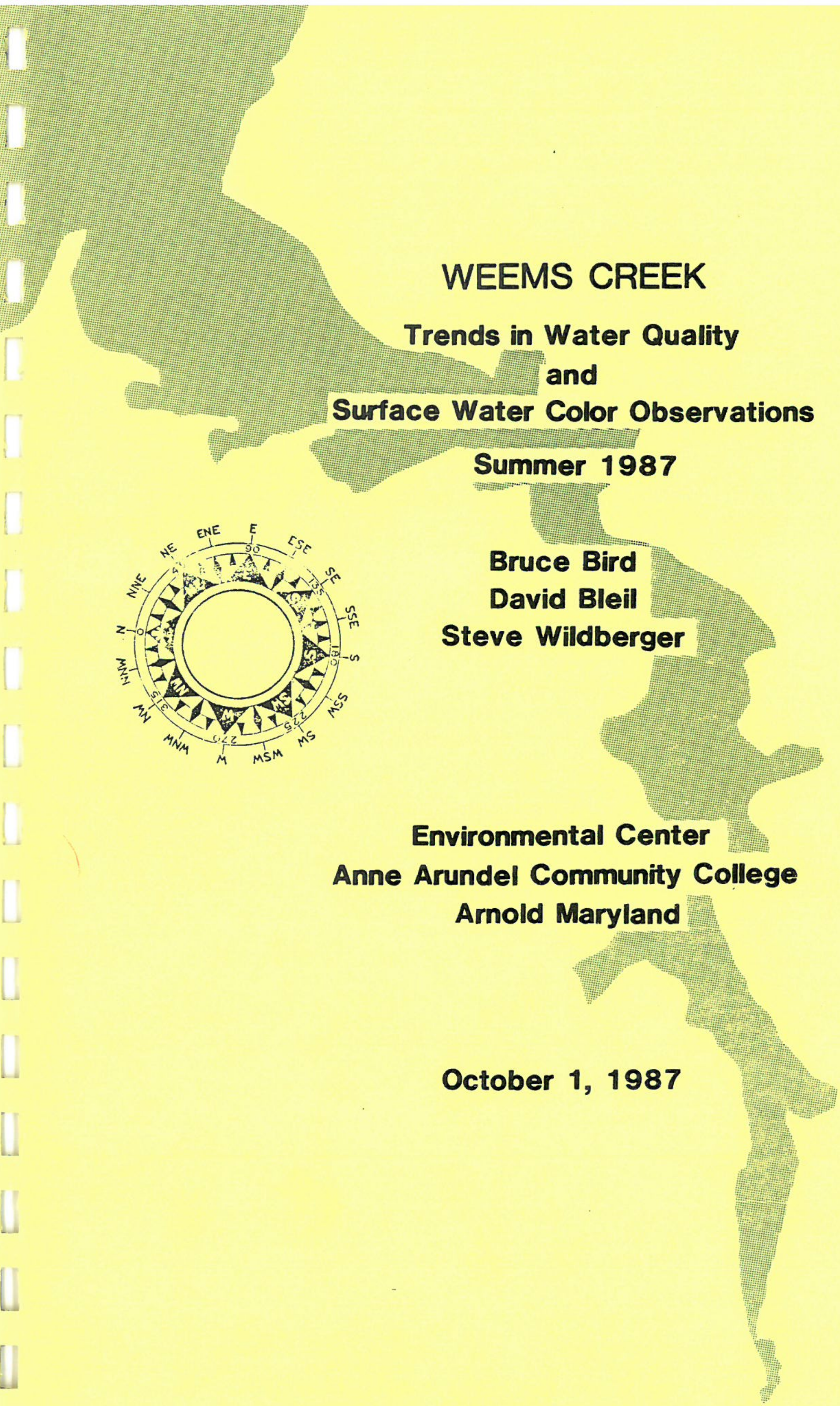
EC-87-003



WEEMS CREEK

Trends in Water Quality
and
Surface Water Color Observations

Summer 1987

Bruce Bird
David Bleil
Steve Wildberger

Environmental Center
Anne Arundel Community College
Arnold Maryland

October 1, 1987

Anne Arundel Community College

WEEMS CREEK

TRENDS IN WATER QUALITY
AND
SURFACE WATER COLOR OBSERVATIONS

SUMMER 1987

BRUCE BIRD
DAVID BLEIL
STEVE WILDBERGER

ENVIRONMENTAL CENTER
ANNE ARUNDEL COMMUNITY COLLEGE
ARNOLD, MARYLAND

OCTOBER 1, 1987

INDEX PAGE

Appendices

ACKNOWLEDGEMENTS

We appreciate the help of Hermann Gucinski in preparing the proposal for this work and for discussions as the work progressed. Barbara Bird and Paul Warner provided much appreciated assistance on some of the water sampling work. Graphs and cover design were done by Sally Barba, Doris Kiser, and Ed Sparks of the Media Center at A.A.C.C. Cathy Wirth helped on the format of the report, did the typing, and cheerfully kept track of all the miscellaneous details required to finish the report.

ABSTRACT

In order to determine the source and characterize the material producing a chocolate brown color in Weems Creek reported by citizens in previous years, nine sampling runs were made in the creek during the summer of 1987.

These measurements indicate that during most of the summer the surface and middle levels had sufficient dissolved oxygen to maintain aquatic life, but the bottom waters for the lower two thirds of the creek did not.

Throughout the summer the turbidity in the upper third of the creek was always much higher than the lower two thirds. This is probably due to particle resuspension caused by tidal action and wind driven circulation. A large increase in turbidity in the upper two thirds of the creek ocurred at the end of July . This was due to the appearance of a high algae concentration. The major contributor was the algae *Gyrodinium uncatenum*. Because this algae produces a dark brown, chocolate colored suspension it is likely the source of previous citizen reports of this color appearing in Weems Creek.

Measurements of turbidity, suspended solids, and particle size distributions indicate the marsh at the headwaters produces a large number of very fine particles. These particles along with those brought into the headwaters by streams and surface runoff maintain a high, fine particle density in the upper third of the creek. Physical, chemical, and biological flocculation processes convert these fine particles into larger, less numerous particles as one proceeds downstrem.

Storm events cause a sharp rise in the surface turbidity because of the increased sediment input from streams and surface runoff. This turbidity increase, howerever, appears to be quite brief, only a few hours for most of Weems Creek.

1. Introduction

Weems Creek is a tidal creek that flows into the Severn River and lies along the northwest boundary of the city of Annapolis. A recent description of the Creek and its watershed is given in a 1982 report (1).

The work reported here was initiated due to citizen reports of unusual chocolate brown water observed in Weems Creek. The objective was to determine the source of this unusual color and to characterize the material that produces it.

2. APPROACH

During the summer of 1987 the creek was monitored primarily by boat while a few measurements were taken from piers at public sites. The location and number of the sampling stations are shown on the map of Weems Creek, Figure 1. Typically for each station measurements were taken at three depths: surface, middle and bottom. These are indicated in data tables and on the graphs by S, M, and B. In situ measurements included temperature, dissolved oxygen, conductivity, salinity, depth of measurement, and Secci depth. In addition, color photographs of the surface were taken and one liter volume samples of the water at the three different depths were collected for later analysis in the laboratory.

The equipment and procedures used for in situ sampling are discussed in Appendix A. In situ field data tables are located in Appendix B and some of the color photographs are shown in Appendix D.

Water samples were analyzed in the laboratory for turbidity, settleable solids, and suspended solids. They were inspected under the microscope and color photomicrographs taken. Spectrometric analysis was also done on some samples. Four samples were sent to the Fine Particle Laboratory of Coulter Electronics Inc. for particle size distribution analysis.

The equipment and procedures used for laboratory analysis are discussed in Appendix A. Laboratory results are tabulated in appendix C.

3. DISCUSSION

A. General Trends

Before discussing the effect of particular storm events it is necessary to determine both meteorological and water quality trends during the summer. Meteorological information for the summer is summarized in Table B1, Appendix B.

The localized nature of summer thunderstorms is indicated by the differences in Table B1, Appendix B between total rainfall as measured at BWI airport compared with the results obtained from the automatic rain gage installed in the Weems Creek Watershed by the Department of Planning and Zoning, Anne Arundel County. There were four to five thunderstorms per month recorded at Weems Creek, most having less than one-half inch of rain, with only two storms, one in June and one in August having a total rainfall of over one inch.

The amount and duration of sunshine is an important contributing factor to the creation of algae blooms in the water. In June and July there were 11 days with over 90% total possible sunshine, and in August there were seven days. July had a period of 7 consecutive days with over 90% total possible sunshine.

Table B1 also shows the dates and corresponding event identifying number for in situ sampling runs that were taken in Weems Creek. The sampling event numbers will be used in later discussions of the variation in turbidity at each sampling station during the summer.

The variation of salinity, dissolved oxygen, and temperature is shown as a function of stream location in Figures 2-9 for each sampling date.

In general, the headwaters surface temperature was always cooler than surface temperatures for the rest of the creek. From station 2.15 to the mouth of the creek the surface temperature did not vary by more than one-half degree Celsius for any given sampling day. There was, however, a trend for the water temperature to increase from June 6 until the end of July and to become cooler from then on. There appears to be no general trend in the variation of water temperature with depth. Some sampling days the water temperature was the same throughout the water column, whereas on other sampling days there could be as much as a three Celsius degrees difference between surface and bottom water.

Surface salinity was reasonably uniform along the creek from station 2.2 to the mouth. In the headwaters the surface salinity varied considerably because of the presence or absence of a storm event prior to the sampling date. The salinity measurements were able to detect the effect of freshwater input from the streams that enter the marsh at the headwaters, but evidently the circulation patterns and volume of water further down the creek prevent large salinity changes from occuring. Over the summer there was a general trend for the salinity of the creek to increase from about 9.5 parts per thousand in June to 10.5 parts per thousand at the beginning of September. Because higher salinity water has a greater density one would expect to find higher salinity at the bottom of the creek and this was normally found except for occasional locations at a few sampling dates.

The dissolved oxygen concentration at the surface stayed above 5 parts per million throughout the summer from station 3 to the mouth of the creek. The water along the bottom of the creek from station 3 to the mouth was below 3 parts per million for the entire summer except for the sampling date of July 29. The mid-depth values ranged from 2 to 7 parts per million along the creek throughout the summer. Since the amount of oxygen needed to support aquatic life is generally taken to be in the range from 3 to 5 parts per million, the creek's deeper water was for the most part close to borderline conditions in its ability to support aquatic life.

Trends in turbidity, suspended solids, and Secci depth along the creek are shown in Figures 10-19. For the most part there is a reasonable correlation between turbidity and suspended solids and an inverse correlation of these two variables with the Secci depth.

During the summer, the general trend for turbidity and suspended solids was to decrease from their highest values at the headwaters to the lowest values at the mouth of the creek. The Secci depth becomes correspondingly larger on going from the headwaters to the mouth.

In order to better see how the creek varied over the summer, the turbidity has been plotted as a function of sampling date in Figures 20-27.

The fluctuations in turbidity observed in the headwaters over the summer are much greater than those seen at the mouth of the creek. There also is a gradual increase in the turbidity over the summer at the mouth of the creek.

B. High Turbidity Events

The plots of turbidity versus event number (sampling date) show peaks for most stations at event numbers 3 (July 14), 6 (August 6) and 7 (August 22). The creek turbidity appears to have returned to its background level for sampling events 1 (June 16), 2 (June 22), 4 (July 14), and 8 (August 22).

In order to account for these results three factors must be considered. First, the presence or absence of a storm prior to sampling; second, the time delay between the end of a storm and the start of sampling; and third, the presence of other processes, such as algae blooms, that can contribute to an increase in turbidity without a direct time correlation to a specific storm.

The time from the end of the last storm to the beginning of sampling for each sampling event is summarized in Table B2. It can be seen that the three peaks in the turbidity for events 3, 6, and 7 correspond to sampling two moderate (.3" to .4") storms within an hour (events 3 and 7) or a heavy (1") storm within 14 hours (event 6) i.e. slightly longer than a tidal cycle (12 hrs.). The background state indicated by events 1, 2, 4, and 8 correspond to time delays between previous storm and sampling of 62, 231, 171 hrs, and 103 hours respectively. The correlation of the turbidity peak of sampling event 6 with a prior storm is not correct. This can be seen by examining Figure 19, the plot of turbidity versus sampling event number for station 1. Station 1 is located in the marsh just below the entrance point of two streams that drain the western part of the watershed. This station would therefore be expected to have the most sensitive response to sediment input due to storm events. Yet while it shows a large increase in turbidity for events 3 and 7, it remains essentially at its normal background level for event 6. On the other hand, stations 2.2 and 3 show their maximum turbidity for sampling date 6. Reference to the laboratory data tables for July 29 (event 5) and August 8 (event 6) gives an explanation for this. On July 29 the first evidence of high algae concentration, indicated by green colored filters, appeared. The algae as initially trapped on the filter (used to determine the amount of suspended solids in the water) appear a dark chocolate color, but after heating the filters in an oven at 105 C for one hour to drive off water trapped on the filter the algae appears green due to their cholorphyll content.

The algae became detectable after the sampling of July 29, reached its maximum concentration about August 5, and was not detectable on September 1. The beginning of the high algae concentration occurred just a few days after a sequence of several days of high temperature, clear sunny days. (See Table B1). This is a typical response pattern for algae in this area. During the summer the algae had their highest concentrations between station 2 and station 4.

The background surface turbidity trend along the creek is about 16 NTU at station 1, 12 NTU at station 2, 6 NTU at station 3 and 5, and 5 NTU at station 6. Using the results found for the values of turbidity and suspended solids on September 1, in order to avoid the effects of light scattering by algae, the turbidity trend can be roughly translated into a trend of normal suspended solids concentration at the surface of 11 mg/l at station 1, 8 mg/l at station 2, 4 mg/l at stations 3 and 5, and 3 mg/l at station 6. Higher concentrations of suspended sediments occur in the headwaters due to the following reasons: 1) The water depth from station 2 to station 1 is less than one meter. This means that tides and wind can continually cause resuspension of fine particles which will tend to mix into surface water; 2) even without a storm event, some of the streams entering the marsh continued to flow, thus transporting suspended solids from the watershed and detritus from the marsh into the headwaters; 3) the greater depth and width of the creek from station 3 to the mouth provides a much greater volume of water to dilute any runoff from the sides of the watershed resulting in a reduced amount of suspended solid per unit volume.

Measurements of turbidity of samples taken in the coves which have storm drains running into them (stations 2.1, 2.2, 3.1, 3.2, 3.9) indicate that immediately after a storm the surface of the water has an increased concentration of suspended solids due to surface runoff but within a few hours the concentration returns to its normal background level.

Evidence of a thin surface layer of freshwater flowing on top of higher salinity water in the creek is shown in plots of salinity versus depth (Figures 28, 29, 30). The plots for August 6 indicate that even 14 hours after the end of the storm (1.09" total rainfall) lower salinity water extends down the creek as far as station 2.15. One hour after the storm (.32" total rainfall) on August 22 a freshwater layer 0.4m deep existed at station one but had not yet affected appreciably the surface water at station 2. The salinity profile at station 1 on September 1 indicates that even four days after the last storm there was still sufficient freshwater flow into the marsh to create a fresh water layer 10 to 20 centimeters thick on the surface.

Similarly, thin layers of fresh water flowing over the top of higher salinity, higher density, creek water also undoubtedly occurs in some of the coves which have fresh water input from the watershed and storm drains. However, there are only limited data to support this conclusion.

During the months June through September, rain is primarily the result of thunderstorms. As indicated in Table B1, many of these storms occur late in the day. Often the rain stops but thunder continues so that darkness would occur before it was considered safe to sample from a pier or open boat. This means that sampling started the next morning has a time delay of 10 hours or more with respect to the previous storm. Our experience on Weems Creek indicates that this delay is long enough for any surface layer of fresh water sediment suspensions to settle or mix with the creek water. Because of this problem, we recommend that future work of this type use automatic samplers triggered by rain events of a specified total rainfall.

C. Particle Size Distributions

In order to better characterize the nature of the suspended solids that exist in the creek, four water samples were analyzed for their particle size distribution by the Fine Particle Laboratory of Coulter Electronics Inc. The results of this analysis are summarized in Table 22, Appendix C, and in Figures 31-39.

Two of the samples were taken on the same date (7/29/83) and allow a comparison between upper (station 2) and lower (station 5) parts of the creek. The particle size distributions at these two locations, shown in Figure 37, are quite different. At the mouth of the creek particle size varies over a wide range from 0.2 to 200 microns with small peaks in the distribution at 10 microns and 160 microns. The majority of the particles have diameters of 10 microns or less (Figure 38 and 39) and the total number of particles per milliliter is only 12,400 (see Table C22). In contrast the particle size distribution at the upper part of the creek has a large peak at about 30 microns with no particles detected larger than 100 microns. The majority of the particles are again less than 10 microns, but the 30 micron particles make up a significant fraction of the population. Since this sample was taken at the location and date of the large algae concentrations in the creek it is tempting to identify the 30 micron particles with algae cells. The total number of particles per milliliter at station 2 was 45,300, about four times greater than at the mouth of the creek. This is consistent with the turbidity, suspended solids, and Secci depth measurements.

The surface samples taken at station 1 and in the stream that drains the subwatershed containing part of the runoff from the Annapolis Mall were collected at different dates. They were, however, taken shortly after storms had ended so that some comparison can be made. Their particle size distributions (Figures 31 and 34) both have a peak around 10 microns, but the stream sample has particle sizes extending out to 100 microns, whereas the marsh distribution stops at about

60 microns. The majority of particles for both locations have diameters less than one micron, but 390,000 particles per milliliter in the marsh is much greater than the 43,500 particles per milliliter for the stream sample.

These results indicate that under high flow conditions the stream supplys a large number of very fine (less than 1 micron) particles to the marsh. The marsh itself also generates a very large number of fine paricles. Then evidently because of physical, chemical, and biological floculating processes (2)(3) that occur in the region of mixing of fresh and salt water at the upper part of the creek these small particles are converted into larger particles (10 micron, 30 micron). This conversion process, along with the dilution due to the increased volume of water in the lower part of the creek, results in a much lower particle concentration at the mouth of the creek.

D. Color Observations

The only direct observation of a color change in the surface water of Weems Creek due to storm water runoff is shown in photograph #1 Appendix D. This picture was taken near station 4 on June 5, a day after a 1.1" storm was recorded at BWI Airport. Regrettably, the recording rain gauge at Weems Creek was not working on this day so the total rainfall at the creek for this storm is unknown. Salinity measurements indicated that there was a thin fresh water layer (about 10cm thick) which was a light tan in color. Stirring the water with an oar to bring up deeper water resulted in the color pattern shown in photograph #2. There appeared to be a brown clear layer at a depth of about 30cm. Microscopic investigation of the two layers indicated that the upper layer was mostly soil particles and the deeper layer had some type of brown algae suspended in it. At this date, a boom extended across the southeast half of the creek because of painting in progress on the new bridge. This ubdoubtedly had changed the surface water circulation patterns near sampling station 4 from what it was when the boom was removed.

The high algae concentrations that occurred toward the end of July produced several patches and streaks of dark, chocolate brown water, examples of which are shown in photographs 3 and 4. Photomicrographs of the dominant algae in these blooms is shown in photograph #5 and clumps of dead and dying algae are shown in photograph #6. Although they appear yellow in these photomicrographs, this is mostly an artifact due to the light source used. In the water these algae are a dark, chocolate brown in appearance. The highest concentrations of algae look like someone had dumped coffee grounds into the creek.

Microscopic examination of the water samples taken from patches of colored water collected from Weems Creek indicate that the predominant organism is an unarmored (naked) dinoflagellate. The plants were observed to vary in color from an olive drab to a golden brown depending on species. Several genera of dinoflagellates are known to be common to the mesohaline waters of the Chesapeake Bay and its tributary creeks.

Unlike the armored forms which leave behind a rigid outline of the cell, the naked dinoflagellates leave no identifiable structure behind when the cell dies and disintegrates. This disintegration can happen very quickly. As the algae uses up the available nutrients in the water column the cells die and begin to decompose. This decomposition process results in removal of dissolved oxygen from water whose saturated oxygen level is already low due to high summer temperature.

In order to confirm our identification of the dominant algae in the creek at the time of the largest blooms fresh water samples were taken to the State Office of Environmental Programs for microscopic examination. The dominant algae was Gyrodinium uncatenum.

For most of the summer the water color of the creek from about station 2.15 to the marsh remained yellow-green in color as shown in photograph #7 and in the background color of photograph #4. In contrast, the rest of the creek (station 2.15 to the mouth) was always blue-gray in color as shown by the background color in photograph #9. This yellow-green color is a result of the much higher concentration of suspended particles in the headwaters as shown by the turbidity, suspended solids, and particle size distribution results.

Spectrophometric analysis of unfiltered water samples indicated a small (less than 2%) absorbtion at the shorter visible wavelengths which decreased as one progressed toward the mouth of the creek. Measurements on filtered samples showed a much reduced absorbtion indicating that the absorbtion was produced by light scattering by the suspended particles. The absorbton decreased for samples taken toward the mouth of the creek because these samples had a much lower concentration of suspended particles.

Two other brief, localized changes in the creek's surface were also noted. At the peak of the algae bloom, on July 29, gas bubbles were seen coming to the surface at station 2.2. Photograph #8 shows the disks of organic film left on the surface when the bubbles broke. Evidently, conditions in the cove at this time promoted the bacterial and chemical processes that lead to gas production at the bottom of the creek.

The other brief, localized surface change that was observed is shown as a close-up in photograph #9 and at a greater distance in photograph #10. These appear to be clumps of bubbles, but efforts to collect and characterize their nature were not successful. It was a fairly windy day so it is possible that the combined action of wind and breaking waves combined with a natural organic film on the water surface generated bubbles that could be stable for a while before breaking up.

E. Miscellaneous Observations

The majority of water samples had settleable solids concentrations of less than 0.1 ml/l. Occasionly bottom samples would have 1 ml/l or less , but this is likely some material that was resuspended during the process of obtaining samples close to the bottom. In samples taken one hour after the storm on July 14 the surface sample at station 1 had 1 ml/l of settleable solids and the sample at the end of Tucker street had 0.1 ml/l settleable solids. High algae concentrations led to samples for which the clumping of algae would cause some of the algae to settle out. On July 29 station 2.2 had 0.8 ml/l of algae clumps settle and on August 6 the surface sample at location 2.15 had 5 ml/l

. Also on August 6 the middle sample at station 2.2 had settleable algae clumps of 7 ml/l. These numbers are lower than the actual amount because a lot of small algae clumps stuck to the side of the collecting cone and did not collect at the bottom of the cone.

Four sediment traps were installed in the bottom of two streams that enter the marsh at the headwaters of the creek. Two different shapes of traps were tried. Our experience with these traps leads us to believe that the amount of trapped material not only depends upon the amount of sediment transported along the bed of the stream but also on the shape of the trap, trap depth, height of trap edge above stream bed, flow velocity, stream width, etc. To obtain meaningful data would thus require an extensive investigation that is well beyond the scope of this contract.

One general observation can be made based on our experience with the traps we installed. The stream bed material trapped in the stream that drains part of the Annapolis Mall was a very fine, silt-clay mixture, whereas the stream that drains the industrial park and apartment complex south of route 50 generated material consisting mostly of coarse sand. This may indicate that the stormwater treatment pond at the Annapolis Mall is effectively trapping coarse soil particles.

SUMMARY

During the summer of 1987 Weems Creek showed a general warming trend of surface water temperature until the end of July. Salinity increased from about 9.5 to 10.5 ppt between June and September. Surface and middle level dissolved oxygen concentration was usually able to support aquatic life for most of the summer, but the bottom waters for the lower two thirds of the creek could not.

Throughout the summer the turbidity in the upper third of the creek was always much greater than that in the lower two thirds because of particle resuspension caused by tide and wind. There was a large increase in turbidity at the end of July due to abundent algae. The major contributor was the algae Gyrodinium uncatenum. This algae produces a dark brown, chocolate colored suspension which was seen at various locations in the upper two thirds of the creek.

Measurements of turbidity, suspended solids, and particle size distributuions indicate that the marsh at the headwaters produces a large number of very small particles. These particles along with the particles brought into the headwaters by streams and surface runoff maintain a high, fine particle density in the upper third of the creek.

Storm events cause a sharp rise in surface water turbidity, but water circulation, floculation, large particle settling, and dilution return the turbidity of the creek to its normal seasonal level within a few hours.

REFERENCES

1. A Greenway Strategy For Weems Creek, Weems Creek Conservancy Maryland Department of Natural Resources, U.S. Department of the Interior, 1982.

