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PHOSPHOROUS LOADING EFFECTS UPON PHYTOPLANKTON STANDING CROP OF THE 18-MILE CREEK EMBAYMENT OF HARTWELL RESERVOIR, SOUTH CAROLINA

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SUMMARY

- Maximum Trophic State Index (TSI) calculated for different loading scenarios of 35% (1983 situation), 75% and 100% of the design flow of the Pendleton-Clemson WWTP ranged from 61 in 1983 to 68 at 100% of design. These index values are indicative of eutrophic conditions, but they are less than 70, a suggested regulatory action level.
- A worst case scenario under summer-time conditions of thermocline influence and the Pendleton-Clemson WWTP at 100% of the design flow showed that the average total phosphorus, bioavailable phosphorus and corrected chlorophyll a concentrations would be 88 ug/L, 36 ug/L, and 44 ug/L, respectively, in the the upper reaches of 18-Mile Creek embayment. Typically, longitudinal phosphorus and algal standing crop concentrations decrease down the embayment.

- During 1983, total phosphorus concentrations in 18-Mile Creek, 200 feet downstream of the Pendleton-Clemson WWTP, at Station EC-1 ranged from 0.1 to 0.8 mg/L. Bioavailable phosphorus concentrations in the creek were generally less than 0.1 mg/L.

- Areal total phosphorus loading into 18-Mile Creek embayment of 16.3 $g/m^2/yr$ was very high in 1983, but total phosphorus sediment loss coefficients (σ) for the plug flow model (PFR) ranged from 35/yr to 107/yr in the 4 segments of the embayment. These coefficients were the highest recorded for southern reservoirs, exceeding the maximum for TVA reservoirs of 11.18/yr.

- Average maximum corrected chlorophyll a ranged from 11.83 ug/L at Station A-5 near the mouth to 32.63 ug/L in the upper reaches of the embayment (Station A-1). During the summer months of July - September, 1983, the embayment average maximum corrected chlorophyll a concentration was relatively stable, only varying from 20.94 ug/L to 22.42 ug/L.

- Total phosphorus input from all known point sources during this study accounted for 83% of the stream load. The major phosphorus contributor to 18-Mile Creek was the Pendleton-Clemson WWTP. It contributed 14% to 20% of the total phosphorus loading to 18-Mile Creek during periods of intermediate flows (50 to 150 cfs). During high flows (>200 cfs), the Penleton-Clemson WWTP was responsible for up to 60% of the total phosphorus load. At extremely low flows (<50 cfs), it was responsible for approximately 45% of the loading to the Creek.

- The Pendleton-Clemson WWTP, which has a design flow of 1.30 mgd, averaged 0.45 mgd or 35% of the design flow during 1983. The WWTP was generally well-operated and maintained. A significant WWTP performance problem was the occasional loss of solids from the clarifier during periods of elevated flow.

CONCLUSION

Eighteen-Mile Creek embayment trophic condition will worsen as the Pendleton-Clemson WWTP approaches 100% of the design hydraulic capacity, yet tertiary wastewater treatment will not be necessary because the anticipated trophic condition is not expected to reach hypereutrophic levels.

RECOMMENDATIONS

- When the Pendleton-Clemson WWTP reaches the design flow of 1.30 mgd, the South Carolina Department of Health and Environmental Control should monitor the situation during normal summer-time conditions and adjust the Plug Flow Reactor Model if necessary.

- Pendleton-Clemson WWTP operators should control the activated sludge system to prevent clarifier washouts that result from elevated flows associated with rainfall events.

1. INTRODUCTION

Three years ago, the South Carolina Department of Health and Environmental Control (DHEC) responded to a phytoplankton bloom complaint (Appendix A) from a resident living along the 18-Mile Creek embayment of Hartwell Reservoir, South Carolina. This complaint was unanticipated because of stricter pollution controls eliminating stabilization ponds within the watershed and centralizing municipal wastewater treatment at a relatively new facility, the Pendleton-Clemson Wastewater Treatment Plant (WWTP), which was operating at 20% of design capacity. Because of anticipated population growth within the 18-Mile Creek watershed and expected increases of nutrient loads into the embayment, DHEC was concerned about present and future impacts of nutrient loading. As part of their evaluation, DHEC requested field and laboratory assistance from the Environmental Services Division of EPA, Region IV to provide information about:

- concentrations of phosphorus transported into the 18-Mile Creek embayment by existing stream loads, and

- the effect of increased creek phosphorus loadings upon embayment phosphorus concentrations and concomitantly trophic condition.

2. STUDY AREA

Eighteen-Mile Creek is a small, shallow, wadeable piedmont stream flowing through a watershed of 55.2 mi^2. It is the major source of water for the 18-Mile Creek embayment of Hartwell Reservoir, South Carolina, which at normal stage is 11,200 acres in area. The creek flows near several townships including Clemson and Pendleton, South Carolina (Figure 2.1) located in the northwestern corner of South Carolina. Eighteen-Mile Creek enters Hartwell Reservoir near Pendleton, South Carolina, and its headwaters are located more than 15 miles upstream near Easley, South Carolina. Topographic features of this watershed range from very steep hill country near the 18-Mile Creek headwaters to wide flat bottomlands near its mouth. Spring branches and small creeks make up a large portion of the overall drainage pattern of the watershed (McCoy, 1963).

Soil types ranging from finely divided clay particles to very coarse grain sand may be found in the watershed (McCoy, 1963; Herren, 1979). Agricultural uses varying from row crops to pastures constitute the largest land use. Included in this percentage are large areas of forest lands which consist of hardwoods and evergreens (Herren, 1979).

The watershed up and downstream of Clemson receives a number of municipal and industrial wastes.

3. STATION LOCATIONS

To accomplish the objectives of this study, EPA concentrated its sampling efforts on the 18-Mile Creek embayment of Hartwell Reservoir and the lower stretch of the creek, downstream of the Pendleton-Clemson WWTP.

EPA sampling locations were divided into embayment stations, creek stations, Pendleton-Clemson WWTP, and other point source discharges (Figures 2.1 and 3.1).

3.1 Embayment Stations

All embayment stations were located over the "old" creek bed, the deepest part of a transverse transect of the embayment (Figure 3.1).

- Station A-1 was located 200 ft downstream of County Road 71 bridge.
- Station A-2 was located 0.8 river mile downstream of County Road 71 bridge. The South Carolina Department of Health and Environmental Control has an ambient monitoring Station, CL-24, at this location.
- Station A-3 was located 1.4 river miles downstream of County Road 71 bridge.
- Station A-4 was located 2.0 river miles downstream of County Road 71 bridge.
- Station A-5 was located 2.4 river miles downstream of County Road 71 bridge.

3.2 Creek Stations

- Station EC-1 was the site for the long term water quality monitoring station on 18-Mile Creek (Figure 3.1). The station was approximately 600 feet downstream of the Pendleton-Clemson WWTP discharge (CP-001).

Stations EC-2 through EC-8 were used during the low and high flow dye studies of June and November.

- o Station EC-2 was 0.45 river mile downstream from CP-001.
- o Station EC-3 was 0.93 river mile downstream from CP-001.
- o Station EC-4 was 1.71 river miles downstream from CP-001.
- o Station EC-5 was 2.16 river miles downstream from CP-001.
- o Station EC-6 was 2.42 river miles downstream from CP-001.
- o Station EC-7 was 2.83 river miles downstream from CP-001.
- o Station EC-8 was 3.21 river miles downstream from CP-001.

3.3 WWTP Station

- o Station CP-001 was located on the east bank of 18-Mile Creek approximately 50 feet downstream of the County Road 279 bridge.

3.4 Other Point Source Discharge Stations

Active point discharges within the 18-Mile Creek watershed were sampled during August 1983 (Figure 2.1). The following facilities were sampled:

- o City of Liberty - Lusk Lagoon (LL)
- o City of Liberty - Owens Lagoon (LO)
- o Whispering Pines Subdivision (WP)
- o Dan River (Liberty) (DR)
- o City of Easley - Lagoon No. 1 and No. 2 (EL1, EL2)
- o Town of Central - Central WWTP (TC)
- o Pendleton Finishing (PF)
- o Pendleton-Clemson WWTP (PC)

A complete characterization of the facilities is included in the Point Sources Monitoring section (5.3) of this report.

4. METHODS

4.1 Embayment Water Quality Monitoring

Physical measurements of the embayment width and length were obtained from scaled maps and transit readings. A recording fathometer was used to measure bottom contour transects (Figure 3.2) according to Engineering Support Branch Standard Operating Procedures (SOPs) (EPA, 1980). These measurements were used to develop an embayment surface area and volume curve (Figure 4.1) and other physical measurements useful in predicting loading scenarios and characterizing the embayment.

During February through September, one day per month was allocated for embayment water sample collections, temperature-oxygen-chlorophyll *a* profile measurements, and Secchi disc and light transmission readings. Temperature and oxygen profile measurements and light transmission and Secchi depth readings were conducted according to the Environmental Biology Section's SOP (EPA, 1982a). Depth integrated water samples were collected from the epilimnion; if the thermocline was absent then depth integrated water samples were collected from the euphotic zone (depths where >1% light transmission occurred). Water samples were mixed thoroughly in the laboratory and subdivided into three subsamples for the purpose of determining chlorophyll *a*, total phosphorus (T-P), bioavailable phosphorus (B-P), ammonia-nitrogen (NH_3-N), nitrite-nitrate-nitrogen (NO_2-NO_3-N) and total Kjeldahl nitrogen (TKN). Total phosphorus and the nitrogen series were determined according to procedures found in the Laboratory Services Branch SOP (EPA, 1981). Chlorophyll *a*, corrected for phaeophytin, was analyzed according to the Environmental Biology Section's SOP (EPA, 1982a). Bioavailable phosphorus (B-P) was determined using EPA's standard algal growth potential test (AGPT) (Miller, *et al*., 1978). Where nitrogen limiting situations existed, AGPT subsamples were spiked with sufficient inorganic nitrogen to change the sample from nitrogen limited to phosphorus limited conditions thus allowing conversion of maximum algal standing crop dry weight to B-P via a factor derived by Miller, *et al*. (1978).

4.2 Creek Water Quality Monitoring

Water quality monitoring on 18-Mile Creek began in March 1983 and ended in November 1983. The objective of characterizing the phosphorus loading to the creek was achieved with a stream stage recorder, creek flow measurements and regular sampling at Stations EC-1 and CP-001.

The stage-discharge curve (Figure 4.2) for 18-Mile Creek was established early in the study using measurements over a wide range of creek flows. Creek flow was measured at Station EC-1 using a wading rod and Price AA current meter. The creek stage was noted at the beginning and end of each flow measurement at the Station EC-1 cross-section. Discharge was computed using the midsection method outlined in the USDI Water Measurement Manual (1975). A stage recorder and staff gauge were installed approximately 200 feet upstream from Station EC-1. During each sampling period, a 7-day stage recorder was set up to provide continuous flow information needed for loading calculations.

The EC-1 station was equipped with two automatic sequential samplers set on 6-hour intervals. One sampler had 5 ml of H_2SO_4 in each bottle to preserve the samples for nutrient analyses. The other sampler collected un-preserved samples for AGPTs. The intake lines for the Station EC-1 samplers were suspended on a rope spanning the stream section and attached to a float providing for continuous submergence without stream bottom contact. Station EC-1 samplers were set to sample with a 20 minute lag behind samplers at the CP-001 (upstream) sampling station. The 20 minutes accounted for the base flow time of travel from Station CP-001 to EC-1 as measured by several time of travel studies. Five complete weeks and two partial weeks were successfully sampled using the automatic samplers at Station EC-1.

Station CP-001 at the Pendleton-Clemson WWTP was located at the discharge from the chlorine contact basin. Two samplers, one preserved with H_2SO_4 and one unpreserved, were located at CP-001 and set to sample at 6-hour intervals. The facility effluent flow measurement system was used to calculate loadings from the CP-001 discharge. The system consisted of a 90° V-notch weir, float, totalizer, and strip chart recorder. The flow measurement system was checked for accuracy several times during the study and found to be accurate.

For high flow periods, individual water samples were analyzed for T-P, B-P, total suspended solids (TSS), NH_3-N, NO_2-NO_3-N, and TKN. Individual water samples were analyzed to define variability under high flow conditions. During base flow, the individual water samples were composited and the one time composite sample was analyzed for the previously listed variables.

4.3 Dye Tracer Studies

Two dye tracer studies were conducted, one at high (storm event) and one at low (base) flow periods in 18-Mile Creek. The procedure used in conducting both tracer studies was a modified time-of-travel practice. A known volume of Rhodamine Wt tracer dye was injected into the effluent channel of the Pendleton-Clemson WWTP. The injected WWTP effluent was monitored for dye at preselected stations (EC-1 to A-2) along 18-Mile Creek downstream of the discharge point (Figure 3.1). A boat mounted

Turner Design Model 10 fluorometer operated in the flow-through mode was used to determine fluorescence. All samples were collected as the dye peak passed the respective station. Successive samples were collected at the peak until a decrease was observed in dye concentrations. The last sample collected before the dye concentration decreased was retained as the representative sample for that station. Sample analyses included T-P, B-P, nitrogen series, and TSS.

The low flow dye study was conducted during a dry period where the non-point source contribution was minimal and creek flow was nearly constant. This period occurred during May 31 to June 1, 1983. Dye was released into the effluent of the Pendleton-Clemson WWTP at 1320 hour on May 13. Monitoring continued along a 4-mile reach of 18-Mile Creek through 1235 hour of the following day.

Conditions for the high flow study were quite different. For this study, a predictable hydrographic response to a single rainfall event was necessary. This event occurred during the period November 15-16, 1983. Dye was released into the effluent of the Pendleton-Clemson WWTP on November 15 at 1210 hour. Dye release coincided with the rising limb of the hydrograph. Dye monitoring continued through 1320 hour of the following day.

4.4 Point Source Sampling

Sampling was conducted at nine active industrial and municipal point source discharges to 18-Mile Creek (Figure 2.1). Two consecutive 24-hour composite samples were collected from each of the nine discharges. Analyses included the respective applicable NPDES permit parameters plus T-P and nitrogen series.

ISCO automatic samplers, Model 1680 or 2100, were used to collect composite samples. Sample collection, preservation and handling was completed according to the Engineering Support Branch SOP's (EPA, 1980).

A continuous flow measurement was made at all nine discharges. If the discharger's flow measurement system was accurate within ±10%, the investigator used the existing system. If the flow sensor or recorder was inaccurate and uncorrectable, the investigator installed a portable ISCO flow meter and recorder.

The following facilities were sampled during the period August 9-11, 1983.

Facility	Sample Code	Location	NPDES No.
Liberty Lusk Lagoon	LL	Liberty, SC	SC0026174
Liberty Owens Lagoon	LO	Liberty, SC	SC0026182
Whispering Pines Subdivision	WP	Easley, SC	SC0028703
Dan River	DR	Liberty, SC	SC0000264
Easley Lagoon #1	EL1	Easley, SC	SC0023078
Easley Lagoon #2	EL2	Easley, SC	SC0023078
Town of Central	TC	Central, SC	SC0025003
Pendleton Finishing	PF	Pendleton, SC	SC0000477
Pendleton-Clemson WWTP	PC	Pendleton, SC	SC0035700

5. RESULTS

5.1 Embayment Monitoring

Stage levels of the embayment can range from 625 feet above mean sea level (msl) as referenced to National Geodetic Vertical Datum to a full pool elevation of 665 feet msl. The median stage during the embayment sampling period (Table 5.1) was 660.9 feet msl, or 0.9 feet higher than the normal pool level of 660 feet msl. Stage level changed a maximum of 7.5 feet during the study period attaining a high of 662.9 feet msl in May and decreasing to a low of 655.4 feet msl in September. At any one time, pool level was no more than 4.6 feet below normal pool stage nor greater than 2.9 feet above the normal pool of 660 feet msl.

For purposes of discussion, the discontinuity layer or thermocline (metalimnion) is defined as 1°C ΔT per 3.28 feet (one meter) fully realizing that many professional limnologists leave interpretation more open-ended by defining the thermocline as "the layer of water which the temperature exhibits the greatest difference in vertical direction" (Ruttner, 1963).

There was no thermocline in the winter months (Figures 5.15.5) nor because of shallowness was a thermocline detected at embayment Stations A-1 and A-2. During April, there were indications that a thermocline was forming. At Stations A-3, A-4 and A-5 near the mouth of 18 Mile Creek embayment there was a definite break in the thermograph at the 6.6 feet. - 9.8 feet depth, respectively. In May, the thermocline became clearly established (Figures 5.3-5.5) at stations A-3, A-4 and A-5. The thermocline was detectable at Stations A-4 and A-5 throughout the remainder of the embayment sampling period. As summer progressed, the thermocline extended down to greater depths until August when the hypolimnion was obliterated and the thermoclinal zone reached to the bottom. In August and September, a thermocline was not detectable at Station A-3, and by September the top of the thermocline was very deep (47 feet to 49 feet) at Stations A-4 and A-5. The extension of the thermocline to the bottom and the loss of hypolimnetic waters from the 18-Mile Creek embayment was attributed to man-made drawdown effects which began in June (Table 5.1). The loss of nutrient-rich hypolimnetic waters in late summer and autumn through drawdown is a major difference between large reservoir and natural lake limnology. This difference effects the study approach to nuisance bloom problems in embayments of reservoirs. More emphasis is usually put on sampling of the epilimnion because summer and autumn nuisance phytoplankton blooms are effected mostly by nutrients entering from the watershed and mixing with epilimnetic waters.

Twice during the study, a temperature survey was conducted to determine the plunge zone (Figures 5.6 and 5.7). These surveys were conducted in March and July. The March creek temperature was 10.7°C. This temperature was detected in bottom waters at Station A-1. At Station A-2, there presumably was a mixing of creek and embayment waters because water temperatures at Station A-2 ranged from 12.7°C at the bottom to 13.6°C at the surface (Figure 5.6). Summertime creek temperature represented by the July survey was 27.2°C. In the shallow pool upstream of Highway 71 bridge (Station EC-8) the bottom water temperature had increased to 27.7°C where it remained at Station A-1, suggesting that the summertime plunge zone begins in the area of Station A-1. Bottom waters at Station A-2 warmed to 29.5°C continuing down the embayment and overflowing the thermocline at Station A-3 where the top of the thermocline was 28.1°C (Figure 5.3). This estimate of the extent of the plunge zone was further substantiated by the dye study of May 13 to June 1 where substantial losses of phosphorus were observed between stations A-1 and A-2.

Throughout the embayment sampling period, euphotic zone depth ranged from 1.3 feet to 33.1 feet and transparency ranged from 0.3 foot to 10.2 feet (Table 5.2). Generally, the euphotic zone increased and transparency increased from Station A-1 down the embayment to Station A-5. April transparencies were generally low ranging from 0.7 foot to 1.0 foot at all stations and exhibiting no trends because measurements followed a storm event (Figure 5.8) the prior week which increased turbidity in the embayment.

Dissolved oxygen (DO) ranged from <1 mg/L several times during the study to 10.9 mg/L at Station A-5 on March 22, 1983 (Appendix F, Figures 5.9 - 5.13). Concentrations were 6.0 mg/L or greater throughout the water column from February to April

(Figures 5.9 - 5.13). In May, when the thermocline was established, greater oxygen demand upon deeper waters began decreasing DO concentrations until substantial portions of the water column contained waters with <1 mg DO/L from June through August (Figures 5.12 - 5.13). With the onset of autumn turnover, low DO waters were only measured in September near the bottom at Stations A-4 and A-5 (Figures 5.12 - 5.13). Throughout the embayment sampling period, the relatively shallow stations, A-1 and A-2, had DO concentrations greater than 4 mg/L except in July when near bottom waters contained <1 mg/L of DO at Station A-2 (Figures 5.9 and 5.10).

Corrected chlorophyll a ranged from 0.39 ug/L at the 36.0 foot depth at Station A-5 on August 15, 1983 to 86.43 ug/L near the surface at Station A-1 on May 17, 1983 (Appendix F, Figures 5.14 and 5.18). Concentrations varied with depth, but usually maximum concentrations were either observed in the euphotic/epilimnion zone or upper layers of the thermocline. Maximum values by station and date were transposed to Table 5.3 which shows over the embayment sampling period that the average maximum corrected chlorophyll a ranged from 11.83 ug/L at Station A-5 to 32.63 ug/L at Station A-1. When all station maximums were averaged by month, the average maximum corrected chlorophyll a ranged from 8.43 ug/L on April 12, 1983 to 34.12 ug/L on May 17, 1983 when the thermocline was well established. During the summer months of July to September, the average maximum chlorophyll concentration was relatively stable in the embayment only varying from 20.94 ug/L to 22.42 ug/L.

Extensive sampling was conducted along numerous transects at the 1-foot depth for the purpose of determining variability of chlorophyll a along the horizontal plane. Collections were made on August 8, 1983 over 16 transverse transects. The percent coefficient of variation (Table 5.4) for the entire embayment was 70.54% with a mean of 14.35 ug/L and a standard deviation of 10.12 ug/L. For any one transect, the percent coefficient of variation was much less, ranging from 7.37% near Station A-1 to 28.58% near Station A-3.

5.2 Creek Water Quality Monitoring

The water quality monitoring of 18-Mile Creek began in March and ended in November 1984. The monitoring effort consisted of monthly sampling at water quality Station EC-1 and the Pendleton-Clemson WWTP effluent (CP-001) as well as two dye studies at low and high flows in May and November, respectively. The monthly sampling events usually covered a full 7-day period, and the dye studies, as discussed later in the report, were each completed in 2 days. Data and charts that show relationships between flow and several water quality parameters are in the Appendices with a complete discussion of the data on an event by event basis (Appendix B).

The monitoring effort produced a data base that provided an in-depth assessment of the current nutrient loadings to the 18-Mile Creek embayment of Hartwell Reservoir, the various sources of nutrients to the system, and the degree to which the nutrient inputs impact creek and embayment water quality. A stage-discharge curve (Figure 4.2) was developed early in the study from flow measurements at Station EC-1. The relationship between rainfall and creek flow was well defined as four of the sampling events occurred during periods of rainfall and elevated creek flow (Figures 5.19 - 5.24). Flows generally were less than 100 cfs during base flow periods, the lowest recorded flow of 37 cfs occurring in August. Flow during rainfall periods often exceeded 200 cfs. The April event, which experienced two periods of slight rainfall (0.20 in and 0.16 in) (Figure 5.8) indicated that the creek flow responded to approximately 0.20 to 0.25 inches of rainfall as recorded at the WWTP (Figure 5.20). The amount of rainfall needed to elevate creek flow would also be dependent on other factors such as antecedent rainfall conditions. Pendleton-Clemson WWTP performance markedly declined during periods of rainfall when WWTP flows increased because of infiltration/inflow in the collection system. Effluent quality was normally good as BOD_5 and TSS concentrations were often less than 10 mg/L during the study (Appendix B). Effluent T-P concentrations ranged from 1.0 mg/L to 2.0 mg/L during the study except when elevated flows occurred and WWTP performance deteriorated. When the effluent TSS concentrations increased because of sludge blanket washouts from the clarifiers, T-P concentrations increased substantially to 30 mg/L (Table 5.5 and Appendix B). The flow to the WWTP exceeded the design flow of 1.30 mgd only once during the sampling periods. However, WWTP flows following rainfall events usually exceeded the preceeding flows by 50% to 100%. The WWTP contributed 14% to 20% of the T-P loading to 18-Mile Creek during periods of intermediate flows (50 to 150 cfs); however, during periods of high flow (>200 cfs), the WWTP was responsible for up to 60% of the T-P loading to the creek. At extremely low flows (<50 cfs), the WWTP was responsible for up to 45% of the T-P loading, primarily because at lower flows, the WWTP flow comprised a higher percentage of the total creek flow. The effect of an immediate upstream point source on stream T-P concentrations has been shown in previous research (Baker, 1983).

The T-P concentrations in 18-Mile Creek at Station EC-1 ranged from 0.09 mg/L to 0.77 mg/L (Table 5.5). The lowest concentrations (0.09 to 0.33 mg/L) occurred during periods of intermediate flow (Figure 5.25). The highest T-P concentration (0.77 mg/L) was observed during a period of high flow (Figure 5.25). High T-P concentrations which were observed during periods of elevated creek flow were usually in response to a decline in performance of the WWTP (Figure 5.25). Higher T-P concentrations were also noted during periods of low flow as the WWTP flow comprised a higher percentage of the creek flow.

The March event shows the creek T-P increasing from 0.11 mg/L to 0.19 mg/L as the creek flow increased, only to be followed by a more dramatic T-P increase to 0.50 mg/L as the WWTP effluent (CP-001) quality deteriorated (Table 5.7). The WWTP in this instance had an increase in effluent TSS from 5 mg/L to 1100 mg/L and T-P from 4.30 mg/L to 24.00 mg/L when a washout of the clarifier sludge blanket occurred. Operator records showed 10 occurrences of clarifier sludge blanket washouts during 1983. Four of these washouts occurred during periods when EPA was sampling the creek and WWTP effluent.

The WWTP effluent B-P concentrations varied widely during the study. The March event showed B-P concentrations of 2.36 mg/L to 3.93 mg/L that comprised 82% of the effluent T-P (Table 5.7). The B-P data for the WWTP was incomplete for many of the sampling events due to unknown inteferences with the AGPT procedure.

Creek B-P concentrations were generally less than 100 ug/L. The percentage of the 18-Mile Creek T-P loading comprised by the B-P fraction during the March event was approximately 30% at low flows (Table 5.7). At higher flows, the percentage of the B-P fraction decreased to less than 10%.

The upper reach of 18-Mile Creek is best defined as an alluvial channel having a typical width of 48 feet and an average depth of one foot. The creek has a large sediment load of clays and sands that move partially as bed load and partially as suspended load. The entrainment, transport and subsequent deposition of the sediment depends largely on the flow regime; however, characteristics such as the property of the sediment itself, changing downstream channel configurations and interfacing pool conditions also alter the fate of the sediment and phosphorus.

In an effort to better estimate the fate of phosphorus in the water column, a predictive phosphorus curve for resuspension and deposition based on changes in particulate phosphorus concentration per unit time versus mean velocity for the high flow dye study was developed. A regression analysis of the data was completed using a parabolic curve of best fit (Figure 5.26). Low flow data was not used in generating the curve since high pool elevations altered free flow conditions at some creek stations.

Particulate phosphorus estimates were determined for each sampling station by substracting the B-P concentration from the T-P concentration. Bioavailable phosphorus was equated to total dissolved phosphorus. This was believed reasonable since the creek lacked substantial algal growths that would normally invalidate this assumption by grossly underestimating particulate phosphorus. The absence of aquatic vegetation was attributed to a continually moving sediment bed load and a creek travel time which prevented establishment of phytoplankton growth.

The predictive curve was developed by plotting the difference in dye peak particulate phosphorus from station to station divided by travel time, versus mean reach velocity. Particulate phosphorus transport showed little response to velocities less than 1.3 feet/sec. (Figure 5.26). This was due to visibly high colloidal solids in the creek during the rainfall/runoff event. These non-settleable particulate phosphorus bearing solids presumably remained in suspension over the entire range of velocities encountered. As the unimpeded creek waters were slowed by embayed waters, velocity decreased from 2.0 feet/sec. to 1.3 feet/sec. and the denser particulate phosphorus bearing solids settled out leaving non-settleable colloidal solids in the creek water column. Since colloidal matter does not effectively settle out, there was little change noted in particulate phosphorus at velocities less than 1.3 feet/sec.

The low flow (58 cfs) dye tracer study was conducted when the embayment was at a high pool elevation (663 feet msl). Therefore, the unimpeded flow reach of interest was from Stations EC-1 to EC-5. This creek reach had a cumulative travel time of 2.50 hours with an average velocity of 1.26 feet/sec. In this reach, dye peak T-P concentrations decreased, B-P increased, and TSS showed little change (Table 5.8).

As creek waters were slowed by the embayment, B-P and TSS concentrations dramatically decreased (Table 5.8 and Figure 5.28). Beyond this point, traced waters impeded by the tributary embayment were displaced downward and traveled only 0.26 river mile along the bottom during the next 2.8 hours.

In contrast, the high flow dye tracer study was conducted at a low pool elevation (657 feet msl) during a storm event. Sampling was started on the rising limb of the hydrograph and continued downstream on the dye peak through the crest and receding limb. Measured flow rates ranged from 86.7 cfs to 103.3 cfs (Table 5.8). The unimpeded flow reach of interest was from Stations EC-2 to EC-8, a distance of 2.76 river miles. This reach had a cumulative travel time of 2.88 hours with an average velocity of 1.41 feet/sec. Total-phosphorus values increased with increasing distance downstream, while B-P and TSS concentrations showed little variation (Table 5.8). The only exception to this trend was noted at sampling station EC-6 where a slight decrease was measured in T-P concentration. Since the mean segment velocity upstream of EC-6 was 0.72 foot/sec., potential deposition of settleable particulate phosphorus could have occurred (Figure 5.26). Again, as the dye traced waters reached the pool interface, a dramatic decrease in velocity produced rapid deposition of TSS and phosphorus.

The dye studies showed that 18-Mile Creek transports phosphorus bearing solids to Stations EC-5 and A-2 depositing them along the confined channel bottom at low pool levels and in the upstream overbank flats at high pool levels.

Concentration profiles generated from dye peak sampling at high and low flow periods show the fate of phosphorus (Figure 5.27) and sediment (Figures 5.28 and 5.29) as they move downstream. Tributary influence between Stations EC-1 and EC-2 prevented any analysis of nutrient fate between these stations (Table 5.8).

