1973), Lippson and Moran (1974), Nelson and Cole (1975) and Hogue (1976).

d. Finally, each series was identified to the lowest practical taxon and photomicrographed.

Data were calculated as eggs and larvae per cubic meter for comparative purposes. Two-way ANOVAS were applied to the data to determine significant differences in egg and larval densities between stations and depths at Ohio River Stations 1, 3, 5 and 14. Due to unequal error variance, log transformations were made on the dependent variables (egg or larval densities) before the two-way ANOVA was employed.

Multiple range tests at the 0.05 level of significance were performed by the Duncan Procedure on the log-transformed data to determine significantly different means.

RESULTS AND DISCUSSION

Fish egg and larval collections were made on 17 occasions at Ohio River Stations 1, 3, 5 and 14, and Little Saluda Creek Station 6, during the period 22 March to 17 August 1978. (Appendix Tables G-1 through G-17).

Ohio River Stations 1, 3, 5 and 14

Fish eggs were found from 5 May through 16 August 1978. Mean egg densities for top, middle and bottom tows by date ranged from 0.00 to 0.31 eggs/m^3 with an overall mean of 0.06 eggs/m^3. The highest densities of fish eggs by station, up to 0.48/m^3, were found during the 19 June sampling period (Figure G-2). No eggs were found during March or April and only two were collected during August (Figure G-7).

Fish larvae were found from 21 April through 16 August 1978. Mean larval densities by date ranged from 0.00 to 1.05/m^3 with an overall mean of 0.21 larvae/m^3. The highest densities of fish larvae by station, up to 1.22/m^3 were found during the 17 May sampling period (Figure G-3). Larval densities remained high during June and gradually diminished during July and August (Figure G-7).

Fifteen taxa[a] of larval fishes were collected from the Ohio River during this study (Table G-1). Suckers were the dominant species collected comprising 40.1% of the total larval fishes found (Table G-2). Gizzard shad comprised 14.9%, freshwater drum 12.3%, carp 10.8%, minnows and other than carp and shiners 9.4% and walleye and sauger together comprised 6.6% of the total. All

[a]Species, genus and/or family.

other fishes individually accounted for less than 3% of the total larvae collected. These included temperate basses, white bass, herrings, goldeye, shiners, sunfishes, yellow perch, longnose gar, and white crappie. No rare or endangered species were collected.

Statistical Analysis

The number of eggs collected per cubic meter (no./m^3) varied between stations and depths. Station 1 egg densities were significantly (α=0.05) higher than egg densities at Station 5 and 14 (Figure G-4; Tables G-3 and G-4). The mean number of eggs was 0.09 eggs/m^3 at Station 1, 0.06 at Station 3, 0.04 at Station 5 and 0.04 at Station 14. Reasons for this distribution are unknown. Bottom egg densities were significantly (α=0.05) higher than those at the surface (Figure G-4; Table G-3 and G-5). Mean egg densities were 0.07 near the bottom, 0.06 at mid-depth, and 0.04 near the surface. This distribution is attributed to the demersal (non-buoyant) eggs which are characteristic of common fishes in the area.

No significant (α=0.05) difference in larval fish densities were found between stations or depths (Table G-6). Mean densities were 0.17 larvae per cubic meter at Station 1, 0.19 at Station 3, 0.23 at Station 5 and 0.26 at Station 14. By depth, larval densities were 0.22 near the surface, 0.22 at mid-depth and 0.20 larvae/m^3 near the bottom.

Little Saluda Creek Station 6

Samples taken at Little Saluda Creek Station 6 with larval fish traps captured only one larval fish, a darter, and four fish eggs. These were all collected on 7 June (Appendix Table G-18). However, a total of 1893 juvenile and adult fishes representing 13 species were also collected (Table G-7). Shiners, representing six species, accounted for 91.8% of these fishes. The largest number of individuals (1645) were collected during the 10 August sample when 86.9% of the total number of fishes were found. Based on life history information, spawning of most of these species probably takes place in Little Saluda Creek.

Study Comparisons

Fish egg and larval collections for the baseline study were made from 18 March to 31 July (PSI, 1976). Eggs and larvae collected during the baseline study were not related to the volume of water filtered, so they are not directly comparable to the results of the 1978 study. However, temporal trends and species compositions during the two studies are comparable. No construction had started prior to the completion of 1977 ichthyoplankton sampling, so both the 1974 and 1977 studies may actually be considered baseline.

The 1974 study was initiated in mid-March and eggs were not collected until the 7 May sampling period (Figure G-5). The largest number of eggs was found on 17 July although no collections were taken from mid-June to mid-July. The temporal occurrence of fish larvae during 1974 was similar to that of the fish eggs (Figure G-5).

The design of the 1977 study was based on the temporal occurrence of fish eggs and larvae in the area as determined from the 1974 study. However, the highest density of eggs (mean $0.32/m^3$) during the 1977 study was found on 17 May, and the highest density of larvae (mean $1.13/m^3$) on 30 April (Figure G-6). By 25 May, both egg and larval densities were lower than previous values, and only a few eggs and larvae were collected during the remainder of the study.

The 1978 study began on 22 March and eggs were first observed during the 5 May sampling period. The highest density of eggs (mean $0.31/m^3$) during the 1978 study was found on 19 June, eggs were observed through July. The highest density of larvae (mean $1.05/m^3$) was found on 17 May. Larval densities remained high during June and gradually declined during July and August (Figure G-7).