2. The Estuary As A Filter, V.S. Kennedy, editor, Academic Press, 1984.

3. Estuaries and Nutrients, B.J. Neilson and L.E. Cronin, Humana Press, 1981.

4. Standard Methods for the Examination of Water and Wastewater, 16th edition, American Public Health Association, 1985.

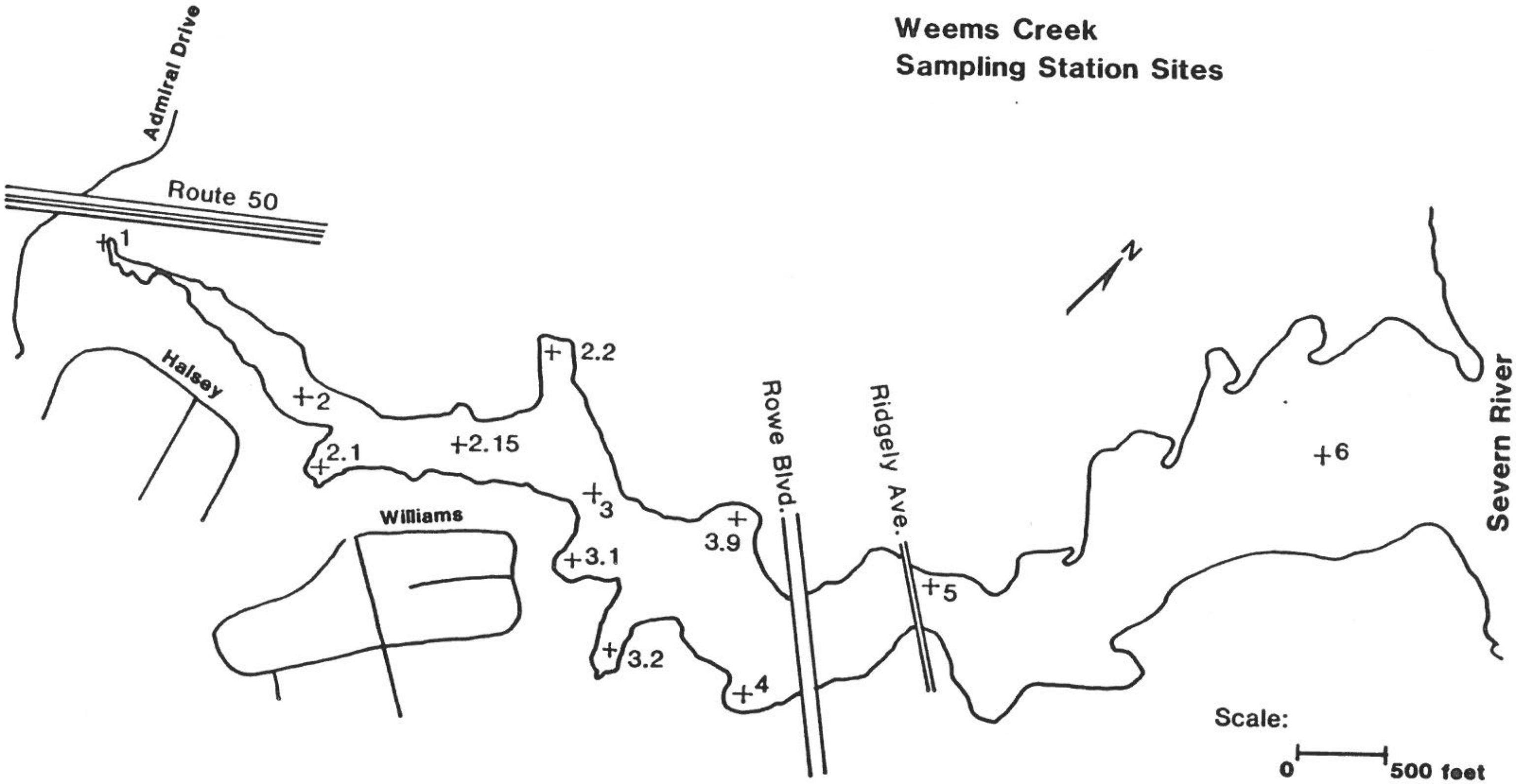


FIGURE 1 - SAMPLING STATION SITES

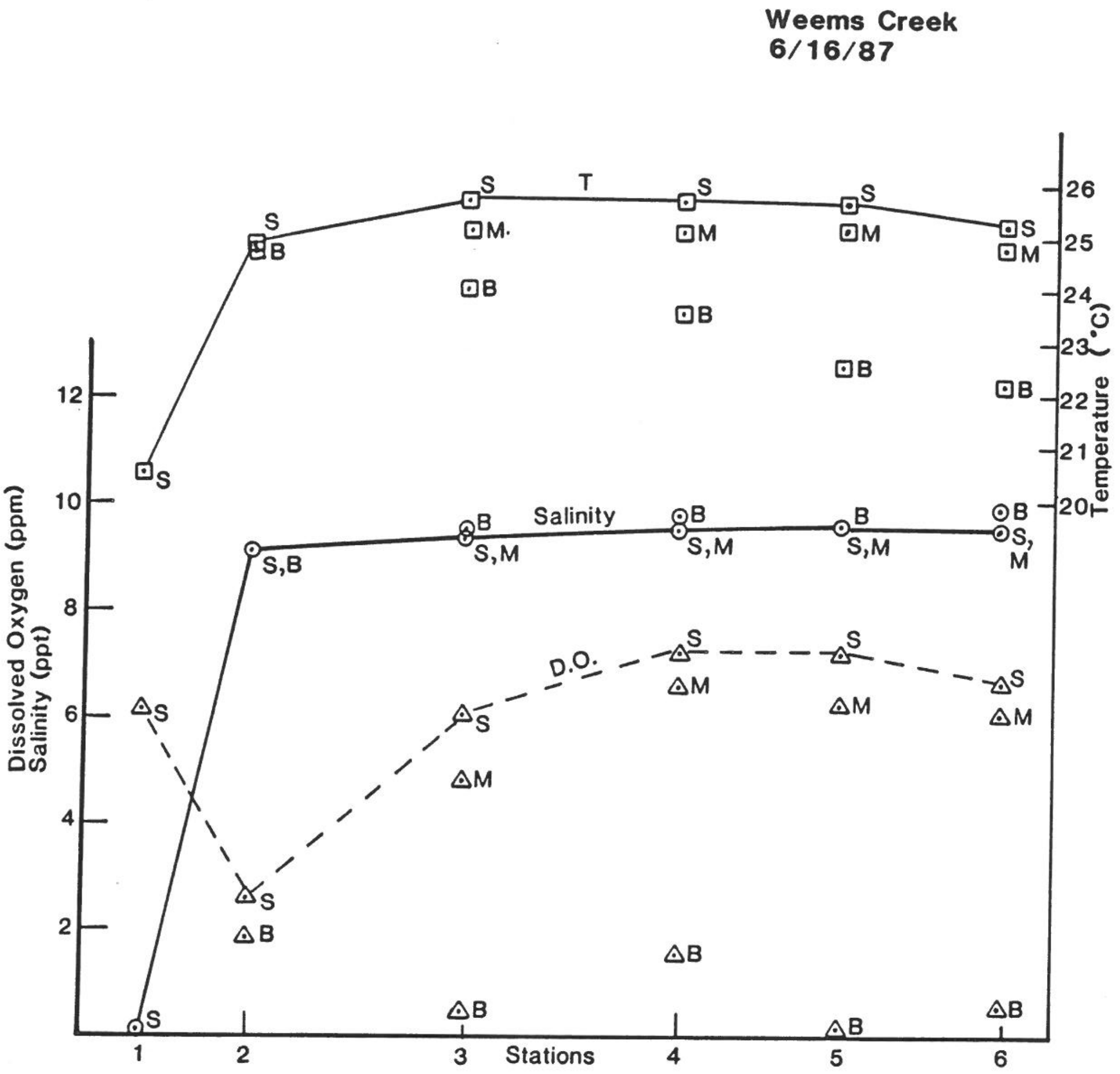


FIGURE 2 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - JUNE 16, 1987

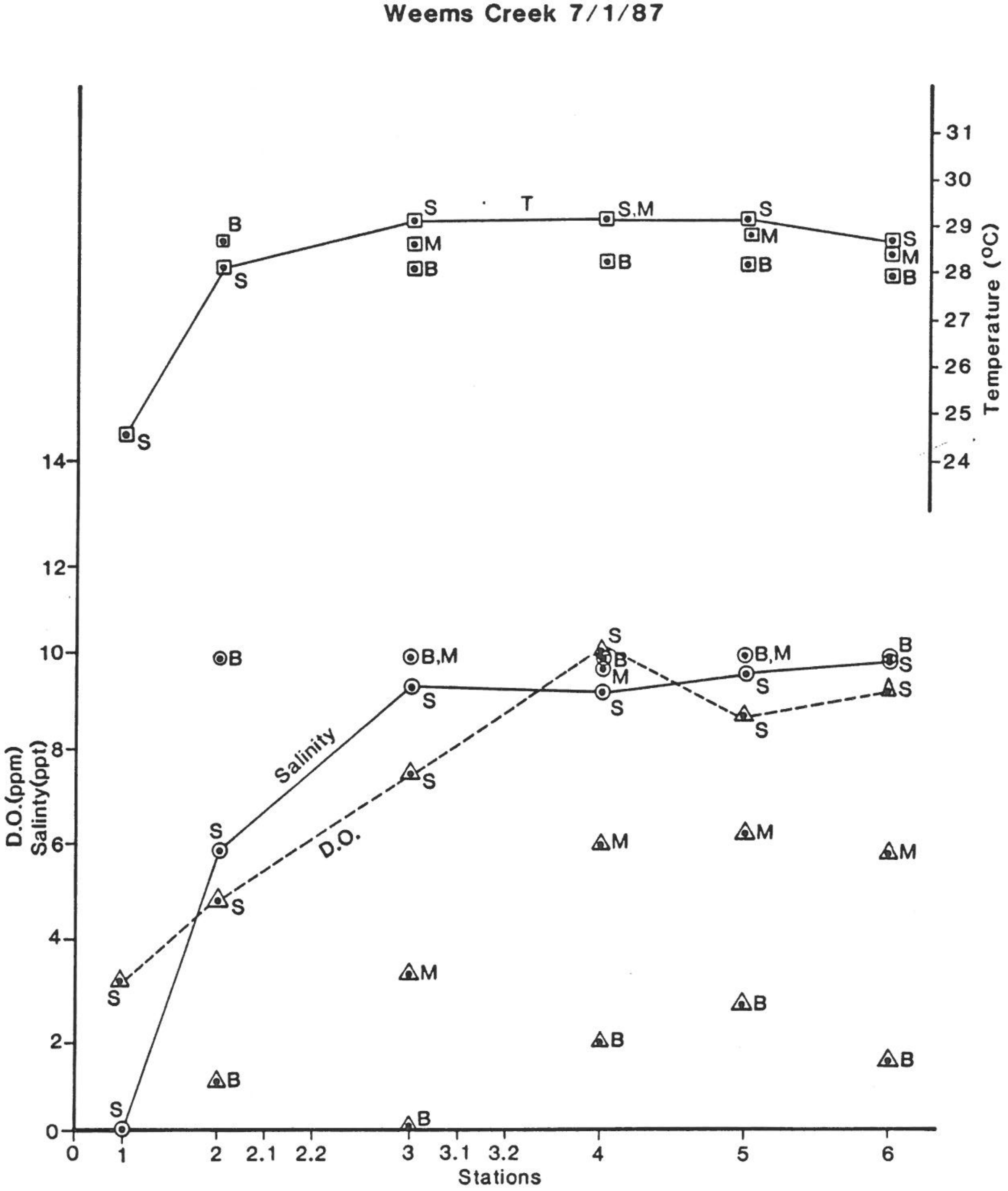


FIGURE 3 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - JULY 1, 1987

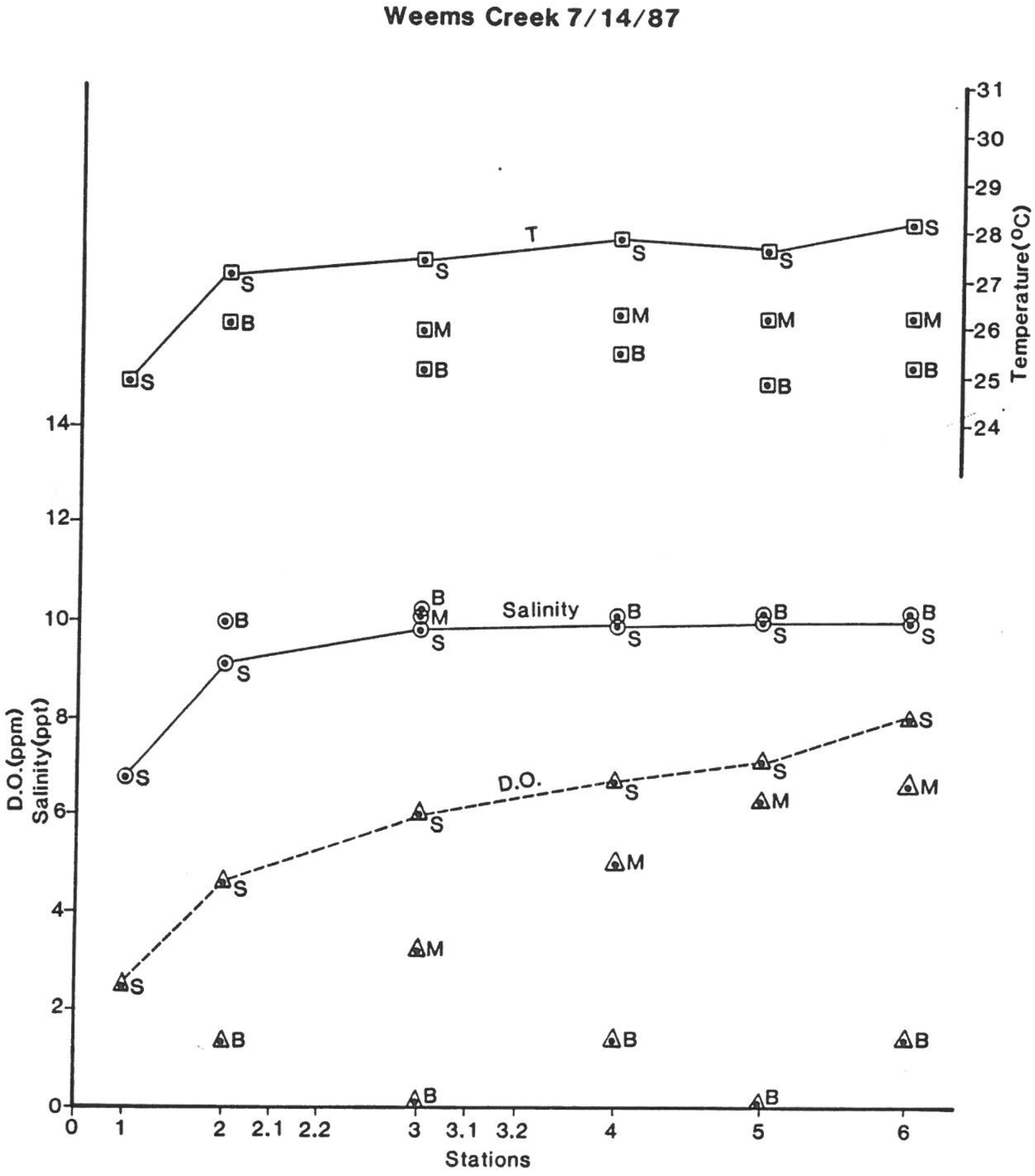


FIGURE 4 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - JULY 14, 1987

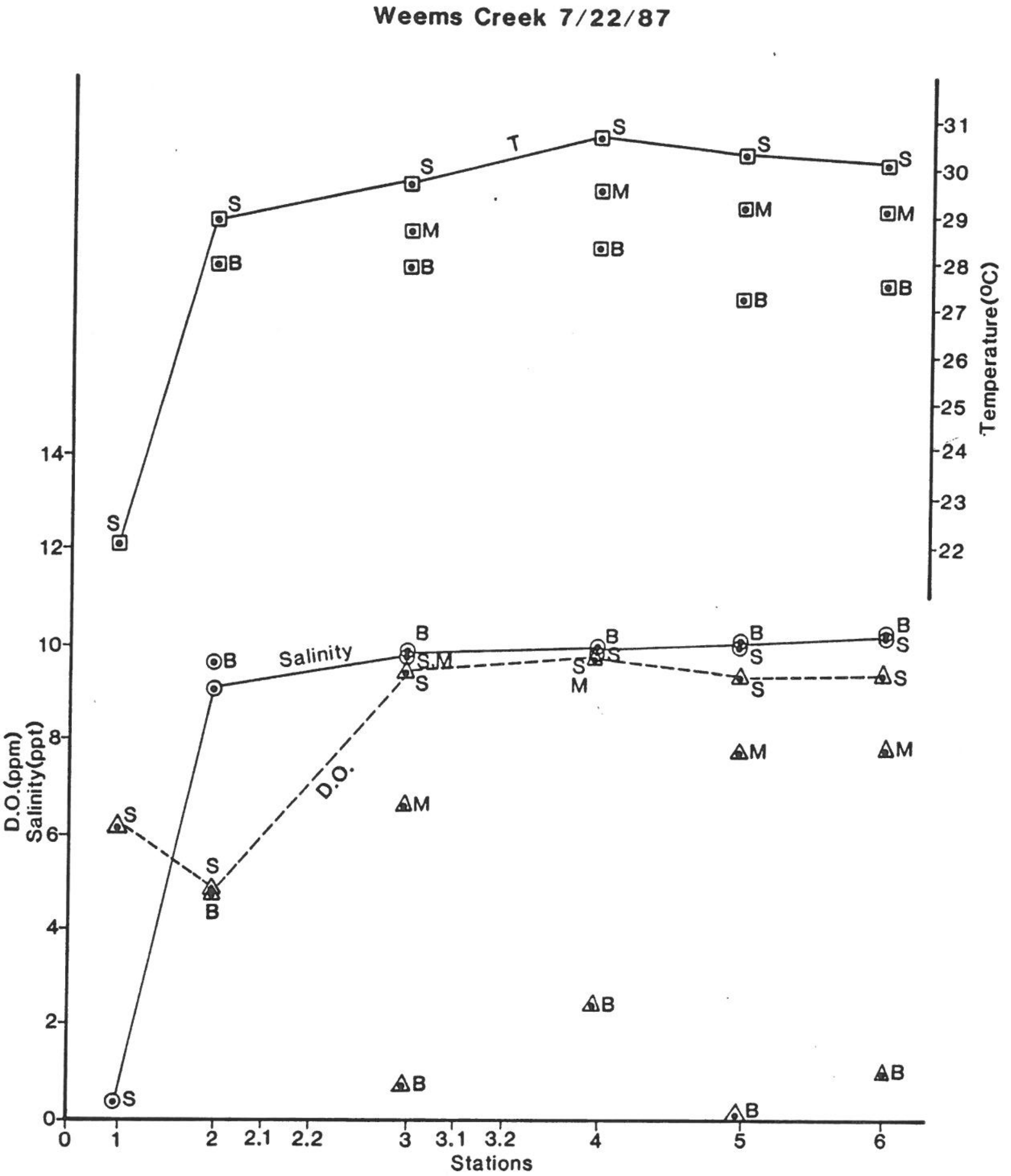


FIGURE 5 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - JULY 22, 1987

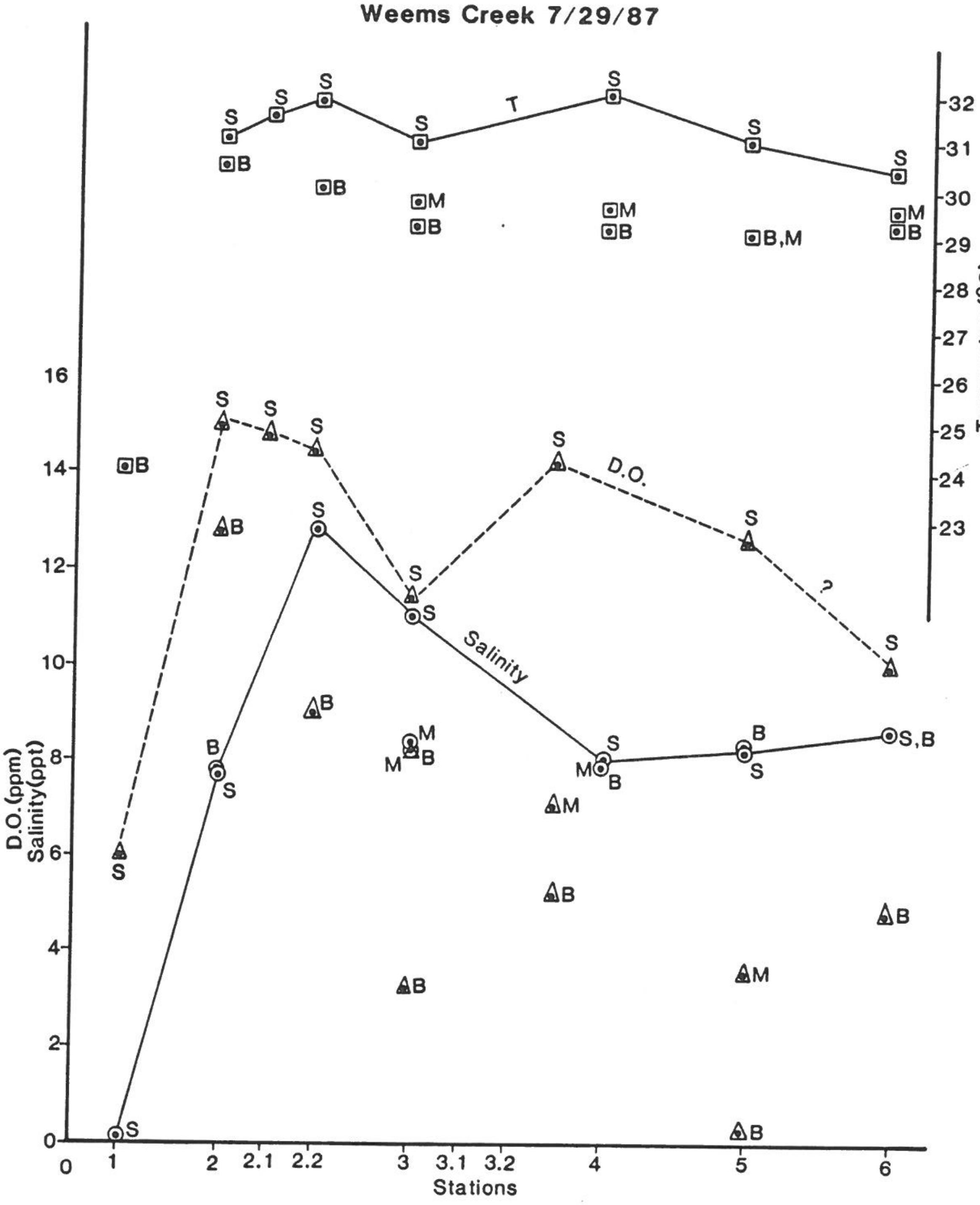


FIGURE 6 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - JULY 29, 1987

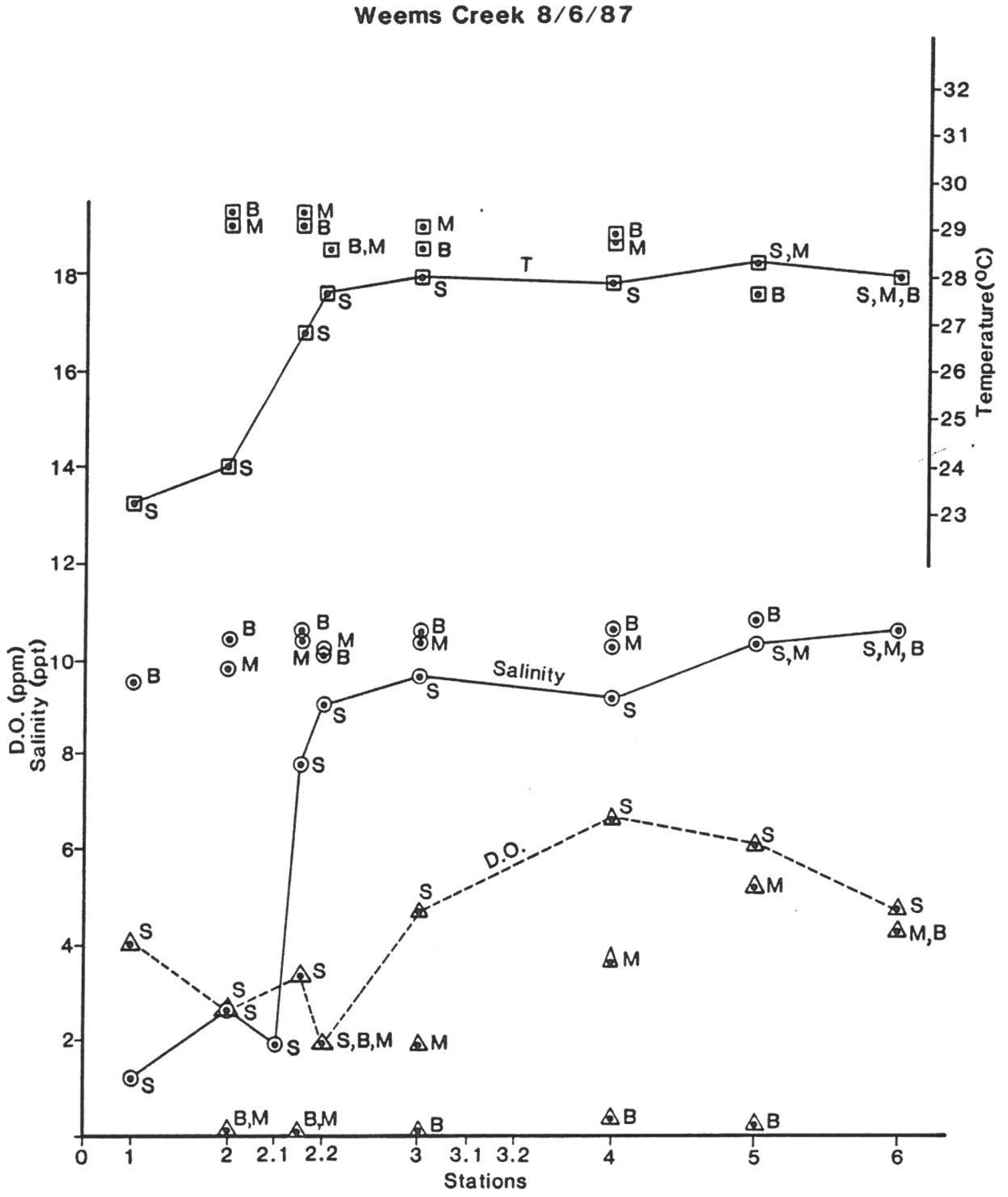


FIGURE 7 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - AUGUST 6, 1987

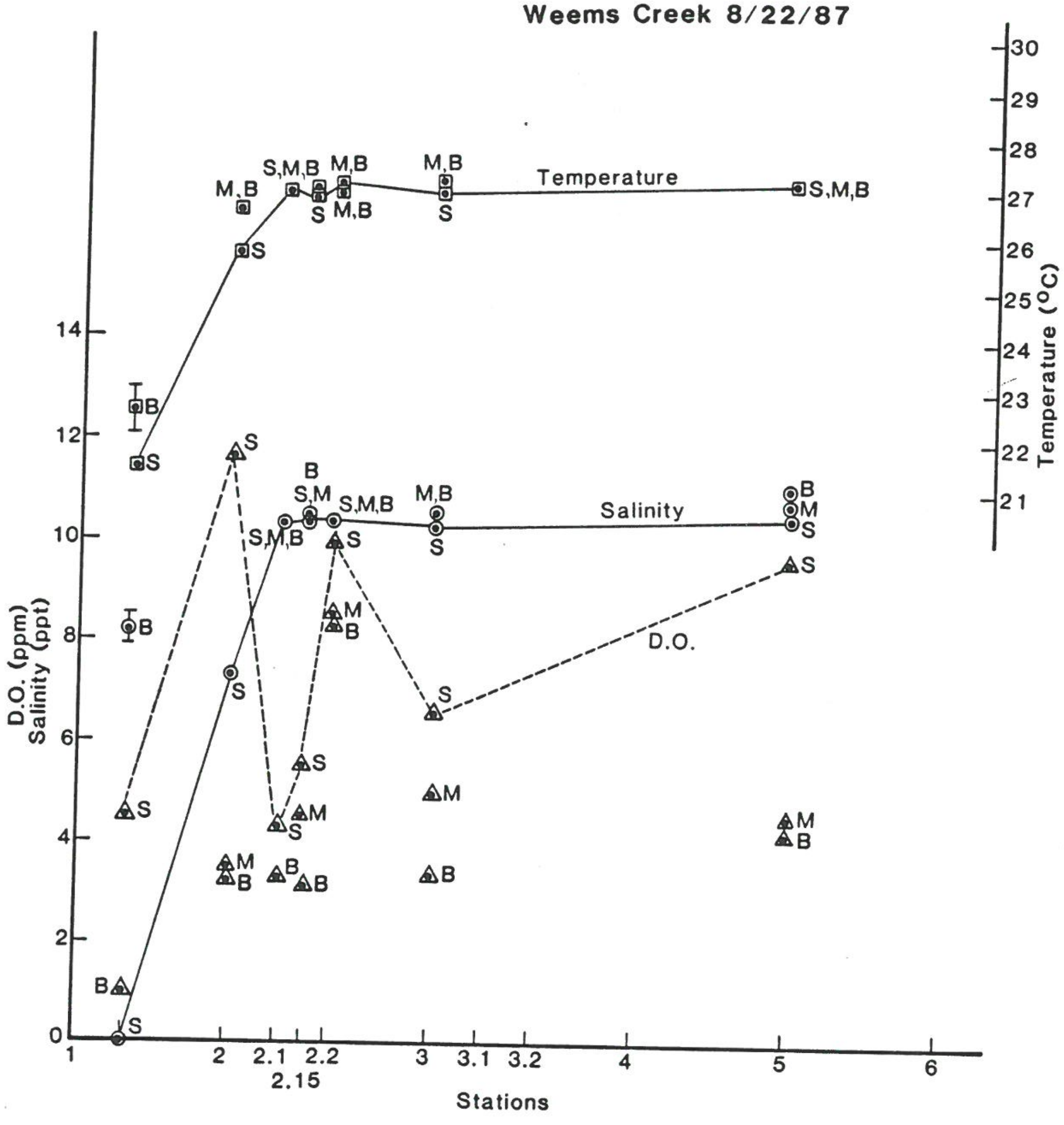


FIGURE 8 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - AUGUST 22, 1987

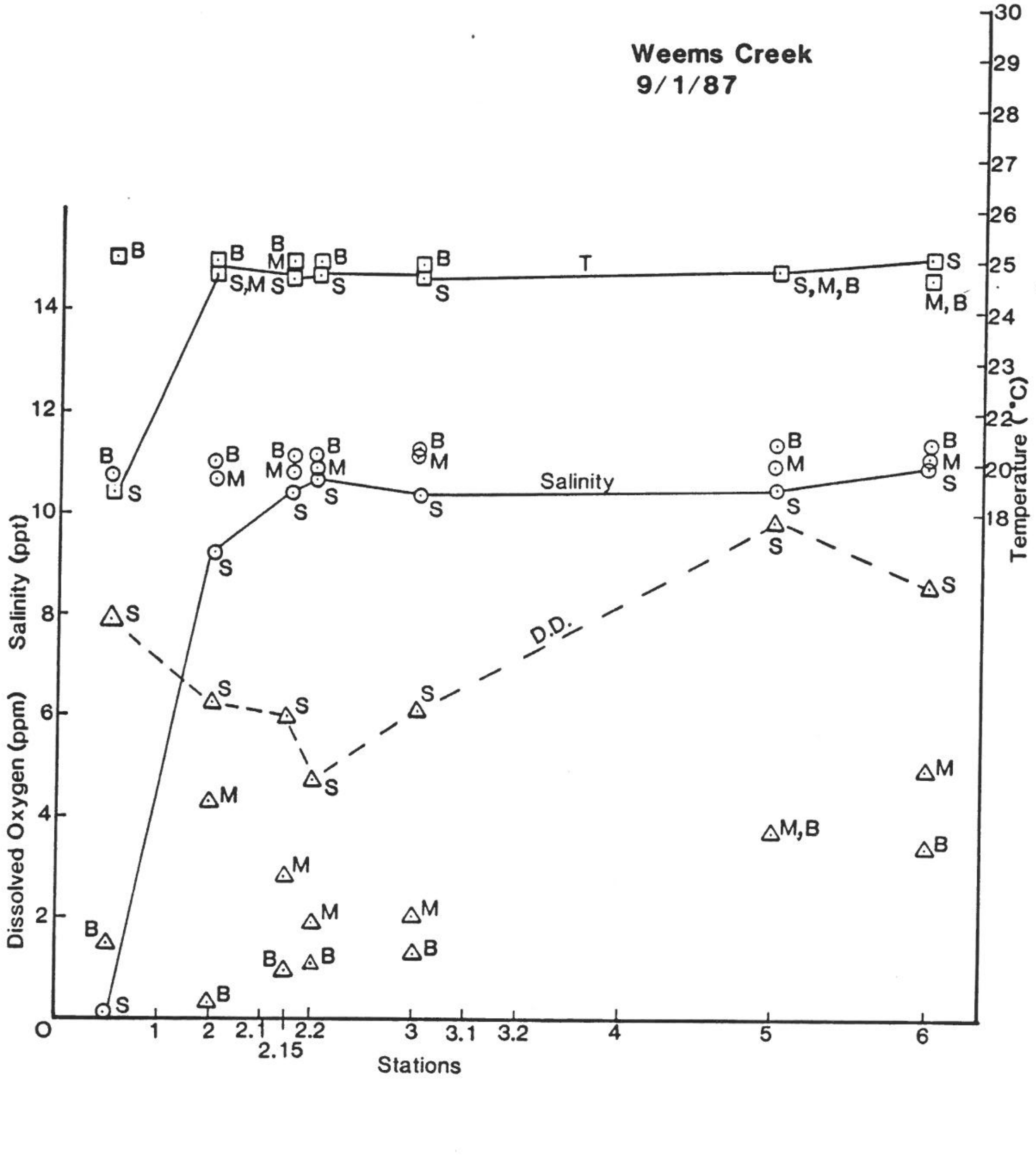


FIGURE 9 - DISSOLVED OXYGEN, SALINITY AND TEMPERATURE DISTRIBUTIONS - SEPTEMBER 1, 1987

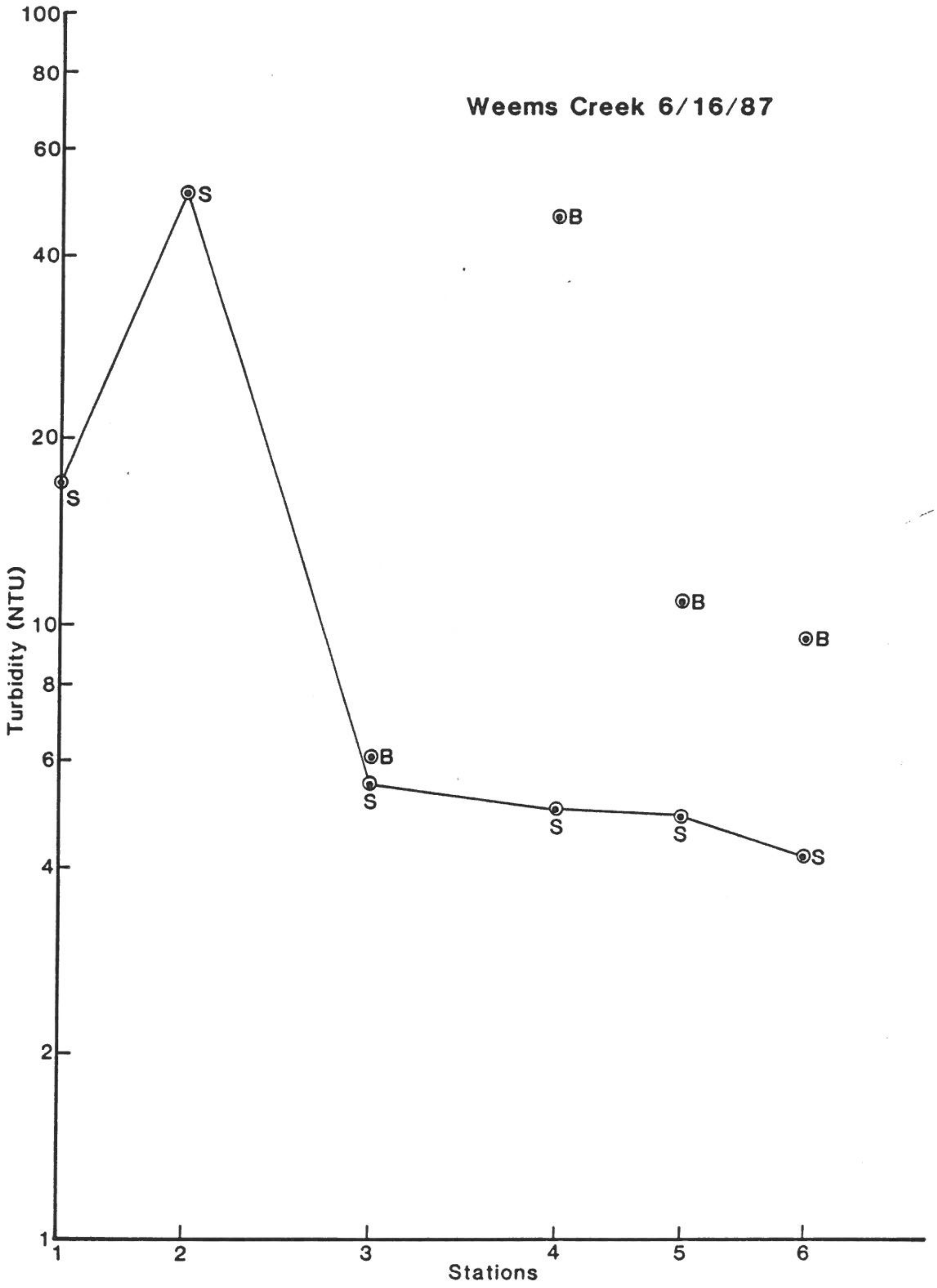


FIGURE 10 - TURBIDITY DISTRIBUTION - JUNE 16, 1987

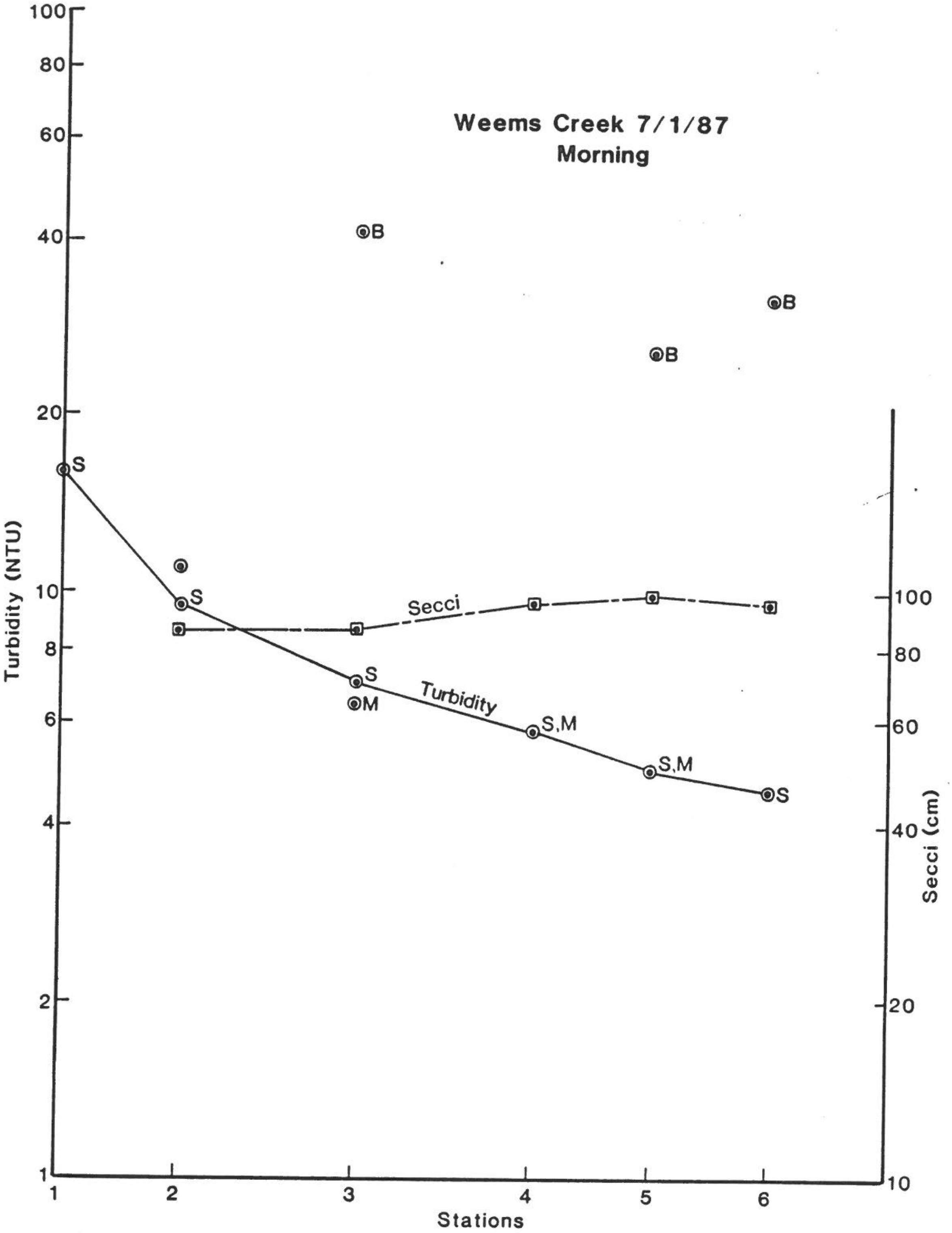


FIGURE 11 - TURBIDITY AND SECCI DEPTH DISTRIBUTION - JULY 1, 1987