5.3 Point Source Monitoring

Basin nutrient loads are summarized in Table 5.6 and Figures 5.30 and 5.31. For the purpose of this discussion, attention is focused on phosphorus because it is easier and less expensive to control than nitrogen. The T-P input from all point sources accounted for 83% of the creek load at Station EC-1 (Table 5.6). Usually it is assumed that point source phosphorus is transported through a stream system although large portions of these inputs may be stored in temporary sinks on a stream bottom. We determined from the dye tracer studies that particulate phosphorus deposition occurs in the creek at low flow. Observing that the flow rate was even lower during the watershed point source monitoring (37 cfs) than during the dye study (58 cfs), we assumed that deposition occurred along a major portion of the creek reach. These nutrient sinks would then be available for resuspension during periods of higher flow (Figure 5.26, Appendix K).

Non-point source phosphorus input to 18-Mile Creek via runoff during the watershed point source basin study was not considered significant since rainfall was sparse (<0.25 inches) during the 2-week period prior to the point source sampling.

The major phosphorus contributor to the creek during the watershed point source study was the Pendleton-Clemson WWTP which accounted for 45% of the total point source phosphorus input. Average daily loading from the Pendleton-Clemson WWTP of 40.9 lbs/day during the watershed point source study was exceeded only one other time during the entire study period (Table 5.6).

5.4 Pendleton-Clemson WWTP Performance

The Pendleton-Clemson WWTP, which has a design flow of 1.30 million gallons per day (mgd), averaged 0.45 mgd or 35% of the design flow during 1983. Staff at the activated sludge facility operated one of two aeration basins in the extended aeration mode. The complete treatment system consisted of two comminutors, a Parshall flume, two static screens, two aeration basins with two 25 hp surface aerators each, two secondary clarifiers, a chlorine contact basin, a 90° v-notch weir for flow measurement, and cascade aeration prior to discharge to 18-Mile Creek. Sludge is aerobically digested and dewatered on 16 drying beds. Return sludge rate was 700 gpm (1.0 mgd) using one of the three available return sludge pumps. Return sludge flow rate is measured using a magnetic flow meter.

Average monthly BOD_5 and TSS concentrations for 1983 were 16 mg/L and 7 mg/L, respectively (Figure 5.32). Effluent quality during the study period was within the average monthly NPDES permit limits of 30 mg/L for both BOD_5 and TSS for all months except March when the average monthly TSS concentration was 35 mg/L. Monitoring was performed once per week for permit parameters. Additional process control testing included settleometers, aeration basin MLSS/MLVSS, and sludge blanket monitoring. Calculation of F:M ratios and appropriate wasting rates (volume and lb/d) were also conducted by the operations staff.

A significant problem concerning Clemson-Pendleton WWTP performance was the occasional loss of solids from the clarifiers during periods of elevated flow. During each of the sampling events when the WWTP experienced elevated flows, the effluent TSS showed marked increases because of solids washout from the clarifiers (Table 5.7). Only one event resulted in flows at the WWTP which exceeded 1.0 mgd or 75% of design flow. The flow during that one event (March 19-24) peaked at 1.35 mgd (only 4% over design) (Table 5.7). Each of the clarifier solids washouts was accompanied by a correspondingly high T-P concentration. During these washout periods, the WWTP was contributing from 50% to 70% of the T-P load to the creek. The WWTP contributed approximately 14% to 20% of the yearly average creek T-P loading.

The cause of the washouts can be attributed to a slow settling sludge as observed by settleometer tests. The surface overflow and solids loading rates during the washout period were below the recommended ranges for secondary clarifiers. Sludge settleability, as indicated by the regular settleometer monitoring data at the WWTP and several EPA measurements was extremely slow (5 minute settled sludge volume >900 ml/L). With sludge that settles at these slower rates and both clarifiers in operation, the effluent is well clarified at low or base flows. However, when influent flow to the WWTP substantially increased, the time needed to adequately settle solids was reduced, sludge blanket levels in the clarifiers increased, and solids washout occurred.

As discussed in the Water Quality Monitoring Section (4.2), most of the washouts occurred during the hours when the WWTP was not staffed. The operators demonstrated during the November sampling event that by using the second aeration basin for equalization, these washouts can be avoided. This equalization option may not be available as WWTP flows approach design levels.

6. PHOSPHORUS LOADING MODELS

6.1 Modified Vollenweider Model

The Modified Vollenweider Model was originally selected to describe the relationship of phosphorus loadings to embayment trophic status (Rast and Lee, 1978; Vollenweider, 1976; Reckhow and Chapra, 1983). The Vollenweider model is a simple lake nutrient model that uses a mass balance approach to predict lake phosphorus concentrations based on phosphorus loadings to a waterbody (Mancini, et al., 1983). The model is based on the following assumptions:

- The lake is completely mixed
- The lake is at a steady state
- Net sedimentation of phosphorus occurs

The model was selected not only because of its simplicity but because it has been shown in many studies (Rast and Lee, 1978) to be a good estimator of in-lake phosphorus concentrations. The model is also used as a management tool to assess the effects of altered phosphorus loadings on lake trophic status.

The form of the modified Vollenweider model used was:

$$P\ (\mathrm{mg/L}) = \frac{L_c}{\bar{z}(1/T_w + \sigma)}$$

where: P (mg/L) = predicted embayment phosphorus concentration

L_c (gm P/m^2/yr) = areal phosphorus loading to the embayment

$\bar{z}$ (m) = mean depth of the embayment

T_w (yr) = hydraulic detention time of the embayment

σ (yr^{-1}) = phosphorus sedimentation coefficient

The T-P loadings from each sampling event were weighted to yield an average yearly loading of 82.4 lb/d (Tables 6.1 and 6.2). Adjustments were made to the phosphorus loading value to account for sampling bias and deposition/resuspension prior to the delivery of phosphorus into the 18-Mile Creek embayment of Hartwell Reservoir (Appendix L). The sampling program was biased towards rainfall with resulting high flows and poor WWTP performance (Section 5.4) as shown by comparing sampling schedule to the rainfall data in Table 6.3 and Figure 5.8. An adjustment for sampling bias was accomplished by comparing the percentage of high flow days sampled during the EPA sampling periods versus the number of days during 1983 where over 0.30 inches of rainfall occurred, the apparent rainfall required to produce a substantial increase in creek flow. Based on our experiences and assessment of the flow tracings, we used a flow of 1.5 times base flow to delimit between high or low flow conditions. Twenty-three percent of the samples collected during the study were collected under high flow conditions. This compared with 13% of the days during 1983 that had over 0.30 inches of rainfall (Table 6.3). Therefore, a downward adjustment of 10% to 74.2 lb/d was imposed on the original unadjusted average yearly T-P loading of 82.4 lb/d (Table 6.2; Appendix L).

The effect of deposition/resuspension on the particulate phosphorus concentrations was considerable from water quality Station EC-1 to the embayment of Hartwell Reservoir. We determined that a velocity of 1.30 fps could resuspend particulate phosphorus in the creek (Figure 5.26). Based on our best estimate of the threshold point between settling or deposition and resuspension, the yearly average loading value was adjusted. A flow of 80 cfs was selected as the criteria to separate the sampling periods according to whether deposition or resuspension was the controlling transport mode. Eighty cfs translated to a velocity of approximately 1.50 fps at Station EC-1, thus insuring suspension as the transport mode. Accounting for transport mode resulted in a downward adjustment of 3.7% to the yearly average loading (revised previously for sampling bias to 74.2 lb/d) which resulted in a final adjusted loading of 71.5 lb/d (Tables 6.1 and 6.2; Appendix L).

The Vollenweider model contains one factor that can be used to adjust the equation. This factor is the phosphorus sedimentation coefficient, σ (yr^{-1}), which is not a physical measure but an average of all the positive and negative effects an embayment system has on phosphorus species (Vollenweider, 1976). The original Vollenweider work on northern lakes showed σ equal to $10/\bar{z}$ (Mancini, et al., 1983). Researchers (Placke, 1983; Higgins and Kim, 1980) have shown that σ values for southern reservoirs can be substantially higher where soil types and reservoir morphology are different. TVA published an average σ value for their reservoirs equal to $92/\bar{z}$ (Higgins and Kim, 1980). Actually, this estimate of σ is quite conservative because the removals of phosphorus through the 18-Mile Creek embayment exceeded the maximum observed by TVA of 11.18/yr or $237/\bar{z}$ (Higgins and Kim, 1980). The calculated σ for the 18-Mile Creek embayment at a pool level of 661 feet msl, an average yearly input T-P at Station A-1 of 118 ug/L, and an out put T-P at Station A-5 of 35 ug/L, was 46.5/yr using the formula:

$$\sigma\ (yr^{-1}) = \frac{\frac{P_i}{P_o} - 1}{T_w}$$

where: P_i (ug/L) = input phosphorus to the embayment

P_o (ug/L) = output phosphorus from the embayment

T_w (yr) = hydraulic detention time of the embayment

The Vollenweider model was used with the adjusted T-P loading value of 71.5 lbs/d to predict embayment T-P concentrations under a variety of scenarios. The embayment pool level of 661 feet msl (1 foot above normal) was used for the assessments as this was the median level throughout the study (Table 5.1). The Vollenweider model predicts an embayment T-P concentration of 43 ug/L (Table 6.4). This predicted value is very close to the average T-P concentration of 44.5 ug/L for stations A-3 and A-4 (Table 6.5). Unfortunately, the average embayment phosphorus concentration predicted by the Vollenweider model produces only one point on the curve (Figure 6.1), and the T-P concentration steadily decreased through the 18-Mile Creek embayment of Hartwell Reservoir. Figure 6.2 shows a similar situation for B-P.

The calculated σ for B-P in the 18-Mile Creek embayment at a pool level of 661 feet msl, an average yearly input B-P at Station A-1 of 67 ug/L, and an output B-P at Station A-5 of 9 ug/L, was 126/yr. The adjusted B-P loading for the study period was 33.8 lbs/d (Table 6.4). The areal B-P loading at a pool level of 661 feet msl was calculated to be 7.7 $gm/m^2/yr$ for B-P. The model predicted a B-P concentration in the embayment of 9 ug/L. The average B-P concentration for Station A-5 was 9 ug/L (Table 6.5). The B-P concentration is similar to the T-P concentration prediction as both appear to estimate concentrations in the area of Stations A-3 to A-5 for the respective parameters.

6.2 Plug Flow Reactor (PFR) Model

The Vollenweider model has inherent weaknesses because of the initial simplifying assumptions about complete mixing and steady state conditions. These weaknesses were realized during the 18-Mile Creek study as the Vollenweider model did not adequately depict the 18-Mile Creek embayment situation. Studies conducted in other southern reservoirs have pointed out the problem of using the Vollenweider approach that yields an average value for reservoir phosphorus (Higgins and Kim, 1980). TVA has suggested that a plug flow reactor model should be the model of choice for reservoirs where longitudinal concentration gradients are observed (Higgins and Kim, 1980; Placke, 1983). The model is of the form:

$$P_x = P_i \, e^{-\sigma T_w}$$

where: P_x (ug/L) = predicted T-P or B-P concentration at segment x

P_i (ug/L) = actual input T-P or B-P concentration to segment x from upstream embayment segment

σ (yr^{-1}) = phosphorus sedimentation coefficient for segment x (yr)

T_w (yr) = hydraulic detention time of segment x

The 18-Mile Creek embayment had previously been divided into 20 sections in order to develop the Area - Volume curve (Figure 4.1). Seventeen of the sections (through Station A-5) were further divided into 4 segments based on the embayment water quality stations for the PFR model evaluation. Station A-1 was used as the input to the embayment. Segment 1 was comprised of sections 1-6, segment 2 of sections 7-11, segment 3 of sections 12-14, and segment 4 of sections 15-17 (Table 6.6). Segment 1 corresponds to the embayment Station A-2, segment 2 to embayment Station A-3, segment 3 to embayment Station A-4, and segment 4 to embayment Station A-5.

Actual embayment T-P and B-P data were used to develop the phosphorus sedimentation coefficient (σ) for each segment (Table 6.1). Our approach was different from the TVA approach in that we varied σ from segment to segment, whereas TVA used an average for the entire waterbody under investigation (Higgins and Kim, 1980). TVA assumed equal depth and width through the reservoirs they evaluated. We did not make that assumption as the detention time of each segment was determined from the 18-Mile Creek embayment Area-Volume curve data.

Eight scenarios were evaluated using the PFR model. Table 6.7 lists the scenarios and results for the T-P evaluations and Table 6.8 lists the B-P results. The predicted epilimnion concentrations under existing conditions with two different thermocline levels were evaluated because the input T-P from 18-Mile Creek tended to mix in the epilimnion. The two thermocline levels were 628 feet msl, which was the average thermocline during the study (not including months where no thermocline existed), and 639 feet msl which was the average thermocline level for the period July to September. The embayment T-P concentrations predicted with the thermocline at 628 feet msl and 639 feet msl show no increase at segment 1 (Station A-2) because the thermocline did not develop in the sections contained within this segment. The T-P concentrations slightly increased at segment 2 (Station A-3) and increased substantially at segments 3 (Station A-4) and 4 (Station A-5) to 48 ug/L and 54 ug/L, respectively, for the 628 feet msl and 639 feet msl thermoclines. The concentrations with the thermocline at 639 feet msl were higher than those at 628 feet msl because of the decrease in volume with the thermocline at higher levels (Table 6.7). Similar results were shown for B-P as the concentrations in segment 3 increased from 15 ug/L to 17 ug/L for the 628 feet msl case and 19 ug/L for the 639 feet msl thermocline (Table 6.8). The predicted B-P concentration for segment 4 with a 639 feet msl thermocline was increased 100% over the observed concentration of 9 ug/L.

Six additional scenarios were evaluated for both T-P and B-P based on projected increases in the flow at the Pendleton-Clemson WWTP. For flows at the WWTP of 75% and 100% of the design flow, the model was used to predict embayment T-P and B-P concentrations for whole embayment, 628 feet msl thermocline, and 639 feet msl thermocline conditions (Tables 6.7 and 6.8).

For both flow conditions (75% and 100% of design), the T-P and B-P concentrations increased as the volume decreased using the embayment, 628 feet msl, and 639 feet msl thermocline conditions. The worst case for all the scenarios would therefore be the 100% of design flow with a thermocline at 639 feet msl. The results of this scenario indicate that a T-P concentration of approximately 70 ug/L could be expected for segments 3 and 4 (Stations A-4 and A-5) and T-P concentrations in the high 80 ug/L range could be expected at segment 1 (Station A-2). These are estimates which are based on yearly average T-P data and the assumptions outlined in Appendix K. Therefore, the peak T-P concentrations within the embayment could exceed the predicted concentrations which were based on yearly average loadings, concentrations, and flows. The B-P worst case results (100% of design flow with a 639 feet thermocline) predict B-P concentrations of approximately 30 ug/L for segments 2, 3, and 4 and a concentration of 36 ug/L for segment 1 (Station A-2).

Although nutrient loading models have been used frequently for management decisions, they are of limited value unless cause and effect relationships can be established, preferably with field data. At first glance, the embayment monitoring data did not show any direct relationships between phosphorus concentration and algal standing crop as expressed via the chlorophyll a variable under phosphorus limiting conditions. A closer examination of the data, however, revealed that a relationship existed between B-P and chlorophyll a.

This relationship was found by comparing the percent difference between expected chlorophyll a and observed chlorophyll a under phosphorus limiting conditions. Working on the assumption that embayment maximum algal standing crops were not measured all of the time in 1983 because of low sampling frequency (once/ month), we used the AGPT to assist us in our analysis of the data. This approach was based on the premise that potential or expected chlorophyll a represents the maximum standing crop that could be realized under optimum growing conditions in the embayment. Therefore, field measurements near the expected chlorophyll a concentrations would represent collections of phytoplankton standing crop at or near maximum growth only limited by phosphorus availability. With this premise, we compared sample collection data differences between expected and observed chlorophyll a standing crop concentrations (Appendix I). At the 25% and 50% difference level, there appeared to be a relationship between B-P and chlorophyll a, but the data set was too small, in our opinion, to use with confidence (Appendix I). At the 75% difference level, we were able to develop a relationship showing the dependence of chlorophyll a upon B-P (Table 6.9 and Figure 6.3) for the embayment monitoring data. This cause and effect relationship is expressed by the following equation:

ug/L Chl. a = Bioavailable Phosphorus in ug/L (1.10) + 4.84

Applying this equation to the PFR model results (Table 6.8), we developed a range of chlorophyll a concentrations expected under various scenarios (Table 6.10). Projections range from a low of 14.7 ug chlorophyll a/L in embayment segment 4 to a high of 31.2 ug chlorophyll a/L in embayment segment 1. This range is well within the range of maximum values observed in 1983 (Table 5.3), and it is generally comparable to the average maximum chlorophyll a concentrations (Table 5.3) found in 1983. Greatest chlorophyll a concentrations were associated with scenarios of reduced retention time because of the thermocline and increased WWTP loadings. From segments 1 through 4 under worst case conditions, maximum chlorophyll a concentrations ranged from 20.2 ug/L to 44.4 ug/L (Table 6.10).

7. TROPHIC STATE

In order to compare the effects of increasing phosphorus loading and attendant water column concentrations upon trophic status, the Carlson (Carlson, 1977) Trophic State Index (TSI) was used. This index uses a univariate approach to trophic classification. It has several advantages over multivariate approaches because of its simplicity, small data requirement, numerical ranking from 0-100 according to an increasing trophic continuum and its reliance on three of the most common and "best" understood trophic indicators; corrected chlorophyll a, T-P and Secchi disc (SD) transparency. The three variables and their associated TSI's are not considered as the basis of a definition of trophic state, but only as indicators of a more broadly defined concept (Carlson, 1977). For these reasons, Carlson's index has been used widely for the purposes of trophic state classification. Carlson recommended corrected chlorophyll a as the variable of choice, and under most circumstances chlorophyll a is the variable of interest to the public and managers who are concerned with potential nuisance blooms (standing crops) of algae. However, faulty decisions do occur when managers rely heavily on chlorophyll a values derived from waters affected by non-algal turbidity or color. If waters are turbid or colored, then an index based on field chlorophyll a will not measure potential trophic condition. Likewise, SD transparency can be misinterpreted in southern piedmont reservoirs containing large amounts of non-algal particulate matter from sediment loading. Many managers rely on T-P concentrations, but "accurate" index values from T-P depend on the assumption that algal biomass is a function of the concentrations of all forms of phosphorus present in the waterbody. The 18-Mile Creek data analysis of T-P and and chlorophyll a indicates this function does not exist (Appendix I). In our opinion, a better index of trophic condition is one based on B-P or algal growth potential as expressed by chlorophyll a. If one assumes that T-P is equivalent to B-P, then one could easily substitute the

B-P values into the Carlson TSI_{TP} equation. We opted to use the TSI_{Chl} equation for purposes of discussion and comparison.

TSI_{Chl} was calculated from the following equation derived by Carlson (1977):

$$TSI_{Chl} = 10 \left(6 - \frac{2.04 - 0.68 \ln chl.}{\ln 2}\right)$$

Table 7.1 and Figure 7.1 present the conversion of TSI values derived from the chlorophyll a concentrations of Table 6.10. Maximum TSI calculated for different loading scenarios ranged from 61 in segment 4 under 1983 conditions to 68 in section 1 under 100% WWTP design loading. Although all of the TSI values are relatively high and indicative of eutrophic conditions as defined by DHEC (Kimsey, et al., 1982), they still were less than 70 which, in our opinion, is a management action level. DHEC (Kimsey, et al., 1982), in classifying 40 of their major publicly owned reservoirs, found that most were eutrophic and ranked basically the same using several different indexing methods. TSI_{Chl} calculated for the 40 lakes ranged from 22 at Robinson Reservoir to 66 at Greenwood Reservoir. Hartwell Reservoir had a TSI_{Chl} of 59. DHEC has a trend monitoring station (CL-024) located at Station A-2 (segment 1). An average chlorophyll a concentration of 23.35 ug/L was reported for this station in 1980-1981. This concentration is equivalent to a TSI_{Chl} of 61 which was less than the 64 calculated for segment 1 (Stations A-1 to A-2) during our 1983 study (Table 6.7) indicating that the TSI_{Chl} is advancing as WWTP loadings increase. The nuisance bloom complaint on April 14, 1981, that originally involved EPA into the study, was followed up by DHEC (Appendix A). The complaint focused on segment 4 where a Chlamydomonas bloom equivalent to a standing crop of 29.93 ug/L of chlorophyll a was reported (Appendix A). This concentration equates to a TSI_{Chl} of 64. Chlorophyll a concentrations of 30 ug/L would not be unusual in southern piedmont waters during the spring, yet the nonpiedmont public may have a different perception of satisfactory water quality than local long-time residents.

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Table 5.1. Stage Level In Feet Above Mean Sea Level (msl), 18-Mile Creek Embayment, Hartwell Reservoir, S. C., 1983

Month/Day	msl in ft
2/24	659.2
3/9	659.4
3/22	660.9
3/24	661.0
4/12	663.0
4/20	662.7
4/25	662.2
5/17	661.2
5/24	662.6
5/31	662.9
6/1	662.8
6/21	661.5
7/7	660.4
7/19	660.5
8/11	658.3
8/15	657.8
9/19	655.4
11/15	656.5
11/17	656.7

Table 5.2 Euphotic Zone Depth and Secchi Disc
Transparency Depth, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., 1983

	Stations									
	A-1		A-2		A-3		A-4		A-5	
Date	E[1]	T[2]	E	T	E	T	E	T	E	T
2/24	1.3	0.3	1.3	0.3	1.3	0.3	3.2	1.0	4.6	1.5
3/22	2.4	0.5	3.6	1.3	5.0	1.8	11.5	4.2	12.9	4.4
4/12	2.4	0.8	2.2	0.7	2.2	0.7	3.0	1.0	2.6	0.8
5/17	3.0	1.0	6.0	2.6	3.9	10.0	13.5	6.2	16.8	6.2
6/21	2.0	2.6	12.0	4.8	14.0	9.2	15.5	9.8	17.0	9.8
7/19	6.0	1.8	14.0	4.3	16.5	4.9	17.0	9.8	23.5	10.2
8/15	5.5	2.5	9.5	3.1	13.0	3.0	19.0	4.6	33.0	5.9
9/19	2.0	1.3	9.0	3.3	18.0	4.6	19.0	4.8	27.0	5.2
Range	1.3-6.0	0.3-2.6	1.3-14.0	0.3-4.8	1.3-18.0	0.3-10.0	3.0-19.0	1.0-9.8	2.6-33.0	0.8-10.2

[1]E = Euphotic zone depth in ft (1% light transmission depth)

[2]T = Transparency depth in ft

Table 5.3. Vertical Profile Maximum Chlorophyll *a* in ug/L, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., 1983

	STATIONS						
Date	A-1	A-2	A-3	A-4	A-5	$\overline{X}$	Range
2/24	11.93	10.97	10.32	18.38	8.60	12.04	8.60-18.38
3/22	11.87	14.51	12.64	25.80	18.38	16.64	11.87-25.80
4/12	5.64	7.73	11.82	10.68	6.27	8.43	5.64-11.82
5/17	86.43	45.15	18.06	8.71	12.26	34.12	8.71-86.43
6/21	18.71	15.48	13.55	17.74	9.80	15.06	9.80-18.70
7/19	53.54	17.42	11.93	13.55	14.84	22.26	11.93-53.54
8/15	40.32	24.38	18.06	12.26	9.68	20.94	9.68-40.32
9/19	—	26.77	24.19	23.87	14.84	22.42	14.84-26.17
$\overline{X}$	32.63	20.30	15.07	16.37	11.83	19.24	
Range	5.64-86.43	7.73-45.15	10.32-24.19	8.71-25.80	6.27-18.38		

Table 5.4. Horizontal Distribution of Chlorophyll a in u/gL, at the One-Foot Depth, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., August 8, 1983

Date	Station Tran-sect	A	B	C	D	E	F	G	H	Mean	S.D.	% C.V.
08/08/83	1A 0	45.80	36.77	30.32	31.61	35.48	43.22	44.51	33.54	37.66	6.06	16.09
08/08/83	1A 1	21.29	33.54	32.90	36.77					31.13	6.77	21.76
08/08/83	1A 2	18.06	17.74	19.67	16.45					17.98	1.32	7.37
08/08/83	1A 3	23.22	19.35	19.03	21.93	21.29	10.97			19.30	4.38	22.67
08/08/83	1A 4	14.19	17.74	19.03	15.80					16.69	2.13	12.77
08/08/83	2A 0	11.67	12.26	12.45	14.53	15.80	14.19			13.48	1.60	11.87
08/08/83	2A 1	10.96	11.14	9.68	9.40					10.30	0.88	8.57
08/08/83	2A 2	11.43	13.48	10.55	10.32					11.44	1.44	12.57
08/08/83	3A 0	9.68	9.68	7.74	12.26	11.61				10.19	1.79	17.56
08/08/83	3A 1	8.38	10.32	14.19	7.74					10.16	2.90	28.58
08/08/83	3A 2	9.03	10.96	8.38	10.96					9.83	1.33	13.51
08/08/83	4A 0	8.58	7.55	--	7.42	7.74	5.29	4.52	8.00	7.01	1.51	21.46
08/08/83	4A 1	7.74	7.74	8.38	5.80					7.42	1.12	15.08
08/08/83	4A 2	7.74	5.80	6.45	6.45					6.61	0.81	12.30
08/08/83	5A 0	6.51	6.84	7.74	7.03	5.55	7.35			6.84	0.76	11.10
08/08/83	5A 1	7.42	7.74	7.42	5.16					6.93	1.19	17.20
08/08/83	5A 2	5.93	6.77	5.48	5.16					5.84	0.70	11.98
						Overall Statistics				14.35	10.12	70.54

[1]S.D. = Standard Deviation

[2]C.V. = Coefficient of Variation

Table 5.5. Summary of Pendleton-Clemson WWTP and 18-Mile Creek Water Quality Data, Hartwell Reservoir, S.C., 1983.

Station	Flow (cfs)	T-P (mg/L)	T-P (lb/d)	B-P (mg/L)	B-P (lb/d)
EC-1	91.4 (37-211)	0.178 (0.09-0.77)	82.4 (30-821)	0.72 (0.007-0.774)	43.3 (3-327)

Station	Flow (mgd)	T-P (mg/L)	T-P (lb/d)	B-P (mg/L)	B-P (lb/d)
CP-001	0.55 (0.3-1.35)	6.1 (1-30)	28.1 (1-270)	3.14 (0.21-14.93)	12.38 (<1-78)

[1]Range in parentheses

[2]The average plant flow during the January to November period was 0.45 mgd

[3]4.0 mg/L excluding June - July high flow event (median of all T-P concentrations was 4.2 mg/L)

[4]Low weekly flow for the year (January - December) was 0.328 mgd

Table 5.6. Eighteen Mile Creek Point Source Discharges, Hartwell Reservoir, S.C., August 9-11, 1983.

Point Source	Day	Flow MGD	NH_3-N Conc. mg/L	NH_3-N Load lb/d	Total P Conc. mg/L	Total P Load lb/d
Liberty Lusk	1	0.073	11.00	6.70	8.8	5.36
	2	0.073	14.80	9.01	8.4	5.12
Liberty Owens	1	0.0437	21.50	7.84	7.8	2.84
	2	0.0338	21.00	5.92	6.3	1.78
Whispering Pines	1	0.0427	4.35	1.55	7.9	2.81
	2	0.0388	4.25	1.37	7.7	2.49
Dan River	1	0.249	0.62	1.28	2.6	5.40
	2	0.240	0.65	1.30	2.7	5.40
Easley Lagoon 001	1	0.098	9.00	7.36	8.5	6.95
	2	0.089	7.60	5.64	8.6	6.38
Easley Lagoon 002	1	0.12	7.00	7.00	7.9	7.90
	2	0.11	5.40	4.95	7.8	7.16
Town of Central	1	0.197	0.20	0.33	2.7	4.44
	2	0.194	0.24	0.39	3.7	5.99
Pendleton Finishing	1	2.20	0.07	1.28	0.8	14.7
	2	2.20	0.09	1.65	0.8	14.7
Pendleton-Clemson WWTP	1	0.394	21.00	69.00	14.0	46.0
	2	0.390	19.00	61.80	11.0	35.8
Point Source Totals	1	3.42		102.30		96.5
	2	3.37		92.00		84.8
Eighteen Mile Ck (EC-1)	1	24.00	0.69	138.10	0.6	120.1
	2	23.87	0.98	195.10	0.5	99.5

Table 5.7. Water Quality Monitoring Data for Pendleton-Clemson WWTP and Creek Station EC-1, Hartwell Reservoir, S.C., March 1983.