The temporal occurrence of fish eggs and larvae were similar between 1974 and 1978. During the 1977 study the highest density of larvae was collected on 30 April 1977. This indicates that both eggs and larvae were present in the river prior to the initiation of the 1977 sampling, and that spawning occurred earlier in 1977 than in 1974 and 1978. The differences in times of egg and larval occurrence between the 1974 and 1978 studies and the 1977 study periods may have resulted from physical variations in the aquatic system, such as water temperatures or the amount of flow. Additionally, the spawning periods for some species are relatively short, and may have occurred on or between sampling periods during one of the study years and not the other.

Species composition varied considerably between the three studies (Table G-8). Freshwater drum were dominant in 1974 accounting for 82.5% of the total larvae collected whereas suckers were dominant in the 1977 and 1978 studies comprising 70.0% and 40.1% respectively of the larval fishes collected.

Although differences in species composition may have resulted from variations in spawning success of the different species, a more probable cause for the differences relates to sampling frequencies and the fortuitous occurrence of the larvae. Of the 17 sampling dates in 1974, 83% of the larvae (primarily freshwater drum) were taken on 17 July. Of the 10 sampling dates in 1977, 68% of the larvae (primarily suckers) were found on 30 April. Because the majority of the larvae were collected on only one sampling date during each of these two studies, the collections were probably fortuitous events that resulted in species composition calculations which reflect ichthyoplankton composition for only short periods during the course of the two spawning periods sampled. During the 1978 study, sampling frequency was increased during peak larval occurrence and the dominant species were not collected during single sampling periods. This probably represents a more accurate description of spawning in the study area.

Baseline data were not collected at Little Saluda Creek during 1974. During the 1977 study, dip netting revealed only one larval fish species, the blacknose dace. No fish eggs were collected in Little Saluda Creek during 1977.

CONCLUSIONS

Fifteen taxa of fishes were collected from the Ohio River during fish egg and larva sampling. The highest densities of fish eggs were found during sampling in mid-June and the highest densities of fish larvae in mid-May. The dominant fish larvae were members of the sucker family followed by gizzard shad, freshwater drum and carp.

Egg densities were significantly higher at Station 1 than at Stations 5 and 14 although reasons for these differences were not evident. Egg densities were also higher near the bottom than near the surface. This was attributed to the demersal character of the eggs of many of the resident fishes. Larval fish densities did not differ significantly between stations or depths.

Qualitative samples in Little Saluda Creek revealed four fish eggs and only one larval fish, a darter, although several species of adult and juvenile fishes, primarily shiners, were collected. Spawning of most of these species probably takes place in Little Saluda Creek.

Temporal and species composition differences were evident between the 1974; 1977 and 1978 studies. The differences were attributed to physical variations in the aquatic system, the fortuitous occurrence of large numbers of larvae on particular occasions and variations in sampling frequencies. Differences did not appear to be related to plant construction activities.

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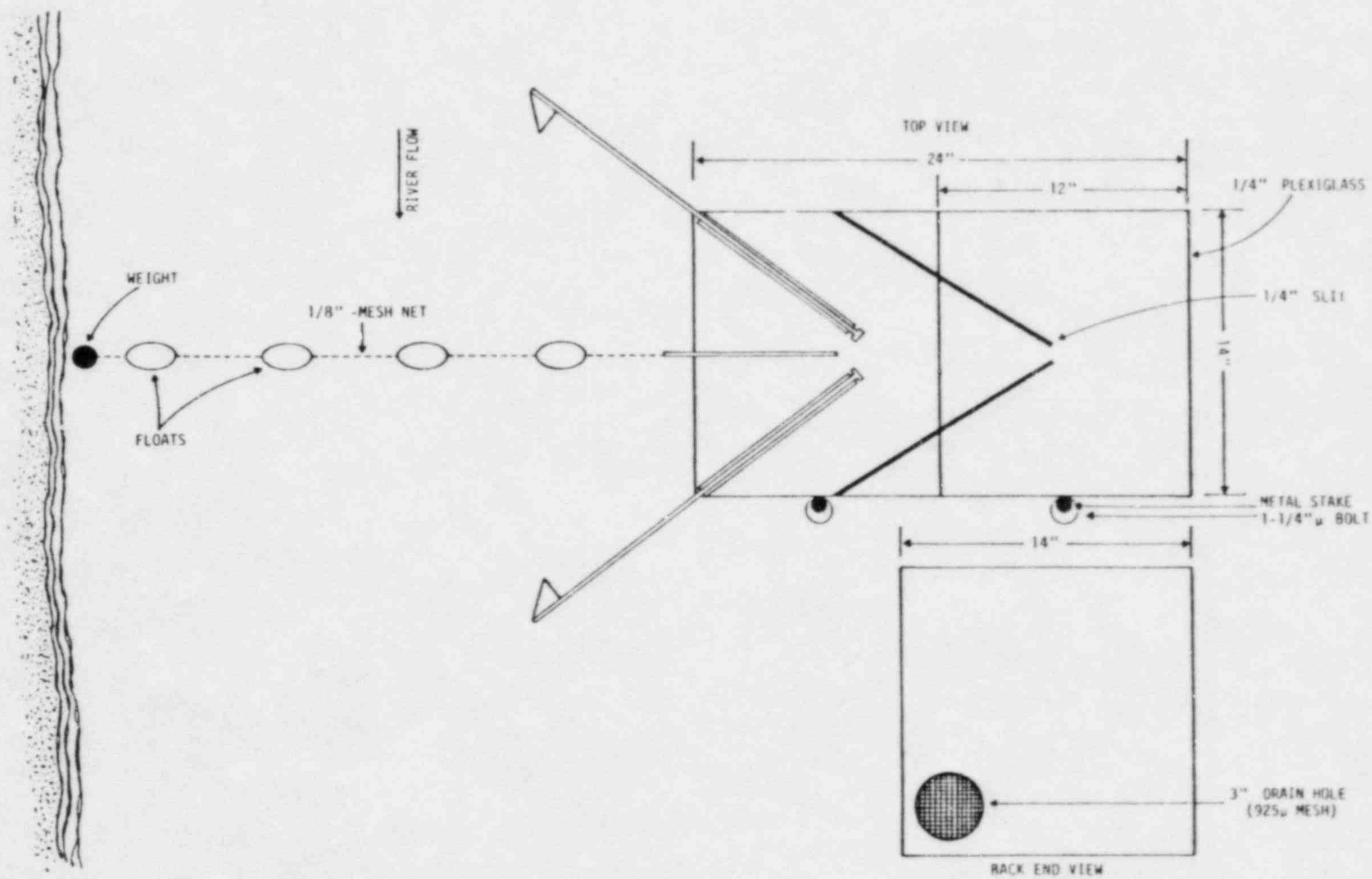