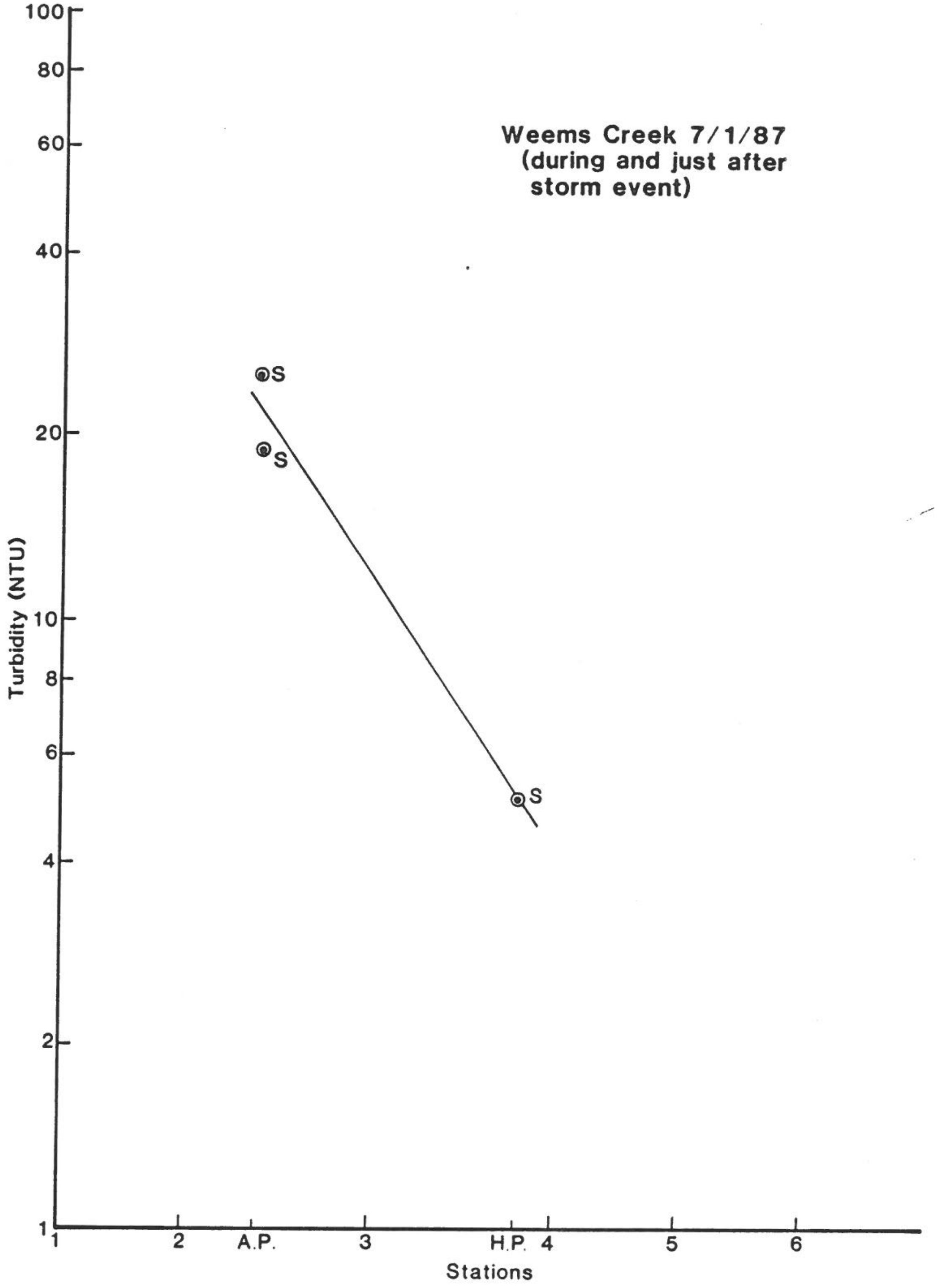


FIGURE 12 - TURBIDITY DISTRIBUTION - JULY 1, 1987

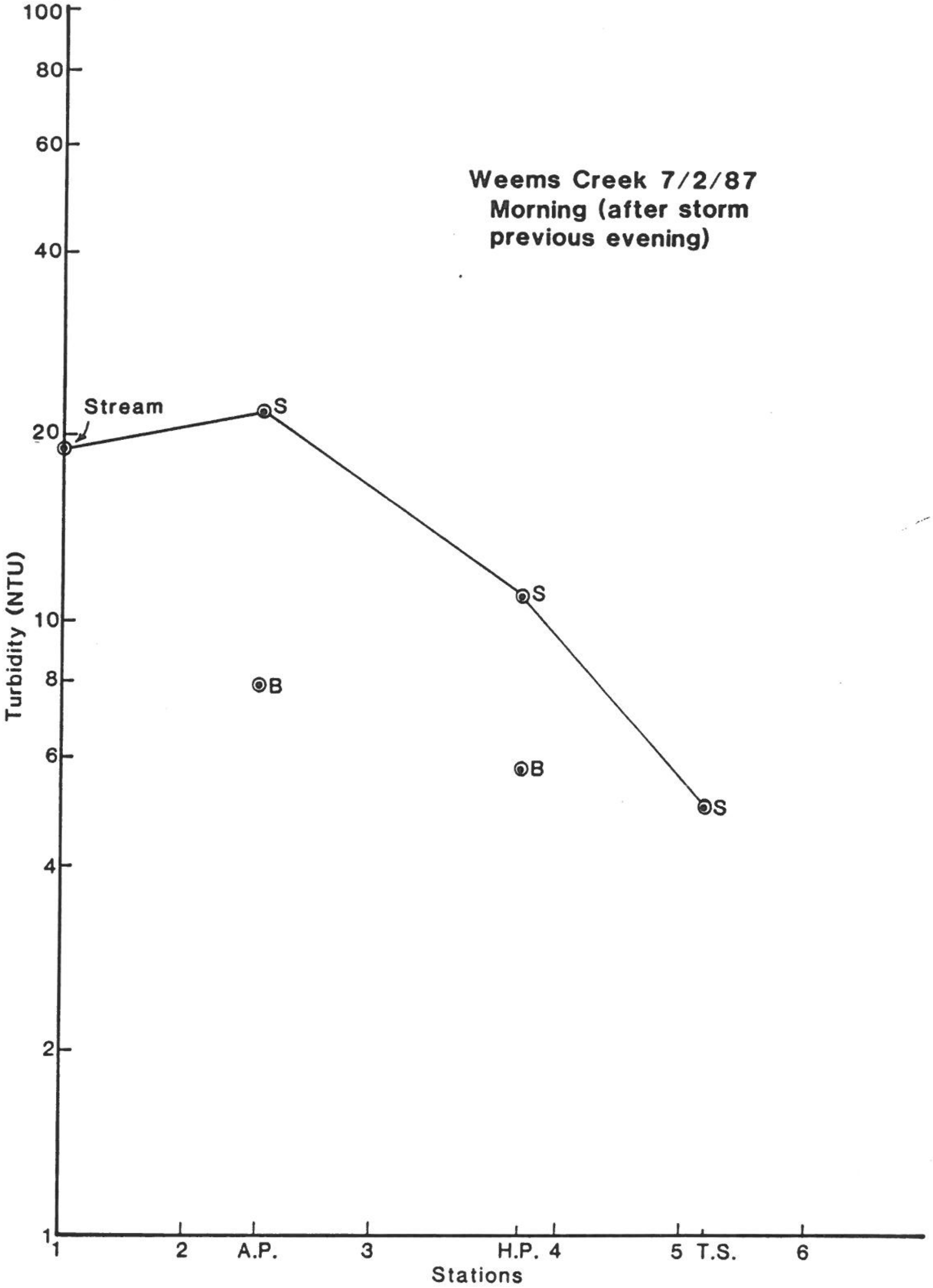


FIGURE 13 - TURBIDITY DISTRIBUTION - JULY 2, 1987

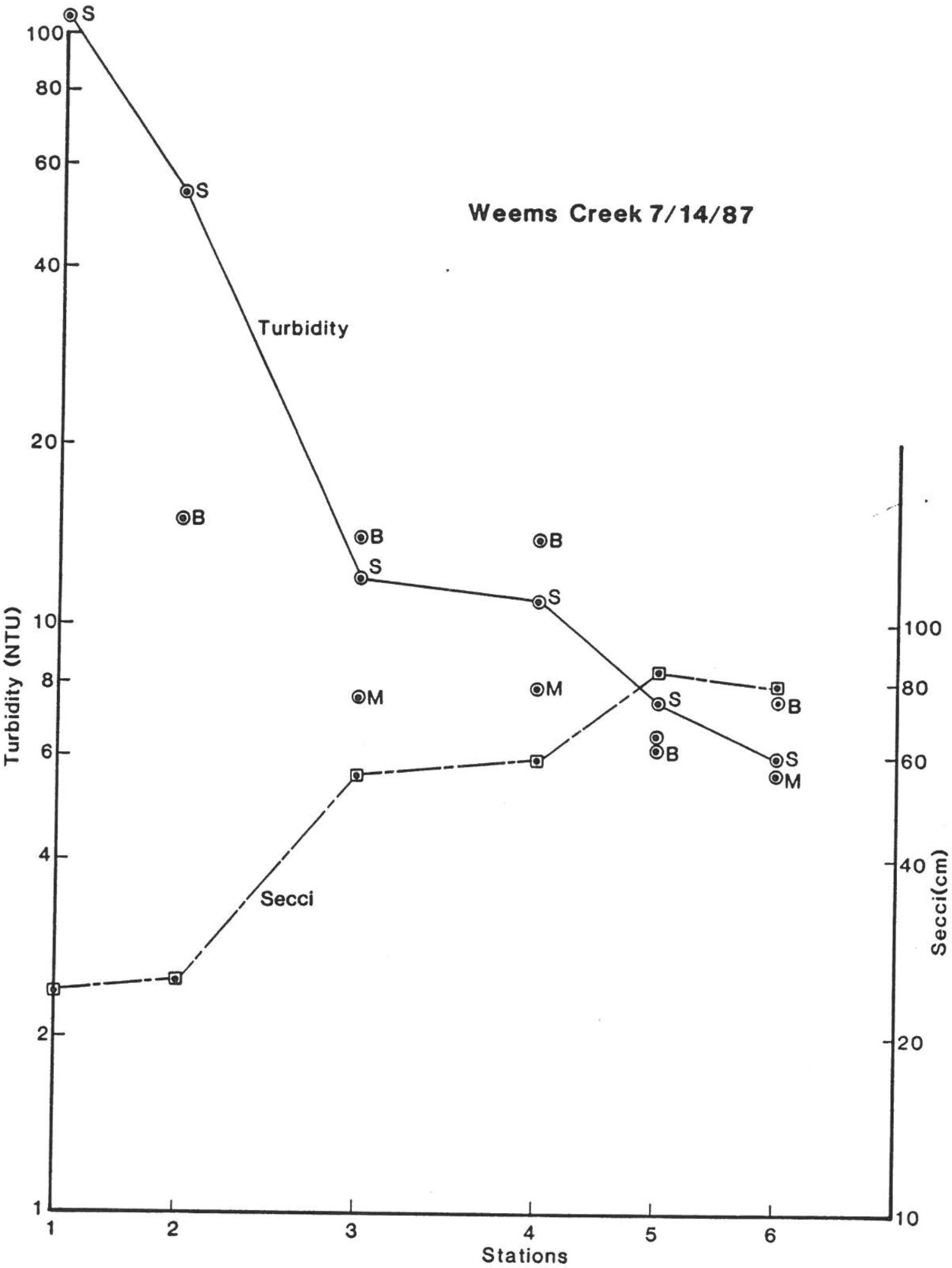


FIGURE 14 - TURBIDITY AND SECCI DEPTH DISTRIBUTION - JULY 14, 1987

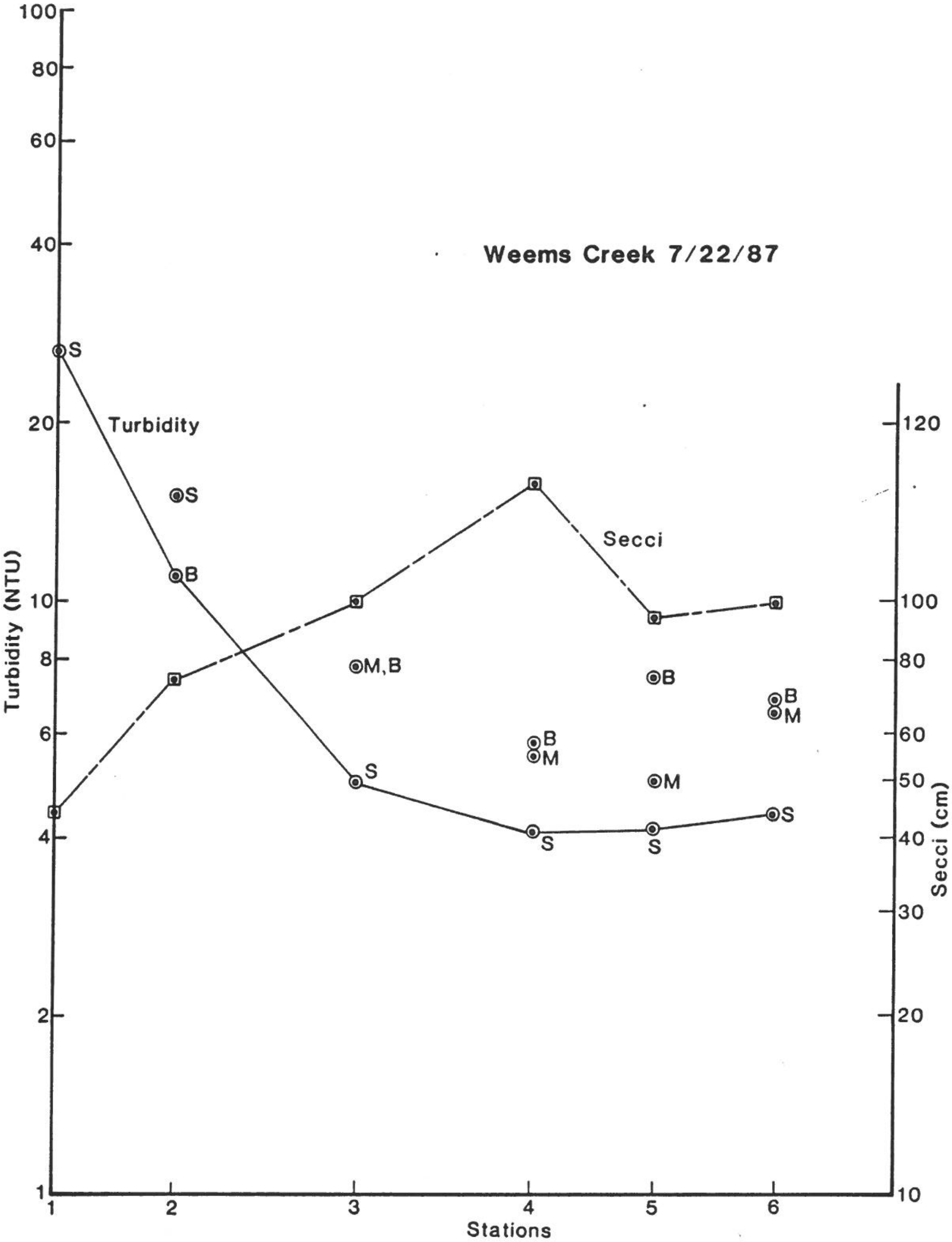


FIGURE 15 - TURBIDITY AND SECCI DEPTH DISTRIBUTION - JULY 22, 1987

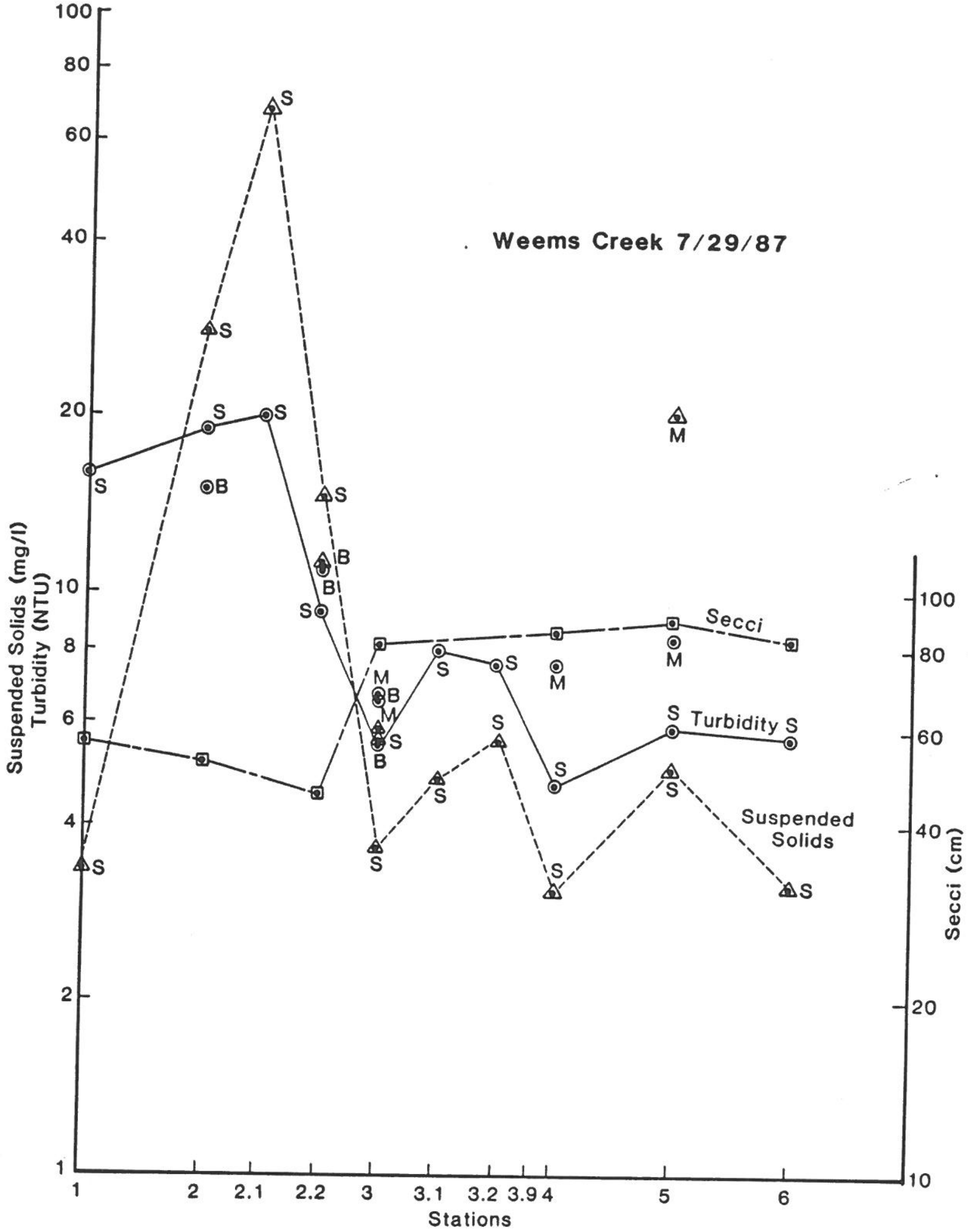


FIGURE 16 - TURBIDITY, SECCI DEPTH AND SUSPENDED SOLIDS DISTRIBUTIONS - JULY 29, 1987

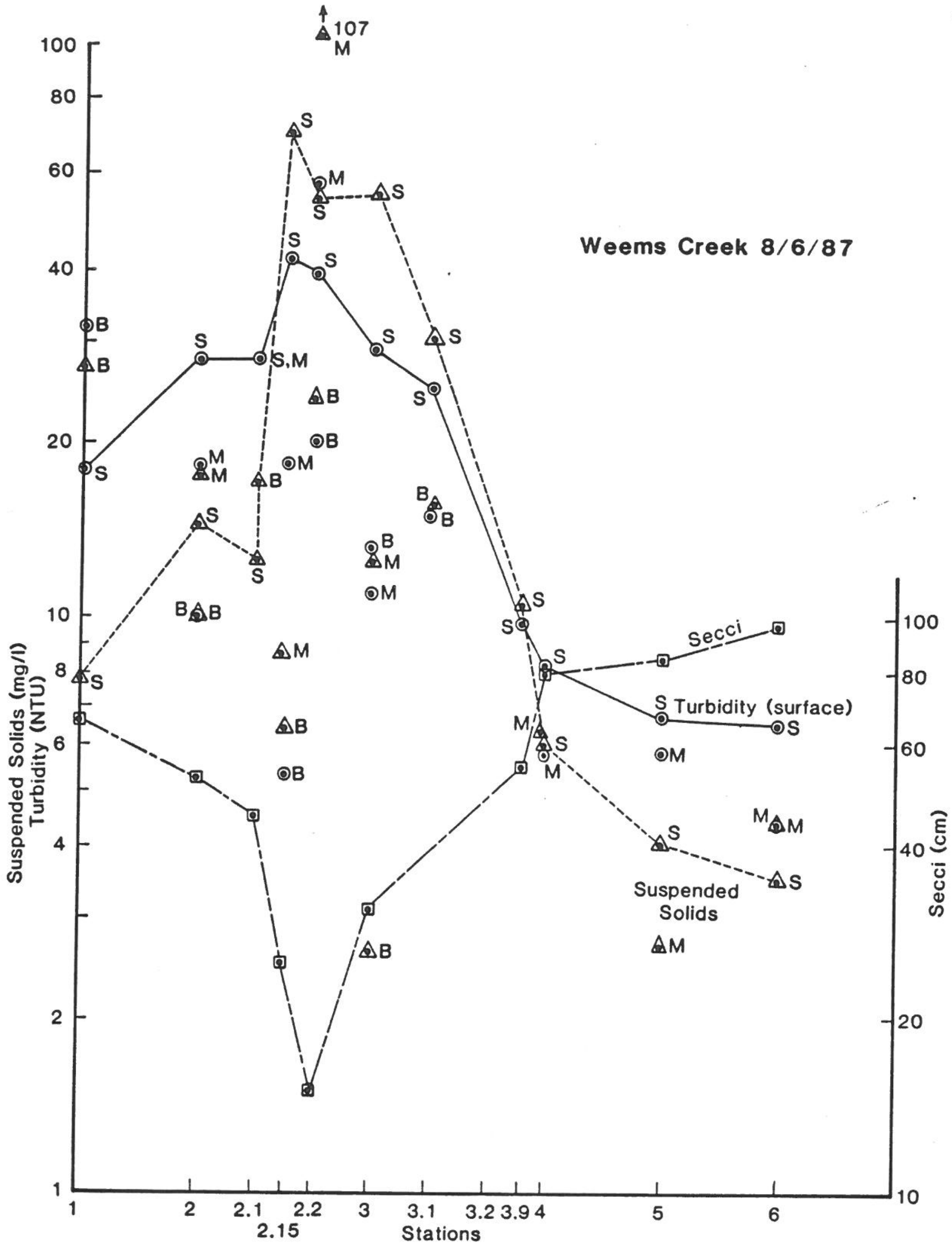


FIGURE 17 - TURBIDITY, SECCI DEPTH AND SUSPENDED SOLIDS DISTRIBUTIONS - AUGUST 6, 1987

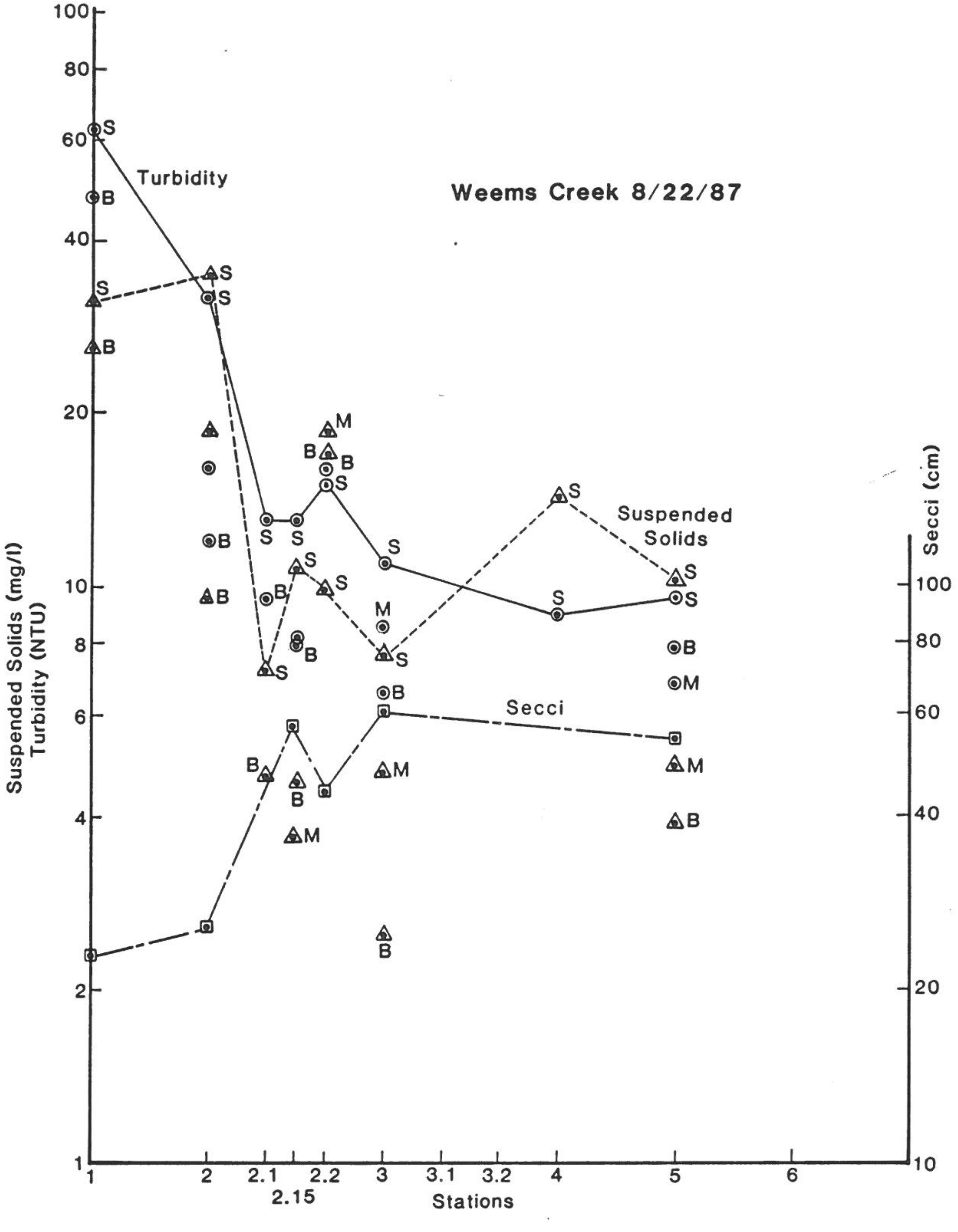


FIGURE 18 - TURBIDITY, SECCI DEPTH AND SUSPENDED SOLIDS DISTRIBUTIONS - AUGUST 22, 1987

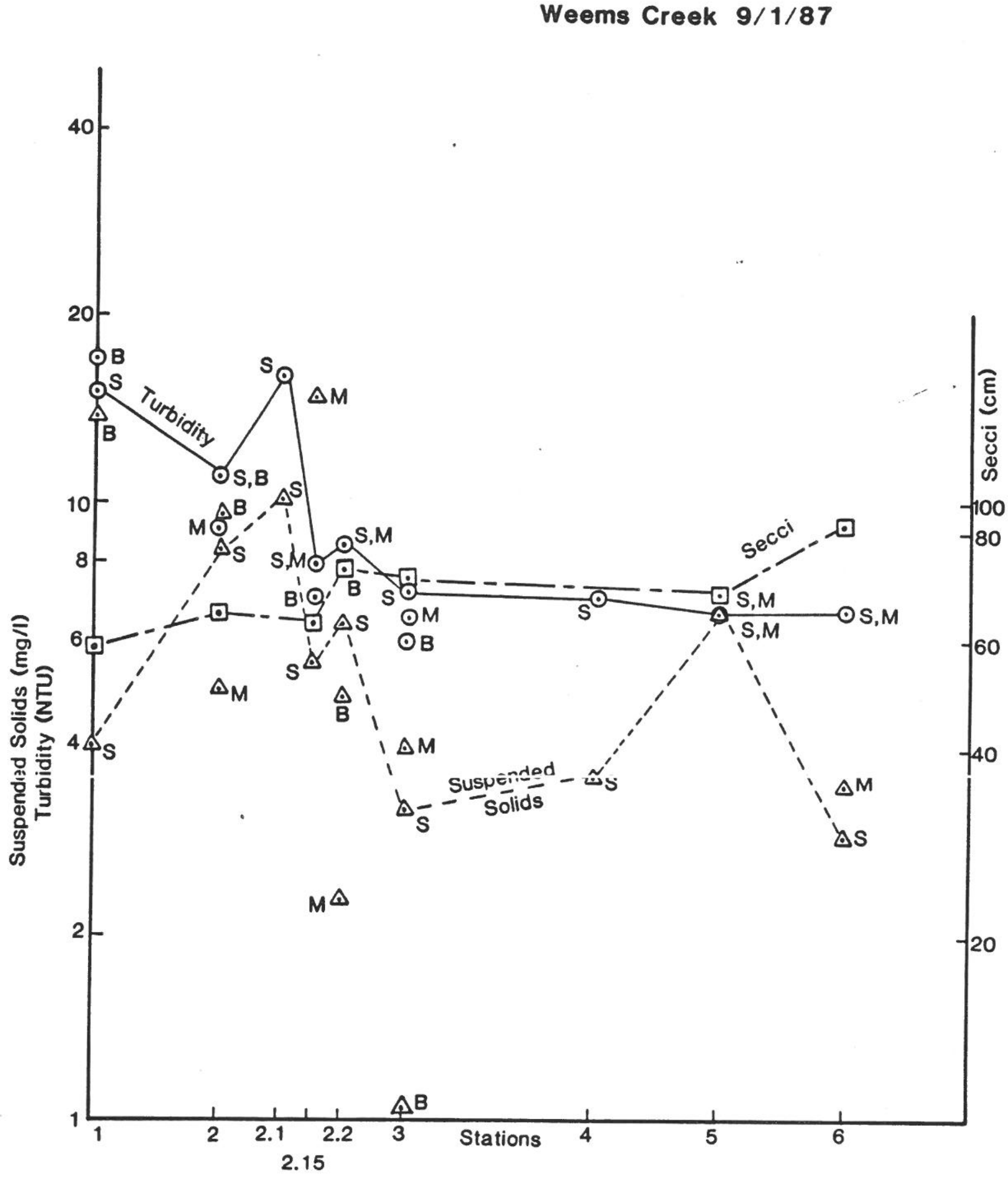


FIGURE 19 - TURBIDITY, SECCI DEPTH AND SUSPENDED SOLIDS DISTRIBUTIONS - SEPTEMBER 1, 1987

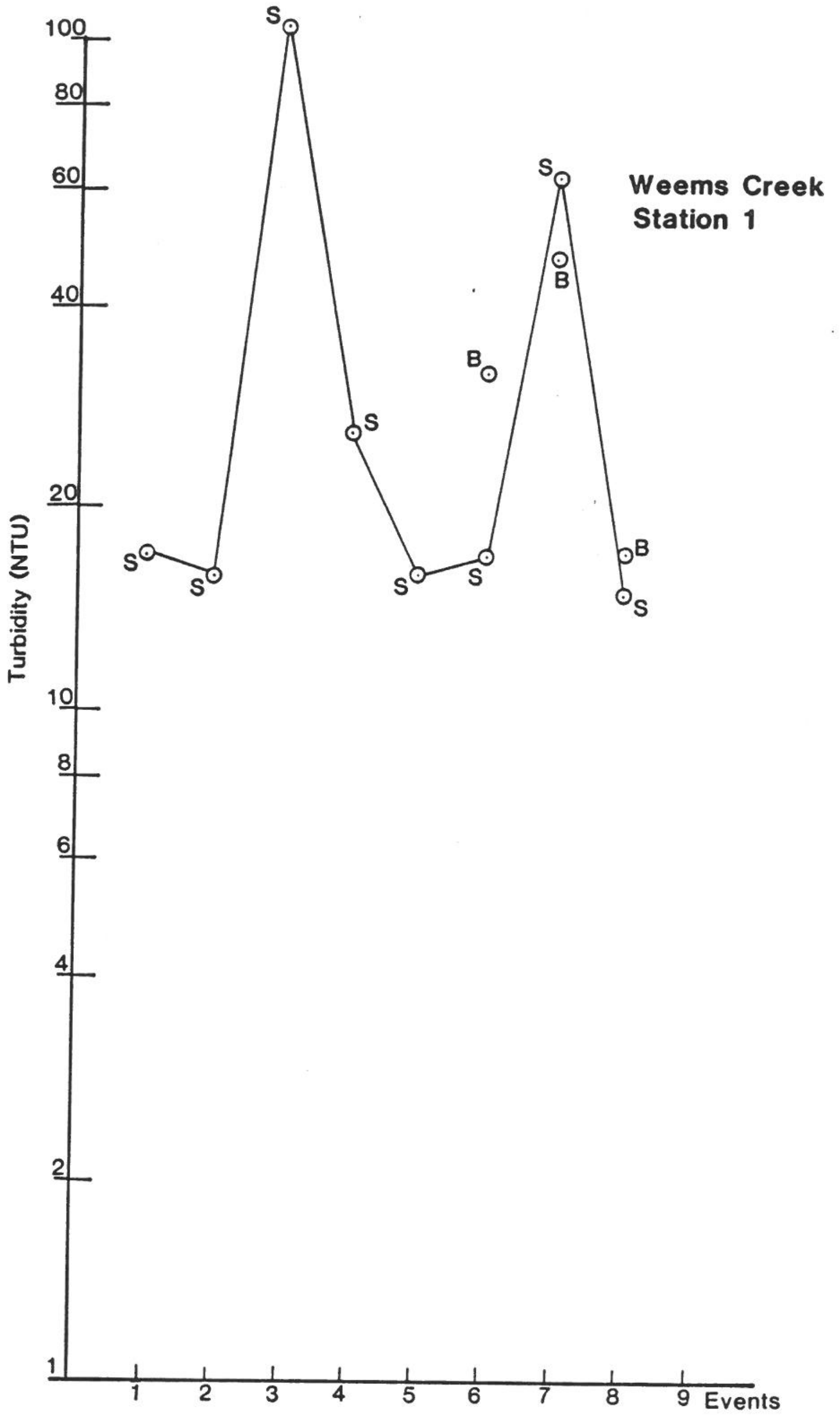


FIGURE 20 - TIME DEBENDENCE OF TURBIDITY - STATION 1

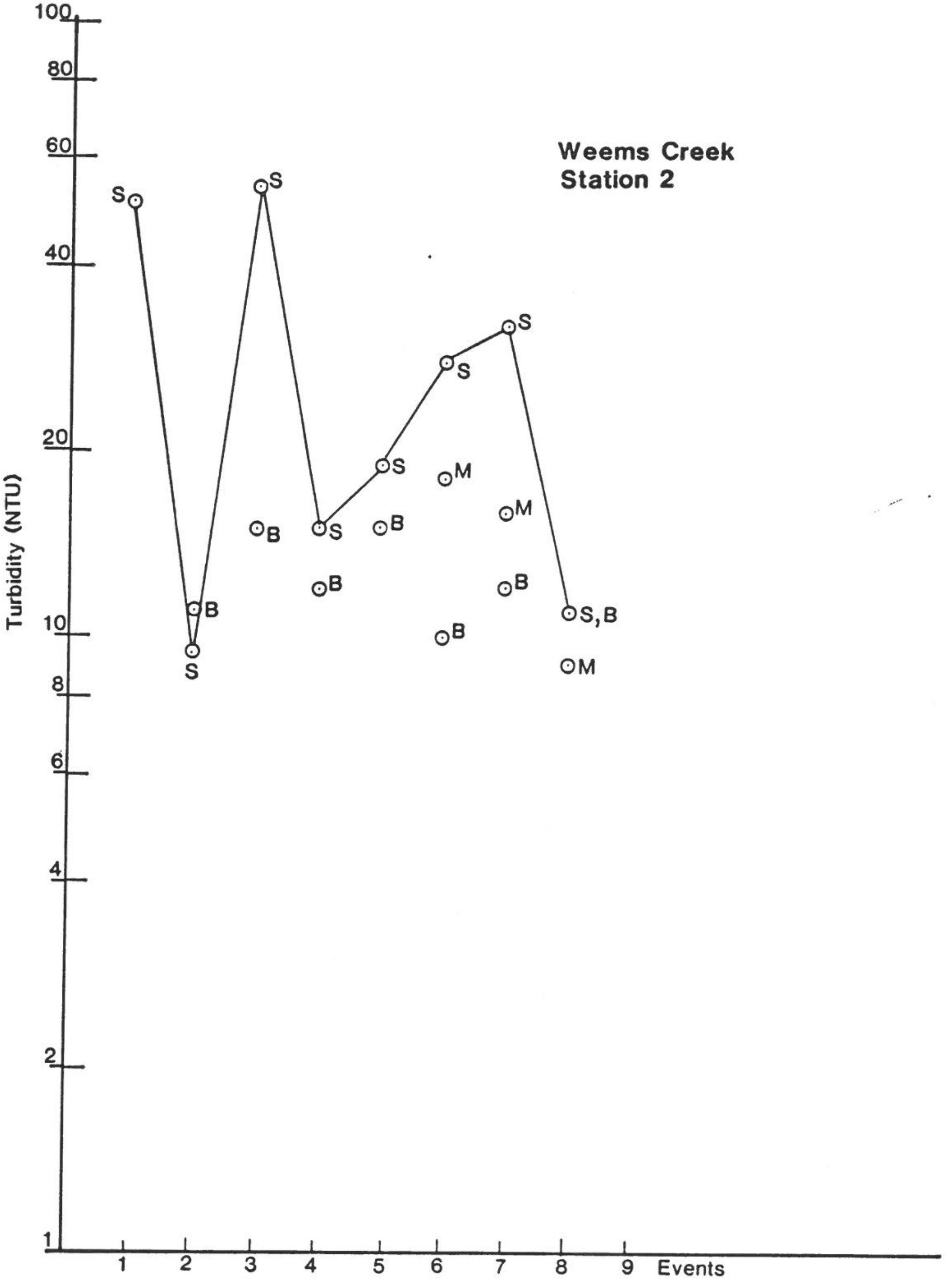


FIGURE 21 - TIME DEPENDENCE OF TURBIDITY - STATION 2

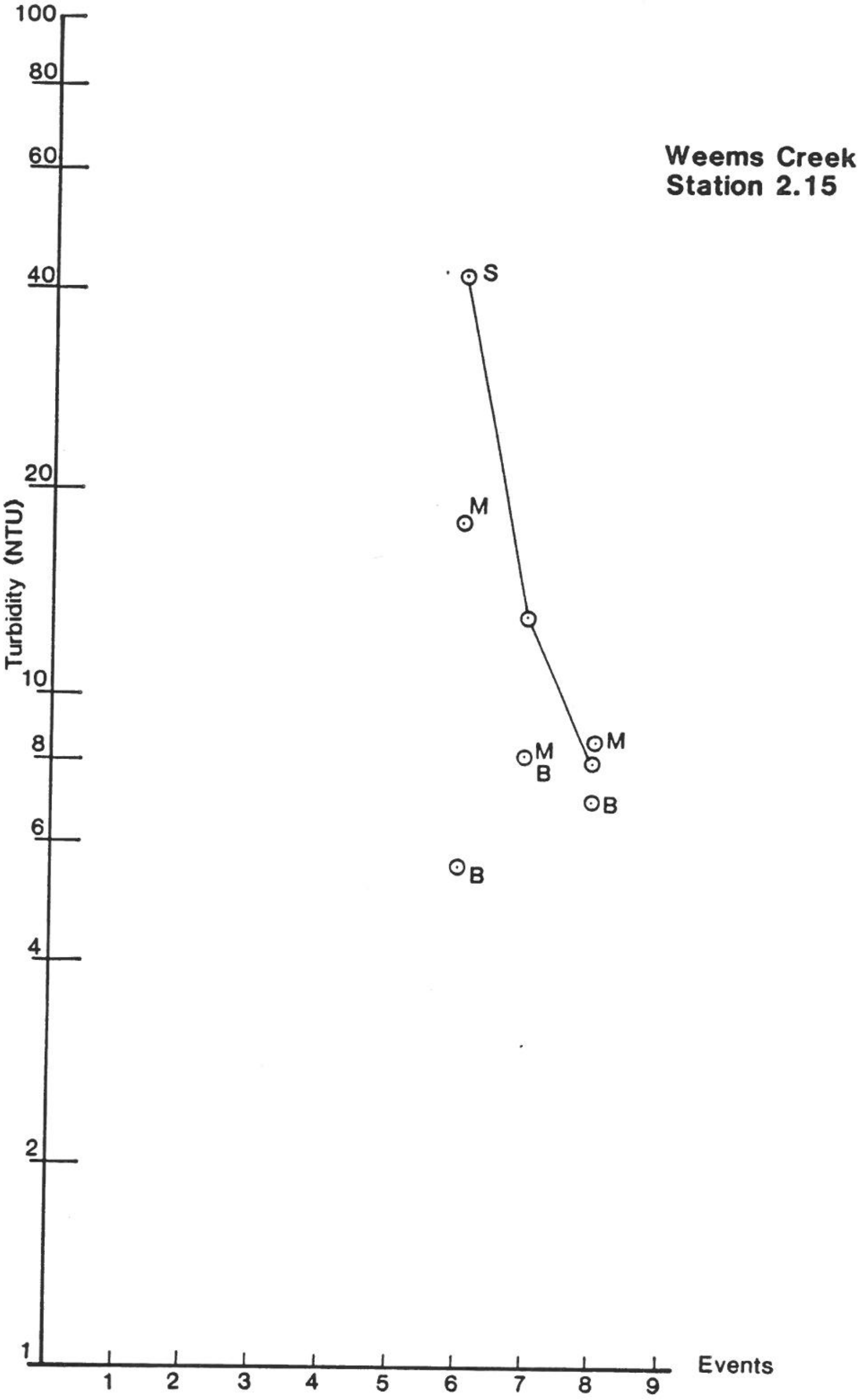


FIGURE 22 - TIME DEPENDENCE OF TURBIDITY - STATION 2.15

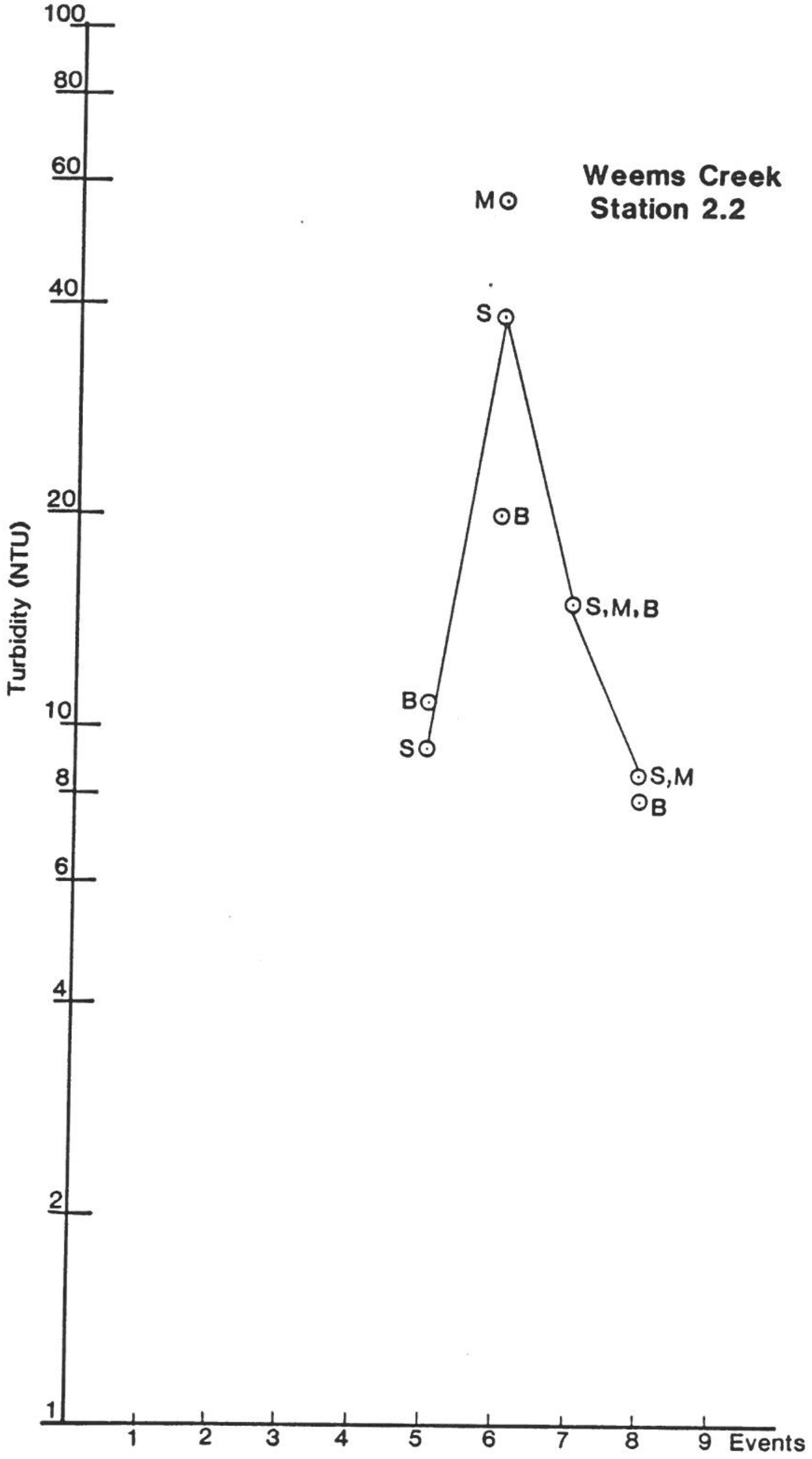


FIGURE 23 - TIME DEPENDENCE OF TURBIDITY - STATION 2.2

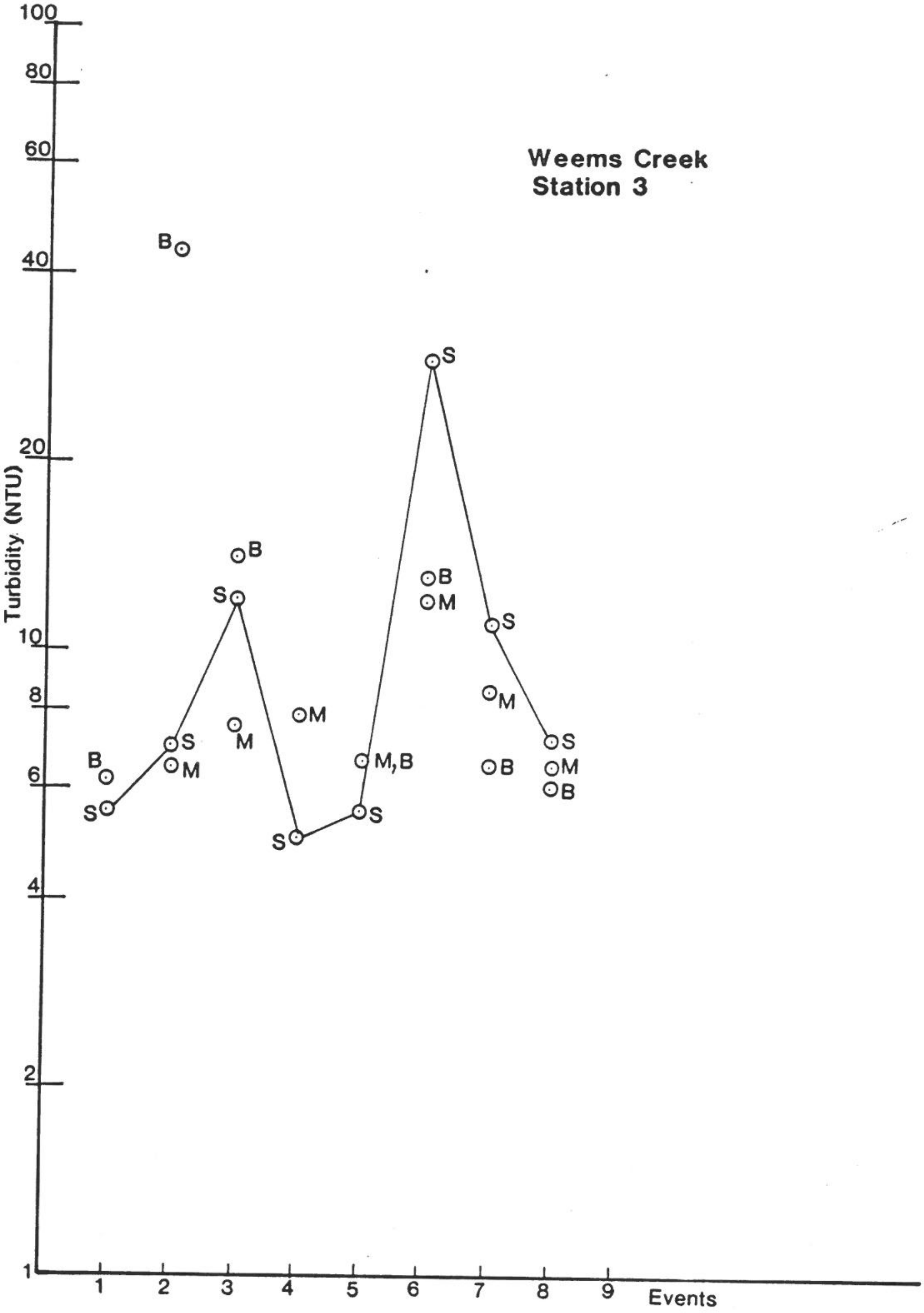


FIGURE 24 - TIME DEPENDENCE OF TURBIDITY - STATION 3

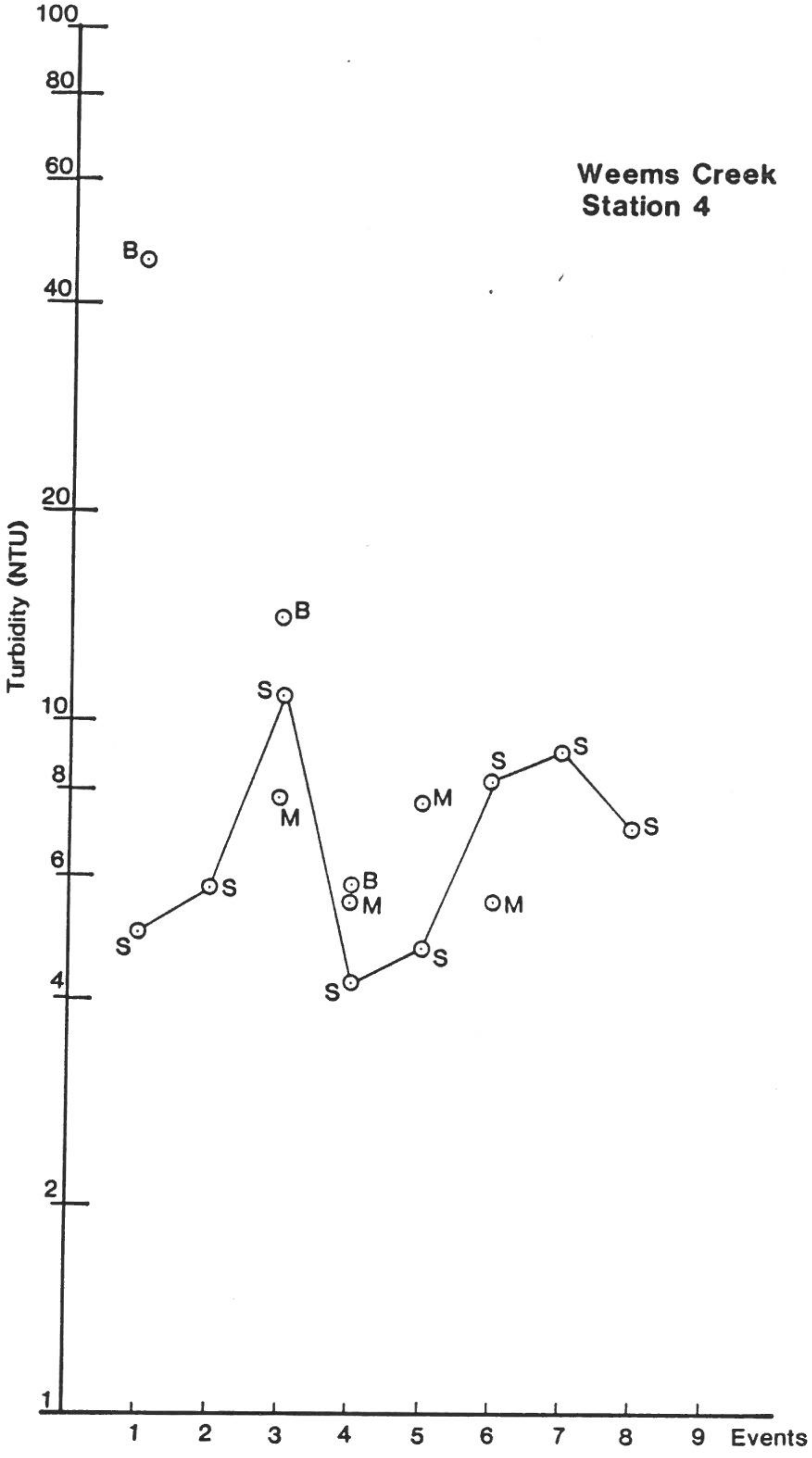


FIGURE 25 - TIME DEPENDENCE OF TURBIDITY - STATION 4