Location: WQ Station (EC-1)

Date	Time	Time	Stage (ft.)	Flow (cfs)	T-P (mg/L)	T-P (lb/d)	B-P (mg/L)	B-P (lb/d)	TSS (mg/L)	TSS (lb/d)
3/19-20	1200-0600	0	0.86	65.10	0.11	39	0.041	14	43	15088
3/20	1200	6	0.81	61.60	0.09	30	0.032	11	160	53124
3/20	1800	12	0.82	62.30	0.10	34	0.029	10	210	70517
3/20	2400	18	1.38	115.30	0.19	118	0.048	30	210	130508
3/21	0600	24	1.75	173.20	0.50	467	0.035	33	390	364084
3/21	1200	30	1.80	183.10	0.35	345	—	0	350	345418
3/21	1800	36	1.48	128.70	0.31	215	—	0	210	145676
3/21	2400	42	1.26	101.10	0.20	109	0.016	9	200	108986
3/22	0600	48	1.16	90.60	0.15	73	0.063	31	78	38090
3/22	1200	54	1.10	84.80	0.13	59	0.073	33	130	59419
3/22	1800	60	1.07	82.00	0.14	62	0.063	28	280	123754
3/22	2400	66	1.03	78.50	0.12	51	0.056	24	120	50774
3/23-24	0600-0600	72	0.96	72.70	0.11	43	0.033	13	54	21160

Location: Pendleton-Clemson WWTP (CP-001)

Date	Time	Time	Flow (mgd)	% T-P (lb/d)	T-P (mg/L)	T-P (lb/d)	B-P (mg/L)	B-P (lb/d)	TSS (mg/L)	TSS (lb/d)
3/19-20	1140-0540	0	0.39	36	4.40	14	3.93	13	4	13
3/20	1140	6	0.31	43	5.20	13	—	0	5	13
3/20	1740	12	0.42	47	4.70	16	—	0	3	11
3/20	2340	18	0.65	19	4.30	23	2.46	13	5	27
3/21	0540	24	1.35	58	24.00	270	—	0	1100	12385
3/21	1740	36	0.65	14	5.70	31	—	0	98	531
3/21	2340	42	0.67	23	4.50	25	3.02	17	37	207
3/22	0540	48	0.25	11	3.60	8	—	0	6	13
3/22	1140	54	0.60	25	2.90	15	2.36	12	NA	0
3/22	1740	60	0.52	13	1.80	8	—	0	NA	0
3/22	2340	66	0.57	20	2.00	10	3.1	15	NA	0
3/23-24	2400-2400	72	0.43	19	2.30	8	3.27	12	6	22

Table 5.8. Dye Tracer Results, 18-Mile Creek, Hartwell Reservoir, S.C., 1983

Station	High Flow Study: Flow (cfs)	T-P (mg/L)	B-P (mg/L)	TSS (mg/L)	Elapsed Time (hr)	Distance (miles)	Low Flow Study: Flow (cfs)	T-P (mg/L)	B-P (mg/L)	TSS (mg/L)	Elapsed Time (hr)
EC-1	86.7	0.21	0.149	96	--	0	58	0.20	0.073	20	--
EC-2 1/	88.6	0.27	0.231	85	0.33	0.45	58	0.27	0.078	37	0.40
EC-3	90.6	0.28	0.225	110	0.75	0.93	58	0.24	0.091	41	0.88
EC-4	--	--	--	--	--	1.71	58	0.20	0.122	41	1.61
EC-5	94.6	0.31	0.224	100	2.02	2.16	58	*0.18	0.142	37	2.50
EC-6	97.8	0.30	0.216	110	2.55	2.42	58	0.14	0.086	15	5.31
EC-7	98.9	0.34	0.216	130	2.85	2.83	58	0.11	0.119	17	7.65
EC-8	103.3	*0.36	0.239	120	3.21	3.21	58	--	--	--	--
A1.1	--	0.17	0.128	15	7.12	3.42	58	--	--	--	--
A1.2	--					3.46	58	.08	0.007	11	22.1
A2.5	--	0.07	0.042	10	24.9	4.07	58	--	--		

1/ Significant tributary influence between EC-1 and EC-2

* Pool interface

Table 6.1. Basic Parameters and Phosphorus Predictions for 18-Mile Creek Embayment, Hartwell Reservoir, S.C.

Basic Embayment Parameters

Symbol	Units	Parameter	Value
$\bar{z}$	m	Mean Depth	5.8
	ft		19.0
A	ac	Surface Area	180
	ha		72.9
	ft^2		7.8×10^6
	m^2		7.3×10^5
V	Ac-ft	Volume	3450
	ft^3		1.5×10^8
	m^3		4.3×10^6
T_w	d	Detention Time	18.6
T_w	yr		0.051
q_s	m/yr	Areal Water Loading	112
T-P	ug/L	Input T-P Concentration	118
B-P	ug/L	Input B-P Concentration	67

Based on Modified Vollenweider

Symbol	Units	Parameter	Value
T-P	lb/d	Average T-P Loading (unadjusted)	82.4
		Average T-P Loading (adjusted)	71.5
B-P	lb/d	Average B-P Loading (adjusted)	33.8
L_c	gm T-P/m^2/yr	Areal T-P Loading	16.3
	gm B-P/m^2/yr	Areal B-P Loading	7.7
T-P	ug/L	Arm Steady State T-P Concentration	43
B-P	ug/L	Arm Steady State B-P Concentration	9
σ	yr^{-1}	T-P Sedimentation Coefficient	46.5
σ	yr^{-1}	B-P Sedimentation Coefficient	126
v_s	m/yr	Apparant Settling Velocity	270

Table 6.1 (Continued)

Based on Plug Flow Model (PFM)

	σ_1 T-P yr^{-1}	T-P	Phosphorus Sedimentation Coefficient Segment 1	107
	σ_2 T-P yr^{-1}		Phosphorus Sedimentation Coefficient Segment 2	35
	σ_3 T-P yr^{-1}		Phosphorus Sedimentation Coefficient Segment 3	43
	σ_4 T-P yr^{-1}		Phosphorus Sedimentation Coefficient Segment 4	0
	σ_1 B-P yr^{-1}	B-P	Phosphorus Sedimentation Coefficient Segment 1	194
	σ_2 B-P yr^{-1}		Phosphorus Sedimentation Coefficient Segment 2	56
	σ_3 B-P yr^{-1}		Phosphorus Sedimentation Coefficient Segment 3	17
	σ_4 B-P yr^{-1}		Phosphorus Sedimentation Coefficient Segment 4	35
628 MSL	T_1 yr^{-1}	Segment 1	Detention Time with Thermocline at 628 ft MSL	.00530
	T_2 yr^{-1}	2		.00470
	T_3 yr^{-1}	3		.00396
	T_4 yr^{-1}	4		.00480
639 MSL	T_1 yr^{-1}	Segment 1	Detention Time with Thermocline at 639 ft MSL	.00530
	T_2 yr^{-1}	2		.00340
	T_3 yr^{-1}	3		.00220
	T_4 yr^{-1}	4		.00137

Table 6.2 Weighted Average Phosphorus Loadings, 18-Mile Creek, Hartwell Reservoir, S.C., 1983

Event	Days	T-P (lb/d)	Q (cfs)	Pool Level (ft msl)
March 19-24	6	96.7	99.9	661
April 14-20	6	47.8	98.6	663
April 23-24	2	68.4	101.6	662
May 13-18	6	63.0	93.5	661
May 18-23	6	113.4	107.4	661
June 30-July 6	7	95.4	57.0	663
August 9-11	2	109.9	37.2	658
November 14-15	1	98.0	87.0	656
Weighted Average		82.4	91.4	661

[1]Weighted Average = $\dfrac{\varepsilon \text{ days x T-P (lb/d)}}{\varepsilon \text{ days}}$

[2]Weighted Average = $\dfrac{\varepsilon \text{ days x Q (cfs)}}{\varepsilon \text{ days}}$

Table 6.3 Recorded Rainfall at Pendleton-Clemson WWTP, 18-Mile Creek, Hartwell Reservoir, S.C., 1983

January	Rainfall (in)	February	Rainfall (in)	March	Rainfall (in)
		02/02/83	1.36	03/01/83	0.17
01/02/83	1.05	02/06/83	0.45	03/06/83	1.48
01/03/83	0.25	02/07/83	0.58	03/08/83	0.21
01/04/83	0.25	02/10/83	0.02	03/18/83	0.09
01/10/83	0.09	02/11/83	0.49	03/19/83	0.47
01/11/83	0.17	02/14/83	0.41	03/22/83	1.16
01/12/83	0.19	02/15/83	0.27	03/25/83	0.18
01/28/83	0.06	02/23/83	2.00	03/26/83	0.55
01/31/83	0.12	02/25/83	0.02	03/27/83	1.50
				03/28/83	0.05
				03/31/83	0.42

April	Rainfall (in)	May	Rainfall (in)	June	Rainfall (in)
04/02/83	0.61	05/04/83	0.34	06/02/83	0.11
04/03/83	0.06	05/08/83	0.10	06/03/83	0.02
04/06/83	0.76	05/14/83	1.67	06/05/83	0.40
04/07/83	0.04	05/16/83	0.48	06/07/83	0.02
04/08/83	0.06	05/17/83	0.89	06/08/83	0.32
04/09/83	0.98	05/19/83	0.07	06/17/83	0.34
04/10/83	0.46	05/20/83	0.83	06/18/83	0.06
04/15/83	0.20	05/21/83	0.43	06/20/83	0.03
04/18/83	0.04	05/22/83	0.05	06/28/83	0.04
04/19/83	0.16	05/23/83	0.28	06/29/83	0.03
04/22/83	0.04				
04/23/83	0.12				
04/24/83	0.52				

July	Rainfall (in)	August	Rainfall (in)	September	Rainfall (in)
07/01/83	0.88	08/02/83	0.18	09/01/83	0.12
07/06/83	0.03	08/06/83	0.13	09/02/83	0.52
07/12/83	0.04	08/08/83	0.08	09/03/83	0.78
07/26/83	0.71	08/12/83	0.50	09/04/83	0.52
		08/25/83	0.67	09/05/83	0.02
		08/26/83	0.04	09/12/83	0.05
				09/13/83	0.19
				09/20/83	0.03
				09/21/83	0.45
				09/22/83	0.29

October	Rainfall (in)	November	Rainfall (in)	December	Rainfall (in)
10/12/83	1.75	11/04/83	0.50	12/02/83	1.60
10/13/83	0.00	11/05/83	0.18	12/03/83	1.83
10/14/83	0.32	11/10/83	0.09	12/06/83	2.10
10/23/83	0.79	11/11/83	0.09	12/12/83	1.80
10/24/83	0.33	11/15/83	1.25	12/14/83	0.06
		11/16/83	0.44	12/15/83	0.13
		11/20/83	0.25	12/22/83	0.93
		11/21/83	0.26	12/23/83	0.30
				12/28/83	0.87
				12/29/83	0.34

Table 6.4. Phosphorus Concentration Predictions
Based on Vollenweider Loading Model, 18-Mile Creek Embayment,
Hartwell Reservoir, S.C., 1983

	Pool (ft)	σ (yr^{-1})	Area (Ac)	Volume (Ac-ft)	$\bar{z}$ (m)	T-P (lb/d)	L_c (gm T-P/m^2/yr)	Predicted T-P* (ug/L)	B-P (lb/d)	L_c (gm B-P/m^2/yr)	Predicted B-P (ug/L)
Total Phosphorus Model Adjusted for Sampling and Transport	661	46.5	180	3450	5.8	71.5	16.3	43	--	--	--
Bioavailable Phosphorus Model Adjusted for Sampling and Transport	661	126	180	3450	5.8	--	--	--	33.8	7.7	9

*Calculated using the formula: $\text{T-P (mg/L)} = \dfrac{L_c}{\bar{z}\,(1/T_w + \sigma)}$

Table 6.5 Average Phosphorus Concentrations, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., 1983

LAKE STATION	AVERAGE T-P (ug/L)	AVERAGE B-P (ug/L)
A-1	118	67
A-2	67	24
A-3	56	18
A-4	35	15
A-5	35	9

Table 6.6. Segment Area-Volume Data, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., 1983

SECTION	SEGMENT	SEGMENT VOLUME (Ac-ft)	AREA (Ac)	VOLUME (Ac-ft)
1			9.8	27.6
2			8.6	30.2
3			1.7	12.4
4			2.6	15.4
5			8.5	76.8
6	1	348.6	18.9	186.2
7			7.5	73.4
8			9.0	103.1
9			3.2	46.1
10			2.3	30.7
11	2	339.2	5.8	85.9
12			6.9	105.6
13			11.1	296.4
14	3	725.9	10.1	323.9
15			15.3	448.5
16			9.7	279.6
17	4	951.7	9.1	223.6
18			12.8	414.5
19			5.8	203.0
20			3.0	112.1
TOTAL			161.7	3095.0

Table 6.7. Total Phosphorus Embayment Concentration Predictions Based on Plug Flow Loading Model, 18-Mile Creek Embayment, Hartwell Reservoir, S.C.

Segment	Station	σ (yr^{-1})*	Observed T-P (ug/L)	Epilimnion at 628 msl T-P (ug/L)	Epilimnion at 639 msl T-P (ug/L)	WWTP at 75% Design Flow T-P (ug/L)			WWTP at 100% Design Flow T-P (ug/L)		
						Embayment	628 msl	639 msl	Embayment	628 msl	639 msl
Input	A-1	--	118	118	118	138	138	138	155	155	155
1	A-2	107	67	67	67	78	78	78	88	88	88
2	A-3	35	56	57	59	65	66	69	73	75	78
3	A-4	43	35	48	54	41	56	63	46	63	71
4	A-5	0	35	48	54	41	56	63	46	63	71

*Based on observed T-P data from Hartwell Reservoir, 18-Mile Creek Area.

Table 6.8. Bioavailable Phosphorus Embayment Concentration Predictions Based on Plug Flow Loading Model, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., 1983.

Segment	Station	σ (yr^{-1})*	Observed B-P (ug/L)	Epilimnion at 628 msl B-P (ug/L)	Epilimnion at 639 msl B-P (ug/L)	WWTP at 75% Design Flow B-P (ug/L)			WWTP at 100% Design Flow B-P (ug/L)		
						Embayment	628 msl	639 msl	Embayment	628 msl	639 msl
Input	A-1	--	67	67	67	84	84	84	100	100	100
1	A-2	194	24	24	24	30	30	30	36	36	36
2	A-3	56	18	18	20	23	23	25	27	28	30
3	A-4	17	15	17	19	19	22	24	22	26	29
4	A-5	35	9	14	18	11	19	23	14	22	28

*Based on observed B-P data from Hartwell Reservoir, 18-Mile Creek Area.

Table 6.9. Regression Analysis of Bioavailable Phosphorus and Chlorophyll a, 18-Mile Creek Embayment, Hartwell Reservoir, S.C., 1983

Source	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
Model	1	169.26683526	169.26683526	32.74
Error	10	51.70576474	5.17057647	PR > F
Corrected Total	11	220.97260000		0.0002

R-Square	C.V.	ROOT MSE	CHLA_OBS MEAN
0.766008	21.5127	2.27389016	10.57000000

Source	DF	TYPE I SS	F VALUE	PR > F
BP	1	169.26683526	32.74	0.0002

Parameter	Estimate	T FOR HO: PARAMETER=0	PR > |T|	ST ERROR OF ESTIMATE
Intercept	4.83507898	4.04	0.0024	1.19814356
BP	1.09934588	5.72	0.0002	0.19214005

Table 6.10. Range of Average Embayment Chlorophyll *a* Concentrations (ug/L) Under Different Loading[a] Conditions, 18-Mile Creek Embayment, Hartwell Reservoir, S.C.

Segments	1983 Loading	WWTP at 75% Design	WWTP at 100% Design
1	31.2	37.8	44.4
2	24.6-26.8	30.1-32.3	34.5-37.8
3	21.3-25.7	25.7-31.2	29.0-36.7
4	14.7-24.6	16.9-30.1	20.2-35.6

[a]Calculations of corrected chlorophyll *a* derived from bioavailable phosphorus concentrations of Table 6.7.

Table 7.1. Maximum Embayment TSI Under Different Loading Conditions, 18-Mile Creek Embayment, Hartwell Reservoir, S.C.

Segments	1983	WWTP at 75% Design	WWTP at 100% Design
1	64	66	68
2	63	65	66
3	62	64	66
4	61	64	66
Ave	62	65	66

FIGURE 2.1

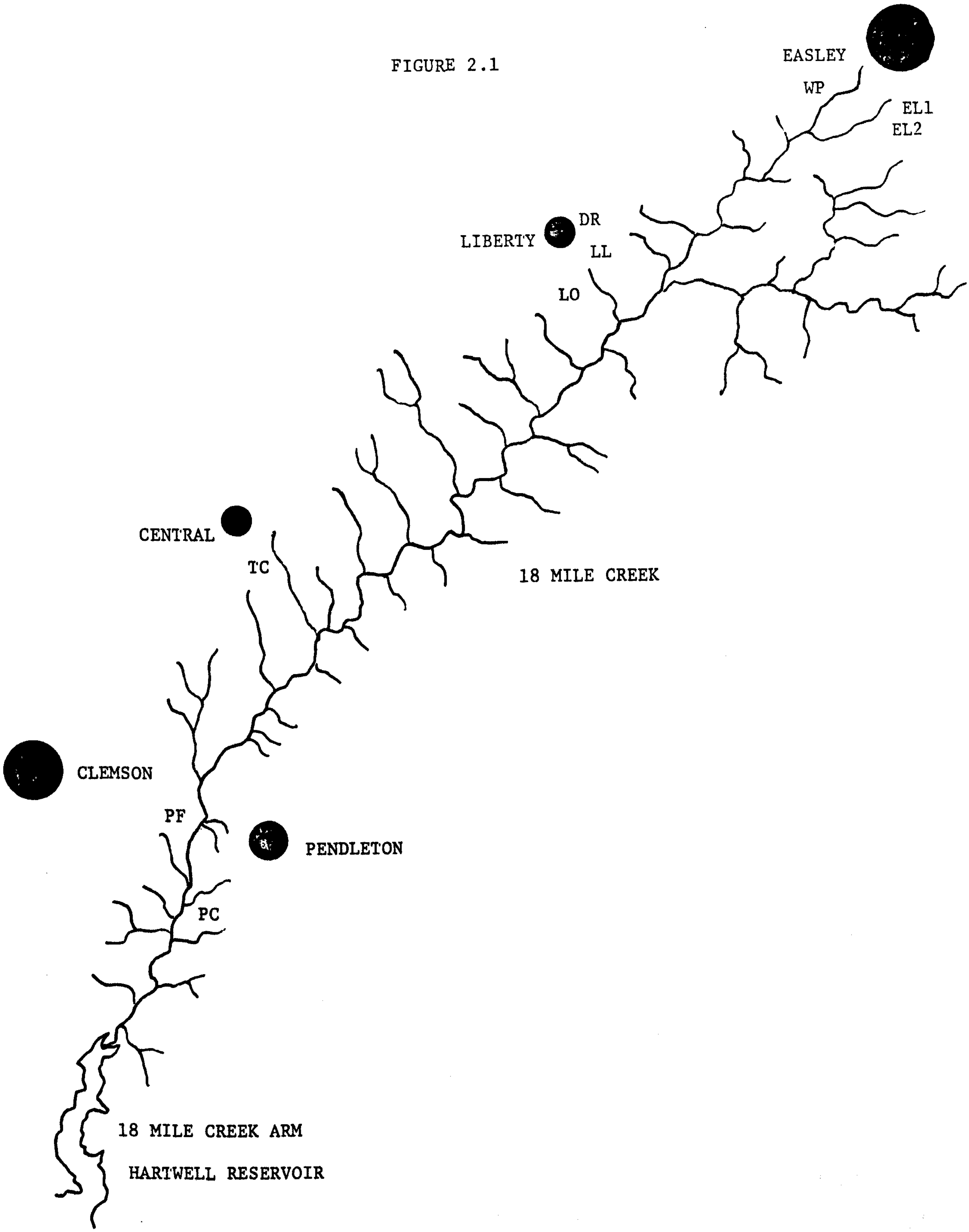

EASLEY
WP
EL1
EL2
DR
LIBERTY
LL
LO
CENTRAL
TC
18 MILE CREEK
CLEMSON
PF
PENDLETON
PC
18 MILE CREEK ARM
HARTWELL RESERVOIR

FIGURE 3.1

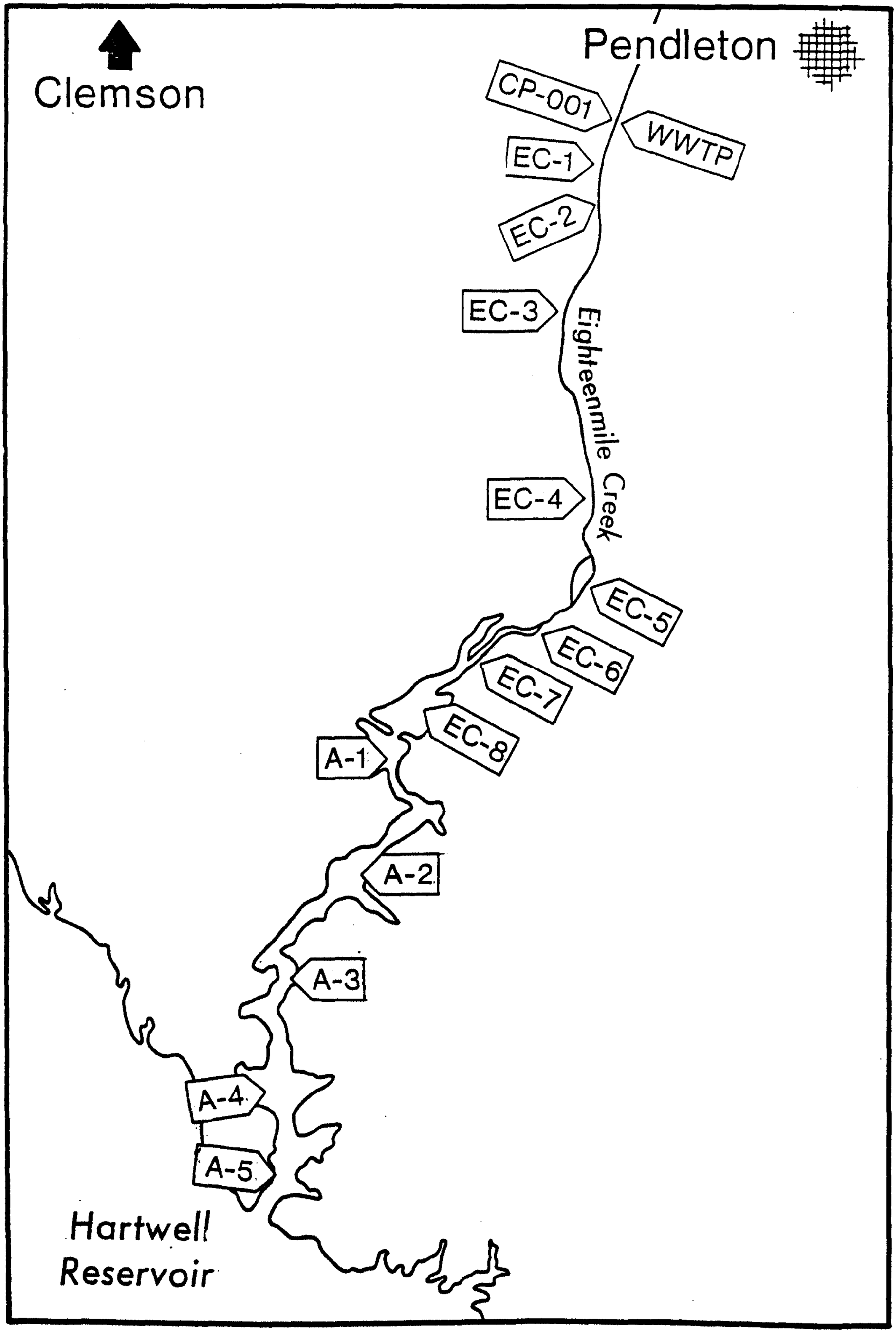

Clemson
Pendleton
CP-001
WWTP
EC-1
EC-2
EC-3
Eighteenmile Creek
EC-4
EC-5
EC-6
EC-7
EC-8
A-1
A-2
A-3
A-4
A-5
Hartwell
Reservoir

FIGURE 3.2

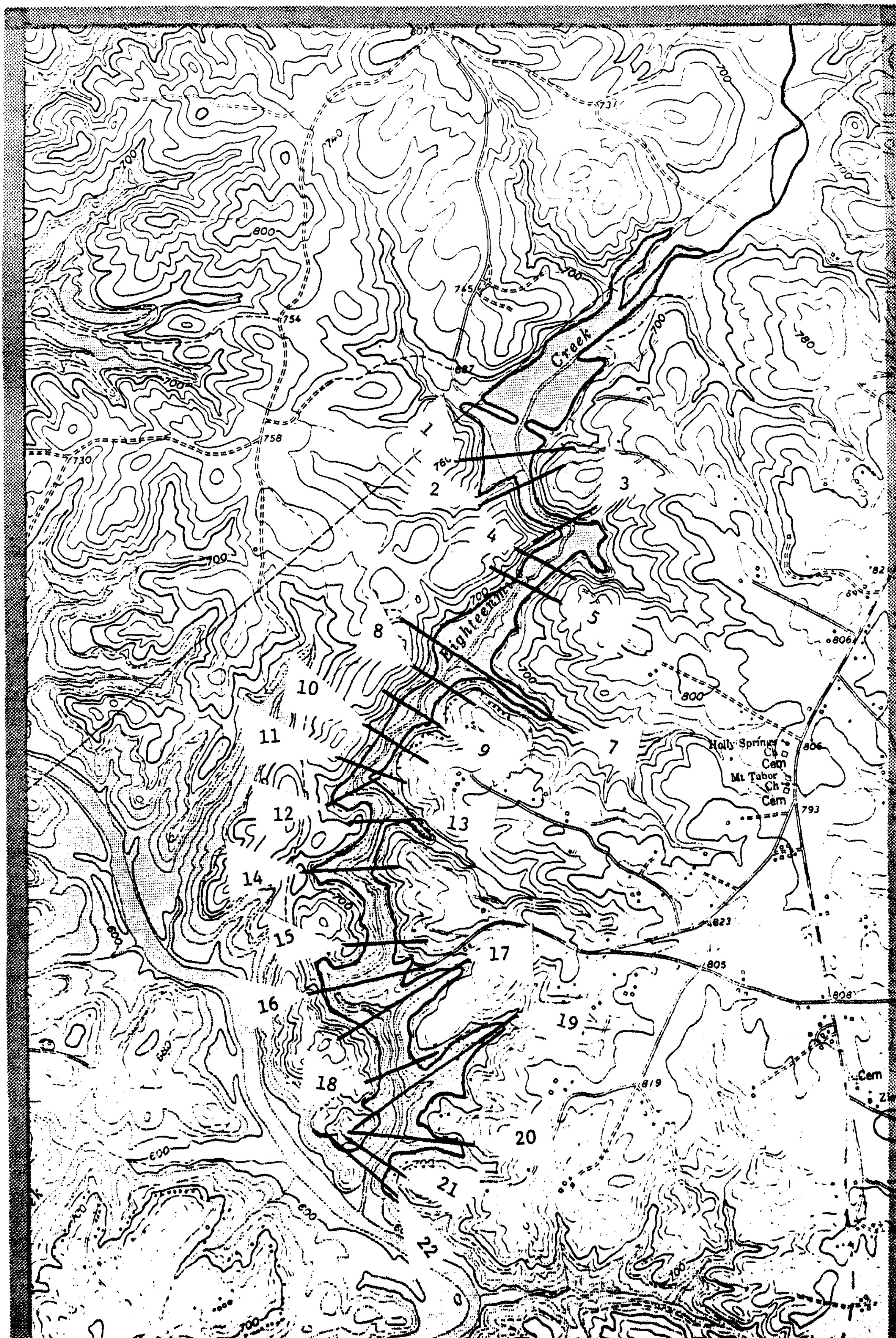

Creek
Eighteenmile
Holly Springs
Ch
Cem
Mt Tabor
Ch
Cem
Cem
1
2
3
4
5
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Figure 4.1

Area–Volume Curve, 18-Mile Creek Embayment
Hartwell Reservoir, South Carolina, 1983

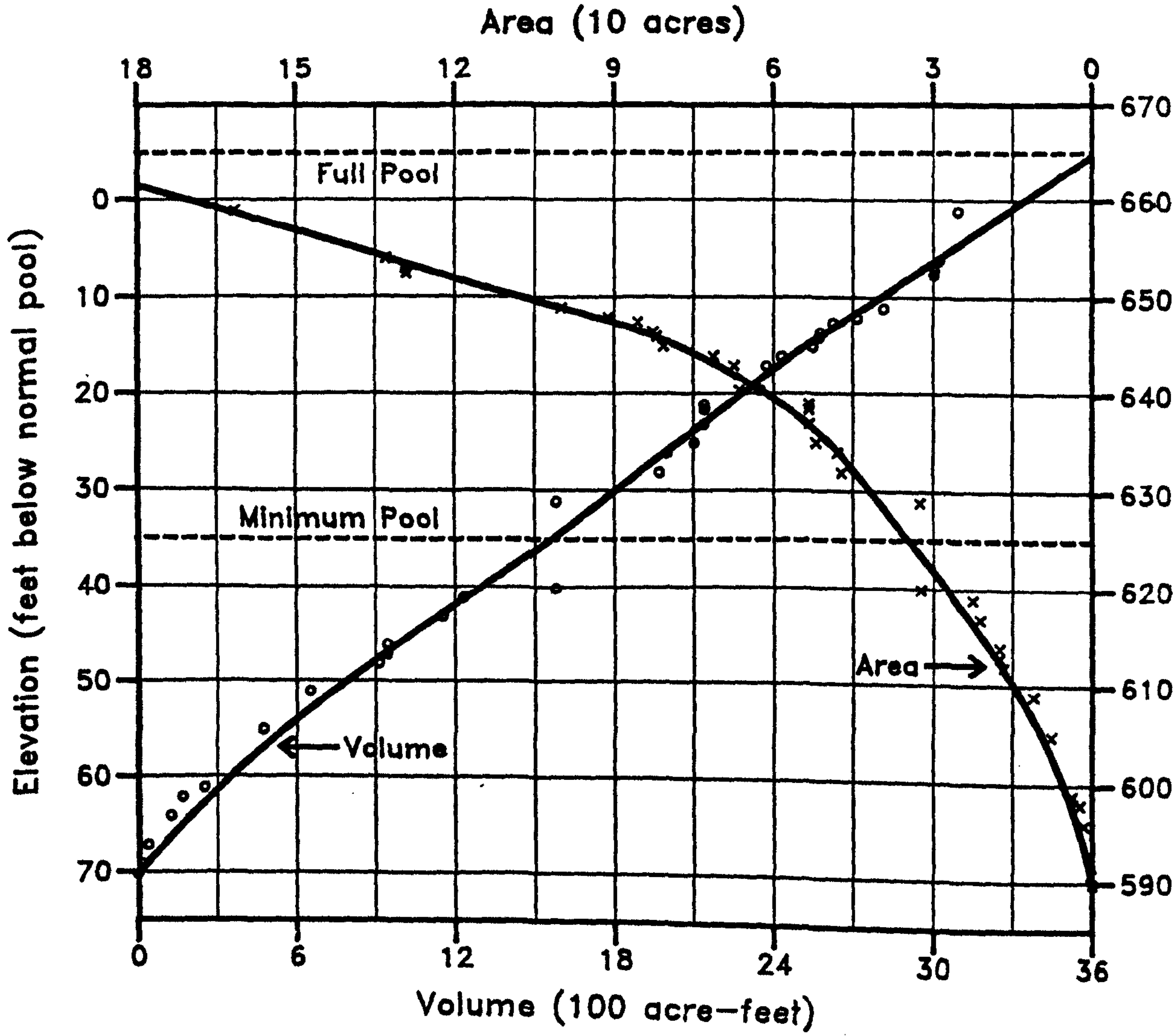


Figure 4.2

Stage – Discharge Curve, 18-Mile Creek at EC-1
Hartwell Reservoir, South Carolina, 1983