Figure G-1. Design of larval fish trap.

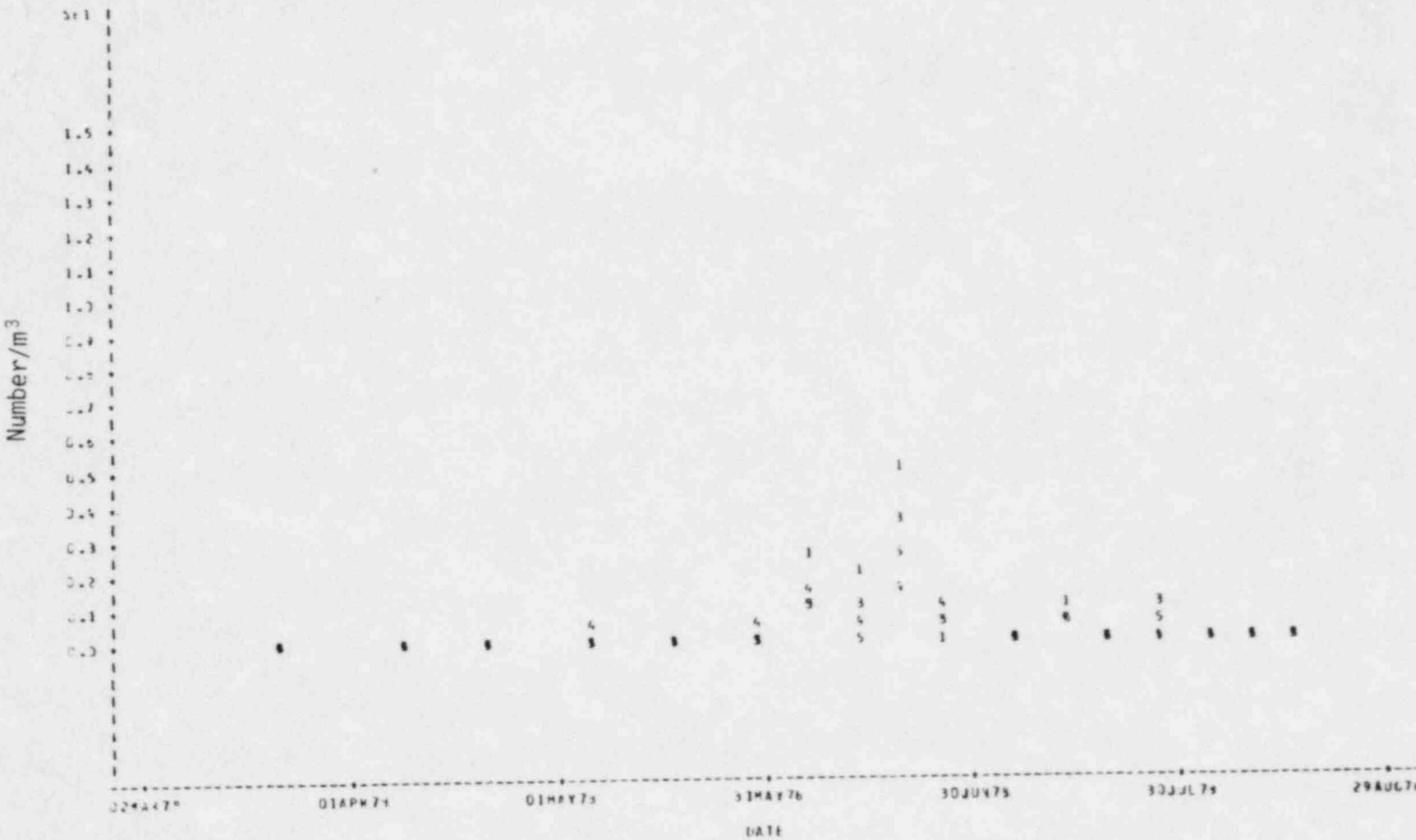

Figure G-2. Mean densities of eggs collected by station, Marble Hill Plant site, 22 March-17 August 1978.