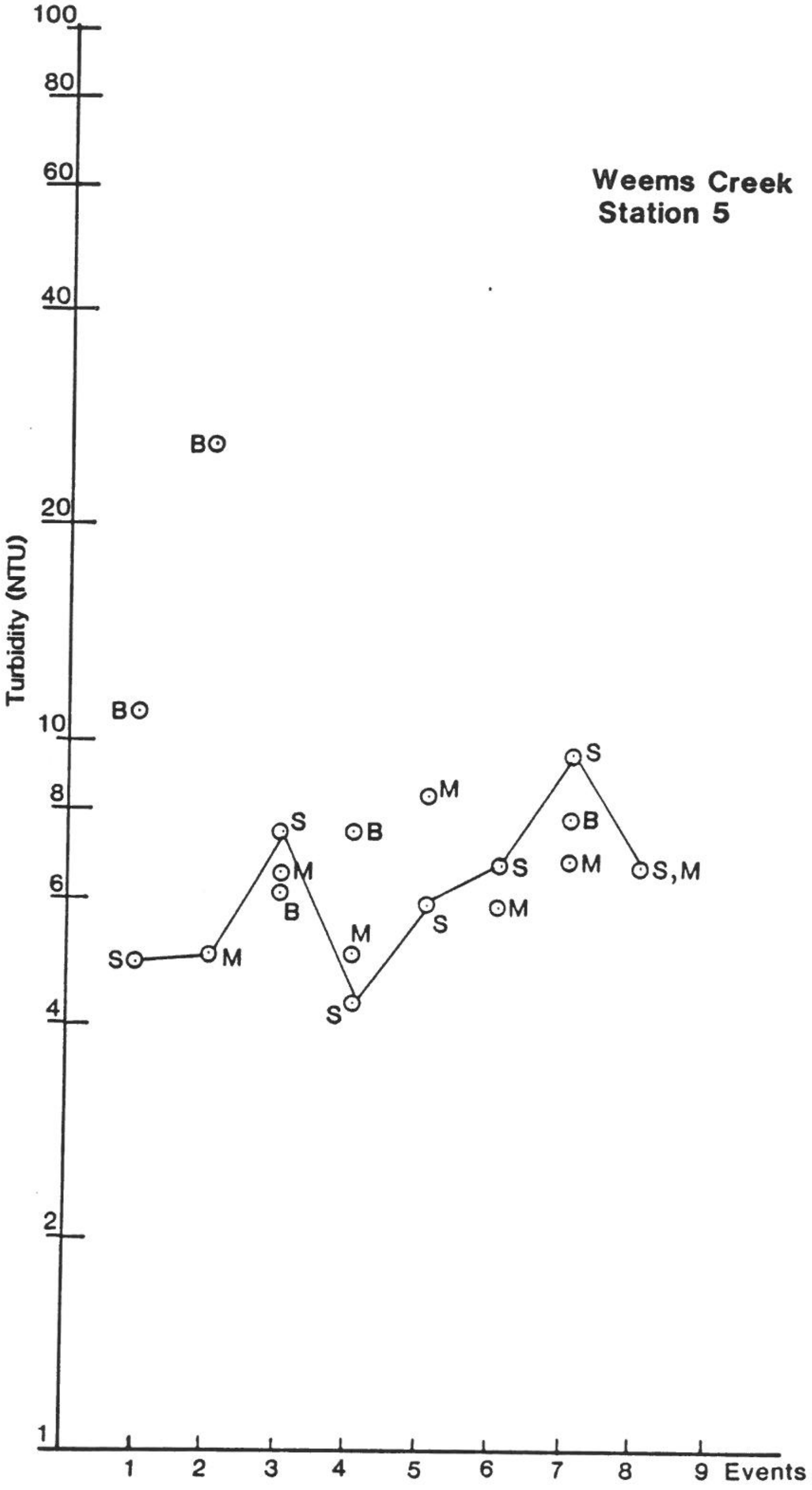


FIGURE 26 - TIME DEPENDENCE OF TURBIDITY - STATION 5

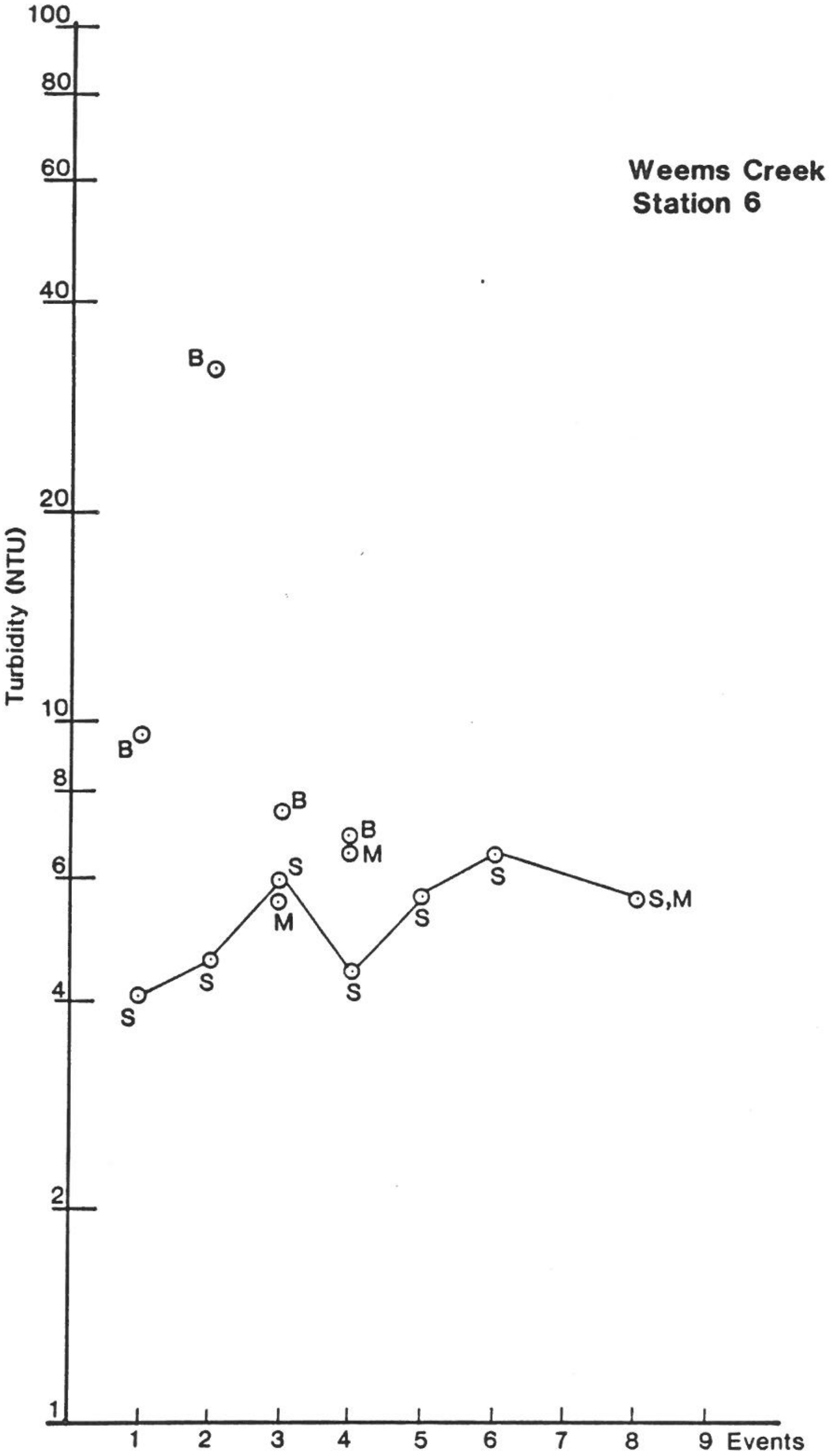


FIGURE 27 - TIME DEPENDENCE OF TURBIDITY - STATION 6

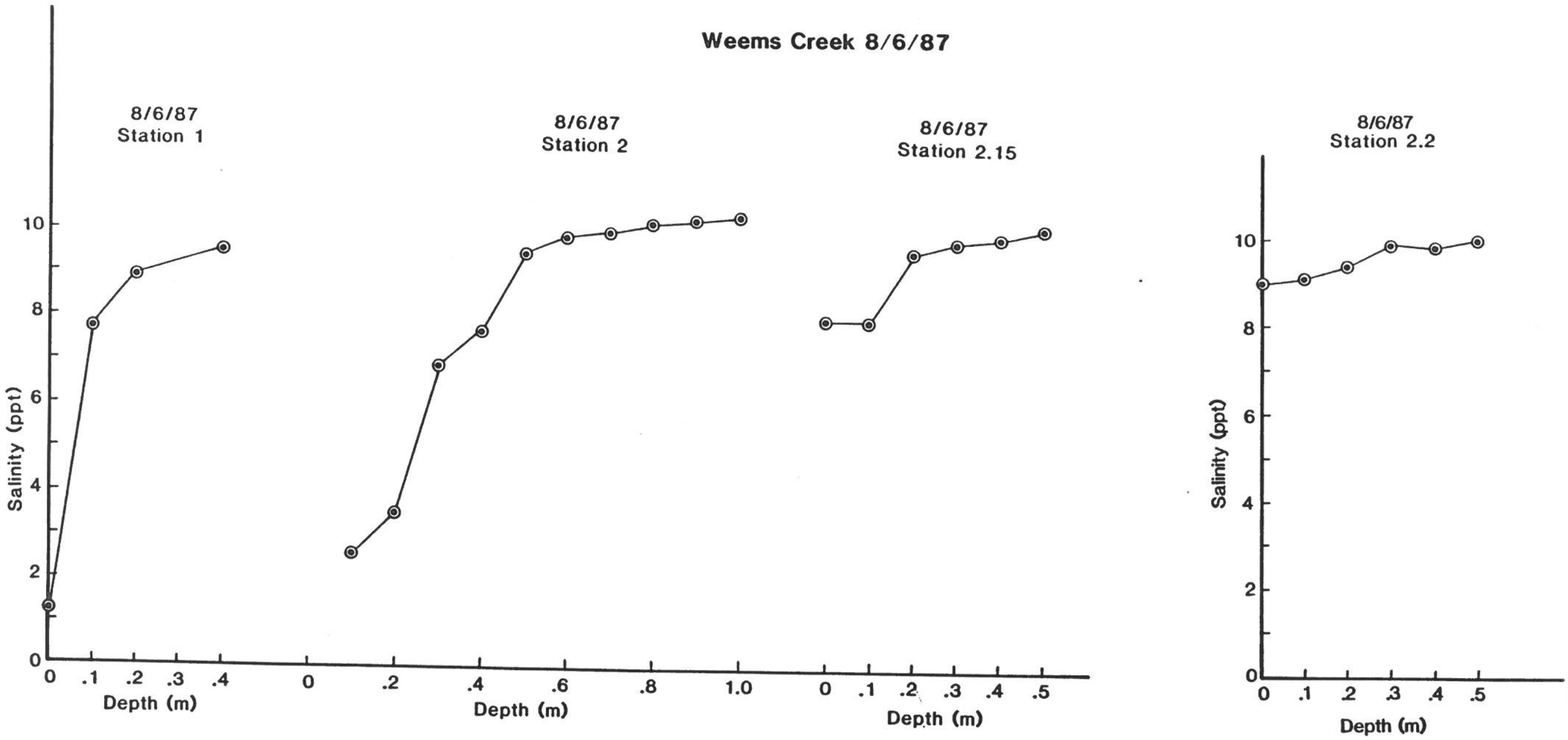


FIGURE 28 - SALINITY PROFILES - AUGUST 6, 1987

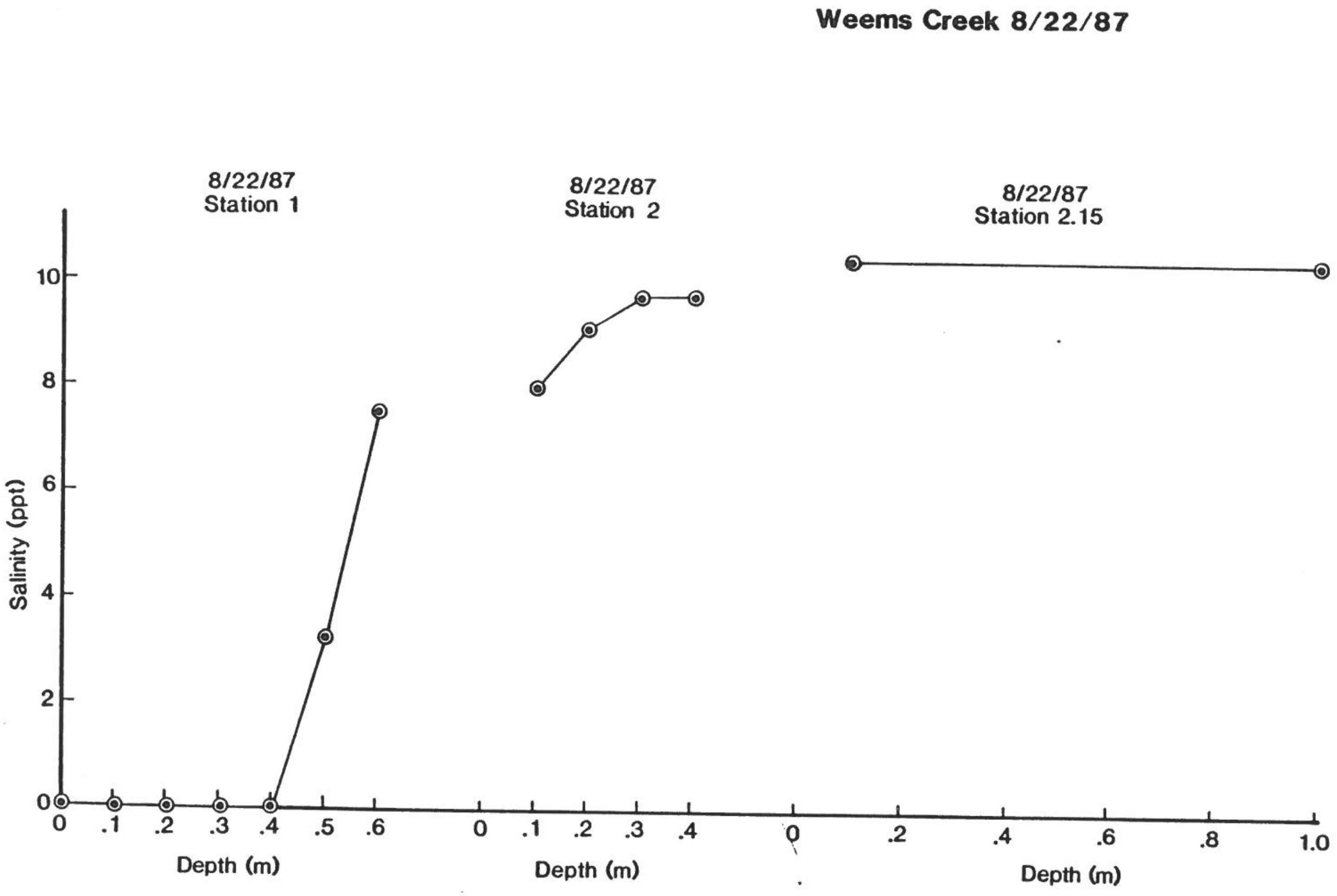


FIGURE 29 - SALINITY PROFILES - AUGUST 22, 1987

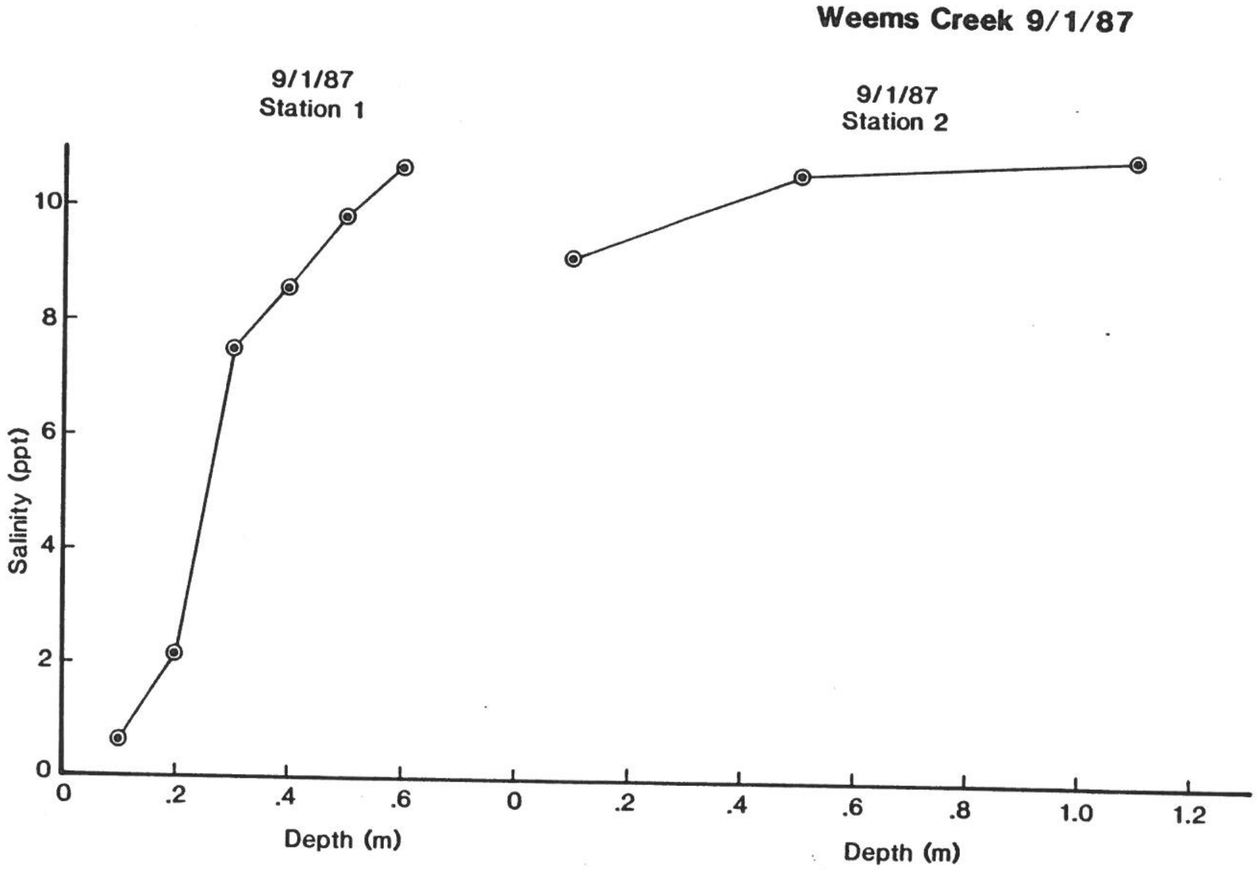


FIGURE 30 - SALINITY PROFILES - SEPTEMBER 1, 1987

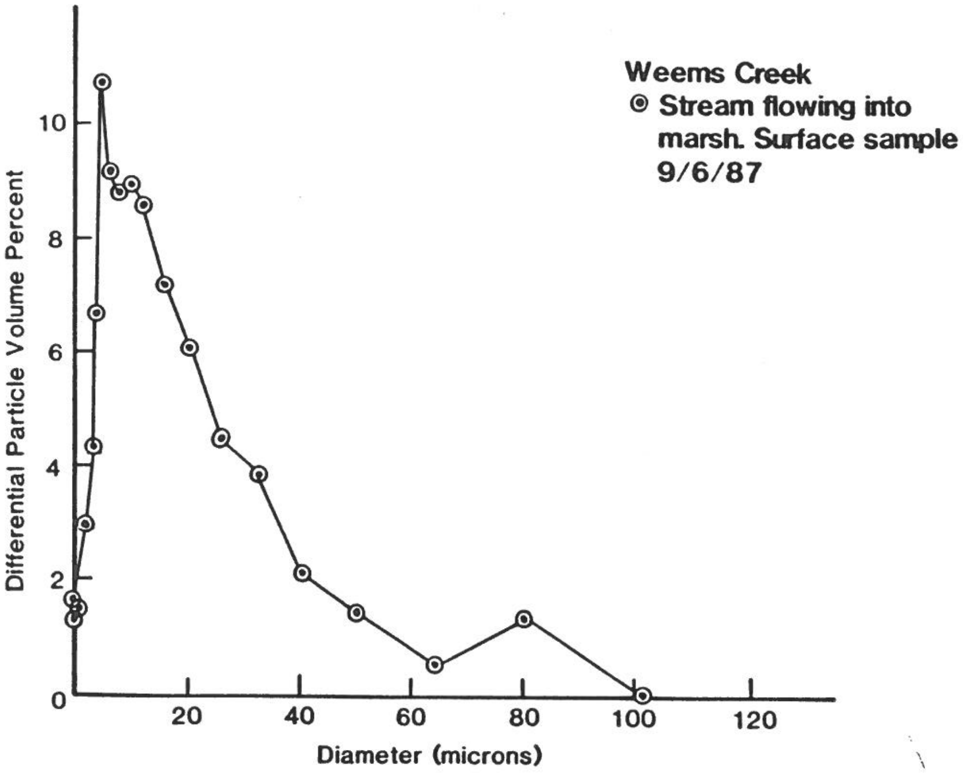


FIGURE 31 - STREAM STATION
DIFFERENTIAL PARTICLE VOLUME VERSUS PARTICLE DIAMETER

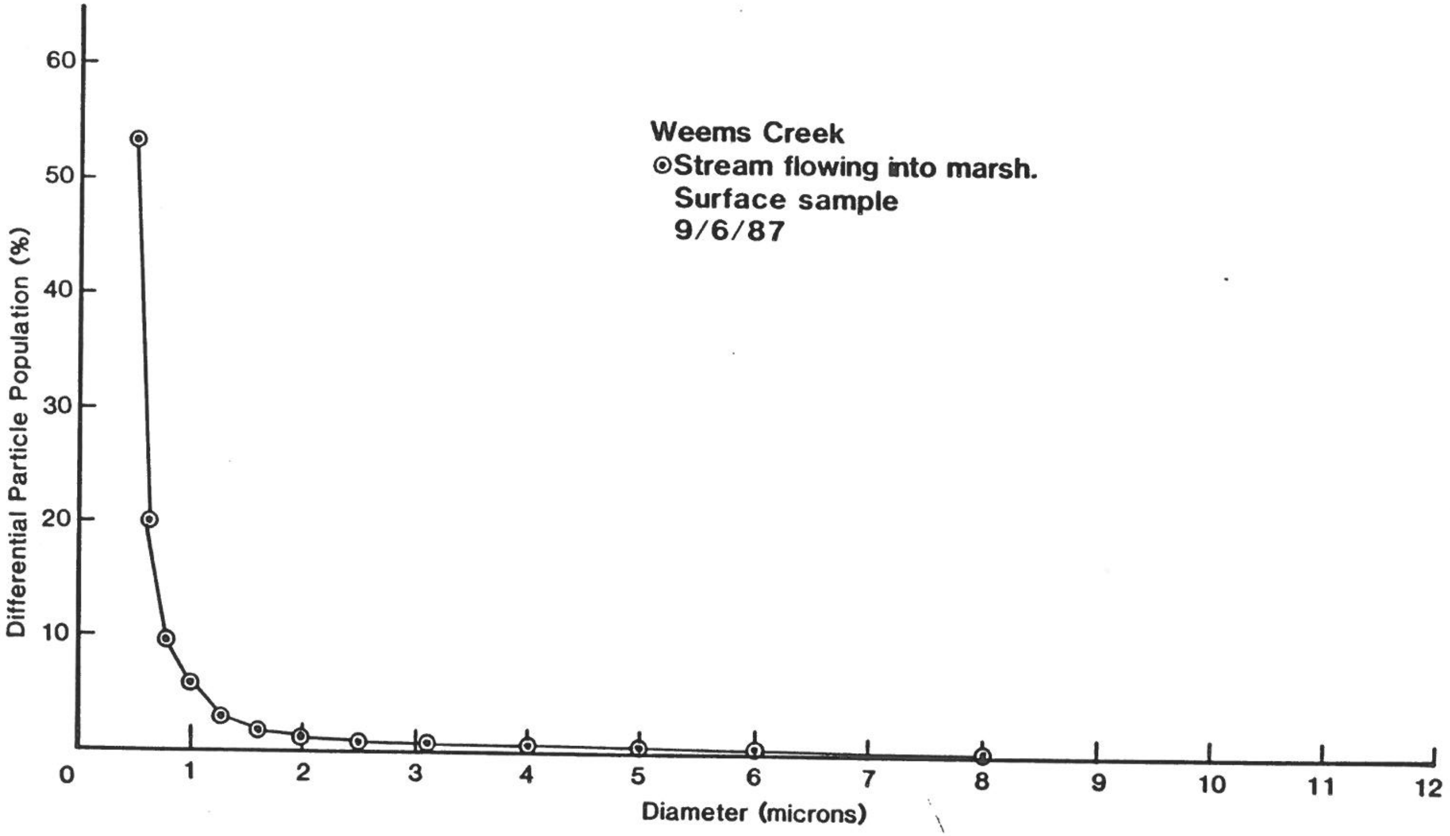


FIGURE 32 - STREAM STATION
DIFFERENTIAL PARTICLE POPULATION VERSUS PARTICLE DIAMETER

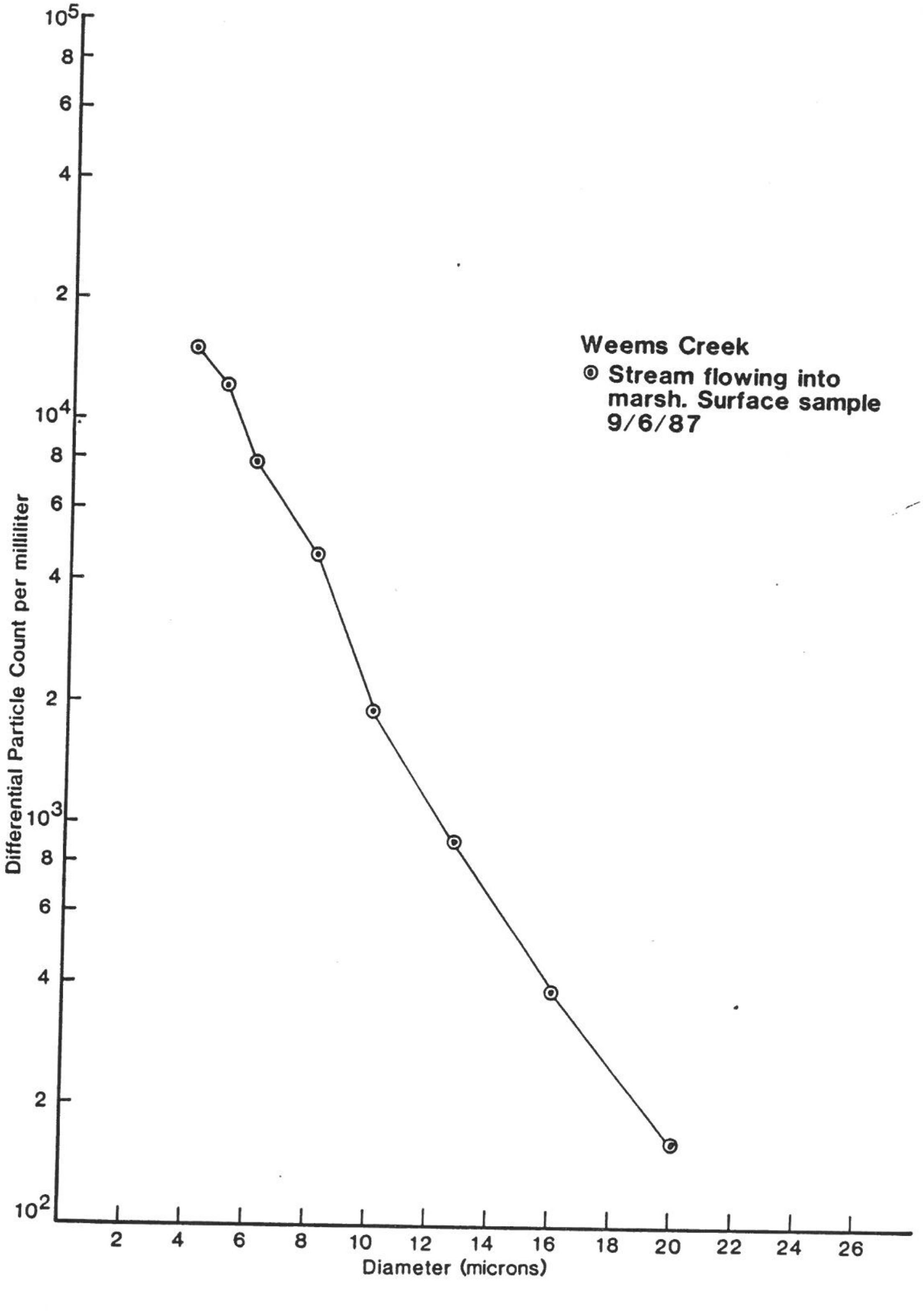


FIGURE 33 - STREAM STATION
DIFFERENTIAL PARTICLE COUNT VERSUS PARTICLE DIAMETER

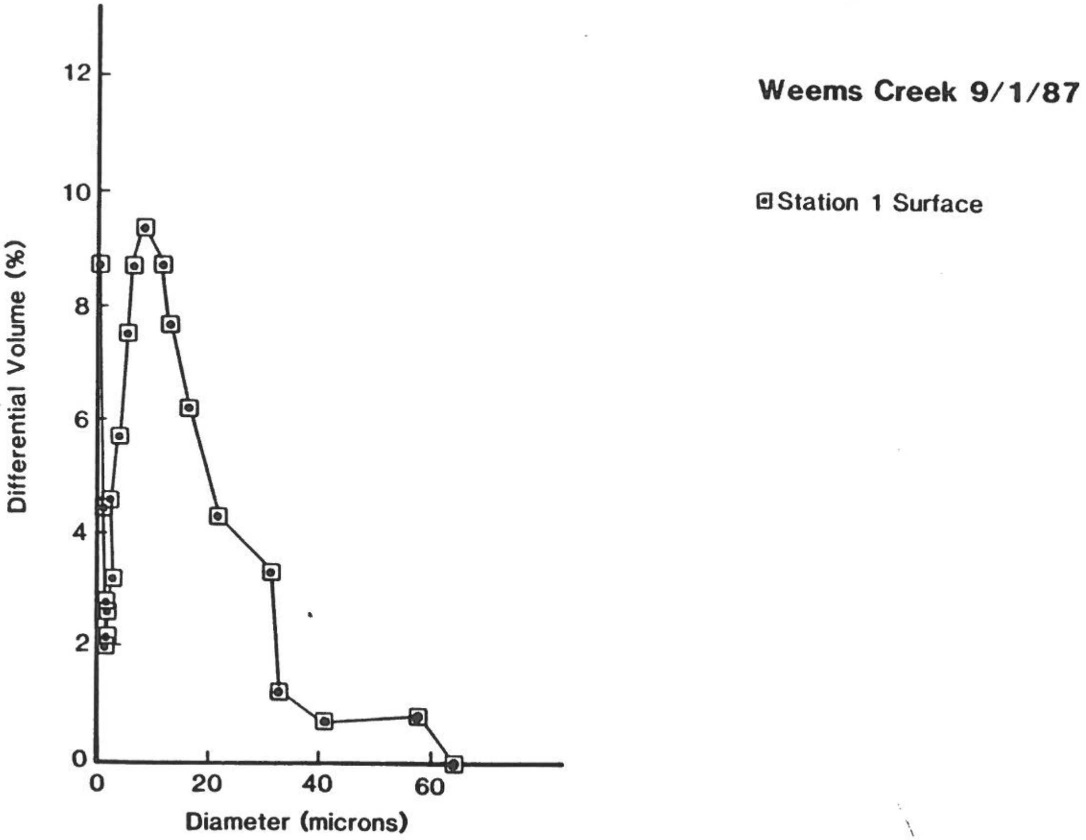


FIGURE 34 - STATION 1
DIFFERENTIAL PARTICLE VOLUME VERSUS PARTICLE DIAMETER

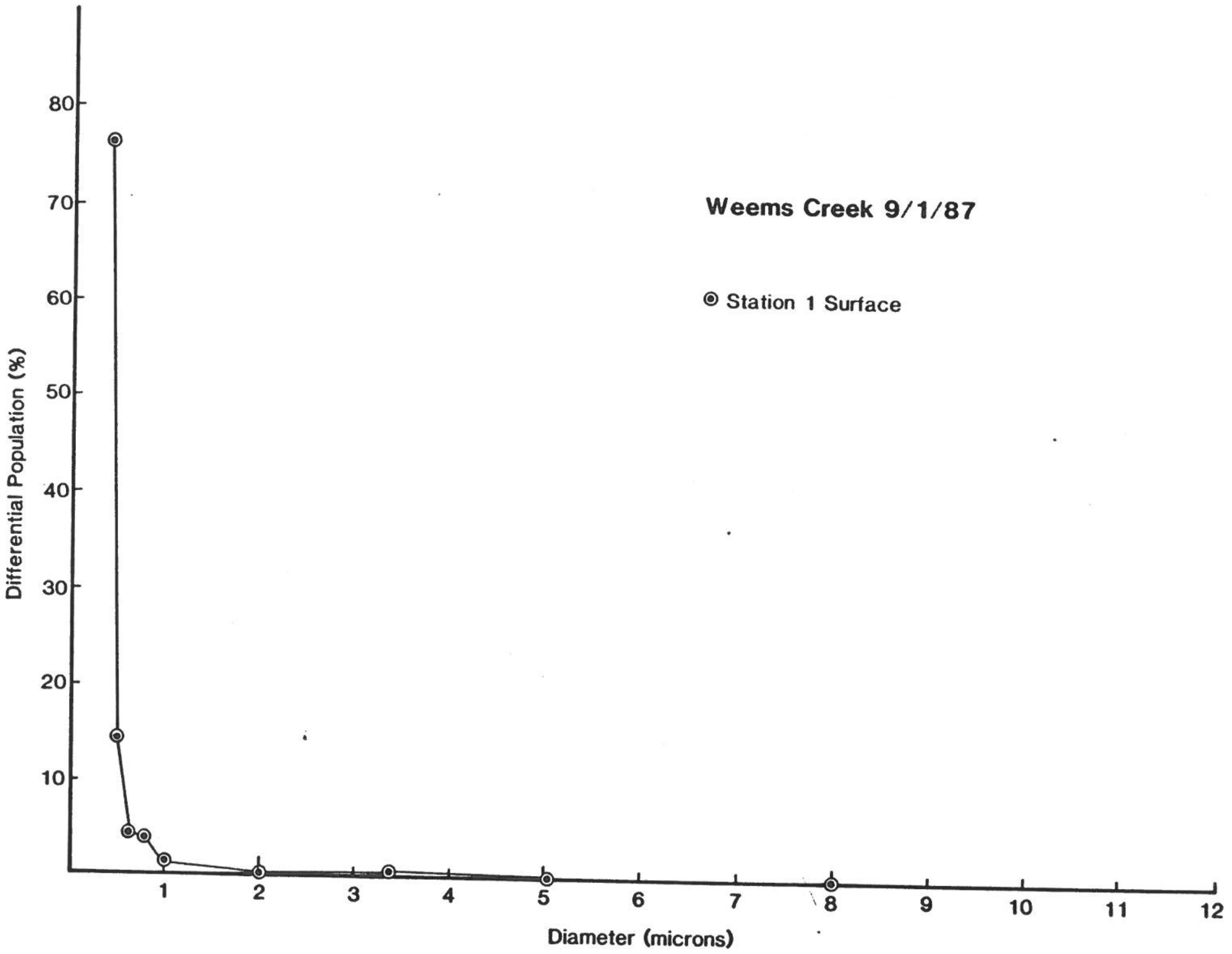


FIGURE 35 - STATION 1
DIFFERENTIAL PARTICLE POPULATION VERSUS PARTICLE DIAMETER

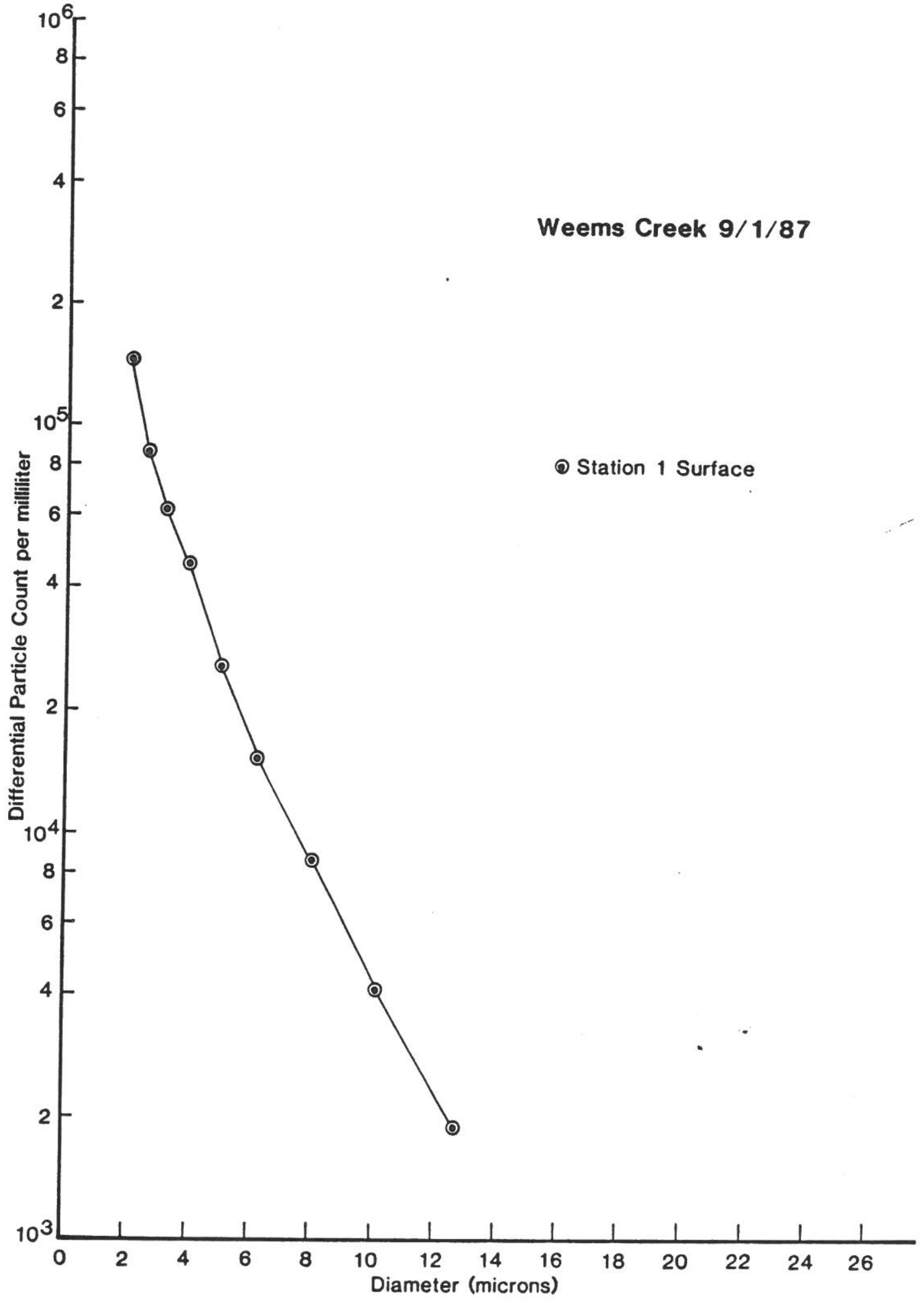


FIGURE 36 - STATION 1
DIFFERENTIAL PARTICLE COUNT VERSUS PARTICLE DIAMETER

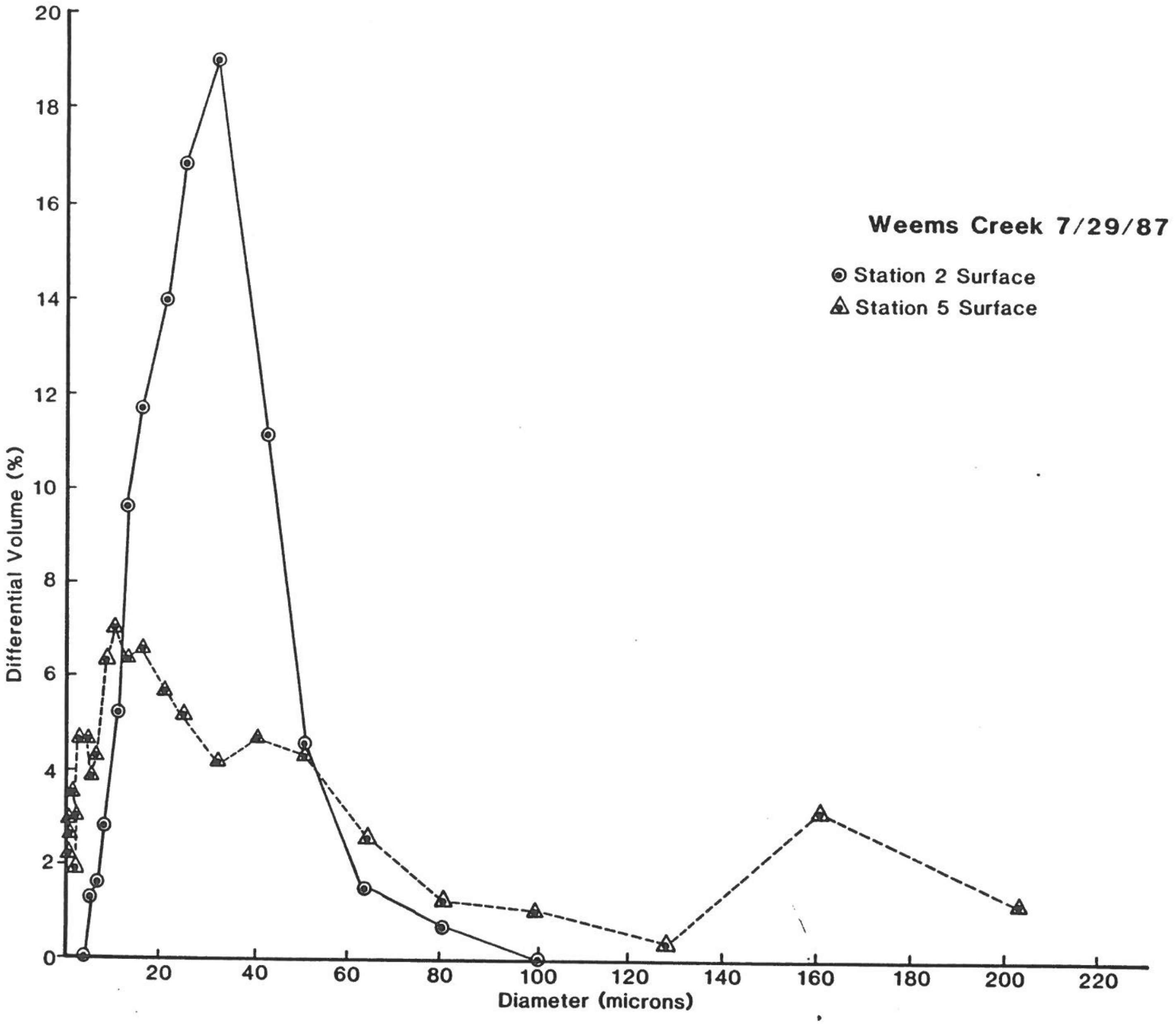


FIGURE 37 - STATIONS 2 AND 5
DIFFERENTIAL PARTICLE VOLUME VERSUS PARTICLE DIAMETER

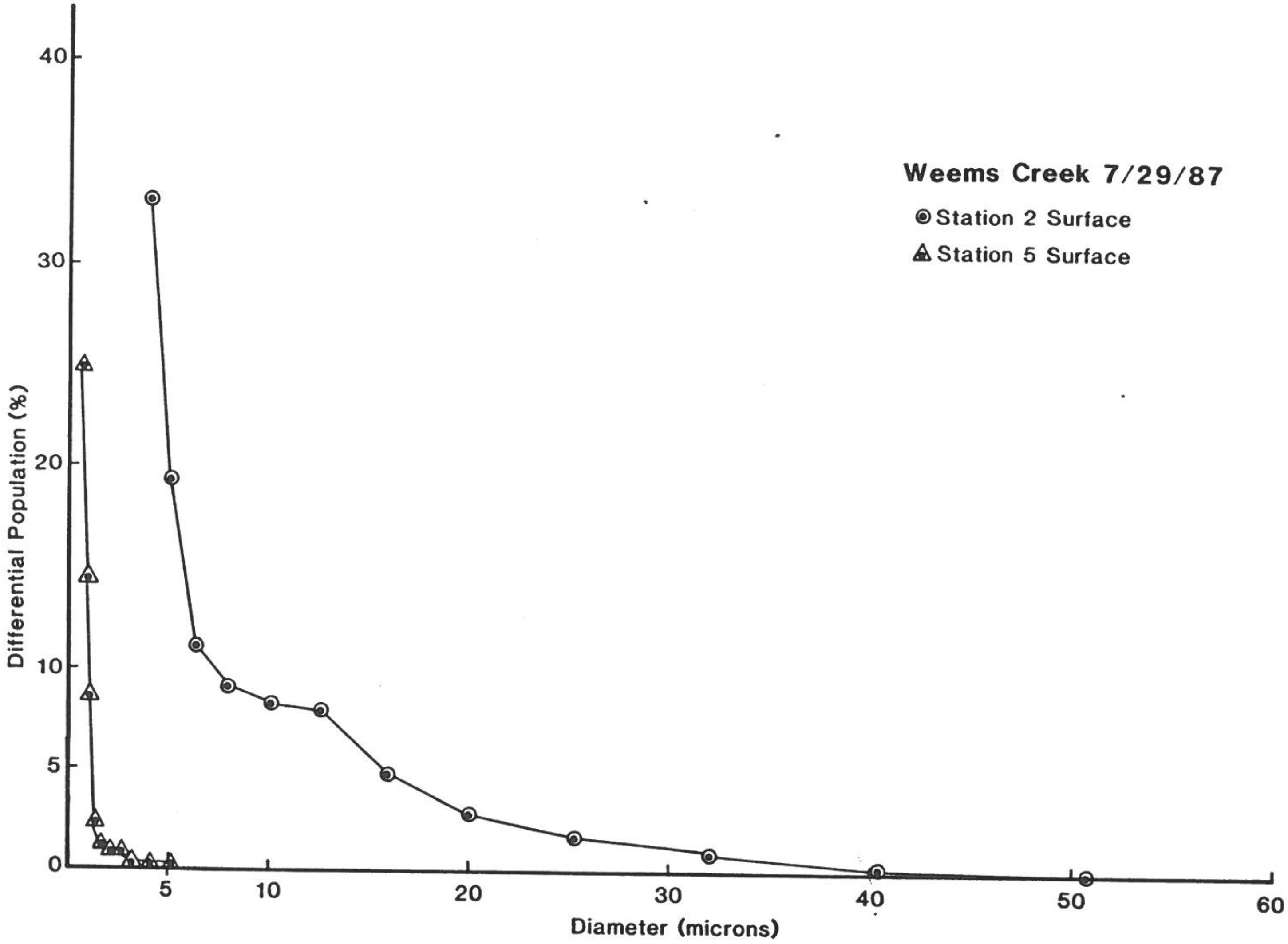


FIGURE 38 - STATIONS 2 AND 5
DIFFERENTIAL PARTICLE POPULATION VERSUS PARTICLE DIAMETER

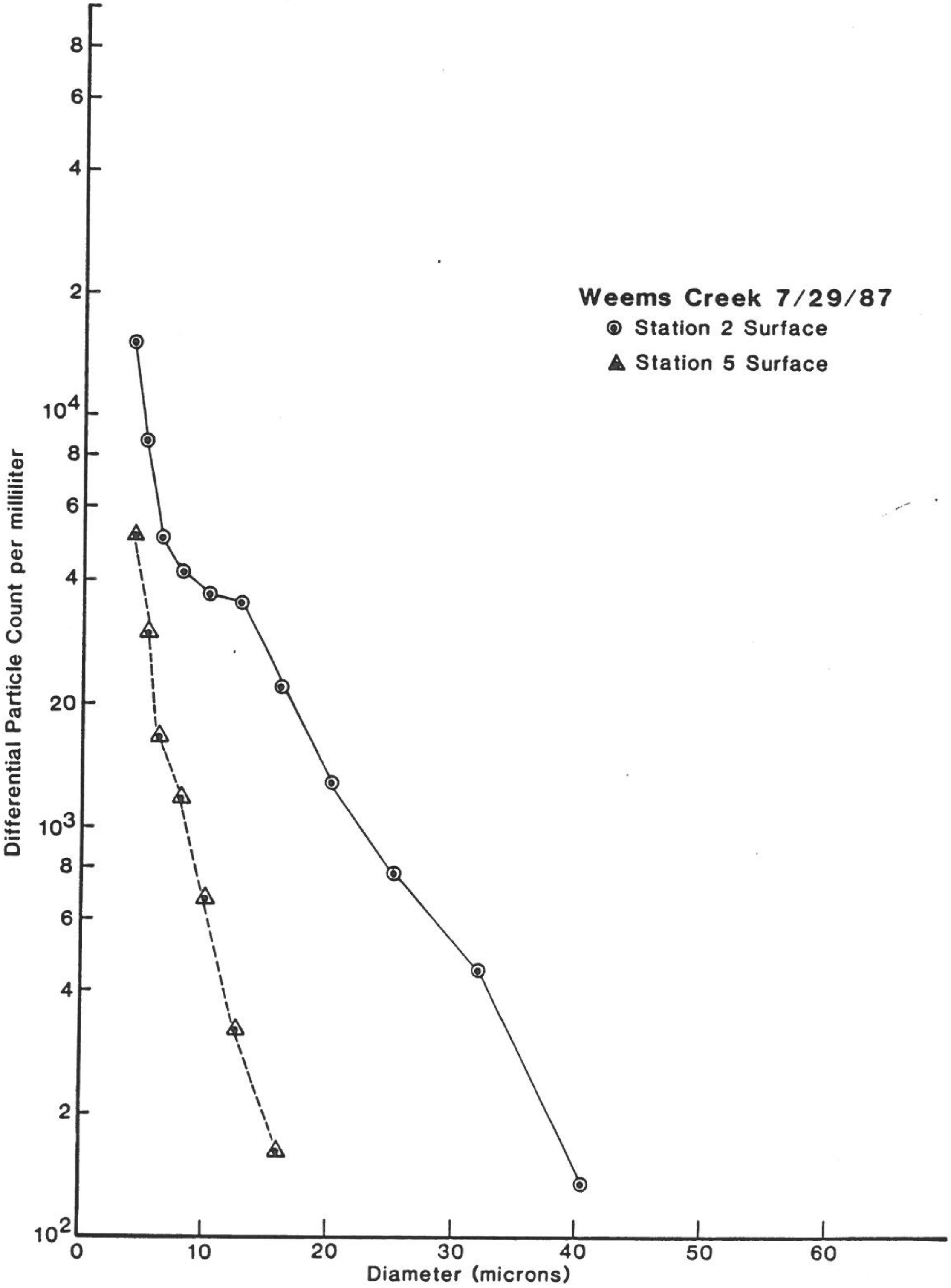


FIGURE 39 - STATIONS 2 AND 5