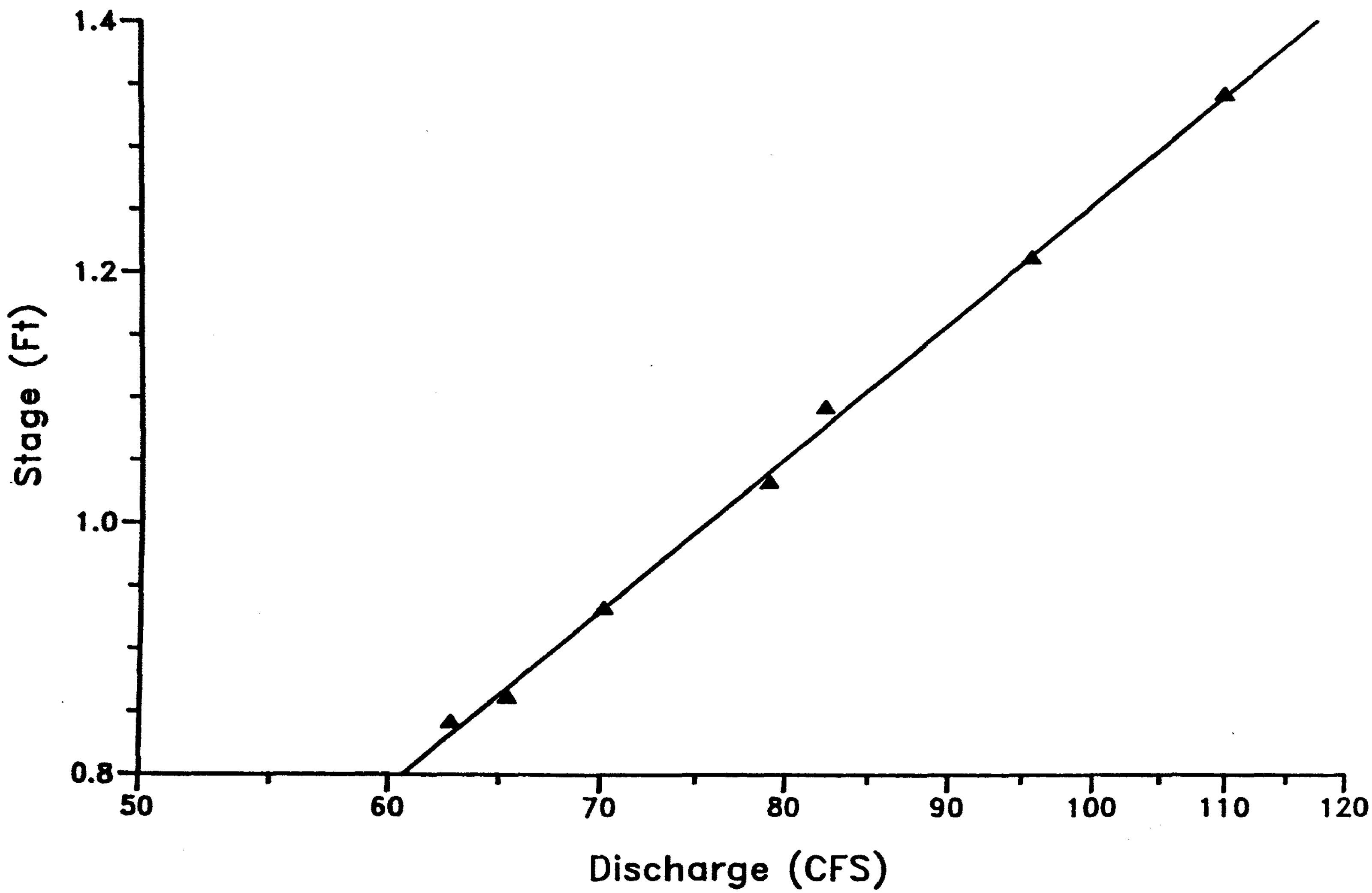


Figure 5.1

Depth Profile Curves of Temperature
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A–1

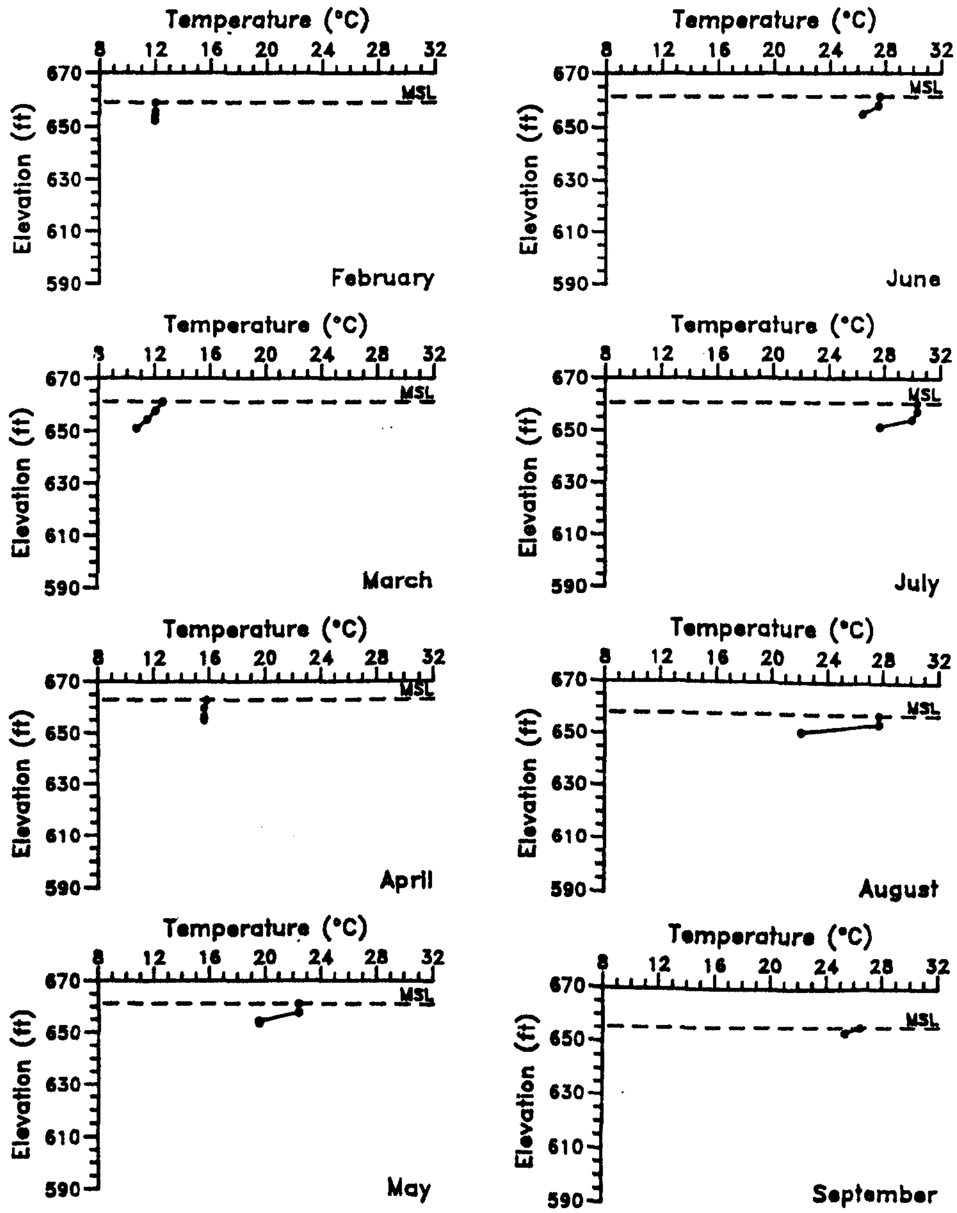


Figure 5.2

Depth Profile Curves of Temperature
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-2

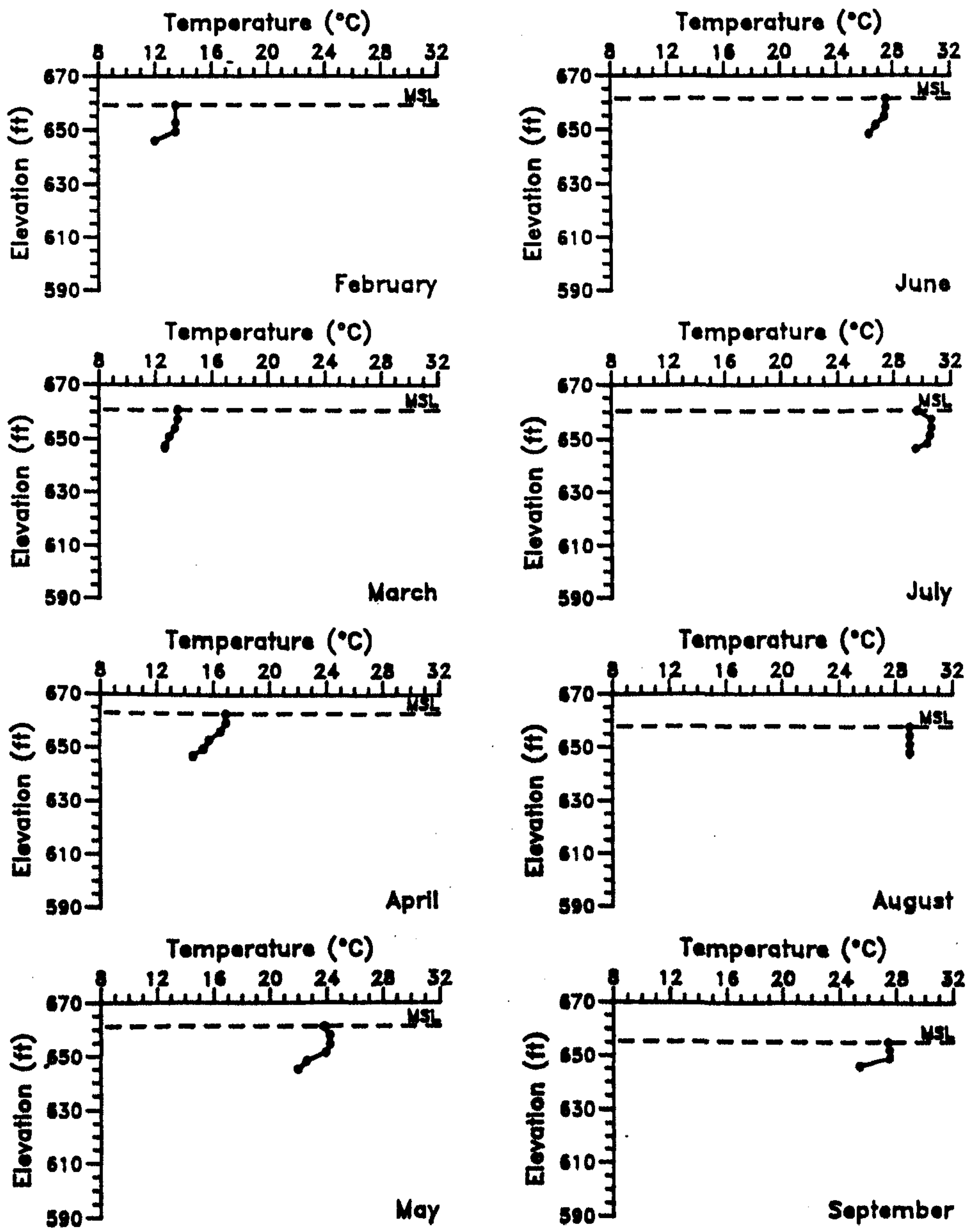


Figure 5.3

Depth Profile Curves of Temperature
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A–3

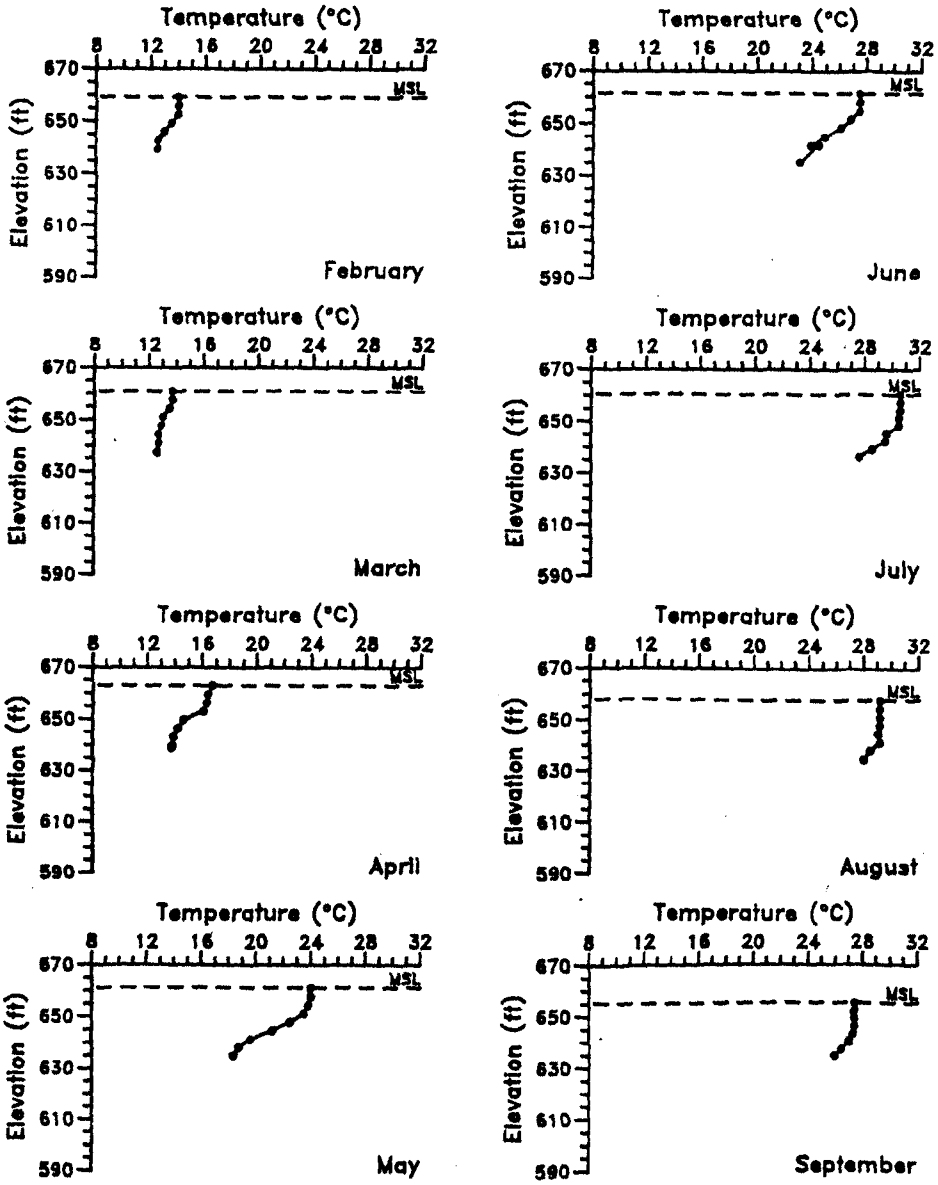


Figure 5.4

Depth Profile Curves of Temperature
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-4

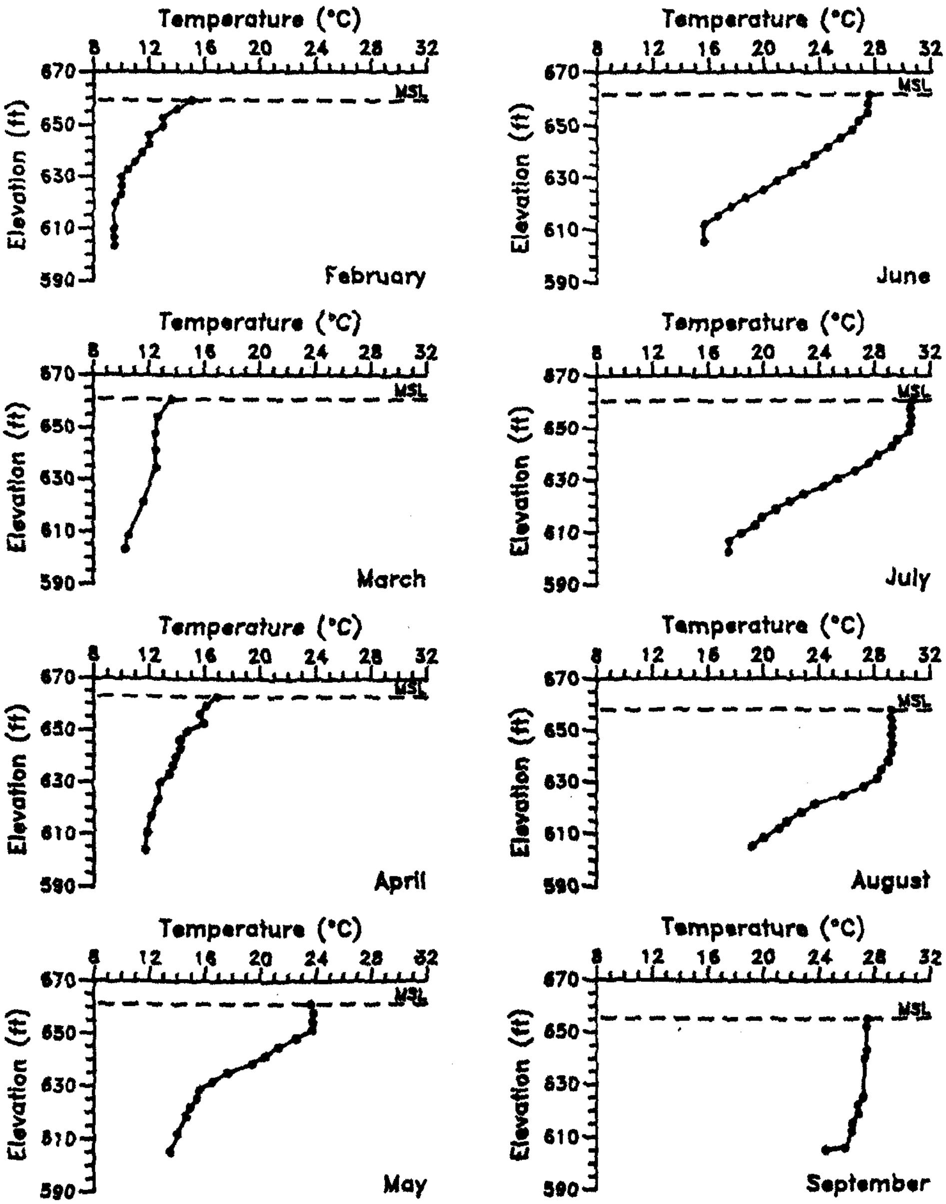


Figure 5.5

Depth Profile Curves of Temperature
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-5

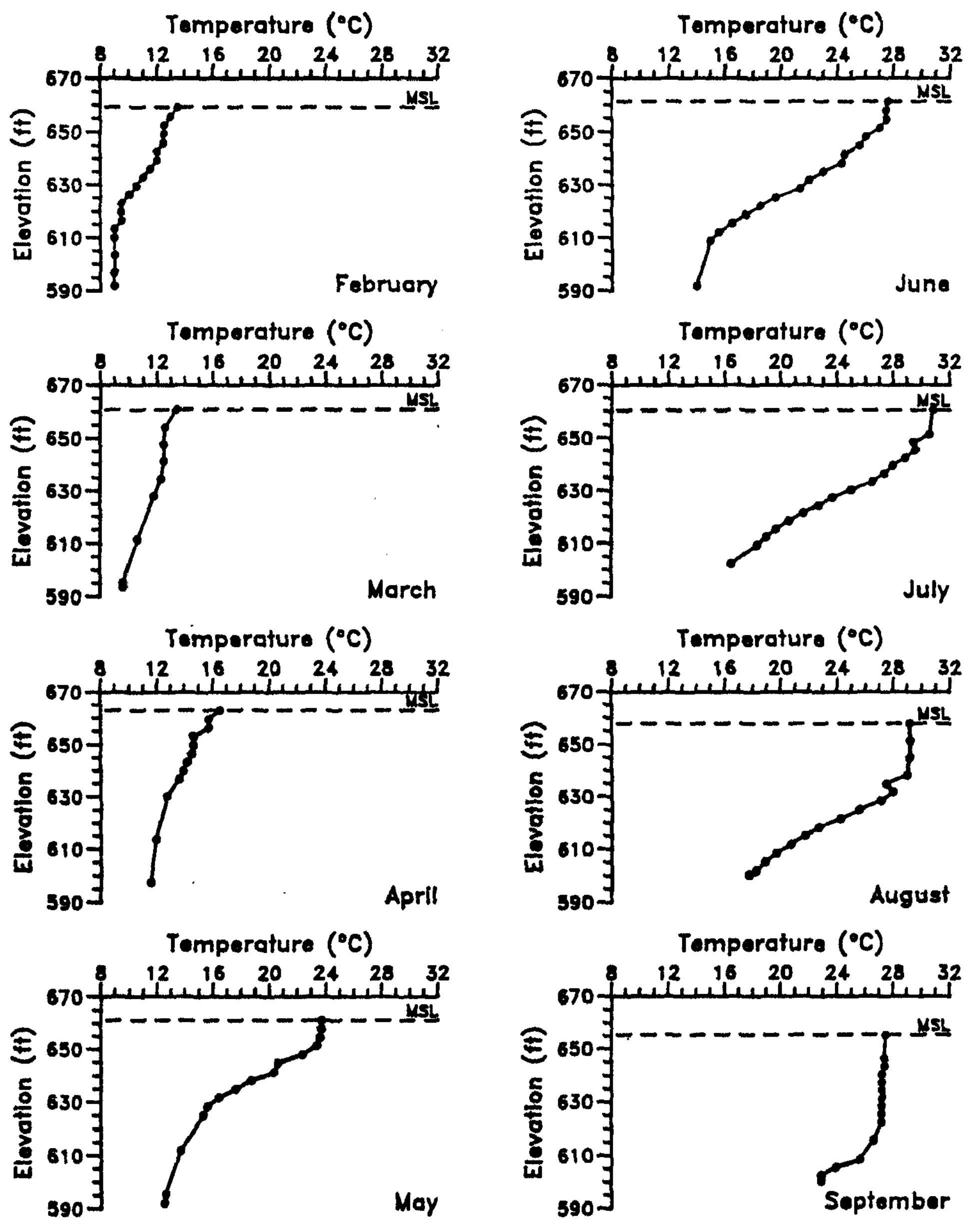


Figure 5.6

Longitudinal Depth Profile of Temperature (°C)
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, March, 1983

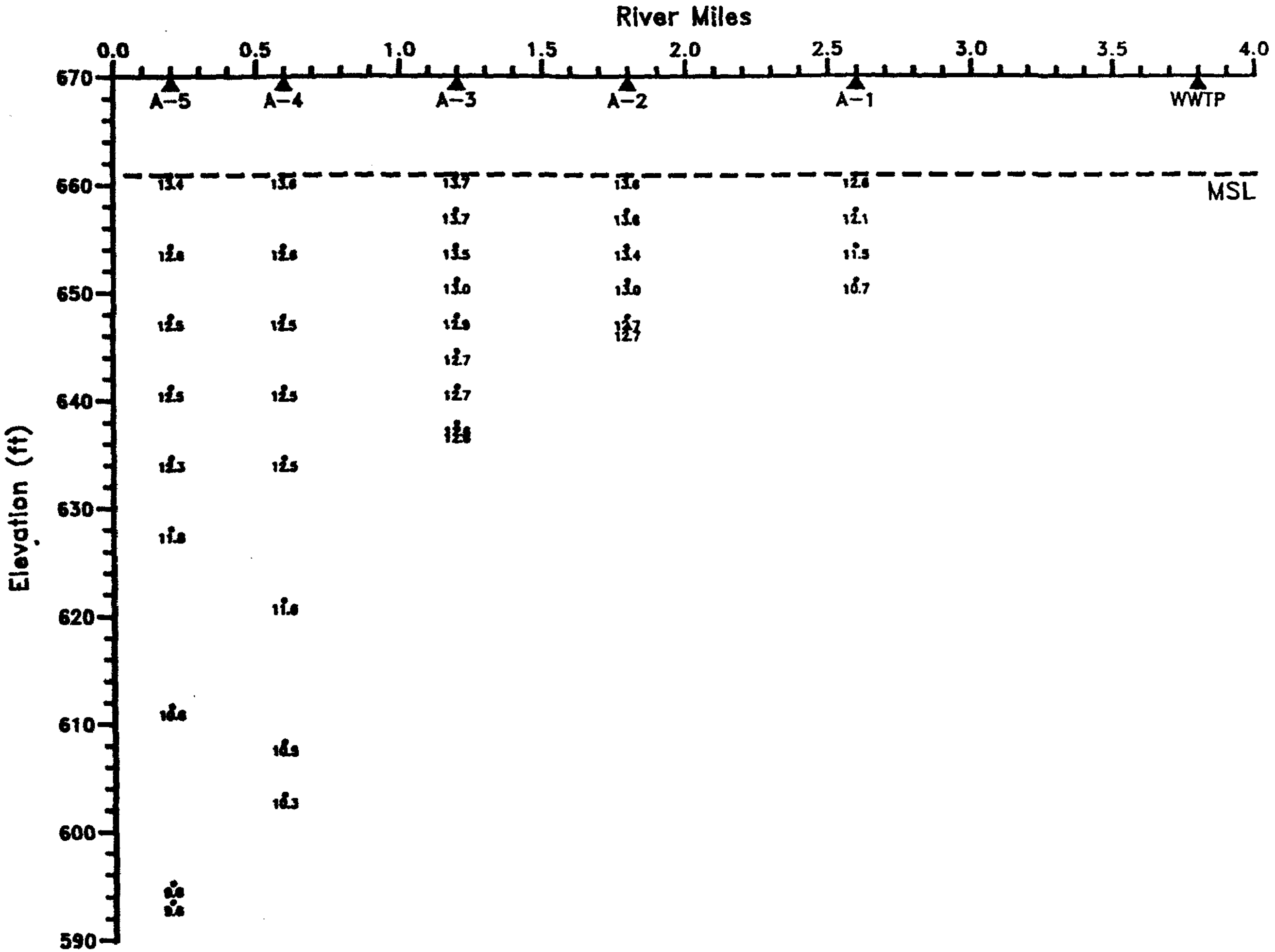


Figure 5.7

Longitudinal Depth Profile of Temperature (°C)
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, July, 1983