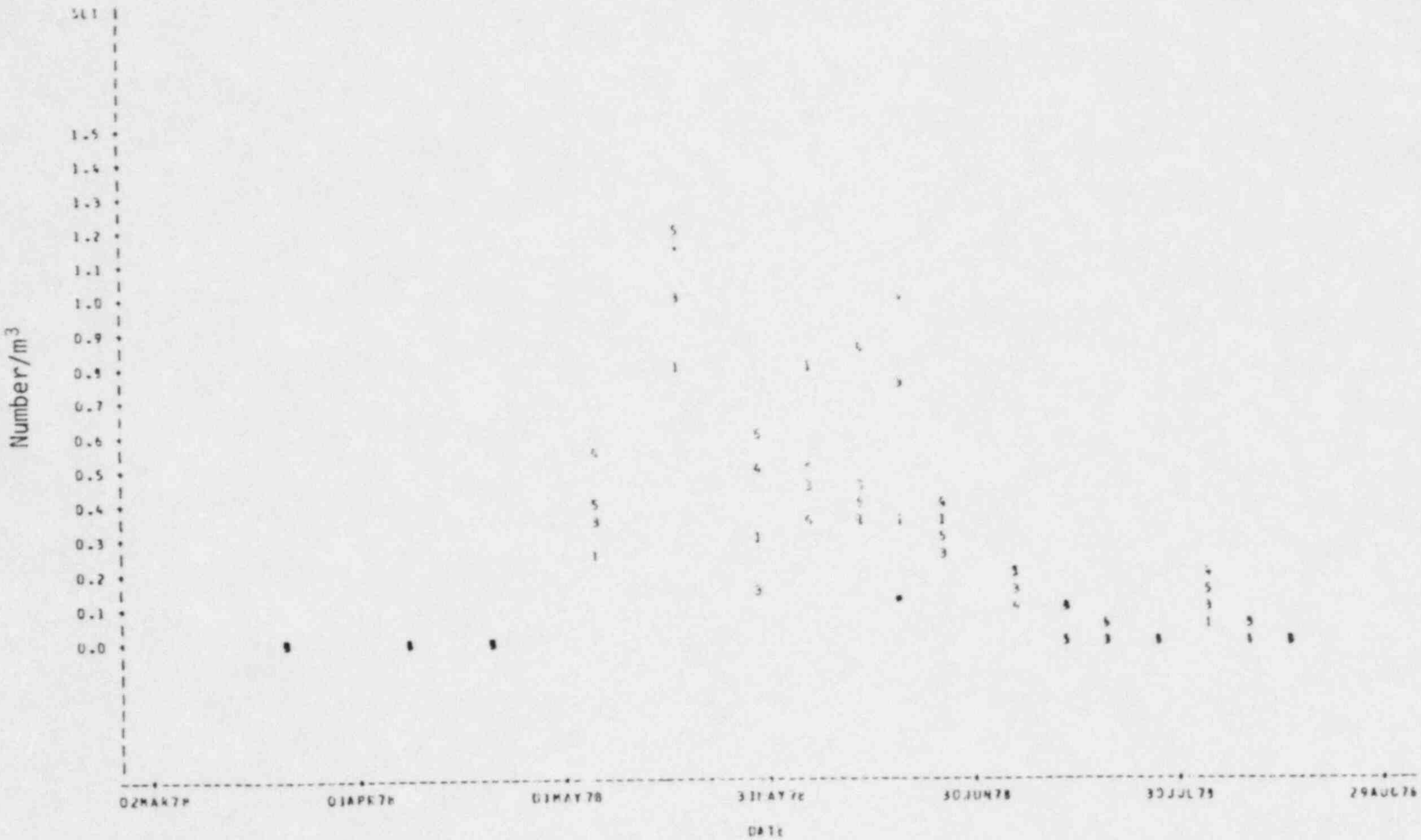

Figure G-3. Mean densities of fish larvae collected by station, Marble Hill Plant site, 22 March-17 August 1978.