DIFFERENTIAL PARTICLE COUNT VERSUS PARTICLE DIAMETER

APPENDIX A

EQUIPMENT AND PROCEDURES

EQUIPMENT AND PROCEDURES

Total Suspended Solids

Total suspended solids were measured following procedure 209C given in Standard Methods, 1985 edition.(4) Because of the high salinity, it was found necessary to do more rinsing of the filter with distilled water than recommended by Standard Methods in order to get reproducible results. Also the filters were placed on aluminum screen drying racks when placed in the oven at 105 C in order to avoid filter transfer to the aluminum planchettes.

Standard Methods quotes results of studies that found a coefficient of variation of 33% at 5.2mg/l and 10% at 24mg/l.

Settleable Solids

Settleable solids were measured by the volumetric method of procedure 209E in Standard Methods.(4)

Turbidity

Sample turbidity was measured using an HF Scientific, Inc., 90 degree scattering nephelometer, model DRT-15B. It was calibrated using a 0.INTU standard solution. Comparison of separate samples taken from the same creek location indicated a precision in turbidity readings of ±5%.

Spectrophotometry

A Perkin Elmer double beam UV-visible spectrophotometer, model Lambda 3, was used to search for optical absorbtion in the visible range of wavelengths.

In situ Water Quality

A Hydrolab Corp., model 6D, in-situ water quality analyzer was used to measure temperature, dissolved oxygen, conductivity, salinity, pH, oxygen-reduction potential, and depth at each station on the creek. Before each sampling run, the instrument was calibrated using standard solutions and procedures recommended by the manufacturer.