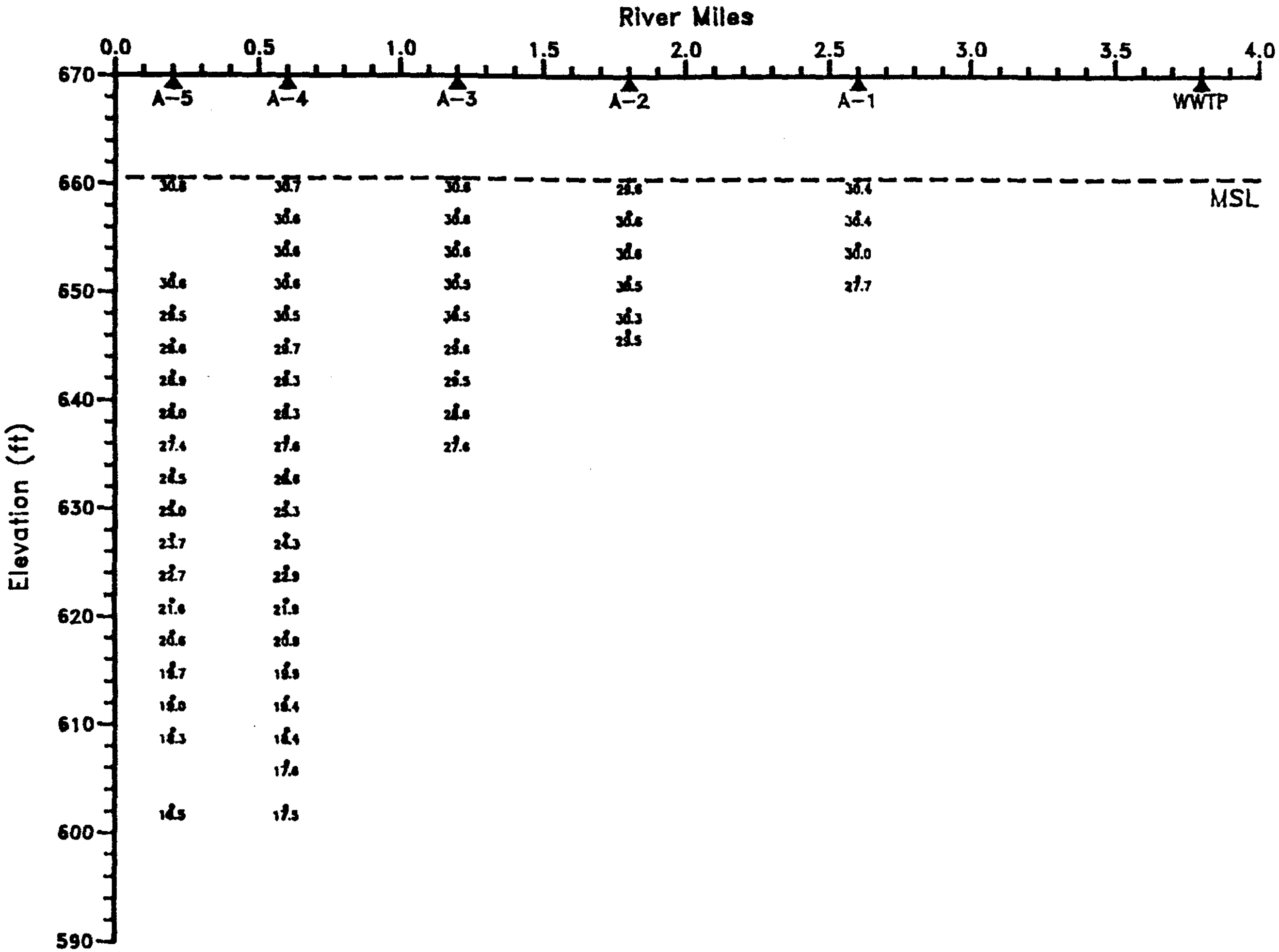


Figure 5.8

Rainfall, 18 Mile Creek Watershed
Hartwell Reservoir, South Carolina, 1983

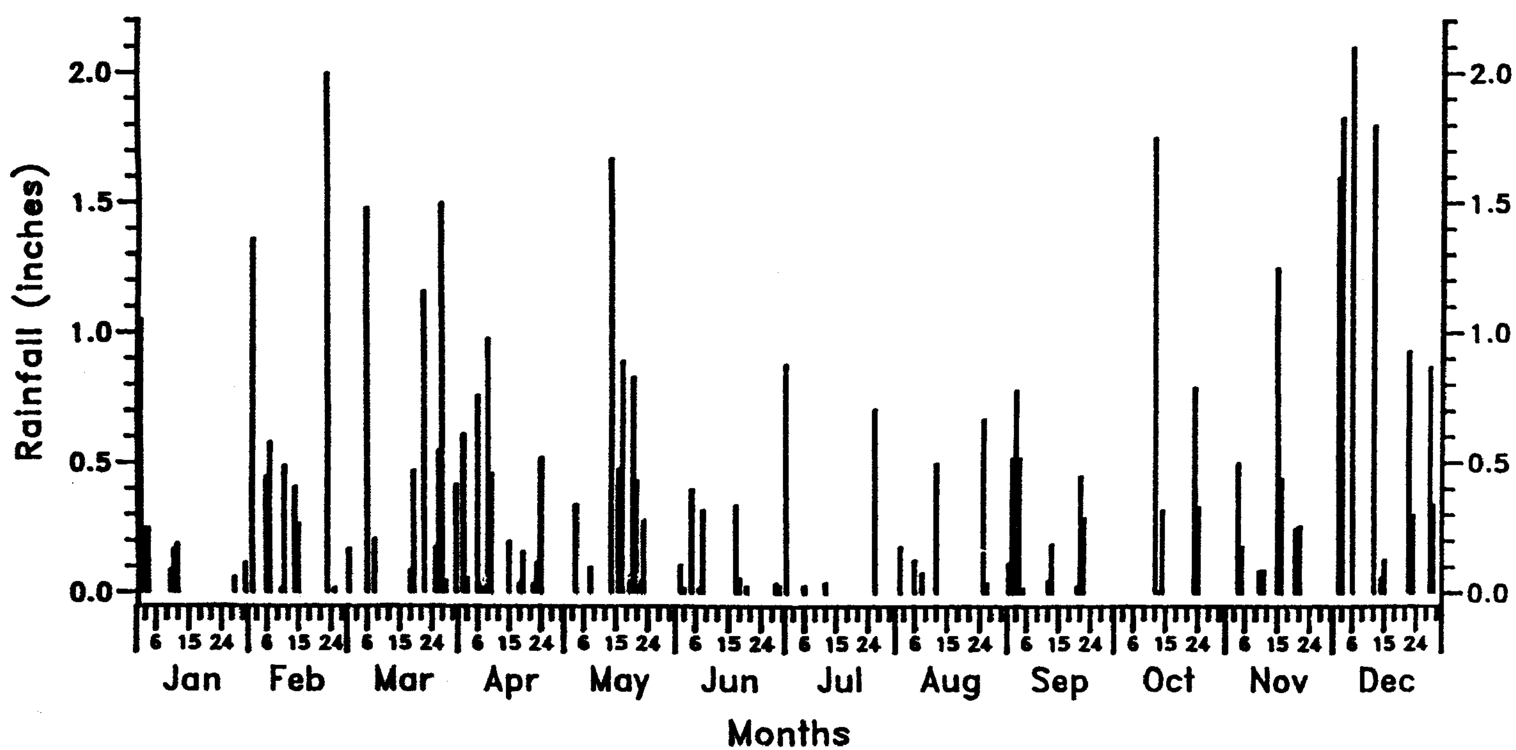


Figure 5.9

Depth Profile Curves of Dissolved Oxygen
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-1

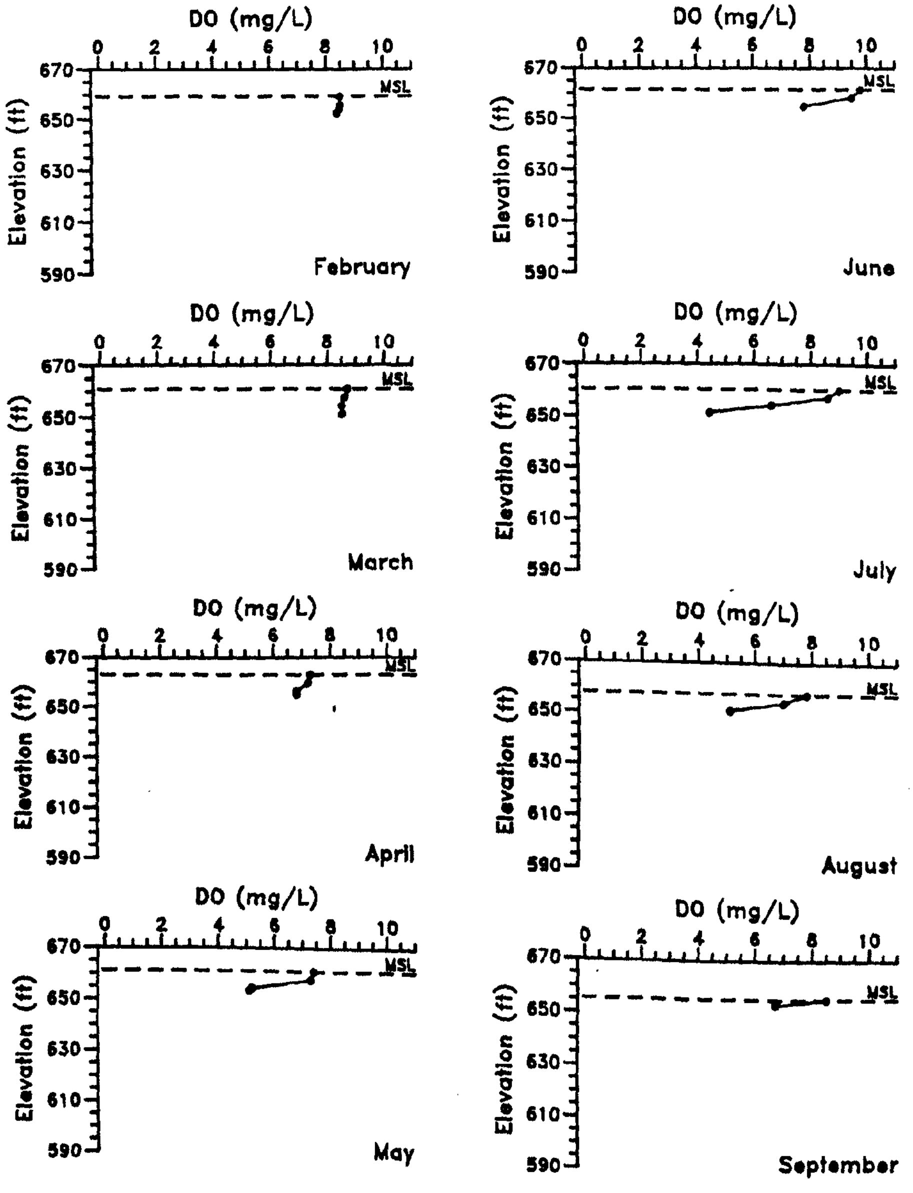


Figure 5.10

Depth Profile Curves of Dissolved Oxygen
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-2

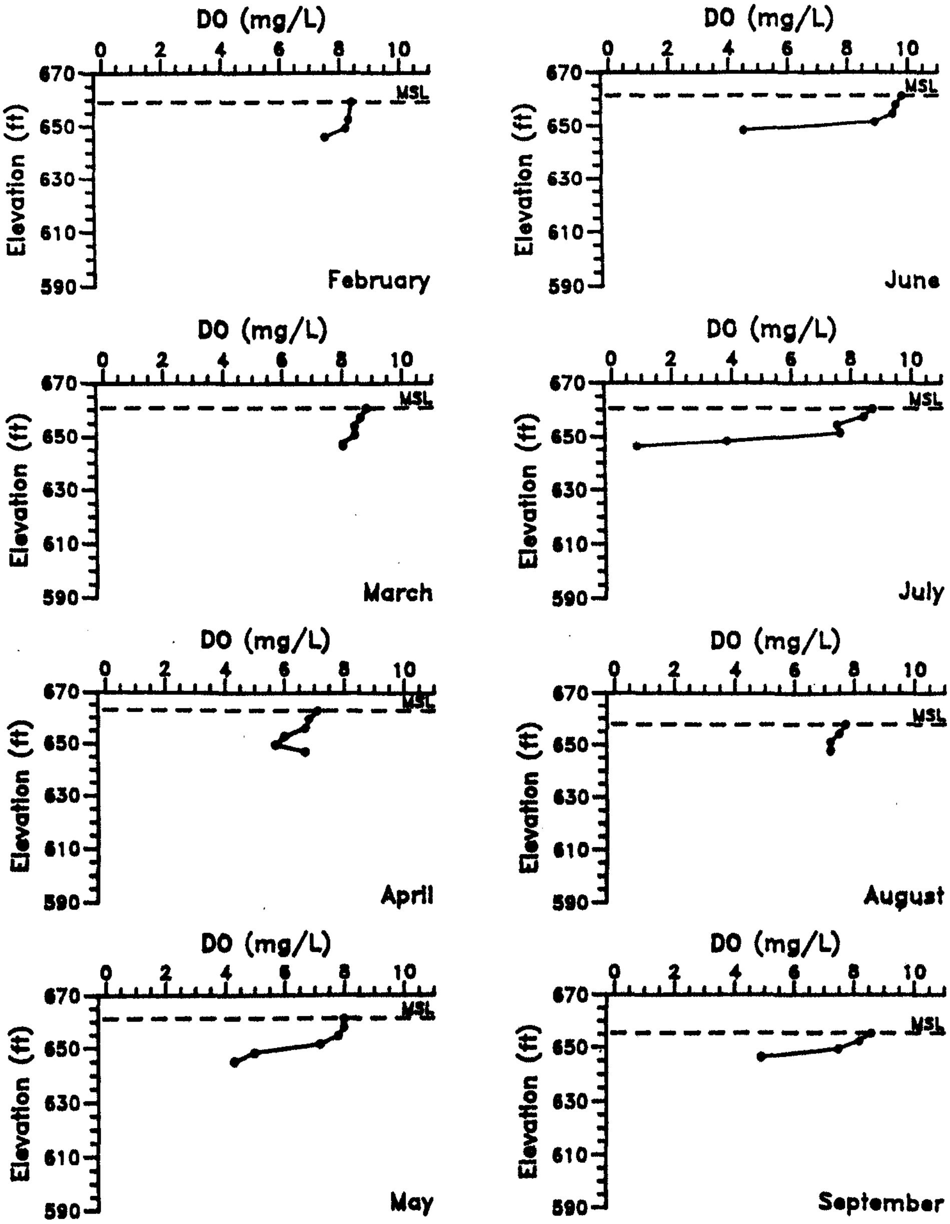


Figure 5.11

Depth Profile Curves of Dissolved Oxygen
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A–3

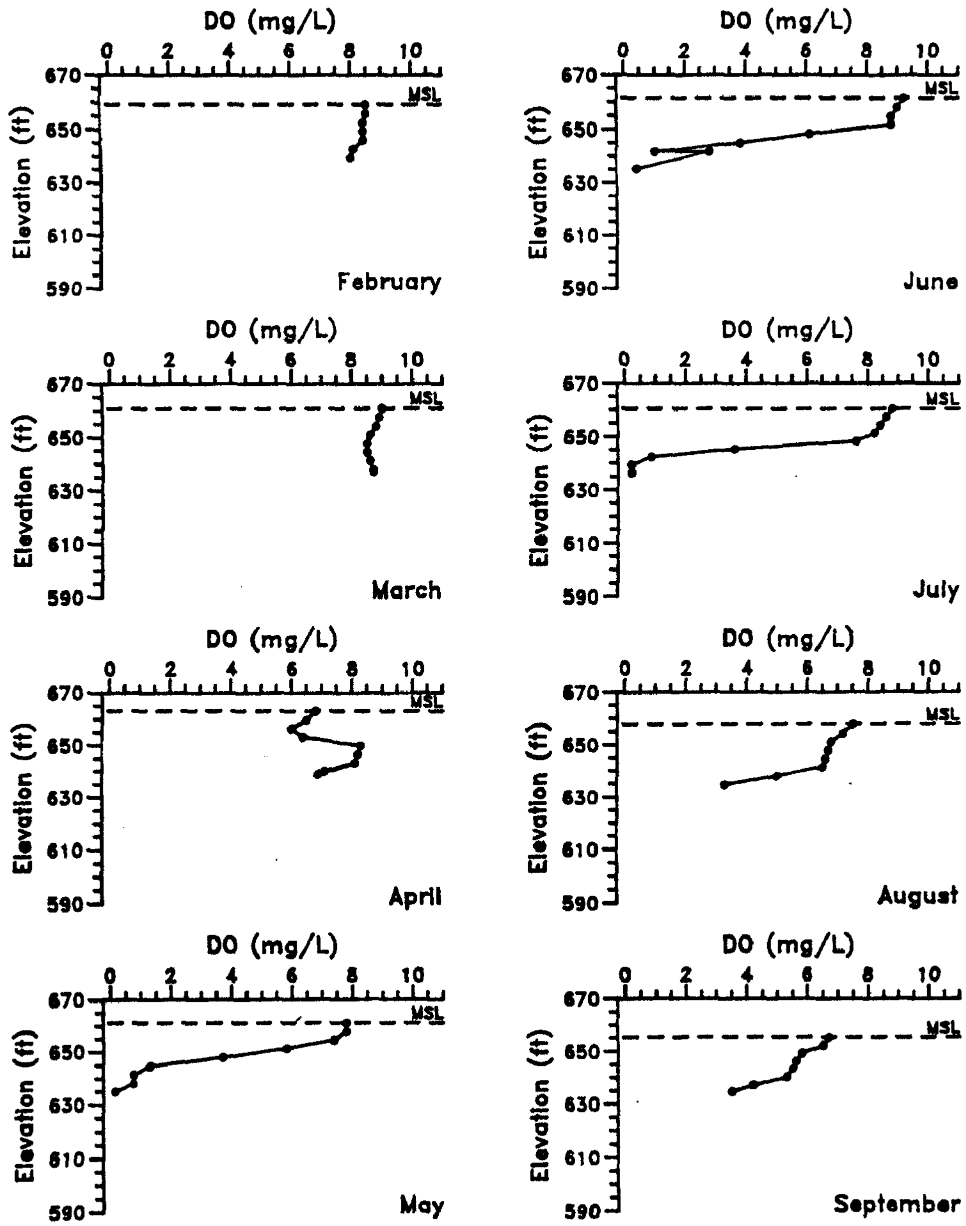


Figure 5.12

Depth Profile Curves of Dissolved Oxygen
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-4

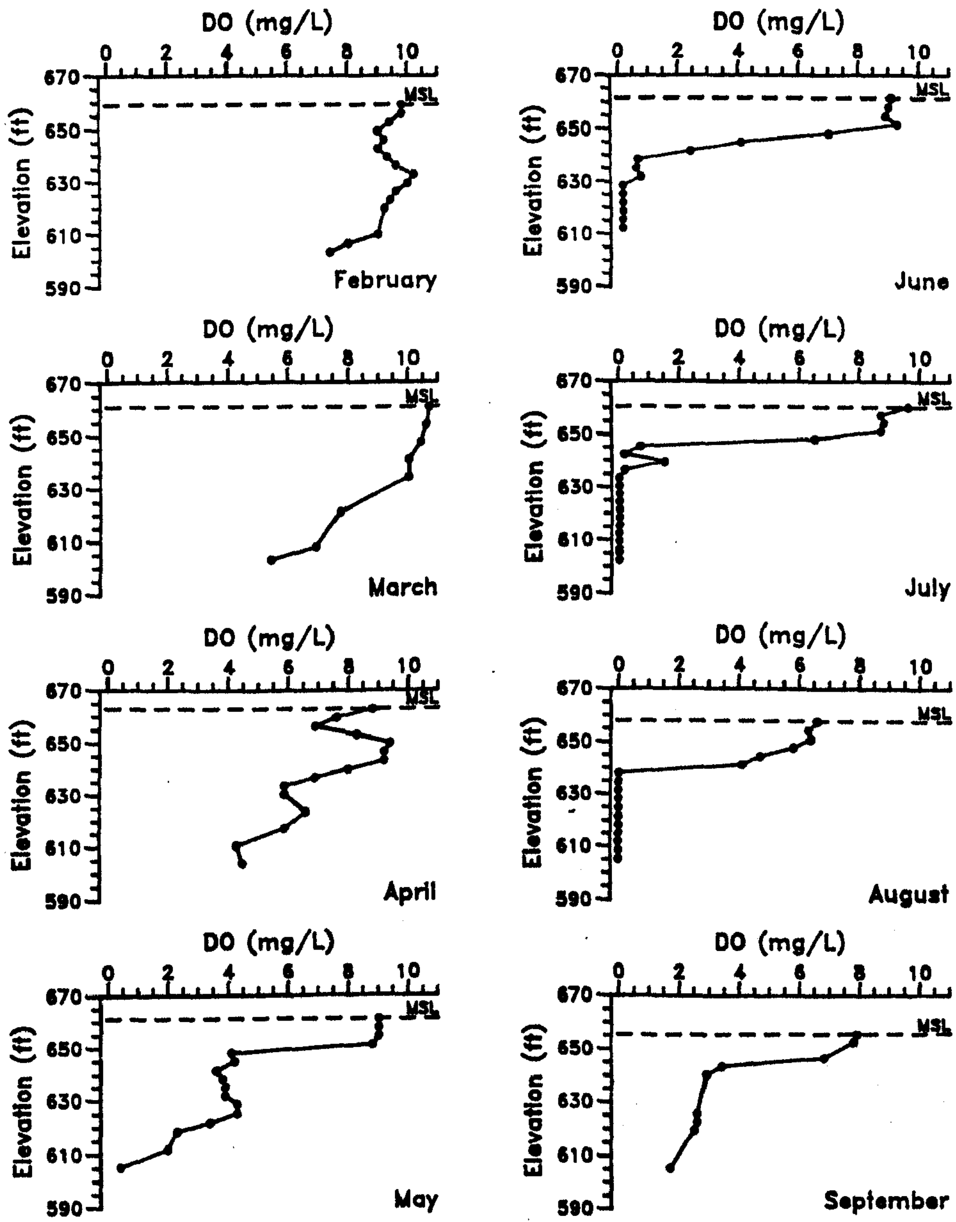


Figure 5.13

Depth Profile Curves of Dissolved Oxygen
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-5

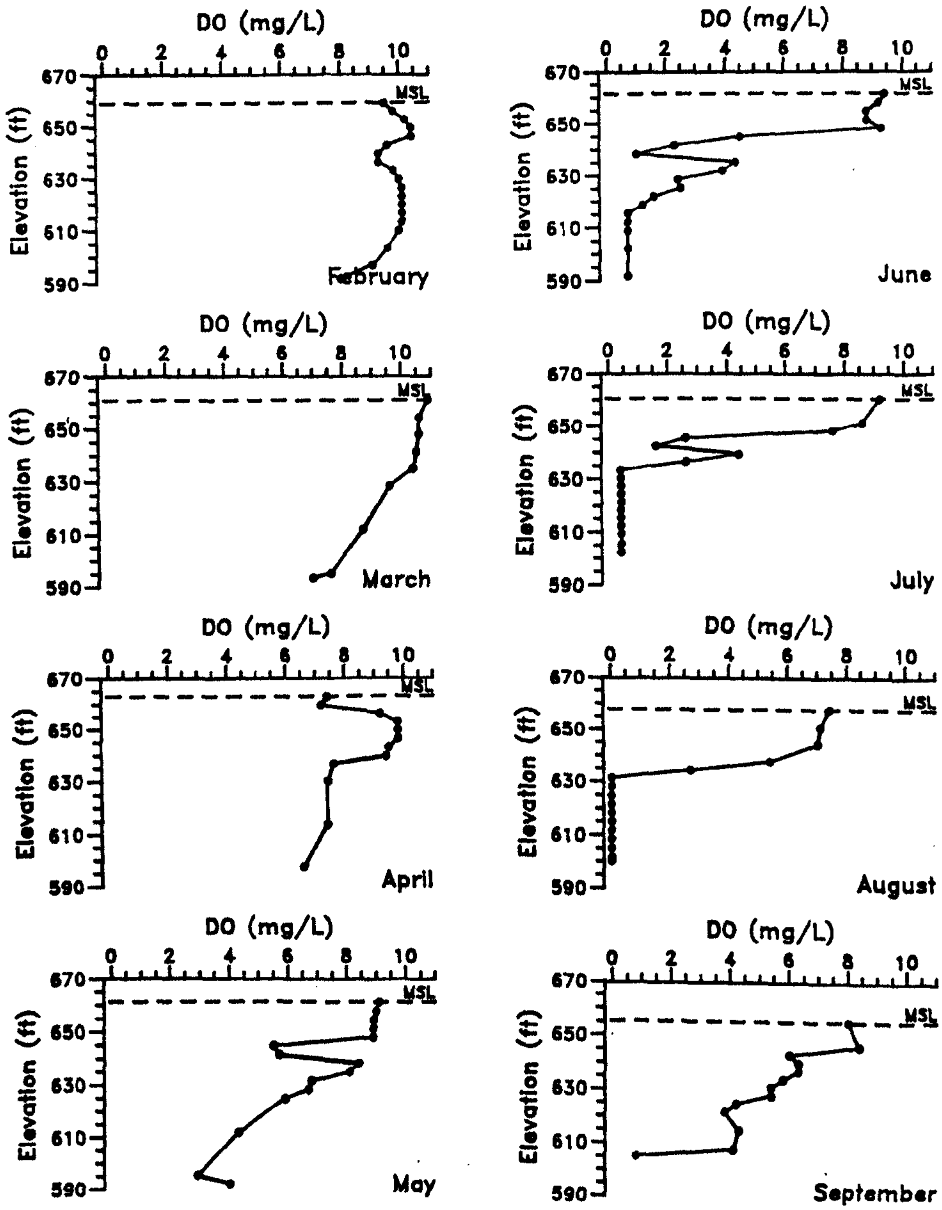


Figure 5.14

Depth Profile Curves of Corrected Chlorophyll a
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-1

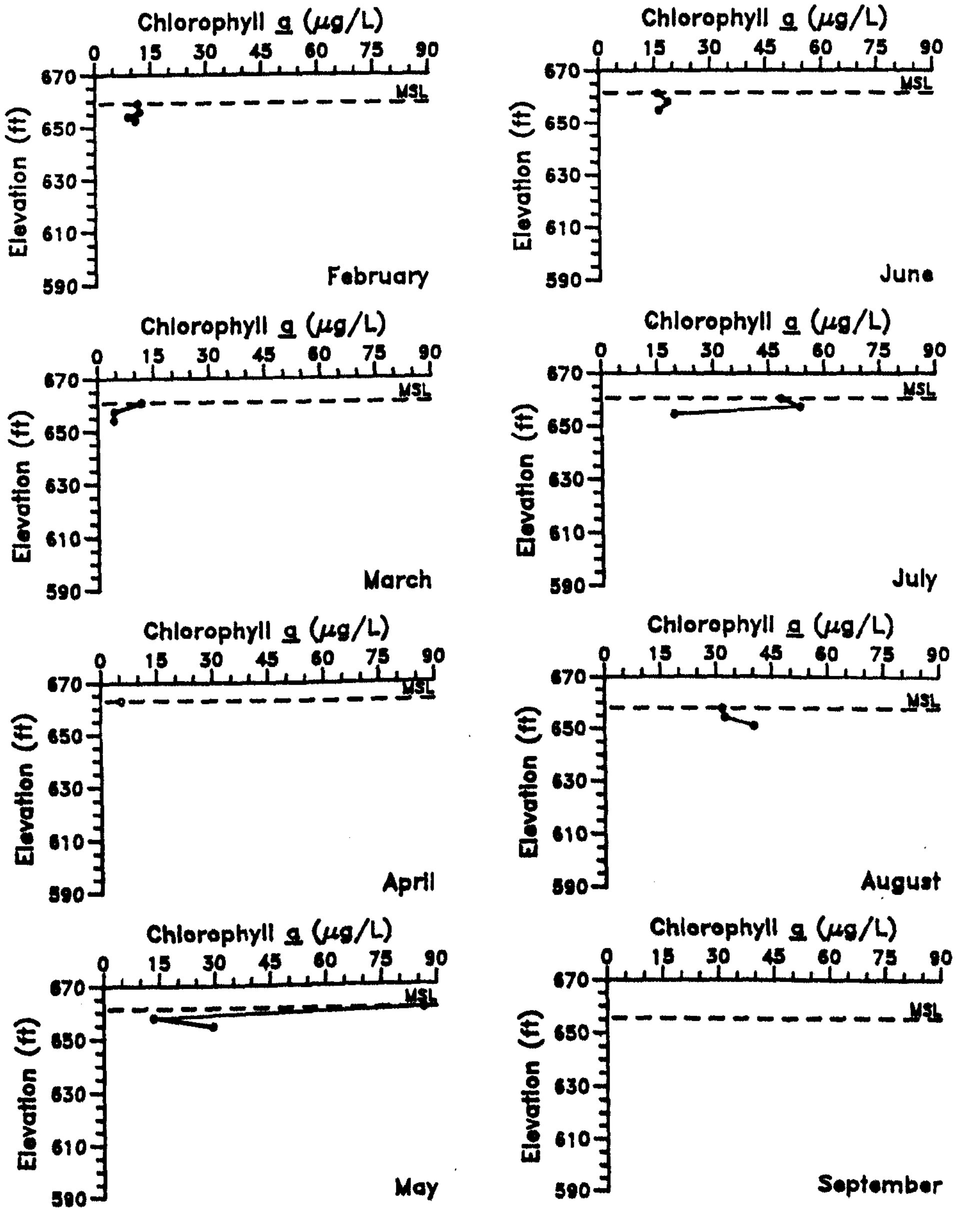


Figure 5.15

Depth Profile Curves of Corrected Chlorophyll a
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-2