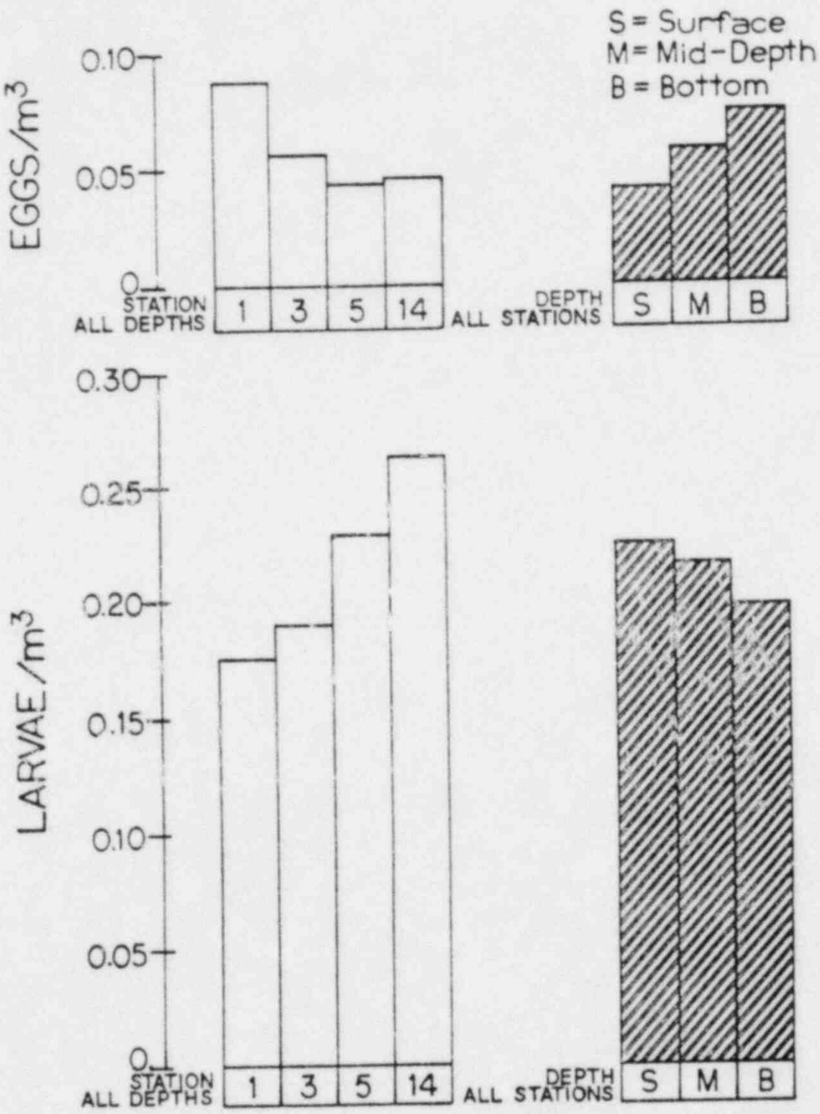

Figure G-4. Mean numbers of fish eggs and larvae per cubic meter collected by station and depth from the Ohio River, Marble Hill Plant site, 1978.

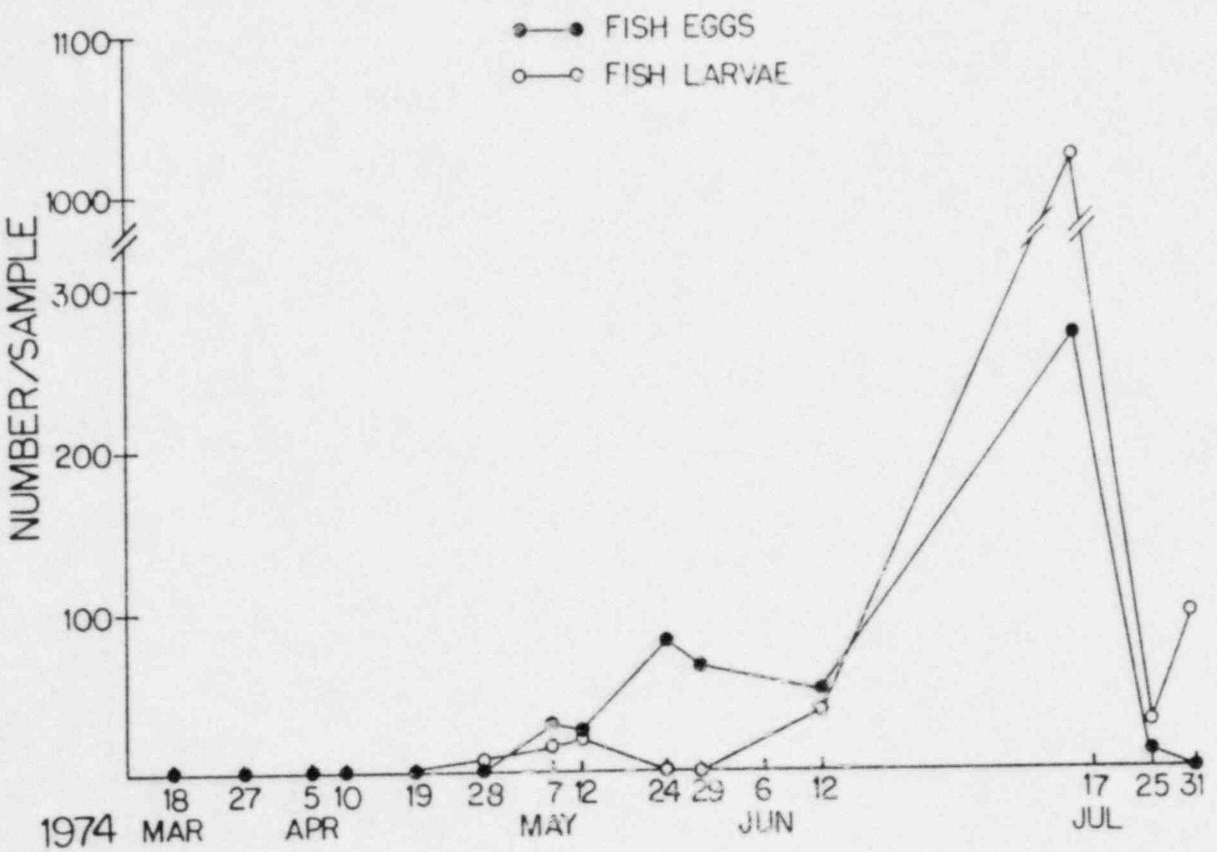

Figure G-5. Fish eggs and larvae collected by 15-minute drift net sets for baseline study (PSI, 1976), Marble Hill Plant site, 18 March - 31 July 1974.