APPENDIX B

FIELD DATA

MO/DAY	(1) MAXIMUM TEMPERATURE (F)	(2) TOTAL % SUNSHINE	(3) RAIN (inches)	(4) WIND RESULTANT DIRECTION	(5) WIND RESULTANT SPEED (mph)	(6) TOTAL RAIN (inches)	(7) SAMPLING EVENT NO.
JUNE							
1	93	71	T	24	5.7		
2	87	88	0	31	5.1		
3	78	23	.13	8	8.9		
4	73	0	1.10	11	3.6	GF	
5	79	96	0	31	6.9		*(0)
6	78	79	0	31	8.2		
7	87	81	0	21	7.5		
8	91	94	0	25	10.4		
9	81	9	.03	27	8.9		
10	76	99	0	31	9.6		
11	78	93	0	19	6.2		
12	81	10	T	22	9.0	.19 (17:10-18:00	
13	86	22	T	26	7.2	.42 (17:50-20:00	
14	87	92	0	17	3.7		
15	95	91	0	25	8.1		
16	86	22	0	2	2.7		*(1)
17	85	99	0	17	3.5		
18	87	99	0	18	6.8		
19	91	93	0	19	7.5		
20	93	47	.27	19	3.1	.36 (21:20-22:00	
21	88	29	.02	23	5.9		
22	92	28	.41	21	5.1	.32 (18:00-19:27	
23	89	19	T	30	5.9		
24	83	84	0	7	6.9		
25	89	96	0	16	3.8		
26	77	0	.52	13	7.8		
27	86	55	T	30	7.1		
28	81	96	0	27	7.4		
29	89	87	0	21	8.6		
30	93	55	.15	24	4.0		

Columns (1-5) are from BWI Airport National Weather Service data sheets.

Column (4) is expressed in units of 10 degrees, i.e. 27 means 270 degrees, the wind is blowing from the west.

Column (6) is based on a recording rain gage stationed in the Weems Creek Watershed and operated by the Department of Planning and Zoning, Anne Arundel County. The time during which it rained is shown in parentheses.

Column (7) indicates the date that sampling was done on the creek. The numbers in parentheses are the event numbers used on the graphs of turbidity versus event number.