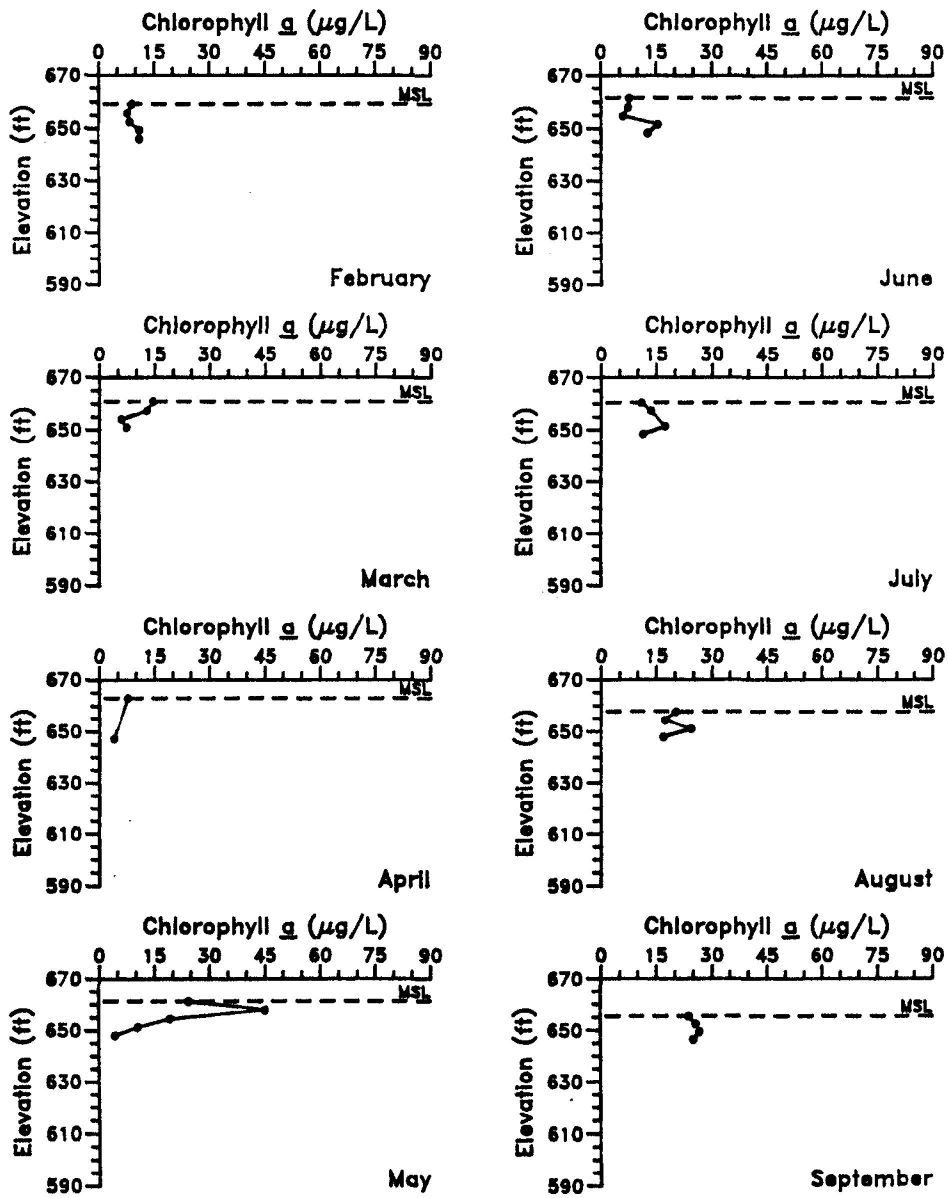


Figure 5.16

Depth Profile Curves of Corrected Chlorophyll a
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-3

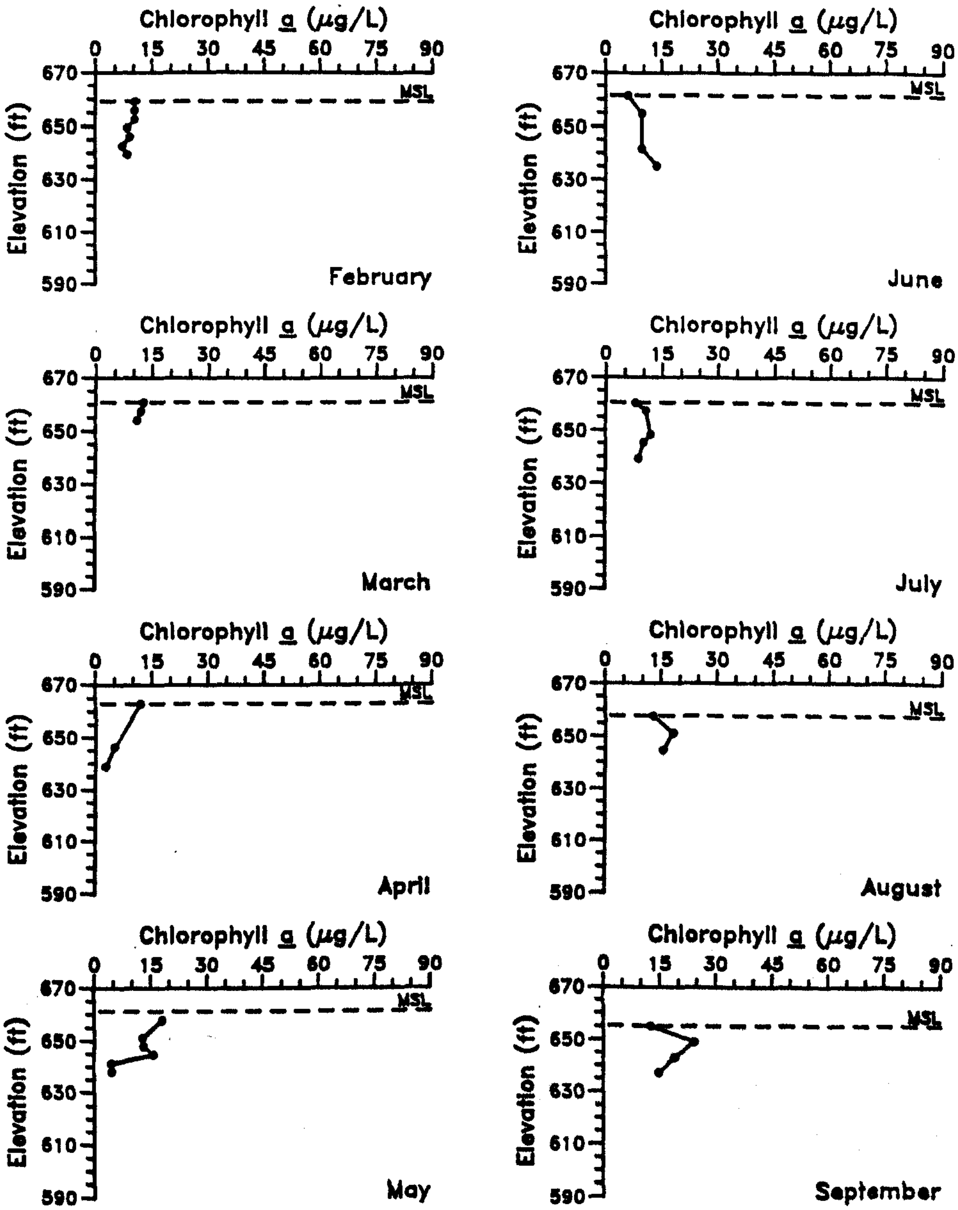


Figure 5.17

Depth Profile Curves of Corrected Chlorophyll a
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-4

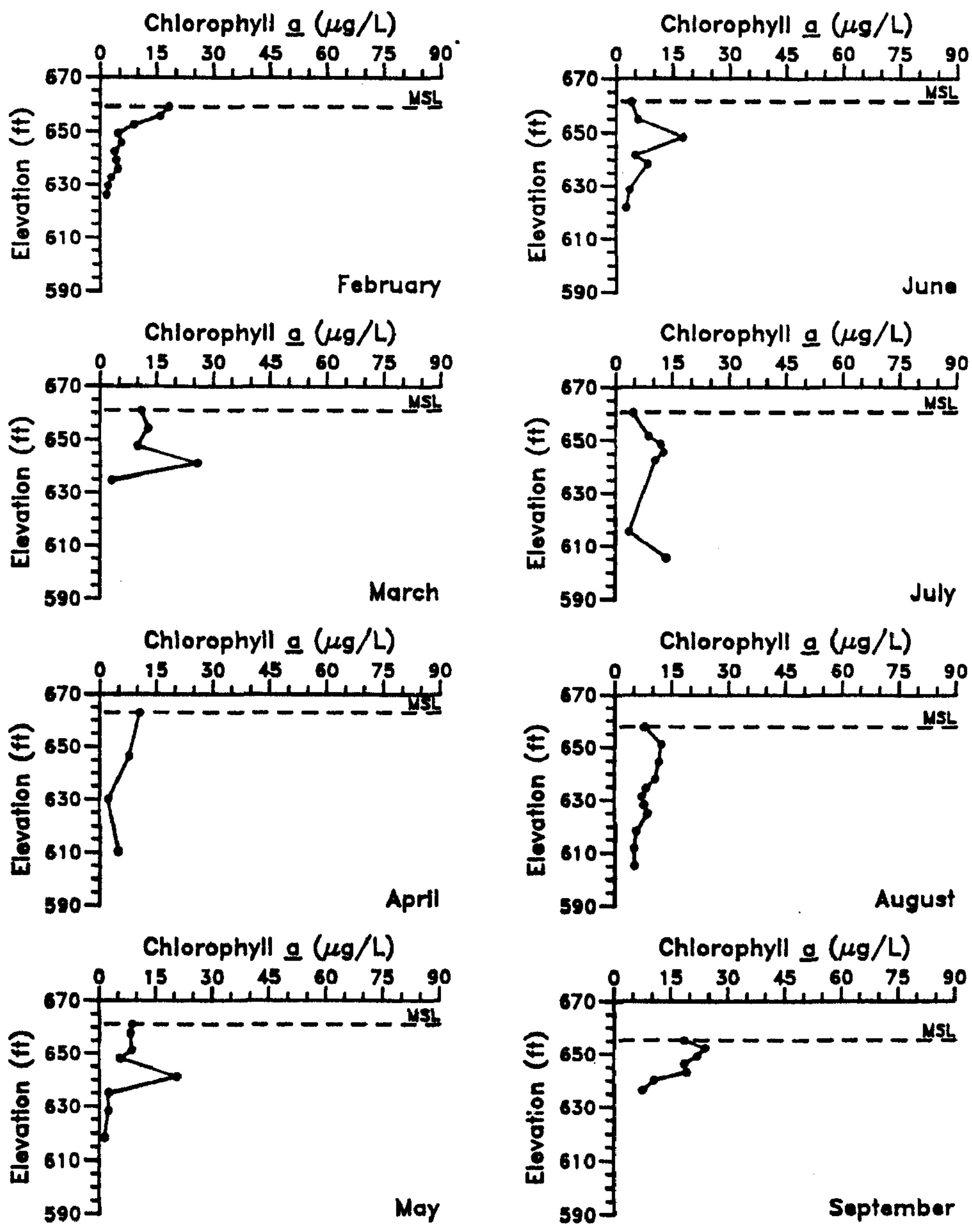


Figure 5.18

Depth Profile Curves of Corrected Chlorophyll a
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983
Station A-5

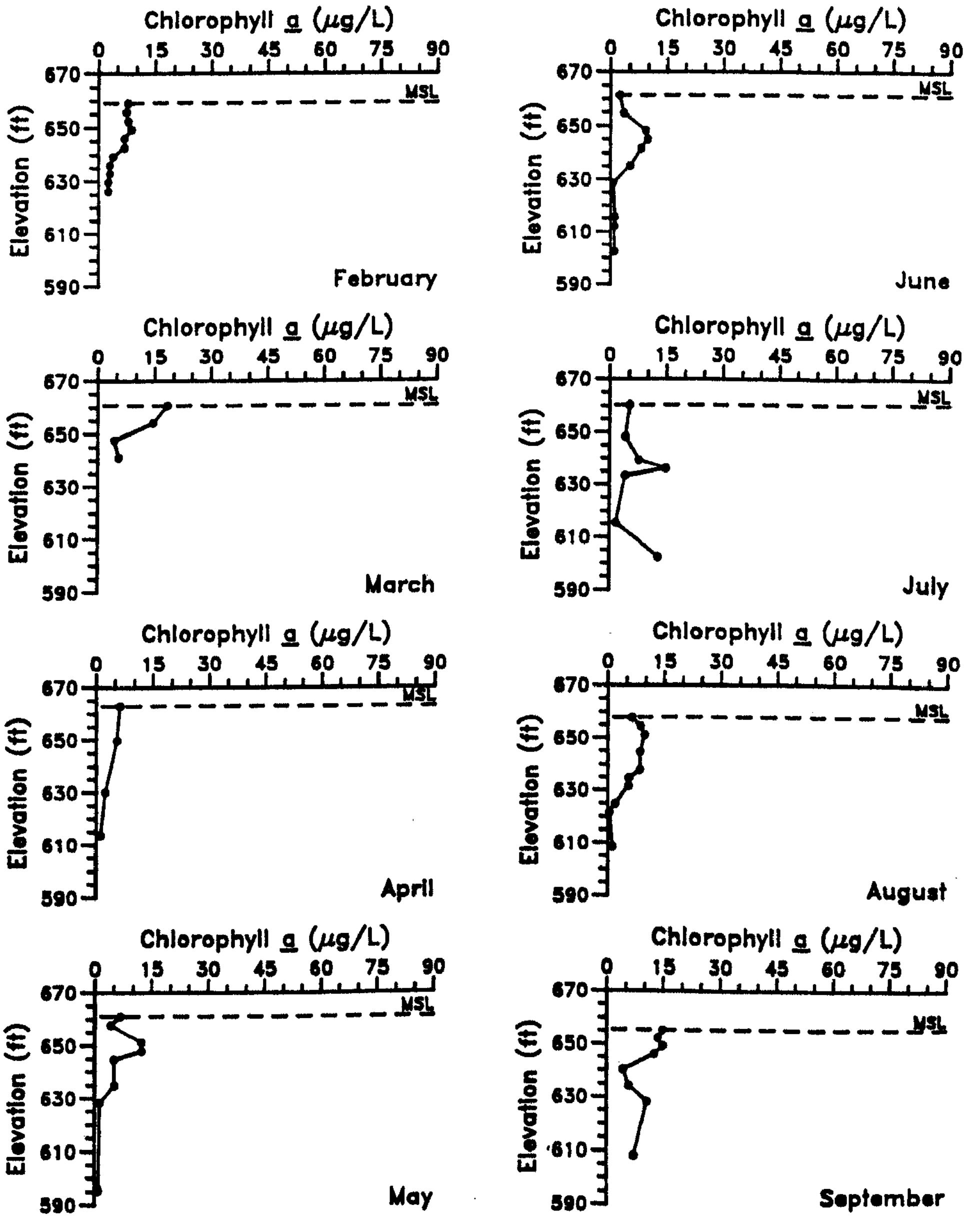


Figure 5.19

Flow Recording, Station EC–1, 18 Mile Creek,
Hartwell Reservoir, South Carolina, March 17 – 24, 1983

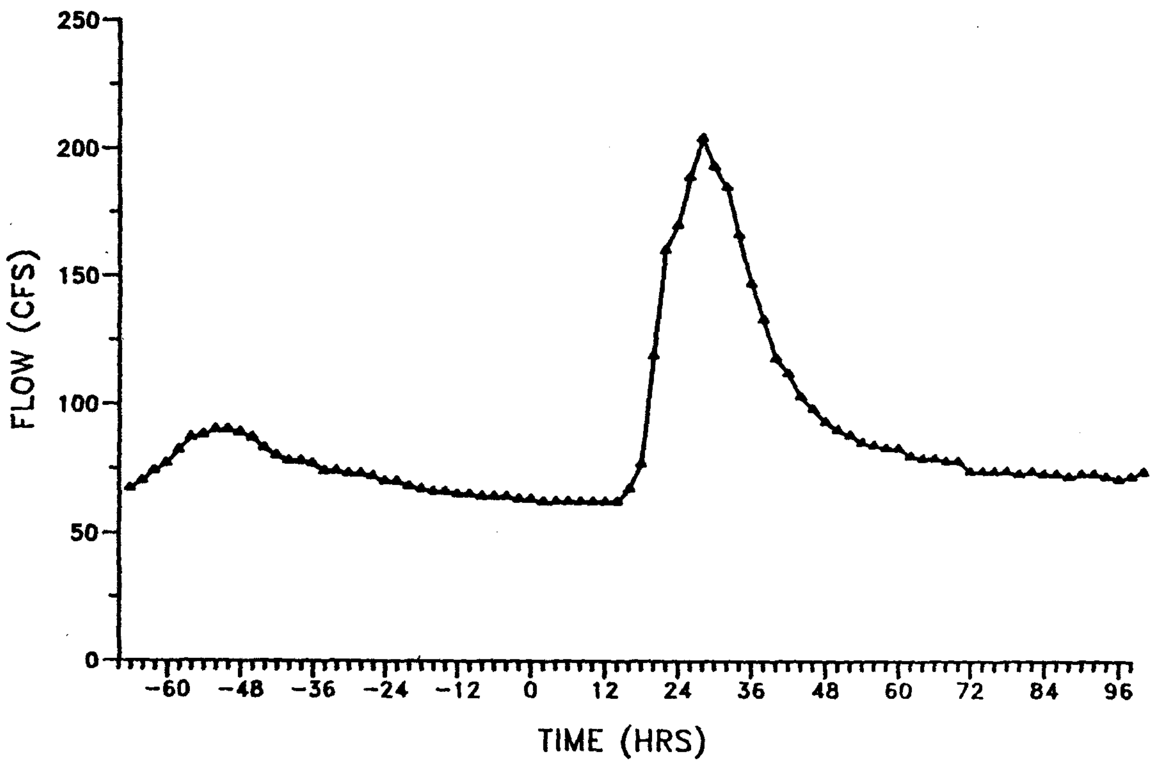


Figure 5.20

Flow Recording, Station EC-1, 18 Mile Creek, Hartwell Reservoir, South Carolina, April 14 - 23, 1983

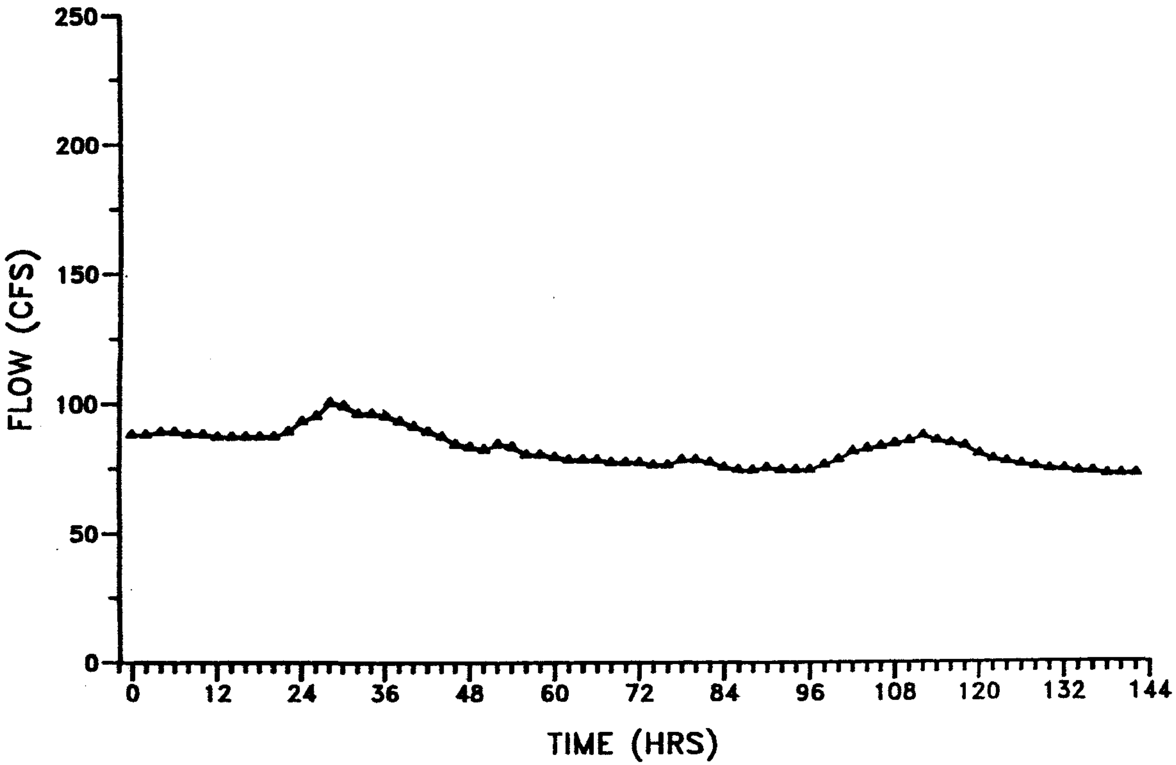


Figure 5.21

Flow Recording, Station EC-1, 18 Mile Creek, Hartwell Reservoir, South Carolina, May 12 - 18, 1983

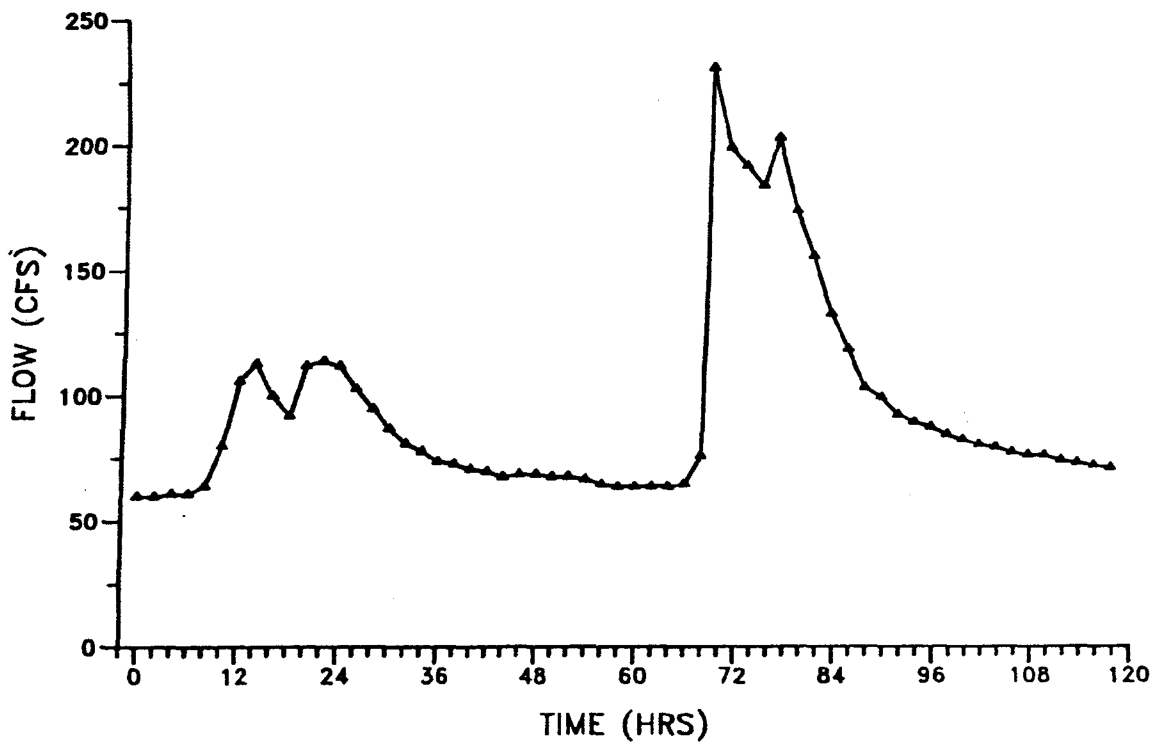


Figure 5.22

Flow Recording, Station EC-1, 18 Mile Creek,
Hartwell Reservoir, South Carolina, May 18 – 24, 1983

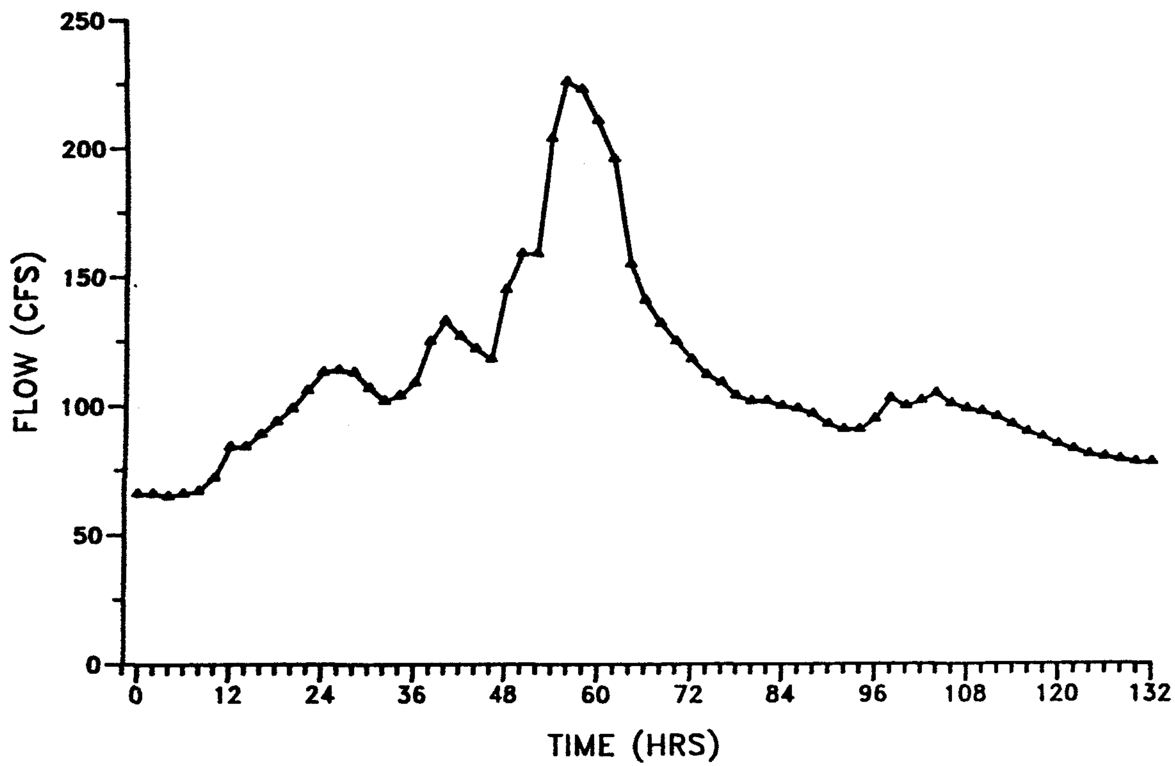


Figure 5.23

Flow Recording, Station EC-1, 18 Mile Creek,
Hartwell Reservoir, South Carolina, June 30 - July 6, 1983

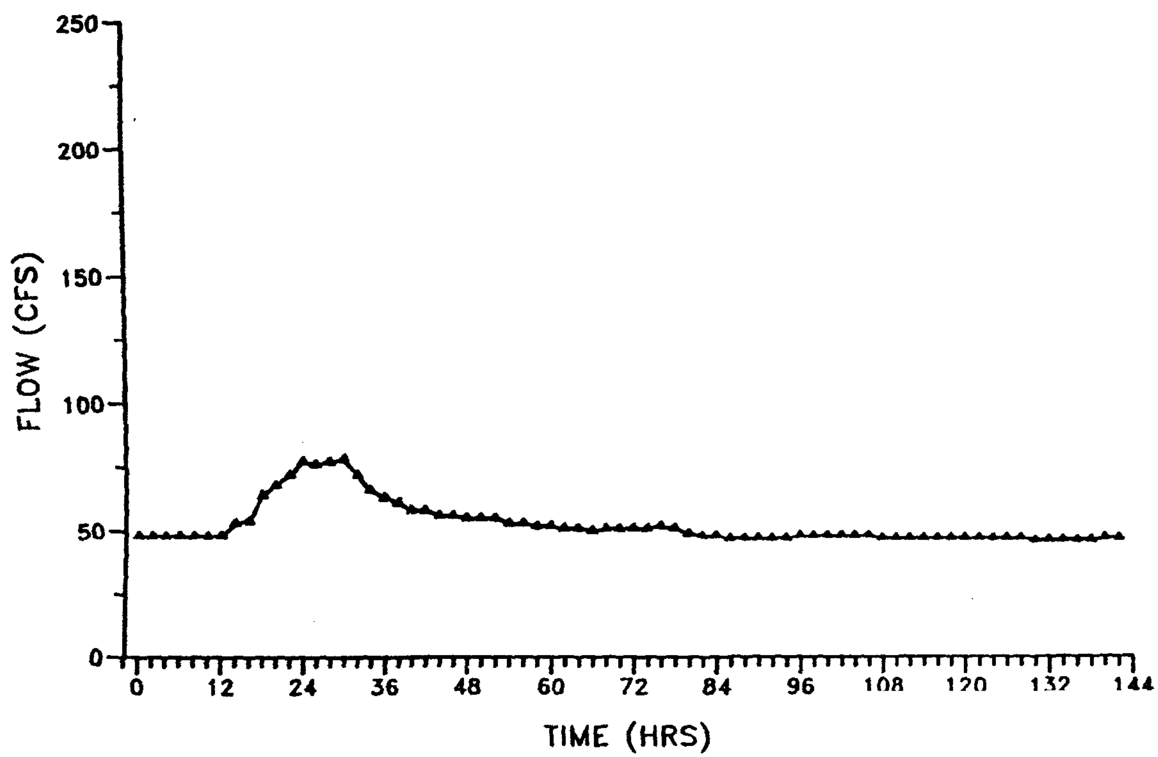


Figure 5.24

Flow Recording, Station EC-1, 18 Mile Creek,
Hartwell Reservoir, South Carolina, November 14 - 16, 1983