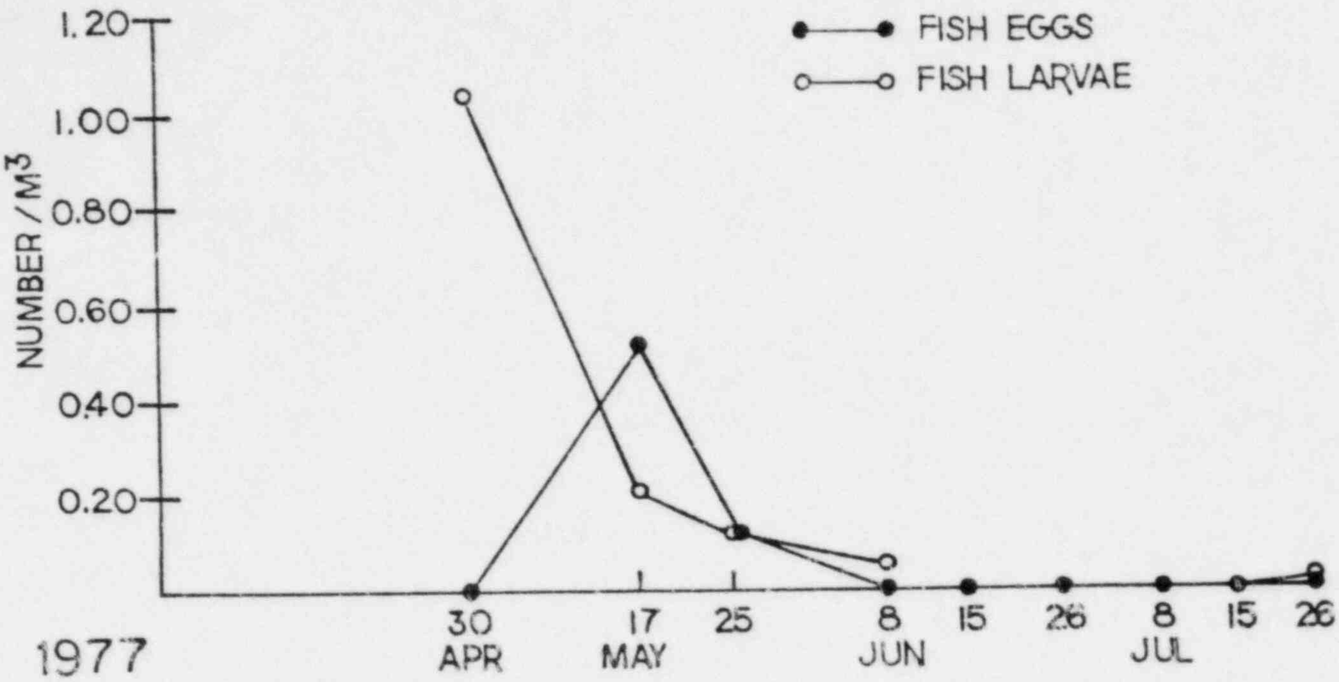

Figure G-6. Fish eggs and larvae collected by 10-minute metered bongo-net tows for construction phase study (ABI, 1978), Marble Hill Plant site, 30 April-26 July 1977.

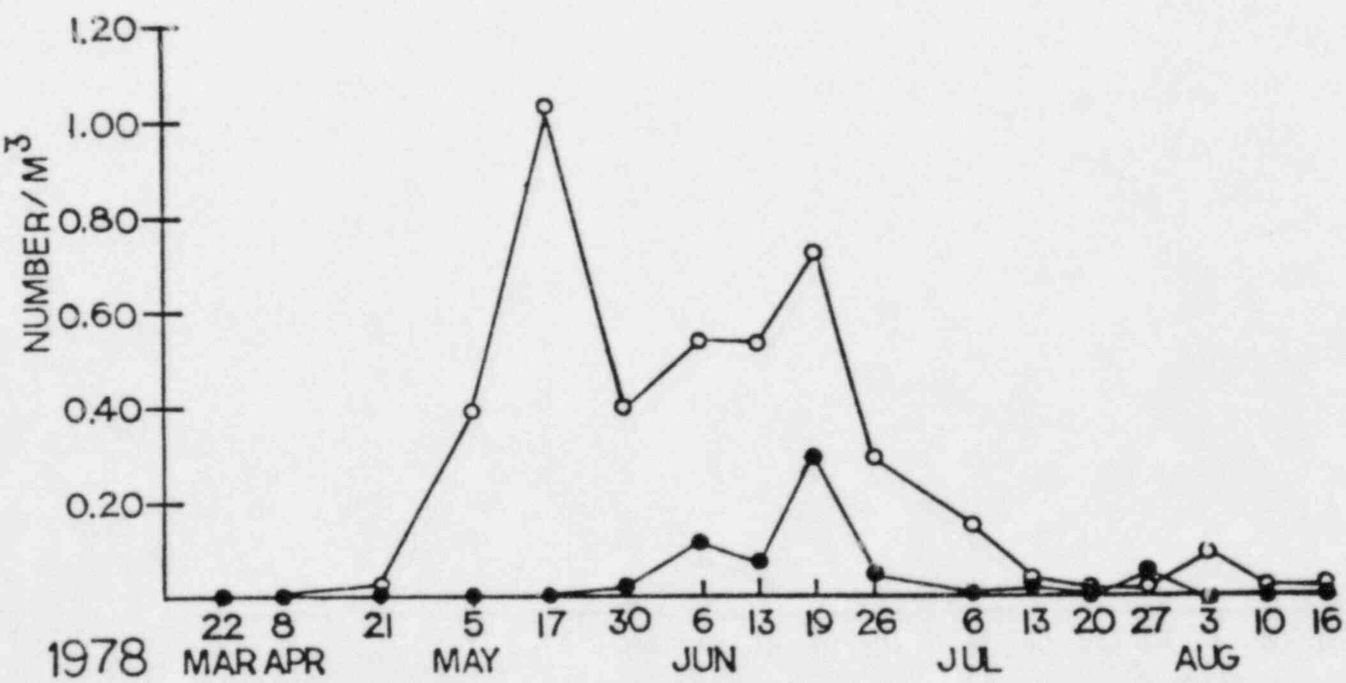

Figure G-7. Fish eggs and larvae collected by 10-minute metered bongo-net tows for construction phase study, Marble Hill Plant site, 22 March-16 August 1978.