TABLE B1 - METEORLOGICAL RECORD AND SAMPLING DATES

MO/DAY	(1) MAXIMUM TEMPERATURE (F)	(2) TOTAL % SUNSHINE	(3) RAIN (inches)	(4) WIND RESULTANT DIRECTION	(5) RESULTANT SPEED (mph)	(6) TOTAL RAIN (inches)	(7) SAMPLING EVENT NO.
JULY							
1	88	28	3.18	33	7.1	.35	*(2,2')
2	89	24	.08	18	10.0		*(2")
3	89	77	0	27	9.0		
4	88	23	0	23	8.4		
5	85	68	0	5	7.6		
6	82	34	.02	16	6.9		
7	84	32	T	31	7.0		
8	94	90	0	31	7.6		
9	92	41	0	29	8.1		
10	92	24	.01	9	7.1	.42 (17:50-18:20	
11	95	71	0	36	7.9		
12	94	49	.74	6	5.4		
13	91	76	0	16	6.6		
14	88	36	.19	29	9.9	.44 (17:59-16:20	*(3)
15	77	96	0	33	8.0		
16	79	51	0	9	6.4		
17	83	100	0	8	6.0		
18	89	100	0	25	7.0		
19	93	94	0	36	7.2		
20	95	92	0	24	10.5		
21	98	98	0	27	9.8		
22	96	99	0	30	8.8		*(4)
23	96	94	0	9	7.0		
24	97	81	.79	27	7.3		
25	95	70	.04	1	7.5	.14 (02:30-13:30	
26	93	54	0	28	10.1		
27	91	79	T	31	7.4		
28	87	97	0	35	9.6	.28 (00:50-01:20	
29	86	100	0	6	7.0		*(5)
30	93	92	0	21	7.5		
31	91	54	0	2	8.4		

Columns (1-5) are from BWI Airport National Weather Service data sheets.

Column (4) is expressed in units of 10 degrees, i.e. 27 means 270 degrees, the wind is blowing from the west.

Column (6) is based on a recording rain gage stationed in the Weems Creek Watershed and operated by the Department of Planning and Zoning, Anne Arundel County. The time during which it rained is shown in parentheses.

Column (7) indicates the date that sampling was done on the creek. The numbers in parentheses are the event numbers used on the graphs of turbidity versus event number.