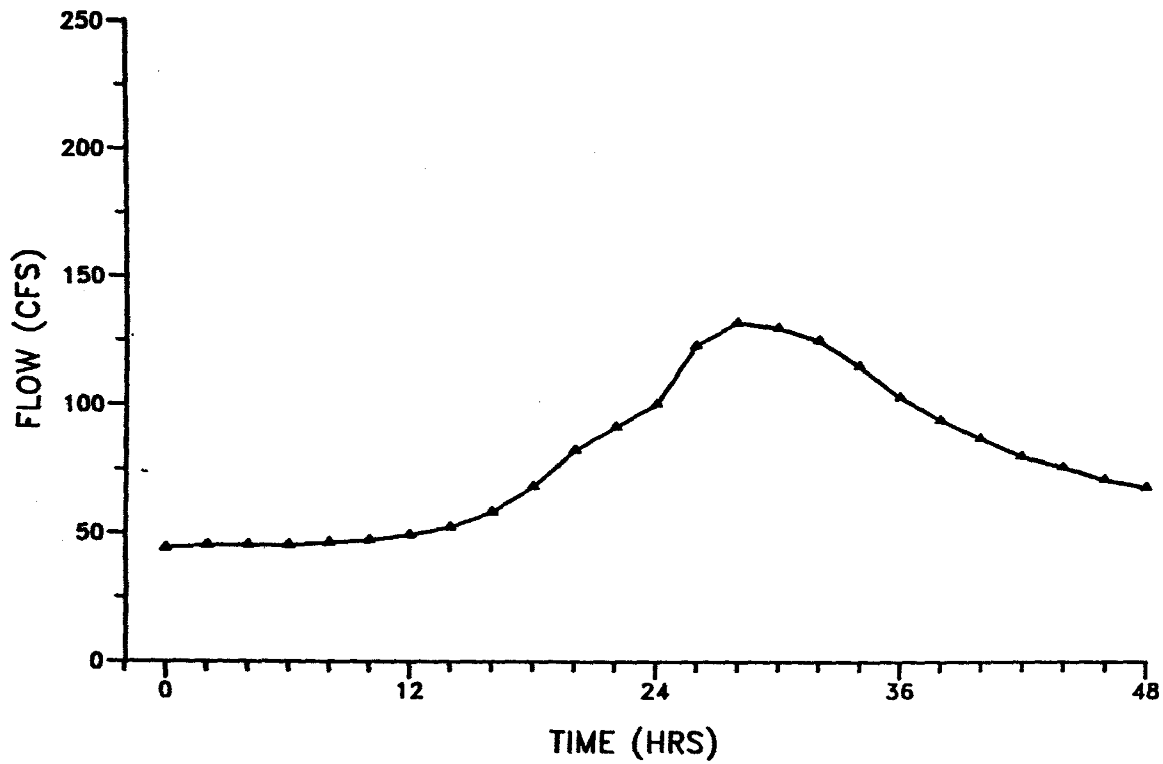


Figure 5.25

T–P vs Flow, Station EC–1, 18 Mile Creek, Hartwell Reservoir, South Carolina, 1983

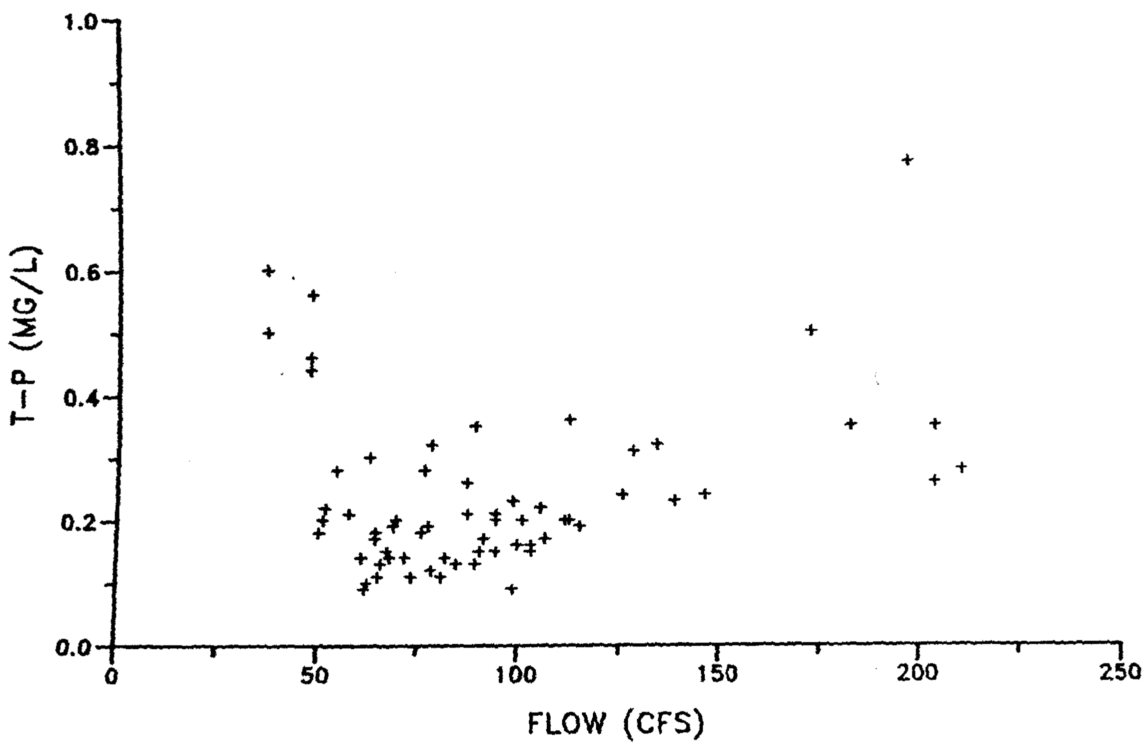


Figure 5.26

18 Mile Creek, Hartwell Reservoir, South Carolina, 1983
Phosphorous Transport vs Velocity

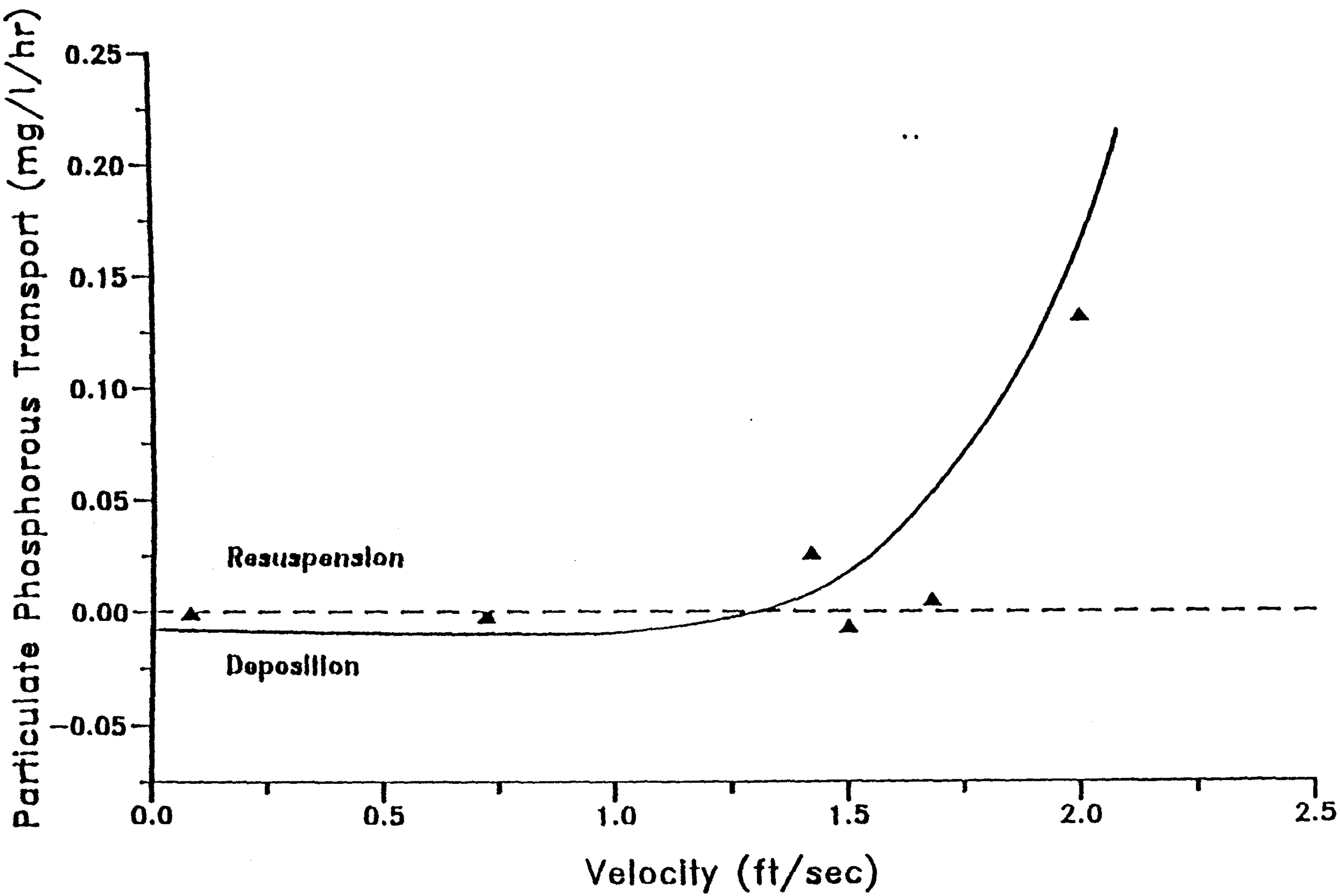


Figure 5.27

Dye Study, Total Phosphorus Concentration Profile, 18 Mile Creek, Hartwell Reservoir, South Carolina, 1983

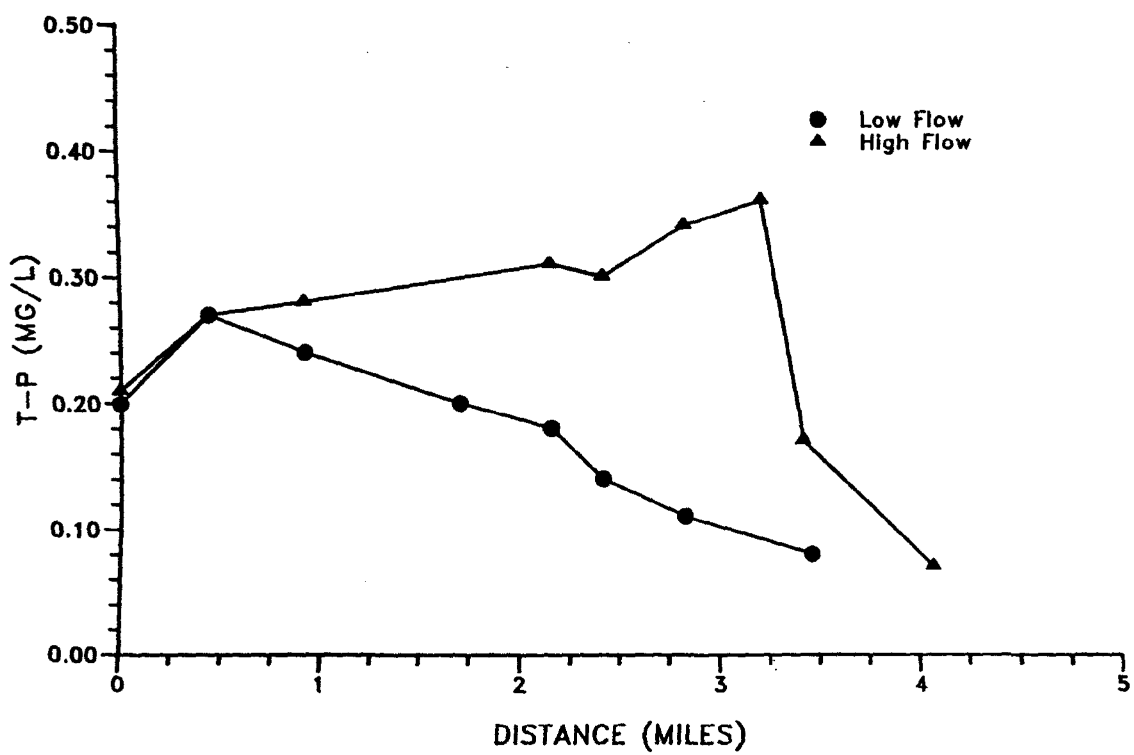


Figure 5.28

Low Flow Dye Study, Total Phosphorus
and Total Suspended Solids Concentration Profile
18 Mile Creek, Hartwell Reservoir, South Carolina, 1983

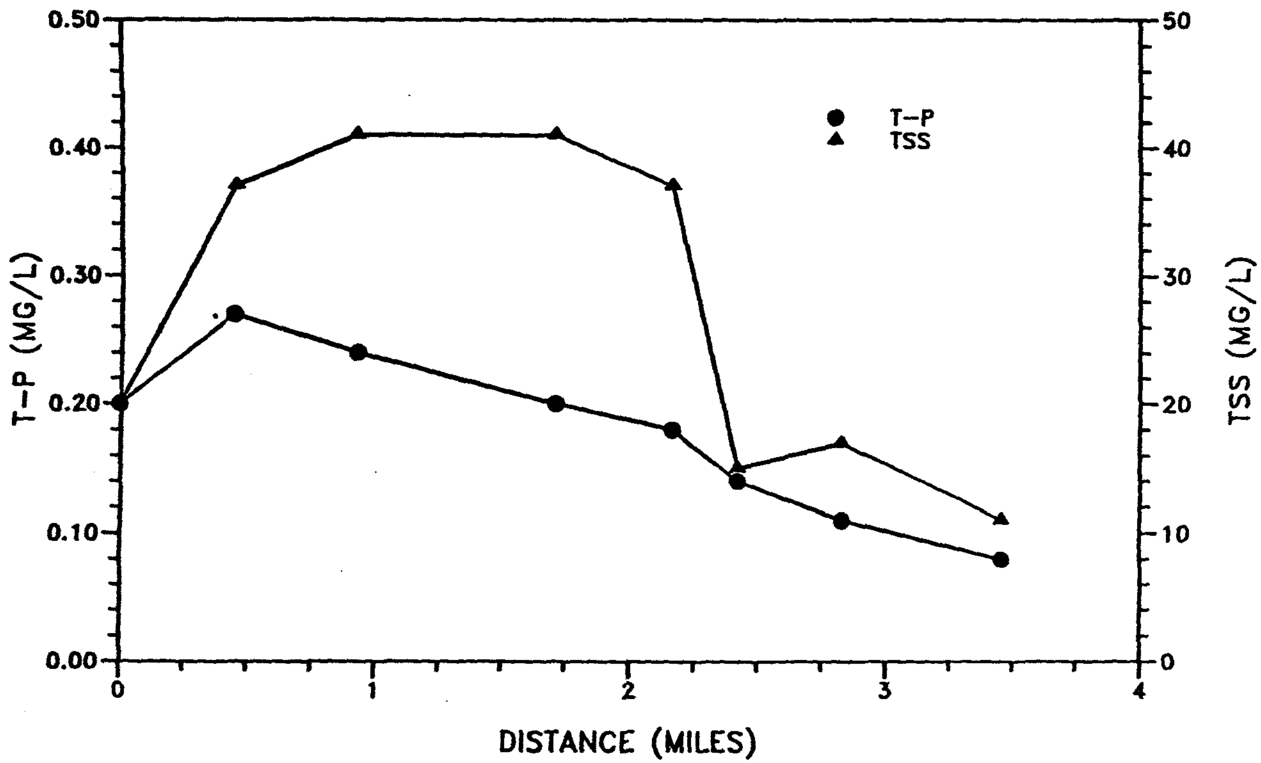


Figure 5.29

High Flow Dye Study, Total Phosphorus
and Total Suspended Solids Concentration Profile
18 Mile Creek, Hartwell Reservoir, South Carolina, 1983

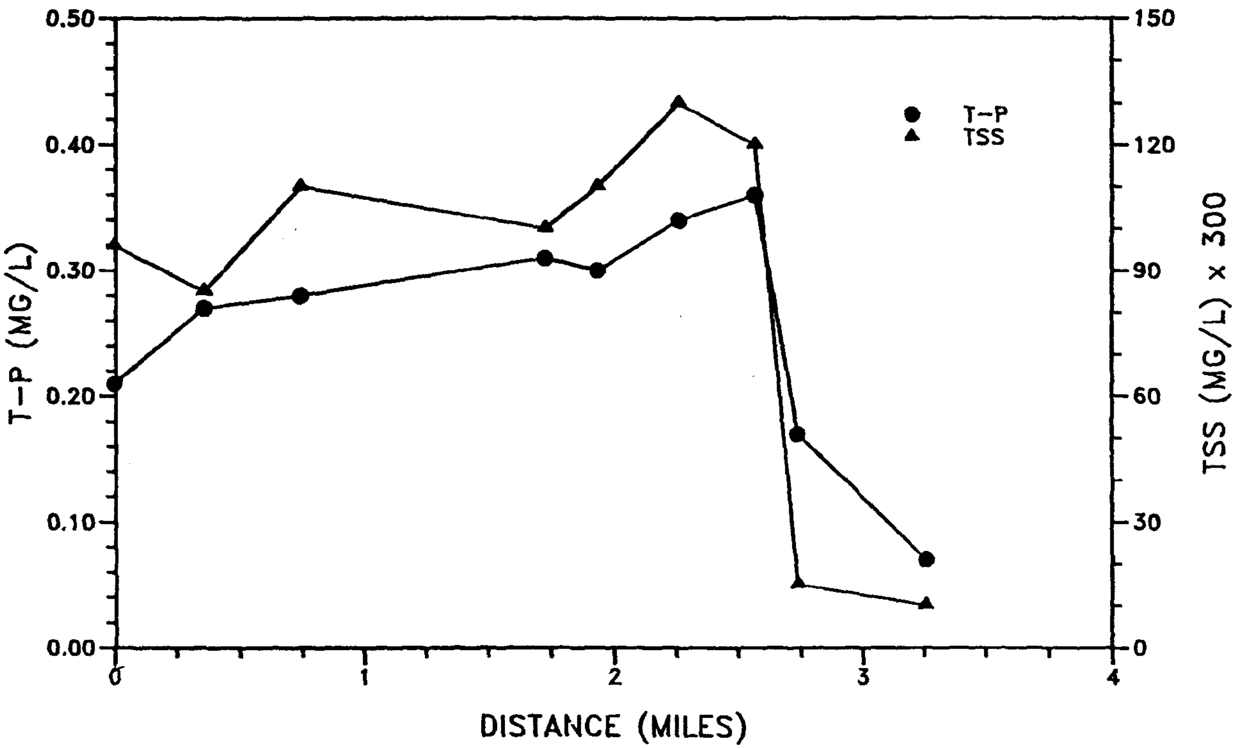


Figure 5.30

Total Phosphorus Loading from Point Sources,
18 Mile Creek Watershed,
Hartwell Reservior, South Carolina, August 1983

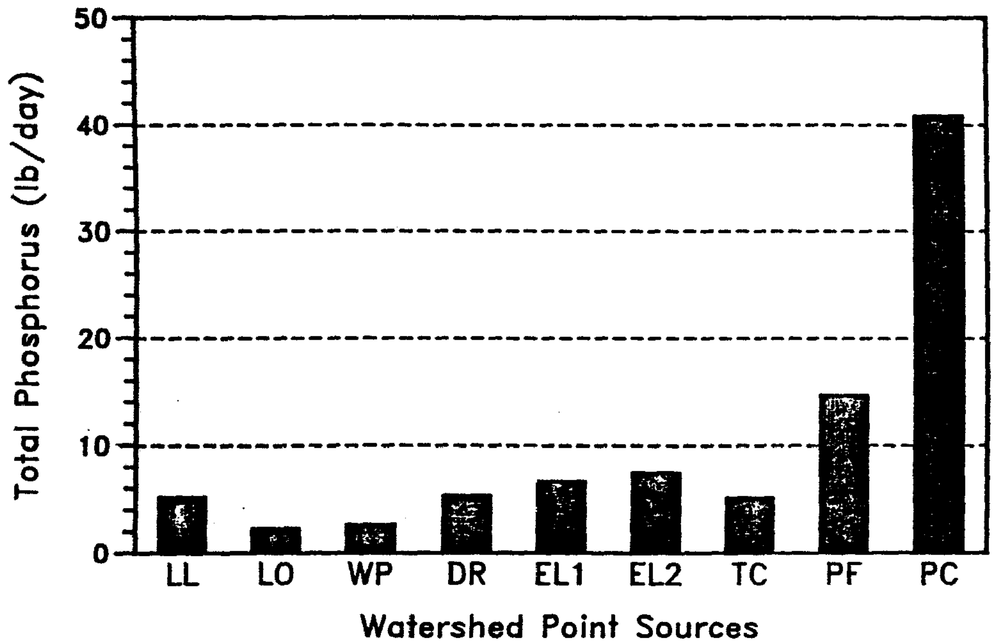


Figure 5.31

Percent Total Phosphorus Loading from Point Source Contributors, 18 Mile Creek Watershed, Hartwell Reservoir, South Carolina, 1983

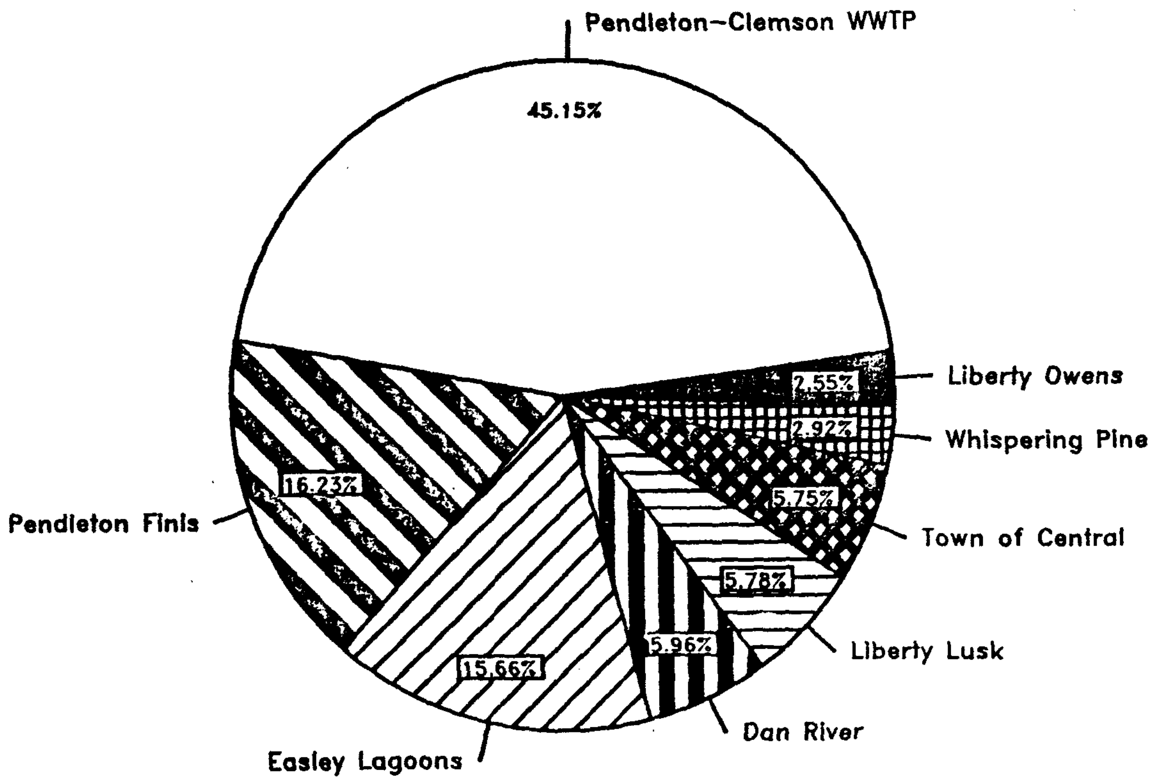


Figure 5.32

Pendleton–Clemson WWTP Performance,
18 Mile Creek Watershed,
Hartwell Reservior, South Carolina, 1983

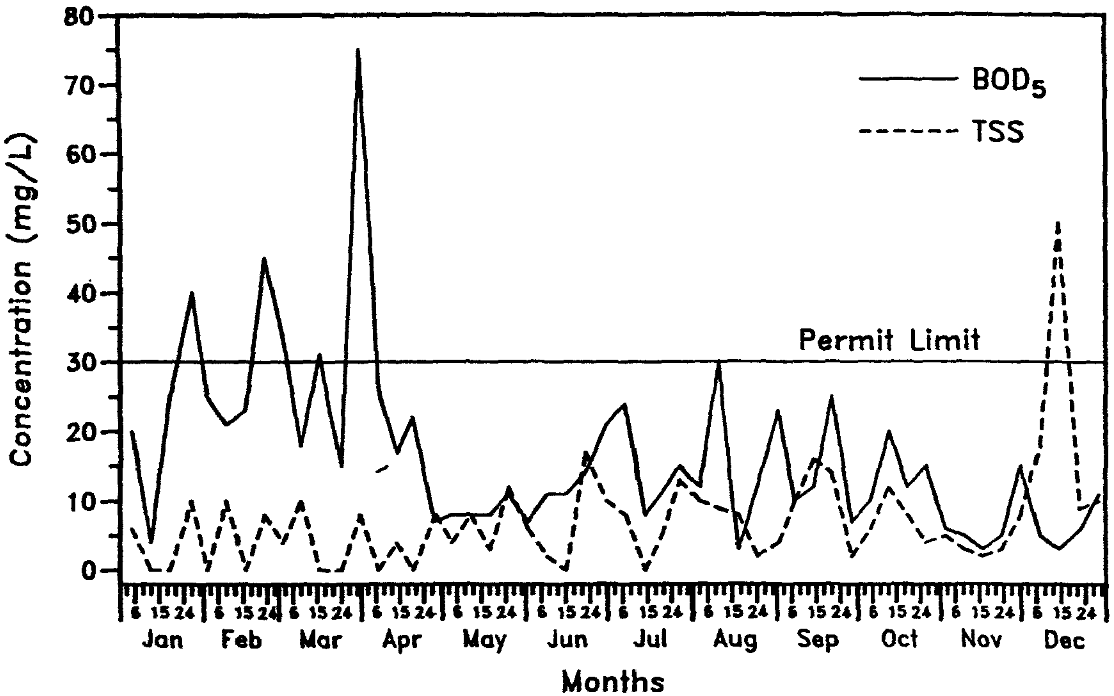


Figure 6.1

T–P Concentration vs Distance
18 Mile Creek Embayment, Hartwell Reservoir
South Carolina, 1983

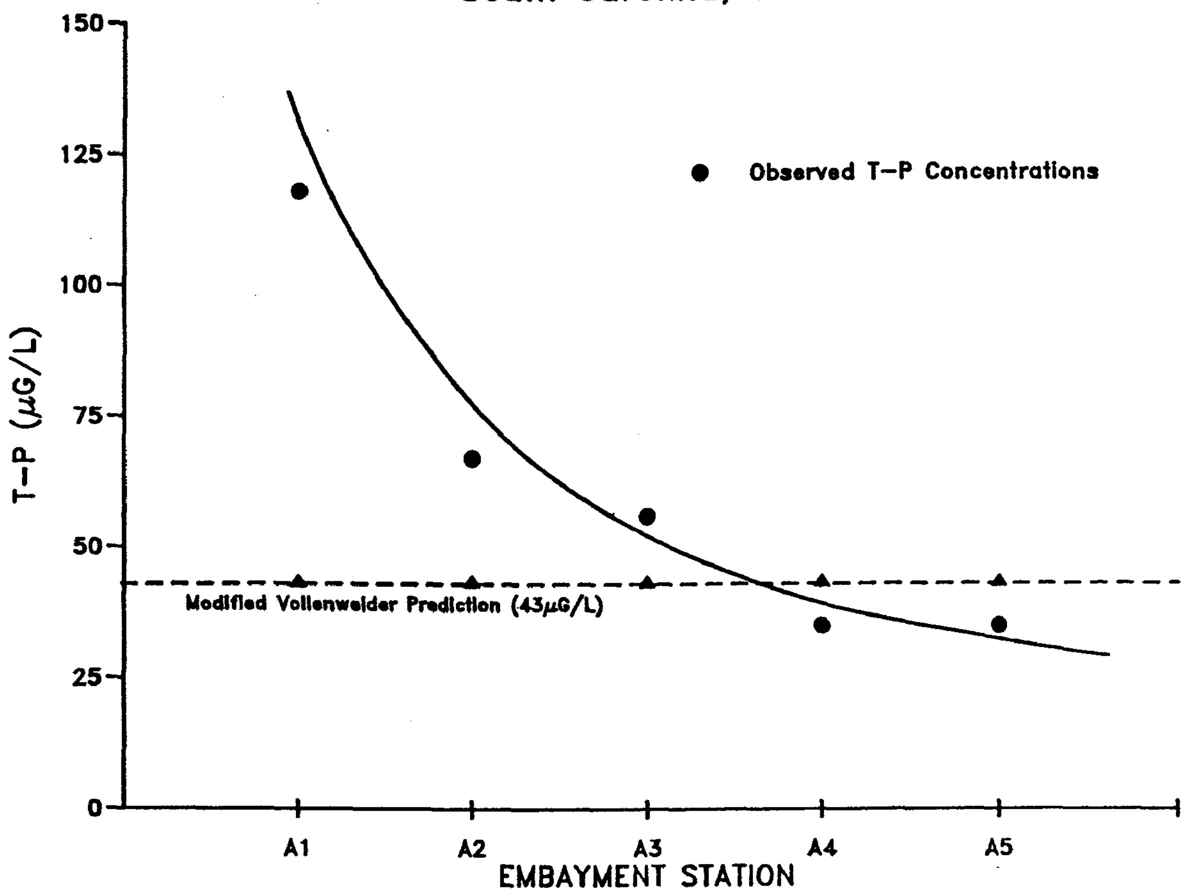


Figure 6.2

B–P Concentration vs Distance
18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