TABLE G-1

SCIENTIFIC AND COMMON NAMES OF LARVAL FISHES
COLLECTED IN THE VICINITY OF THE MARBLE HILL PLANT SITE
1978

ORDER SEMIONOTIFORMES	
Lepisosteidae-gars	
Lepisosteus osseus	longnose gar
ORDER CLUPEIFORMES	
Clupeidae-herrings	
Dorosoma cepedianum	gizzard shad
ORDER OSTEOGLOSSIFORMES	
Hiodontidae-mooneyes	
Hiodon alosoides	goldeye
ORDER CYPRINIFORMES	
Cyprinidae-minnows and carp	
Cyprinus carpio	carp
Notropis sp.	shiner
ORDER PERCIFORMES	
Percichthyidae-temperate basses	
Morone chrysops	white bass
Morone sp.	temperate basses
Centrarchidae-sunfishes	
Lepomis sp.	sunfishes
Pomoxis annularis	white crappie
Percidae-perches	
Perca flavescens	yellow perch
Stizostedion sp.	sauger and walleye
Sciaenidae-drums	
Aplodinotus grunniens	freshwater drum

TABLE G-2

PERCENTAGE COMPOSITION OF LARVAL FISH TAXA
OHIO RIVER STATIONS 1, 3, 5 AND 14
MARBLE HILL PLANT SITE
22 MARCH - 16 AUGUST 1978

	STATION				
	1	3	5	14	Overall
LONGNOSE GAR	0.0	0.0	0.2	0.0	0.0
HERRINGS	0.4	0.0	0.0	0.1	0.1
GIZZARD SHAD	14.3	11.3	12.6	19.8	14.9
GOLDEYE	0.0	0.2	0.0	0.1	0.1
MINNOWS	13.0	11.7	9.2	5.6	9.4
CARP	10.4	11.1	12.0	9.9	10.8
SHINERS	0.0	0.0	0.3	0.1	0.1
SUCKERS	37.2	38.8	43.9	39.5	40.1
WHITE BASS	0.2	0.2	1.0	1.1	0.7
TEMPERATE BASSES	3.0	2.7	2.3	3.4	2.9
SUNFISHES	0.0	0.0	0.2	0.1	0.1
WHITE CRAPPIE	0.0	0.0	0.2	0.0	0.0
YELLOW PERCH	0.0	0.2	0.0	0.3	0.1
WALLEYE & SAUGER	3.7	6.7	7.9	7.3	6.6
FRESHWATER DRUM	15.4	15.2	9.0	11.1	12.3

TABLE G-3

TWO-WAY ANOVAS FOR STATION AND DEPTH EFFECTS OF EGGS COLLECTED
MARBLE HILL PLANT SITE
22 MARCH - 17 AUGUST 1978

DEPENDENT VARIABLE: EGGS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	11	0.17002201	0.01545655	1.55	0.1133	0.062718	178.6325
ERROR	255	2.54089026	0.00996428		STD DEV		EGGS MEAN
CORRECTED TOTAL	266	2.71091228			0.09982122		0.05588076

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
STATION	3	0.07635447	2.55	0.0550	3	0.07602622	2.54	0.0557
DEPTH	2	0.04537638	2.28	0.1047	2	0.04686450	2.35	0.0973
STATION*DEPTH	6	0.04829116	0.81	0.5647	6	0.04829116	0.81	0.5647

TABLE G-4

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE EGGS BY STATION
MARBLE HILL PLANT SITE
22 MARCH - 17 AUGUST 1978

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL = .05 DF=255 MS=.0099643

GROUPING		GEOMETRIC MEAN	N	STATION
	A	0.087975	66	1
B	A	0.055305	66	3
B		0.045275	69	4
B		0.042500	66	5

TABLE G-5

DUNCAN'S MULTIPLE RANGE TEST FOR VARIABLE EGGS BY DEPTH
MARBLE HILL PLANT SITE
22 MARCH - 17 AUGUST 1978

MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT.

ALPHA LEVEL=.05 DF=255 MS=.0099643

GROUPING		GEOMETRIC MEAN	N	DEPTH
	A	0.074591	90	B
B	A	0.056586	89	M
B		0.041126	88	S

TABLE G-6

TWO-WAY ANOVAS FOR STATION AND DEPTH EFFECTS OF FISH LARVAE COLLECTED
MARBLE HILL PLANT SITE
22 MARCH - 17 AUGUST 1978

DEPENDENT VARIABLE: LARVAE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	11	0.39522202	0.03592927	0.60	0.8302	0.016421	126.9840
ERROR	395	23.67222055	0.05992967		STD DEV		LARVAE MEAN
CORRECTED TOTAL	406	24.06744257			0.24480538		0.19278443

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
STATION	3	0.32137401	1.79	0.1472	3	0.32274211	1.80	0.1457
DEPTH	2	0.03609956	0.30	0.7401	2	0.03625079	0.30	0.7392
STATION*DEPTH	6	0.03774845	0.10	0.9958	6	0.03774845	0.10	0.9958

TABLE G-7

TOTAL NUMBER AND RELATIVE ABUNDANCE OF ADULT AND JUVENILE FISHES COLLECTED USING LARVAL FISH TRAPS, LITTLE SALUDA CREEK STATION 6
MARBLE HILL PLANT SITE
22 MARCH-17 AUGUST 1978