TABLE B1 - METEORLOGICAL RECORD AND SAMPLING DATES

SAMPLE EVENT NO.	DATE OF PREVIOUS STORM	TIME AND DURATION OF STORM	TOTAL AMOUNT OF RAIN	SAMPLING DATE	SAMPLING START TIME	DELAY TIME
0	6/4	Unknown	?	6/5	10 am	16 hrs
1	6/13	17:50-20:00 (2 hrs 10 min)	.42"	6/16	10 am	62 hrs
2	6/22	18:00-19:27 (1 hr 27 min)	.32"	7/1	10 am	231 hrs
2	7/1	19:40-21:20 1 hr 40 min)	.35"	7/1	8:20 pm	0 (during storm)
2	7/2			7/2	8:15 am	11 hrs
3	7/14	15:15-16:20 (1 hr 5 min)	.44"	7/14	5:20 pm	1 hr
4	7/14	15:15-16:20 (1 hr 5 min)	.44"	7/22	10 am	171 hrs
5	7/28	00:50-01:20 (30 min)	.28"	7/29	1 pm	11.5 hrs
6	8/5	02:00-08:00 (6 hrs)	1.09"	8/6	10 am	14 hrs
7	8/22	09:00-12:15 (3 hrs 15 min)	.32"	8/22	1:30 pm	1 hr
8	8/28	03:00-03:20 (20 min)	.34"	9/1	10 am	103 hrs

TABLE B1- TIME DELAY BETWEEN SAMPLING & STORMS

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED Oxygen (ppm)	SALINITY (ppt)	CONDUCTIVITY (Millimhos/cm)	SECCI (cm)
	4	.1 (S)	24.47	6.95	1.3	3.29	20
		1.5 (M)	23.14	3.62	8.9	15.6	
		3.0 (B)	22.21	0.09	9.2	16.1	
10:45 am	5	.1 (S)	23.49	12.45	5.6	10.51	30
		1.7 (M)	23.07	5.04	8.9	15.7	
		3.7 (B)	21.80	0.34	9.2	16.1	
10:05 am	6	.1 (S)	23.18	10.45	8.2	14.5	64
		1.7 (M)	22.91	7.11	8.7	15.3	
		3.5 (B)	22.82	3.10	9.2	16.1	

TABLE B3 - WEEMS CREEK FIELD DATA - JUNE 5, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED Oxygen (ppm)	SALINITY (ppt)	CONDUCTIVITY (Millimhos/cm)	SECCI (cm)
10:10 am	1	.1 (S)	20.55	6.19	0.1	1.35	72
	2	.1 (S)	24.95	2.61	9.1	16.1	68
		.8 (B)	24.82	1.88	9.1	15.9	
	3	.1 (S)	25.74	6.06	9.3	16.3	100
		1.4 (M)	25.23	4.81	9.4	16.5	
		2.8 (B)	24.02	0.47	9.5	16.6	
	4	.1 (S)	25.69	7.25	9.5	16.6	100
		1.4 (M)	25.10	6.61	9.5	16.6	
		2.9 (B)	23.58	1.59	9.7	16.8	
	5	.1 (S)	25.66	7.20	9.6	16.7	98
		1.9 (M)	25.19	6.34	9.5	16.6	
		3.8 (B)	22.58	0.17	9.7	16.9	
	6	.1 (S)	25.29	6.63	9.5	16.6	105
		1.6 (M)	24.83	6.09	9.6	16.7	
		3.3 (B)	22.20	0.58	9.9	17.3	

TABLE B4 - WEEMS CREEK FIELD DATA - JUNE 16, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
10:10 am	1	.1 (S)	24.90	2.50	6.8	12.38	24
10:30 am	2	.1 (S)	27.14	4.63	9.1	16.1	86
		1.0 (B)	26.25	1.35	10.0	17.3	
11:00 am	3	.1(S)	27.44	6.00	9.8	17.0	87
		1.4 (M)	25.97	3.30	10.1	17.5	
		2.8 (B)	25.16	0.14	10.2	17.6	
11:20 am	4	.1 (S)	27.84	6.72	9.9	17.3	96
		1.3 (M)	26.27	5.00	10.0	17.3	
		2.6 (B)	25.52	1.41	10.1	17.6	
11:45 am	5	.1 (S)	27.65	7.12	10.0	17.3	99
		1.95 (M)	26.17	6.30	10.1	17.5	
		3.9 (B)	24.87	0.14	10.2	17.8	
12:10 pm	6	.1 (S)	28.20	8.04	9.95	17.3	96
		1.8 (M)	26.21	6.65	10.0	17.4	
		3.6 (B)	25.23	1.45	10.2	17.6	

TABLE B5 - WEEMS CREEK FIELD DATA - JULY 1, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (^oC)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
5:30 PM	1	.1 (S)	24.63	3.18	0.0	0.150	24
5:45 PM	2	.1 (S)	28.18	4.88	5.9	11.75	25
		.9 (B)	28.66	1.01	9.9	17.3	
6:05 PM	3	.1(S)	29.10	7.53	9.3	16.4	56
		1.55 (M)	28.65	3.30	9.9	17.2	
		3.1 (B)	28.08	0.20	9.9	17.3	
6:25 pm	4	.1 (S)	29.17	10.05	9.2	16.2	59
		1.5 (M)	29.22	6.00	9.7	16.9	
		3.0 (B)	28.32	1.87	9.9	17.2	
6:40 pm	5	.1 (S)	29.17	8.75	9.6	16.7	84
		1.95 (M)	28.85	6.23	9.9	17.0	
		3.9	28.24	2.66	9.9	17.2	
7:00 om	6	.1 (S)	28.74	9.28	9.8	17.0	79
		1.95 (M)	28.53	5.83	9.9	17.1	
		3.9 (B)	27.99	1.44	9.9	17.2	

TABLE B6 - WEEMS CREEK FIELD DATA - JULY 14, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
10:00 am	1	.1	22.14	6.22	0.4	1.62	44
10:35 am	2	.1 (S)	29.00	4.87	9.1	16.0	74
		.8 (B)	28.03	4.78	9.6	16.7	
10:55 am	3	.1 (S)	29.78	9.45	9.81	17.1	100
		1.3 (M)	28.75	6.65	9.8	17.1	
		2.6 (B)	27.99	0.75	9.9	17.3	
12:15 pm	4	.1 (S)	30.77	9.77	9.9	17.2	116
		1.3 (M)	29.62	9.75	9.9	17.3	
		2.6 (B)	28.44	2.44	10.0	17.4	
12:40 pm	5	.1 (S)	30.42	9.36	10.0	17.3	94
		1.9 (M)	29.28	7.76	10.0	17.4	
		3.9 (B)	27.36	.13	10.1	17.5	
1:05 pm	6	.1 (S)	30.21	9.40	10.1	17.4	100
		1.8 (M)	29.21	7.78	10.0	17.4	
		3.6 (B)	27.65	0.98	10.2	17.6	

TABLE B7 - WEEMS CREEK FIELD DATA - JULY 22, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
1:00 pm	1	.1 (S)	24.1	6.0	.01		56
1:40 pm	2	.1 (S)	31.	15.16	7.7		51
		.9 (B)	30.5	12.8	7.8		
2:00 pm	2.1	.1 (S)	31.5	14.8			
2:15 pm	2.2	.1 (S)	31.8	14.5	12.8		45
		1.6 (B)	30.	9.	19?		
2:40 pm	3	.1 (S)	31.	11.4	8.7		82
		1.5 (M)	29.5	8.2	8.4		
		3.0 (B)	29.2	3.2	8.2		
3:20 pm	4	.1 (S)	32.	14.2	8.0		87
		1.5 (M)	29.5	7.0	7.9		
		2.9 (B)	29.4	5.2	7.8		
3:40 pm	5	.1 (S)	31.	12.6	8.2		90
		2.1 (M)	29.	3.5	8.3		
		4.2 (B)	29.1	0.3	8.3		
4:05 pm	6	.1 (S)	30.3	10.0	8.6		83
		2. (M)	29.	8.8	8.8		
		4. (B)	29.6	4.8	8.6		

TABLE B8 - WEEMS CREEK FIELD DATA - JULY 29, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
9:45 am	1	.1	23.23	4.00	1.2	2.33	66
10:15 am	2	.1 (S)	24.0	2.59	2.6	5.93	53
		.5(M)	29.02	.05	9.8	16.3	
		1.0(B)	29.35	.08	10.4	18.0	
11:15 am	2.15	.1 (S)	26.82	3.34	7.8	14.03	25
		1.0 (M)	29.32	0.90	10.4	18.1	
		2.0(B)	29.14	0.15	10.6	18.3	
11:40 am	2.2	.1 (S)	27.65	1.90	9.0	16.2	15
		.8 (M)	28.96	1.97	10.2	17.7	
		1.6 (B)	28.83	1.88	10.1	17.6	
12:10 pm	3	.1 (S)	27.96	4.65	9.6	16.8	31
		1.4 (M)	29.00	1.85	10.4	18.0	
		2.8 (M)	28.55	0.19	10.6	18.3	
12:45 pm	3.9						55
	4	.1 (S)	27.83	6.60	9.1	16.0	8.0
		1.3 (M)	28.80	3.63	10.3	17.9	
		2.7 (B)	28.92	0.37	10.6	18.3	
1:10 pm	5	.1 (S)	28.29	6.01	10.3	17.8	85
		1.9 (M)	28.32	5.22	10.3	17.8	
		3.9 (B)	27.61	.24	10.8	18.7	
2:45 pm	6	.1 (S)	27.95	4.71	10.6	18.4	97
		1.5 (M)	28.00	4.27	10.6	18.3	
		3.7 (B)	28.00	4.30	10.6	18.4	

TABLE B9 - WEEMS CREEK FIELD DATA - AUGUST 6, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (°C)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
1:30 pm	1	.1 (S)	21.45	4.51	0.0	.271	23
		.6 (B)	22.1-23.0	1.0	8.5-7.9	10.5-9.5	
	2	.1 (S)	25.72	11.66	7.3	13.51	
	2.1	.1 (S)	26.88	4.13	10.3		
		1.0 (B)	26.73	3.29	10.3		
	2.15	.1 (S)	26.81	5.52	10.4	17.9	57
		1.0 (M)	26.89	4.52	10.4	17.8	
		2.1 (B)	26.99	3.12	10.5	18.1	
	2.2	.1 (S)	27.00	9.98	10.4	18.0	
		.9 (M)	26.90	8.55	10.4	17.8	
		1.9 (B)	26.89	8.38	10.4	18.0	
	3	.1 (S)	26.92	6.53	10.3	17.9	43
		1.5 (M)	27.05	4.92	10.5	18.1	
		3.0 (B)	27.14	3.36	10.5	18.4	
4:00 pm	5	.1 (S)	27.15	9.66	10.55	18.2	55
		2.0 (M)	27.13	4.55	10.8	18.7	
		4.0 (B)	27.12	4.22	11.0	18.9	

TABLE B10 - WEEMS CREEK FIELD DATA - AUGUST 22, 1987

TIME	STATION	DEPTH (m)	TEMPERATURE (^oC)	DISSOLVED OXYGEN (ppm)	SALINITY (ppt)	CONDUCTIVITY (millimhos/cm)	SECCI (cm)
10:10 am	1	.1 (S)	18.57	7.91	0.1	1.272	58
		.6 (B)	25.01	1.50	10.7	18.3	66
10:38 am	2	.1 (S)	24.70	6.26	9.2	17.8	
		.5 (M)	24.79	4.31	10.7	18.5	
		1.1 (B)	24.91	0.38	11.0	18.9	
10:55 am	2.15	0.1 (S)	24.60	5.98	10.4	17.9	64
		.9 (M)	24.51	2.83	10.8	18.6	
		1.8 (B)	24.88	0.98	11.1	19.1	
11:20 am	2.2	.1 (S)	24.69	4.78	10.7	18.5	79
		.7 (M)	24.73	1.90	10.9	18.7	
		1.5 (B)	24.89	1.08	11.1	19.1	
11:38 pm	3	.1 (S)	24.65	6.03	10.4	18.0	75
		1.5 (M)	24.84	2.02	11.1	19.0	
		2.9 (B)	24.87	1.33	11.2	19.2	
12:00 pm	5	.1 (S)	24.78	9.82	10.5	18.2	71
		1.8 (M)	24.76	3.72	11.0	18.9	
		3.7 (B)	24.74	3.78	11.4	19.5	
12:10 pm	6	.1 (S)	25.05	8.65	11.0	18.8	86
		1.8 (M)	24.69	4.95	11.1	19.0	
		3.5 (B)	24.71	3.42	11.4	19.5	

TABLE B11 - WEEMS CREEK FIELD DATA - SEPTEMBER 1, 1987

APPENDIX C

LABORATORY RESULTS

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/l)	TURBIDITY (NTU)	FILTER COLOR
4	Surface		53.2	
	.3		140.8	
	Bottom		7.7	
5	Surface		27.9	
	Bottom (-1m)		9.5	
6	Surface		12.8	
	Bottom (-1m)		7.7	

TABLE C12- LABORATORY RESULTS - JUNE 5, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/l)	TURBIDITY (NTU)	FILTER COLOR
1	Surface		17.0	lt gray-brown
2	Surface		51.0	lt orange-brown
3	Surface		5.5	lt orange
	Bottom		6.2	lt gray-brown
4	Surface		5.0	lt gray-brown
	Bottom		47.0	dark brown-black
5	Surface		4.9	lt gray-brown
	Bottom		11.0	med. red-brown
6	Surface		4.2	lt gray-orange specks
	Bottom		9.6	

TABLE C13- LABORTORY RESULTS - JUNE 16, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/l)	TURBIDITY (NTU)	FILTER COLOR
1	Surface		16.0	lt organe
2	Surface		9.5	lt brown
	Bottom		11.0	lt brown
3	Surface		7.0	lt gray-brown
	Mid		6.4	gray brown
	Bottom		43.0	med-dark brown
4	Surface		5.8	lt gray-brown
	Mid		5.8	lt gray-brown
	Bottom			
5	Surface		5.0	lt gray-brown
	Mid		5.0	dark brown
	Bottom		26.0	dark brown
6	Surface		4.6	lt gray
	Mid			lt gray
	Bottom		32.0	

TABLE C14A- LABORATORY RESULTS - JULY 1, 1987 - DAY

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/1)	TURBIDITY (NTU)	FILTER COLOR
Heinman Park	Surface		5.2	lt gray-brown
Ackerlnd Park	Surface		19	med. orange brown
Ackerlnd Outfall	Surface		25	dark brown

TABLE C14B- LABORATORY RESULTS - JULY 1, 1987 - EVENING

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/l)	TURBIDITY (NTU)	FILTER COLOR
Tucker St	Surface		5.1	lt brown-gray
Heinman Park	Surface		11.0	lt brown-gray
Heinman Park	Bottom		5.8	lt gray
Ackerlnd Park	Surface		22	med. brown
Ackerlnd Park	Bottom		7.9	lt gray-brown
Admiral D N. of Jen	Surface Stream		19	med. orange
Admiral D S. of Jen	Surface Stream		19	med. dark orange-brown

TABLE C15- LABORATORY RESULTS - JULY 2, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/1)	TURBIDITY (NTU)	FILTER COLOR
1	Surface		104	dark brwn-orange specks
2	Surface		54	dark brown
	Bottom		15	med. brown
3	Surface		12	med. brown
	Mid		7.5	med. brown
	Bottom		14	med. orange-brown
4	Surface		11	med. brown
	Mid		7.8	med. brown
	Bottom		14	dark brown/black specks
5	Surface		7.4	med. brown
	Mid		6.5	med. brown
	Bottom		6.2	dark brown/black specks
6	Surface		6.0	med. brown
	Mid		5.6	med. brown
	Bottom		7.5	dark brown
Heinman Park Tucker St	Surface		8.8	med. brown

TABLE C16- LABORATORY RESULTS - JULY 14, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/1)	TURBIDITY (NTU)	FILTER COLOR
1	Surface		26	dark orange
2	Surface		15	med. orange-brown
	Bottom		12	med. orange-brown
3	Surface		5.0	med. light-brown
	Mid		7.8	med. brown
	Bottom		7.8	dark brown
4	Surface		4.2	light brown
	Mid		5.5	light brown
	Bottom		5.8	med. brown
5	Surface		4.3	light brown
	Mid		5.0	light brown
	Bottom		7.5	dark brown
6	Surface		4.4	light brown
	Mid		6.5	med. brown
	Bottom		6.8	dark brown

TABLE C17- LABORATORY RESULTS - JULY 22, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/1)	TURBIDITY (NTU)	FILTER COLOR
1	Surface	3.4	16	lt brown-orange
2	Surface	28.1	19	med green-brown
2.1	Surface	68.05	15	dark green
2.2	Surface	14.8	9.3	med green
	Bottom	12.3	10.9	dark green
3	Surface	3.65	5.5	lt brown
	Mid	5.85	6.7	med brown-green
	Bottom	5.6	6.5	dark red-brown
3.1	Surface	4.8	8.0	med gray
3.2	Surface	5.6	7.6	lt brown
4	Surface	3.1	4.7	lt brown
	Mid	8.2	7.6	dark green
5	Surface	5.1	5.9	lt brown
	Mid	20.2	8.4	dark red-brown

TABLE C18 - LABORTORY RESULTS - JULY 29, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/1)	TURBIDITY (NTU)	FILTER COLOR
1	Surface	7.8	18	med. tan-orange
	Bottom	27.8	32	dark tan-orange
2	Surface	14.4	28	med. brown
	Mid	17.6	18.5	med. brown
	Bottom	10.5	10	med. brown-gray
2.1	Surface	12.5	28	med. tan orange
	Bottom	17.1	28	med. tan orange
2.5	Surface	70.0	42	dark green
	Mid	8.6	18	dark green
	Bottom	6.4	5.6	med. light tan
2.2	Surface	53.1	39	med. green
	Mid	107.2		spkld blk-brn-grn
	Bottom	23.8	20	med. green
3	Surface	53.6	29	dark green
	Mid	12.5	12	med. green
	Bottom	2.6	13	brown-white
3.1	Surface	30.3	25	med. green
	Bottom (1m)	15.5	15	med. green
3.9	Surface	10.5	9.8	med lt brn-tan
4	Surface	5.6	8.2	brown-tan
	Mid	6.0	5.5	lt brown-tan
5	Surface	4.05	6.7	med. brown
	Mid	2.7	5.8	spkld brn-white
6	Surface	3.5	6.5	med. brown
	Mid	4.4		med. brown

TABLE C19- LABORATORY RESULTS - AUGUST 6, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/l)	TURBIDITY (NTU)	FILTER COLOR
1	Surface	31.3	63	dark brown
	Bottom	26.2	48	dark brown
2	Surface	34.9	32	dark brown
	Mid	18.6	16	dark brown
	Bottom	9.6	12	dark brown
2.1	Surface	7.2	13	dark brown
	Bottom	4.7	9.5	dark brown
2.15	Surface	10.8	13	dark brown
	Mid	3.7	8.2	dark brown
	Bottom	4.6	8.0	dark brown
2.2	Surface	9.9	15	med grn-brown
	Mid	18.4	15	med grn-brown
	Bottom	16.7	16	med grn-brn
3	Surface	7.6	11	med brown
	Mid	4.8	8.5	dark brown
	Bottom	2.5	6.5	med brown
4	Surface	14.2	9.0	med green
5	Surface	10.2	9.6	med green
	Mid	4.9	6.8	med brown
	Bottom	3.9	7.8	med brown

TABLE C20- LABORATORY RESULTS - AUGUST 22, 1987

STATION	DEPTH (m)	SUSPENDED SOLIDS (mg/l)	TURBIDITY (NTU)	FILTER COLOR
1	Surface	4.1	15.0	med orange
	Bottom	13.7	17.0	dark orange brown
2	Surface	8.4	11.0	med brown
	Mid	5.0	9.1	med brown
	Bottom	9.4	11.0	med brown
2.1	Surface	10.2	16.0	med orange-brown
2.15	Surface	5.5	8.0	med brown
	Mid	14.8	8.5	med brown
	Bottom	4.7	7.0	med brown
2.2	Surface	6.4	8.6	med brown
	Mid	2.3	8.5	med brown
	Bottom	4.9	7.8	med brown
3	Surface	3.2	7.2	med lt brown
	Mid	4.0	6.5	med lt brown
	Bottom	1.1	6.0	med brown
4	Surface	3.6	7.0	med lt brown
5	Surface	4.5	6.7	med lt brown
	Mid	4.8	6.7	med lt brown
6	Surface	2.9	5.7	med lt brown
	Mid	3.5	5.6	med lt brown

TABLE C21- LABORATORY RESULTS - SEPTEMBER 1, 1987

DATE SAMPLE COLLECTED	LOCATION	DEPTH	VOLUME % STATISTICS				COEFFICIENT COST OF VARIATION	TOTAL PARTICLE COUNT (per ml)	TURBIDITY (NTU)	SUSPENDED SOLIDS (mg/1)	SECCI (cm)
			MEAN	MEDIAN	MODE	STANDARD DEVIATION					
			-------------microns--------------								
9/06/87	N. Stream	Surface	8.47	8.81	5.95	2.85	33.61%	43,491	38	17.6	
8/22/87	1	Surface	4.70	6.55	8.99	3.65	76.39%	389,546	64	31.3	22.9
7/29/87	2	Surface	24.88	26.65	33.61	1.69	6.81%	45,320	19	28	51
7/29/87	5	Surface	10.27	11.3	11.38	4.33	42.15%	12,412	5.9	5.1	90

TABLE C22- PARTICLE SIZE DISTRIBUTIONS

APPENDIX D

COLOR PHOTOGRAPHS

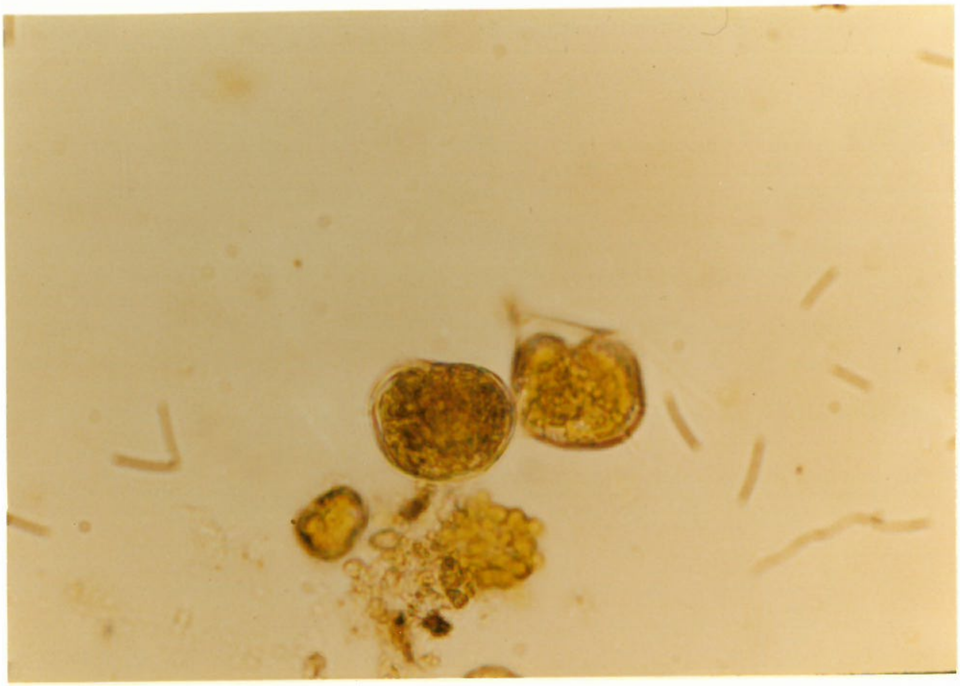
COLOR PHOTOGRAPHS

1. Tan Surface layer produced by stormwater runoff. (Station 4, June 5, 1987)

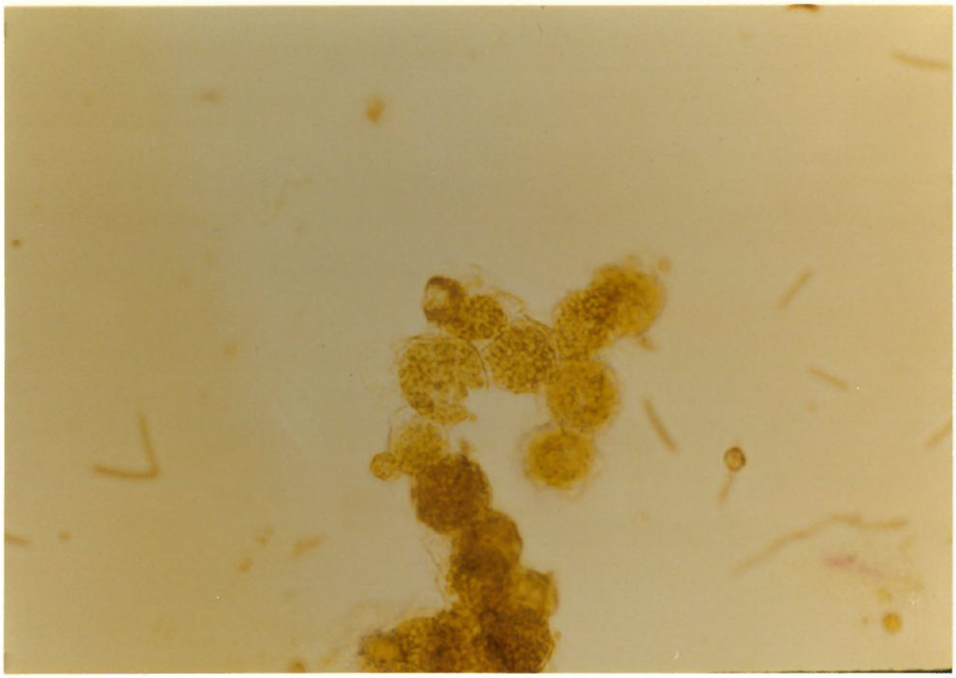
2. Colors produced by stirring water and mixing lower brown layer with surface tan layer. (Station 4, June 5, 1987)

3. Algae bloom - dark brown streaks in water. (Station 2.1, July 29, 1987)

4. Algae bloom. (Station 2, August 6, 1987)



5. Algae cells. (Station 2.2, July 29, 1987)



6. Clump of algae cells. (Station 2.2, August 6, 1987)

7. Yellow-green water in front of marsh.
(Station 1, July 14, 1987)

8. Organic films left by breaking gas bubbles.
(Station 2.2, August 6, 1987)

9. Close-up of bubble clumps on surface. (Station 5, August 6, 1987)

10. Long view of bubble clumps. (Station 5, August 6, 1987)