Species	Number collected	% Relative abundance
stoneroller	11	0.6
emerald shiner	93	4.9
river shiner	2	0.1
common shiner	2	0.1
taillight shiner	2	0.1
spotfin shiner	1	0.0
sand shiner	1	0.0
shiner (*Notropis* sp.)	1637	86.5
blacknose dace	11	0.6
creek chub	65	0.3
white sucker	2	0.1
sucker	1	0.0
green sunfish	5	0.3
bluegill	53	2.8
sunfish (*Lepomis* sp.)	4	0.2
rainbow darter	2	0.1
darter (*Etheostoma* sp.)	1	0.0
TOTALS	1893	100.0

TABLE G-8

RELATIVE ABUNDANCE AND DENSITIES OF DOMINANT LARVAL FISH SPECIES COLLECTED IN THE OHIO RIVER AT THE MARBLE HILL PLANT SITE DURING 1974[a], 1977 AND 1978

Species	1978 % Abundance	1978 No./m^3	1977 % Abundance	1977 No./m^3	1974 % Abundance
suckers	40.1	0.08	70.0	0.12	2.0
gizzard shad	14.9	0.03	7.7	0.01	6.5
freshwater drum	12.3	0.02	3.8	<0.01	82.5
carp	10.8	0.02	13.6	0.02	2.8
minnows	9.4	0.02	0.0	0.00	5.0

[a]Larval fish densities were not calculated during the 1974 study.

H. MAMMALS

INTRODUCTION

The eastern cottontail rabbit (*Sylvilagus floridanus*), the eastern fox squirrel (*Sciurus niger*), and the eastern gray squirrel (*Sciurus carolinensis*) represent important game animals in the State of Indiana. For the years 1962-65, the average annual calculated kill of cottontails was about 1,540,000 (Mumford, 1969), making cottontails the most important game animal in Indiana. Mumford (1969) reported annual Indiana harvests of eastern gray and fox squirrels to be approximately 300,000 and 1,130,000, respectively.

MATERIALS AND METHODS

Roadside counts of cottontail rabbits were conducted on three consecutive mornings during the May sampling trip. A route approximately 5.5 miles long around the perimeter of the Marble Hill Plant site was chosen (Figure 1). Due to construction, this route was 1.6 miles shorter than the route used in the baseline and 1977 studies. On the first and third days, the route was followed in a clockwise direction. A counterclockwise direction was followed on the second day. Counts were conducted in accordance with methods described by Lord (1959) and Kline (1965). The survey began about 20 minutes before sunrise and continued until about

20 minutes after sunrise. Pace was maintained below 20 mph during the survey.

Time-area counts of squirrels were conducted during the March and November sampling trips. Counts of 15 minutes duration each were made at five locations on each of two consecutive days in the woods on the east-facing slope of the Marble Hill Plant site. Counts were made between 8 and 10 am.

The distance to an observed squirrel was measured according to the method of Goodrum (1940), and the area of the field of view in which the squirrel was observed was calculated as follows:

$$\text{Observed area} = (0.75 \times \pi r_m^2)\ N$$

where: 0.75 = that portion of the area of a circle which the observer can see without moving

r_m = mean distance to observed squirrel

N = total number of observations

From these calculations, the number of squirrels per unit of observed area was estimated.

RESULTS AND DISCUSSION

Rabbits

During the May road count, a total of four cottontail rabbits was observed (Appendix Table H-1). An average of 0.24 rabbits per mile of observed road was calculated. This figure represented a large drop in rabbit population from previously reported on-site counts of 0.55 rabbits/mile in 1977 (ABI, 1978) and 1.1 rabbits/mile in 1974 (PSI, 1976).

There were several circumstances which may have adversely affected the reliability of the roadside counts. While approximately the same route was used, the 1978 route was 1.6 miles shorter than the route used in the baseline and 1977 pre-construction counts. The route was shortened due to heavy construction on the road down the east-facing slope and on the floodplain. This area has the most forest area and was the location of most of the observations made during the 1977 counts. In addition, a heavy rain occurred during the first day's count. It has been documented that rain will decrease roadside counts ([illegible]oris, 1956; Kline, 1965).

On the second day's count only one rabbit was observed (Appendix Table H-1). The day was heavily overcast with fog. The third day's count was the highest (three rabbits) and also had the best weather. Temperatures were approximately the same as in 1977 when 12 rabbits were observed.

From the preceding results, it may be seen that roadside counts were probably influenced by bad weather.

Squirrels

Squirrels were counted at the same general locations used in baseline (PSI, 1976) and 1977 pre-construction counts (ABI, 1978).

Only one eastern fox squirrel was observed at Station 13 during 1978 (Appendix Tables H-2 and H-3). This lone squirrel was sighted in March and yielded a density of 0.35 squirrels per acre of observed woodland. This density figure was very nearly the same as reported during March 1977 (0.36 squirrels/acre) and much lower than reported during the baseline study (1.0 squirrels/acre). As in the 1977 survey, no eastern gray squirrels were observed.

Although eastern gray squirrels were reported in the baseline study, none were observed in 1977 or 1978. It is possible that no grays live in the east slope woods since gray and fox squirrels are known to live apart from each other. In addition, grays prefer woodlands where ample ground cover exists (Hoffmeister and Mohr, 1957). The woods on the east-facing slope of the Marble Hill site are more open, a condition favorable to eastern fox squirrels.

As in the case of the cottontail census, the number of time area counts made in these studies were too few to draw conclusions from the data. Data from the present study indicate that construction activites have not significantly altered the fox squirrel population on the site.

CONCLUSIONS

Rabbit populations appeared lower in 1978 surveys than in 1977 or 1974 and fox squirrel populations appeared about the same as in 1977. Rabbit surveys in 1978 were probably influenced by bad weather which may have decreased the roadside counts.

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