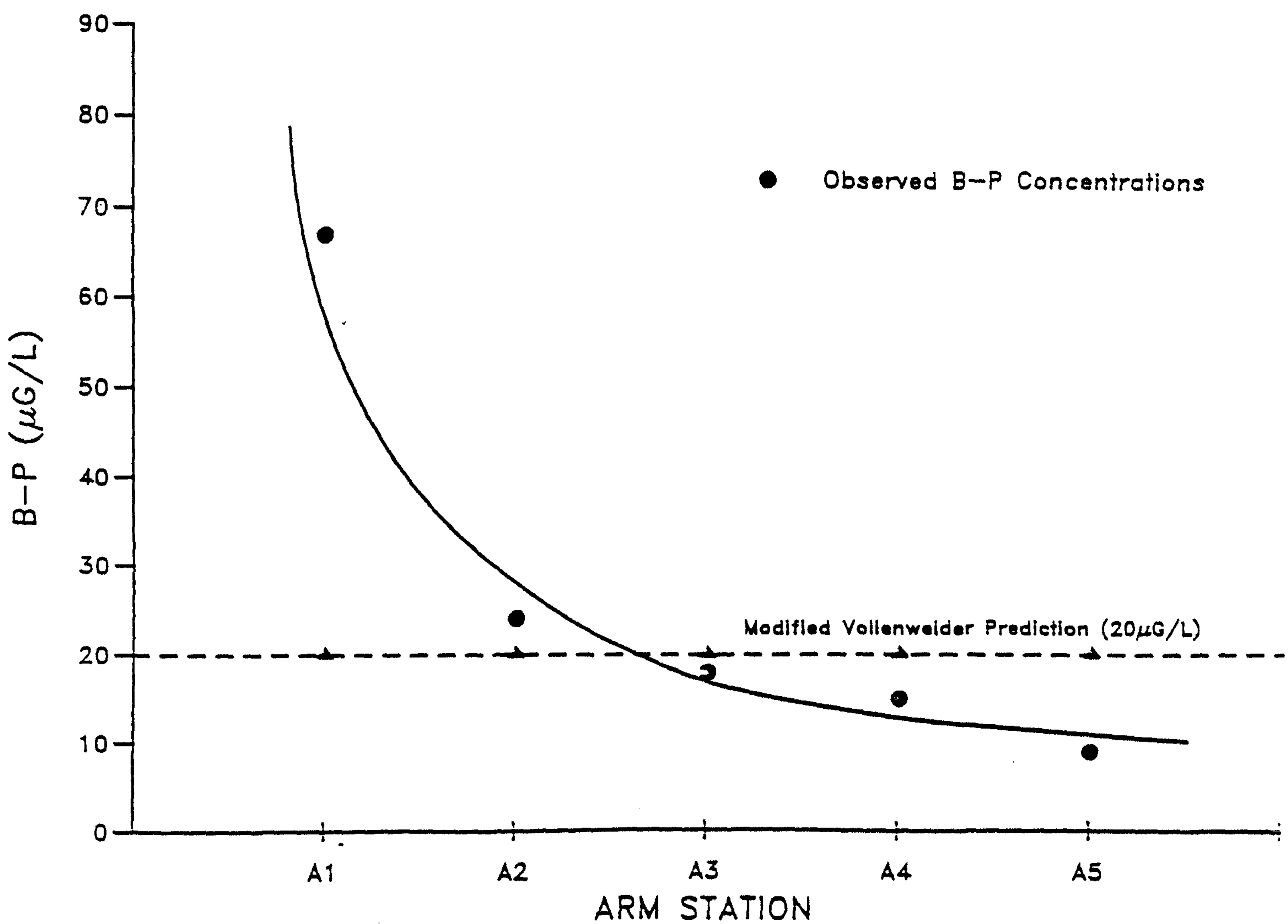


Figure 6.3

Relationship of In-Arm Bioavailable Phosphorus and Chlorophyll a, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

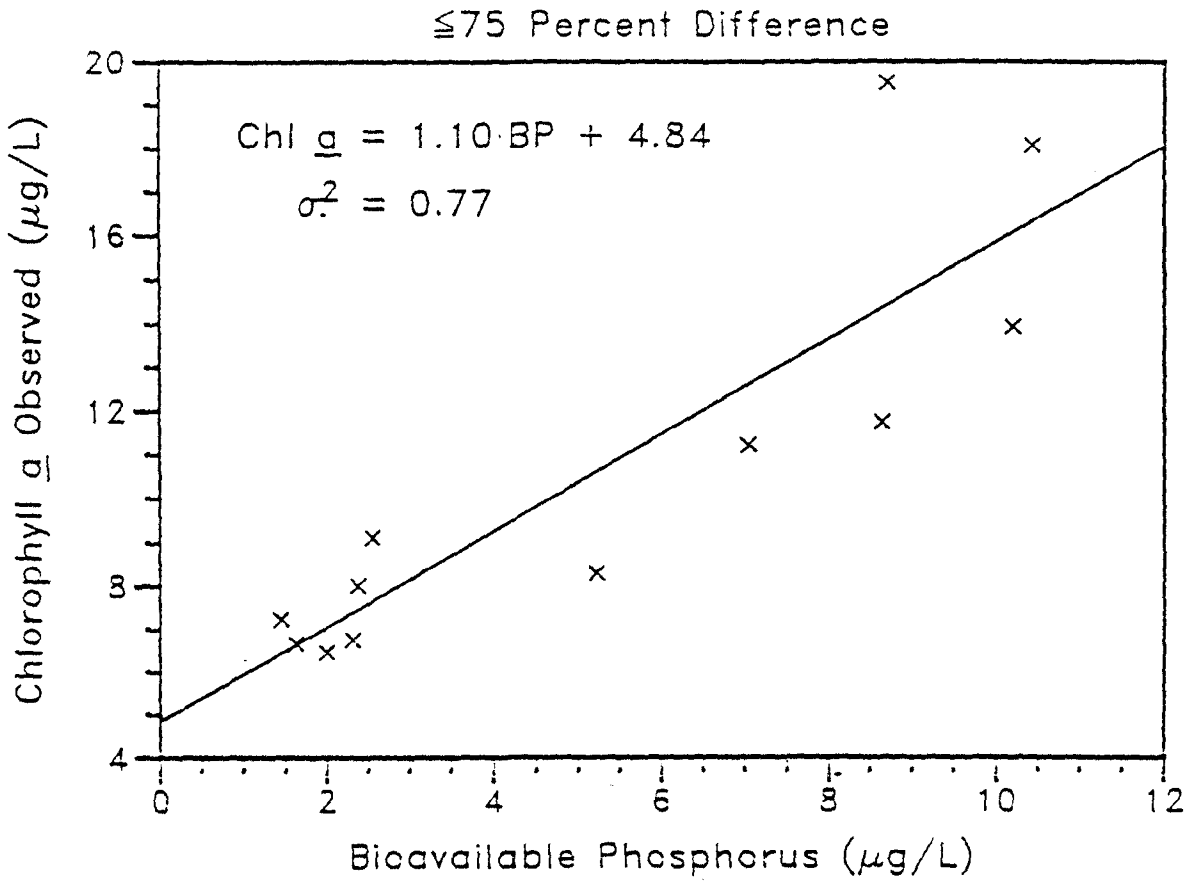
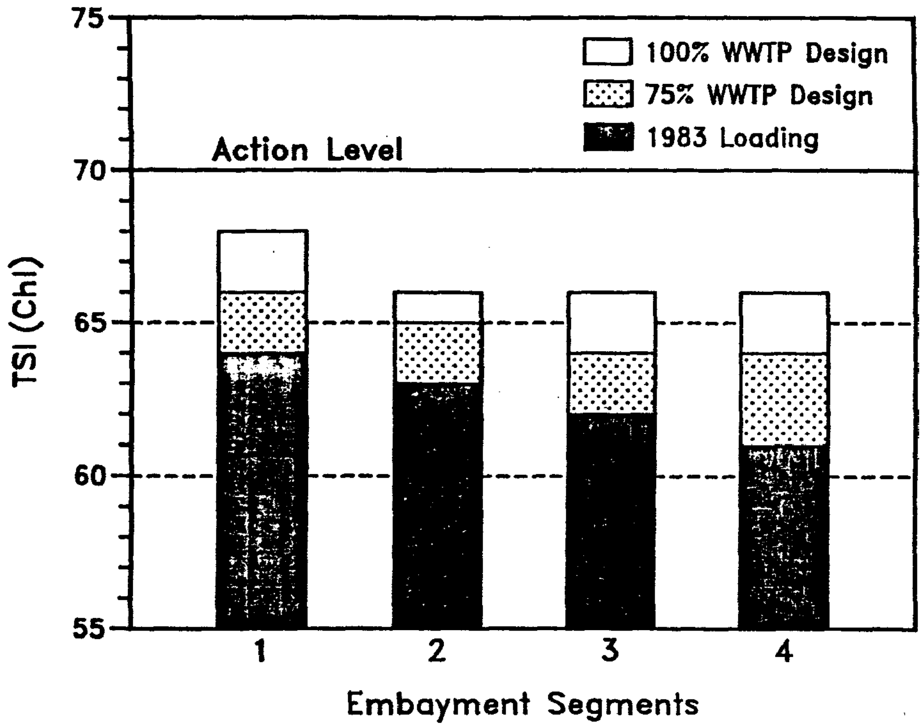


Figure 7.1

Maximum Embayment TSI under Different Loading Conditions, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina



APPENDIX A

CORRESPONDENCE

South Carolina Department of Health and Environmental Control

2600 Bull Street
Columbia, S. C. 29201

April 1, 1981

Dr. Ronald Raschke
Ecology Branch
U. S. Environmental Protection Agency,
Region IV
Bailey Road
Athens, Georgia 30601

Dear Ron:

Please find enclosed a portion of the information concerning Eighteen Mile Creek which we discussed last week during the preliminary survey of the stream. This information addresses two basic areas: sample analyses results from previous work in that arm (cove) of the lake and the location of wastewater discharges to the stream system.

I am planning to visit the area again this Thursday (April 2) to ascertain where the zone of complete mixture between Eighteen Mile Creek and the effluent from the Clemson/Pendleton treatment facility occurs. As soon as I have this determination, I shall forward it to you. Also, our district director from that area called this week to relate a complaint from an individual about an algal bloom in the Eighteen Mile Creek arm of the lake. I plan to meet with our director in Clemson on April 2 as well to discuss this complaint.

I hope that this information will be useful as a starting point for the proposed work in this area. As I gather more data and/or information concerning this area of the lake, I shall pass it along to you. As you develop your strategy for the investigation of this area, do not hesitate to contact me if I can be of assistance. In the interim, if there are any questions concerning this information, please notify me as such.

Thank you for your assistance.

Sincerely,

Mike

Mike Marcus
Stream & Facility Monitoring Section
Environmental Quality Control

MM/al

enclosure

South Carolina Department of Health and Environmental Control

2600 Bull Street
Columbia, S.C. 29201

April 3, 1981

Ms. Rebecca Hanmer, Regional Administrator
Environmental Protection Agency,
Region IV
345 Courtland Street, N.E.
Atlanta, GA 30365

Dear Ms. Hanmer:

For the past few years, EPA's Ecology Branch in Athens, Georgia, has assisted us by conducting algal assay growth potential tests. These tests have proven to be an important factor in the evaluation of nutrients originating from wastewater treatment plants and the resulting response of algal populations in downstream waters. Two particular cases where algal assay testing has been done by the Ecology Branch are the Woodsen Subdivision Wastewater Treatment Plant and Lake Greenwood - Western Carolina Sewer Authority Mauldin Road Treatment Plant Studies. We are very appreciative of this assistance from the Ecology Branch and of the interest, cooperation and high level of expertise provided by Dr. Ronald Raschke and Mr. Don Schultz in completing this work.

At this time, we have need for additional assistance from Dr. Raschke and Mr. Schultz. We are in the process of evaluating the potential impact of nutrients being discharged to 18 Mile Creek in Anderson County, S. C., on the waters of the 18 Mile Creek arm of Lake Hartwell. Also, we would like to have previous algal assays studies conducted on Broadway Lake repeated this summer. The Broadway Lake studies are being conducted to evaluate the effects of BMP installation under the joint EPA-USDA Model Implementation Program project. As before, this activity will be closely coordinated between our Division of Biological, Stream and Facility Monitoring and Emergency Response and Ecology Branch personnel. Your approval for assistance is requested and we look forward to working with EPA's Ecology Branch personnel on these studies.

Yours very truly,

John E. Jenkins

John E. Jenkins, P.E., Deputy Commissioner
Environmental Quality Control

JEJ/RWS/al

cc: Jim Finger
Lee Tebo
Ronald Raschke
Noel Hurley
Chester Sansbury
Russ Sherer

South Carolina Department of Health and Environmental Control

COMMISSIONER
Robert S. Jackson, M.D.
2600 Bull Street
Columbia, S.C. 29201

April 3, 1981

Ms. Rebecca Hanmer, Regional Administrator
Environmental Protection Agency,
Region IV
345 Courtland Street, N.E.
Atlanta, GA 30365

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At this time, we have need for additional assistance from Dr. Raschke and Mr. Schultz. We are in the process of evaluating the potential impact of nutrients being discharged to 18 Mile Creek in Anderson County, S. C., on the waters of the 18 Mile Creek arm of Lake Hartwell. Also, we would like to have previous algal assays studies conducted on Broadway Lake repeated this summer. The Broadway Lake studies are being conducted to evaluate the effects of BMP installation under the joint EPA-USDA Model Implementation Program project. As before, this activity will be closely coordinated between our Division of Biological, Stream and Facility Monitoring and Emergency Response and Ecology Branch personnel. Your approval for assistance is requested and we look forward to working with EPA's Ecology Branch personnel on these studies.

Yours very truly,

John E. Jenkins

John E. Jenkins, P.E., Deputy Commission
Environmental Quality Control

JEJ/RWS/al

cc: Jim Finger
Lee Tebo
Ronald Raschke
Noel Hurley
Chester Sansbury
Russ Sherer

South Carolina Department of Health and Environmental Control

2600 Bull Street
Columbia, S.C. 29201

Commissioner
Robert S. Jackson, M.D.

April 17, 1984

Dr. Ronald Raschke
Ecology Branch
U.S. Environmental Protection Agency,
Region IV
Bailey Road
Athens, GA 30601

Dear Ron:

Per our telephone conversation of today, please find enclosed results from our chlorophyll a and phytoplankton sampling of Eighteen Mile Creek on April 2, 1981. These samples were collected in the main portion of Eighteen Mile Creek arm of Lake Hartwell near the Corps of Engineers boat ramp in response to a citizen's complaint of an algal bloom in the arm of the lake.

I reviewed my files on Eighteen Mile Creek but was unable to obtain any other information that would be useful to your current project. Nevertheless, I do hope this enclosed material will be beneficial.

If I can provide any further assistance, please contact me.

Sincerely,

Mike

Mike Marcus
Stream and Facility Monitoring Section
Environmental Quality Control

MM/al

Enclosure

complaint invest. John D. Johns
4-2-81

18 Mile Creek 4-2-81
Chlorophyll a ($\mu g/l$)

replicates
1- 28.35
2- 29.93
3- 31.50

$\bar{X} = 29.93$

Blank - 0.465

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

J. MARION SIMS BUILDING • COLUMBIA, SOUTH CAROLINA 29201 • PHONE 803-758-5654

MEMO-LETTER®

TO Mike Marcus

DATE 4-14-81

SUBJECT 18 mile Ck Complaint
Lk. Hartwell, Anderson Co.
Phyto Collected by M M. + ACB

This sample had an algal population of 2451 cells/ml.
Dominating the sample was Chlamydomonas sp, a green flagellate. The color of the water was probably a result of the algal growth.

Jeff Pearce
Biological Monitoring

18 mi. ... CK
... Lake Hartwell

South Carolina Department of Health and Environmental Control

BIOLOGICAL MONITORING - COUNTS AND IDENTIFICATION

Page ____ Of ____

Form 50

STATION (2-16)	YR 17-18	MO 19-20	DA 21-22	TIME 23-26	DEPTH 27-31	R 32	33	T 34	S# 35-36	LAB USE:
	81	04	02	1545	.16		D		001	

PARAMETER (2-10)		VALUE (12-19)
STRIPSCNT	(1)	
FIELDSCNT	(2)	20
SCRAPEVOL	(2)	
MAGNLVL	(4)	375
TOT-TAXA	(3)	10
SAMPRET	(5,1)	
ANA-DATE	(8)	81/04/03
ANA-REM	(50) 1	
ANA-REM	(50) 2	
ANA-REM	(50) 3	

PARAMETER (2-10)		VALUE (12-41)
CNT-METH	(19)	SEDGWICK-RAFTER
1 ST-ABUND	(30)	CHLAMYDOMONAS SP.
2 ND-ABUND	(30)	GLENODINIUM SP.
3 RD-ABUND	(30)	ANKISTRODESMUS SP.
4 TH-ABUND	(30)	NA
ANA-NAME	(15)	JGP

BLANK (27-80) BK 62-80

STATION (2-16)	YR 17-18	MO 19-20	DA 21-22	TIME 23-26	DEPTH 27-31	R 32	33	T 34	S# 35-36
					.		F		

PARAMETER (2-11)		VALUE (12-21)	UN 22-23	COEF. VAR (24-28)
COCBG	(5)	344	02	.
FILBLGR	(5)	129	02	.
COCGR	(5)	301	02	.
FILGR	(5)		2	.

PARAMETER (2-11)		VALUE (12-21)	UN 22-23	COEF. VAR (24-28)
GRNFL	(5)	1032	02	.
NONGRNFL	(5)	516	02	.
CENTR	(5)		2	.
PENAT	(5)	129	02	.

PARAMETER (2-11)		VALUE (12-21)	UN 22-23	COEF. VAR (24-28)
CENSHL	(5)		2	.
PENSHL	(5)		2	.
				.
				.
TOTWTWT	(8)			.
TOT-COUNT	(8)	2451	C2	.

STATION (2-16)	YR 17-18	MO 19-20	DA 21-22	TIME 23-26	DEPTH 27-31	R 32	33	T 34	S# 35-36
					.		G		

1	2	UN 3-4	CF (5-10)	S 11	L 12	FIRST NAME (14-31)	SECOND NAME (32-49)	VA 50-51	TALLY 52-56	LAB USE ONLY 1	2	3	4
	2		4	A	G	ASTERIONELLA	GRACILLINA		1	8		7	
	2			B	G	SCENEDESMUS	QUADRICAUDA		1	3			
	2			C	F	CHLAMYDOMONADACEAE	CHLAMYDOMONAS		24	5			
	2			D	F	OSCILLATORIACEAE	OSCILLATORIA		3	2			
	2			E	F	GOMPHONEMACEAE	GOMPHONEMA		1	8			
	2			F	F	CHROOCOCCACEAE	CHROOCOCCUS		4	1			
	2			G	F	GLENODINACEAE	GLENODINIUM		12	6			
	2			H	F	NAVICULACEAE	NAVICULA		1	8			
	2			I	F	CHROOCOCCACEAE	DACTYLOCOCCOPSIS		4	1			
	2			J	F	OOCYSTACEAE	ANKISTRODESMUS		6	3			
	2			K									
	2			L						57			
	2			M									
	2			N									
	2			O									
	2			P									
	2			Q									
	2			R									
	2			S									
	2			T									
	2			U									
	2			V									
	2			W									
	2			X									
	2			Y									
	2			Z									

COMPLAINT,
18 Mile Creek

South Carolina Department of Health and Environmental Control
BIOLOGICAL MONITORING FIELD DATA SHEET I

SPRING
SUMMER 1, 2, 3
FALL
OTHER 18-MILE CK SPECIAL
Form 20

STATION (2-16)	YR 17–18	MO 19–20	DA 21–22	TIME 23–26	BLANK (27–32)	33	34	S 35–36	BLANK (37-80)
	81	04	02	1545		B		01	

1 PARAMETER (2-10)	VALUE (12-21)	UNIT (22-31)	LAB USE ONLY
CLOUD-CVR	0		PER CENT COVERAGE
AIRTEMCEL	+26		DEGREES CENTIGRADE
SURFWTEMP	+18		DEGREES CENTIGRADE
TRANSPAR	0.45		METERS
MAXDEP			METERS
WAVEHGHT			METERS
PRECIP	9 9		TYPE-INTENSITY-DURATION
RIVER-STG			LOW-HIGH-FLOOD
TIDE-STG			SEE MANUAL

STORET DATA

STATION	DATE

Time	Depth (M)	D.O.	TEMP (°C)	CONDUC	pH	SALIN	% RB
	82048	00300	00010	00094	00400	00480	00002
1606	0.3	12.3	18.0	50.0	8.4		
1605	1.0	12.3	17.5	50.0			
1604	2.0	10.8	15.5	50.0			
1603	3.0	11.0	14.0	35.0			
1602	4.0	11.0	13.5	35.0			
1601	5.0	10.5	13.0	40.0			
1600	6.0	9.9	12.0	40.0			
1559	7.0	9.5	11.0	50.0			
1558	8.0	9.2	11.0	45.0			
1557	9.0	8.4	10.0	45.0			
1556	9.5 ~~10.0~~	8.6	10.0	40.0			
	11.0						
	12.0						
	13.0						
	14.0						
	15.0						
	16.0						
	17.0						
	18.0						
	19.0						
	20.0						
	21.0						
	22.0						
	23.0						
	24.0						

STATION (2-16)	YR 17–18	MO 19–20	DA 21–22	TIME 23–26	DEPTH(FT) (27–31)	R 32	33	T 34	S 35–36	BLANK (37-80)
							D			

1 (2-10)	11	(12-19)	(20-33)	(34-41)	(42-46)
SEDCLASS	A	SED-NAME	BOULDER	SED-COMP	•
SEDCLASS	B	SED-NAME	RUBBLE	SED-COMP	•
SEDCLASS	C	SED-NAME	COARSE GRAVEL	SED-COMP	•
SEDCLASS	D	SED-NAME	MEDIUM GRAVEL	SED-COMP	•
SEDCLASS	E	SED-NAME	FINE GRAVEL	SED-COMP	•
SEDCLASS	F	SED-NAME	COARSE SAND	SED-COMP	•
SEDCLASS	G	SED-NAME	MEDIUM SAND	SED-COMP	•
SEDCLASS	H	SED-NAME	FINE SAND	SED-COMP	•
SEDCLASS	I	SED-NAME	SILT	SED-COMP	•
SEDCLASS	J	SED-NAME	CLAY	SED-COMP	•
SEDCLASS	K	SED-NAME	ORGANIC MATTER	SED-COMP	•

SEDIMENT ANALYSIS REQUIRED FOR MACROINVERTEBRATE SAMPLES

COLLECTORS: ACB, JMM, DJ METERS FROM SHORE

NOTES:
1 Plankton
4 Chl A

SAMPLES COLLECTED

#	Parameter		#	Parameter	
1	PHYTO-ID	BOTTLE		MACROINV	MULTIPLT
4	PHYTO-CHLA	TUBE		MACROINV	DREDGE
	PERI-ID	BOTTLE		MACROINV	QUALIT.
	PERI-CHLA	TUBE		FISH	
	PERI-BIOM	VIAL			

APPENDIX B

STREAM AND PENDLETON-CLEMSON WWTP WATER QUALITY MONITORING

DISCUSSION OF EACH SAMPLING EVENT

WATER QUALITY MONITORING

March 19-24 Sampling Period

The March sampling event was the first full six day sampling period during the 18 Mile Creek study. Rainfall on March 18 (0.09 in.) and 19 (0.47 in.) produced a slight increase in streamflow as shown on the stage recorder chart (Figure B1). The rainfall did not result in increased flows at the Pendleton-Clemson WWTP and plant performance was not affected. Rainfall on March 21 of 1.16 in. did cause a significant increase in stream flow from less than 65 cfs to over 200 cfs within 14 hours (Time 12 hrs. to 26 hrs. - Figure B1). The stream T-P concentration remained at less than 0.20 mg/l until 24 hours into the event (Table B1, Figure B1). At this time, 0540 on March 21, the WWTP experienced a dramatic increase in effluent TSS and T-P concentrations (Figure B2). The effluent TSS increased from 5 mg/l to 1100 mg/l within 6 hours and the T-P concentration similarly responded with an increase from 4.3 mg/l to 24 mg/l (Table B2). The decline in effluent quality can be traced to the increased flow to the WWTP during the period of rainfall in the Pendleton-Clemson area. Plant flows increased from 0.42 mgd at 1740 on March 20 to over 1.35 mgd at 0540 on the 21st (Table B2).

The WWTP, prior to the rainfall event, contributed from 36 to 43 percent of the total T-P loading (lb/d) to 18 Mile Creek. The WWTP averaged approximately 14 to 21 percent, excluding periods of rainfall or extremely low flows, during the remainder of the study. At 2400 on March 20 the stream T-P loading had increased to 118 lb/d, however the loading from the WWTP had not yet increased. The increased stream T-P loading at this time (18 hr.) was due to non-point source contributions from within the watershed. The effects of the WWTP are first noticed at 0540 following the wash-out of solids from the secondary clarifiers (Table B2). The WWTP during this time period contributed 58 percent of the total stream T-P loading. As the WWTP flow decreased to below 0.65 mgd the effluent quality improved. TSS and T-P concentrations dropped to 6 mg/l and 3.60 mg/l, respectively, by 0540 on March 22 (Table B2). The percentage contribution of T-P by the WWTP to the stream dropped to less than 25 percent for the remainder of the sampling period.

At the peak of the WWTP flow the TKN and NH_3 values were 68 mg/l and 0.92 mg/l, respectively. At this time (24 hrs.) the WWTP was contributing 48 percent of the stream TKN load and 22 percent of the stream NH_3 load.

The WWTP contributed 93 percent of the B-P loading to the stream at the beginning of the sampling period. Generally the WWTP contributed a higher percentage of the stream B-P loading than T-P loading at base flows. The B-P data for this event show that the percentage of the T-P load in the stream comprised by B-P was approximately 30 percent at low flows. Because the B-P loading remained relatively constant during the period of increased flows, the percentage of the T-P load in the stream comprised by B-P at high flows was significantly less (10 percent and below). The B-P data for the WWTP at high flows was not available due to interferences in the algal assay procedure.

April 14-19 Sampling Period

The April sampling was the only full seven day period sampled during the study when flows were not elevated by a rainfall event. The flow in 18 Mile Creek remained fairly steady during the week at a stage height of approximately 0.95 to 1.25 ft. and an average flow of 98.9 cfs (Table B3). The stream flow did show a slight response to 0.20 inches of rainfall early in the week and a very minimal response to 0.16 inches of rainfall towards the end of the sampling period. The average WWTP flow for the week, 0.44 mgd or 0.68 cfs, was below the average flow of 0.52 mgd for April, 1983. Also the WWTP flow comprised less than 1.0 percent of the total flow in 18 Mile Creek. The WWTP seldom, even during periods of rainfall when infiltration/inflow increased WWTP flows, contributed more than 1.0 percent of the total stream flow.

The WWTP effluent T-P averaged 2.6 mg/l and 10 lb/d for the seven day period (Table B4). This was 21 percent of the total T-P loading to 18 Mile Creek during the sampling period. The effluent quality was very high with respect to TSS and BOD_5 as evidenced by the concentrations for the April 19-20 period of 3.0 mg/l and 4.3 mg/l, respectively (Table B5).

The WWTP was removing a significant amount of NH_3 via nitrification within the activated sludge system. The average effluent NH_3 concentration for the seven day period was 1.4 mg/l (Table B4). The contribution of the WWTP to the TKN and NH_3 loadings in 18 Mile Creek during the sampling period was less than 7.5 percent for both parameters.

May 13-18 Sampling Period

The May 13-18 sampling event was the first of two weeks sampled in May. A second week was sampled (May 19-24) because of the failure of the automatic sampler set to collect the samples for the B-P analysis during the first week of sampling. The May 13-18 sampling event actually experienced two seperate periods of high flow (Figure B3). The rainfall preceeding the sampling period consisted of 0.34 in on May 4 and 0.10 in on May 8. Rainfall of 1.67 in occurred on May 13 to 14 and the stream flow in 18 Mile Creek increased from 59 cfs to over 112 cfs at 1115 on May 14 (Table B6). Smaller rainfall amounts of 0.48 in on May 16 and 0.89 in on May 17 resulted in a larger increase in stream flow to over 204 cfs (Figure B3). The higher flows at apparently smaller rainfall amounts could be due to either the antecedent rainfall early in the week which caused the runoff to be greater on the 17th or the occurance of greater rainfall on the 16th or 17th elsewhere in the 18 Mile Creek watershed that was not recorded at the WWTP.

The WWTP, as occurred in March, experienced a loss of solids from the treatment system during the first and second high flow periods. The effluent TSS was 8 mg/l immediately prior to the first flow increase at 0455 on May 13. The WWTP flow increased from 0.45 mgd to 0.65 mgd and the effluent TSS concentration increased, following a six hour lag as the blanket level rose in the clarifiers, to 780 mg/l (Figure B4). The T-P concentration also responded to the solids loss by increasing from 5.1 mg/l to 27 mg/l (Table B7). The T-P concentration in 18 Mile Creek increased from 0.21 mg/l to 0.36 mg/l during this time period

(12 to 24 hr.) and the WWTP was responsible for 60 percent of the T-P loading at the 18 hr. mark of the sampling event (Figure B4). As the WWTP flow decreased to less than 0.50 mgd the effluent quality improved as TSS concentrations fell below 15 mg/l and T-P concentrations decreased to the 5.0 to 7.0 mg/l range (Table B7).

It should be noted that the solids loss occurred even though the plant flow did not exceed 50 percent of design and both clarifiers were in operation. However, the plant flow did increase by approximately 50 percent over the base flow level prior to the first rainfall period. As discussed in this report the solids losses often occurred during the time periods when the plant was not staffed. This was true for both of the rainfall periods during the first May sampling event. The washouts occurred at 0455 on March 14 and from 1655 on March 16 to 0455 on March 17 (Figure B4).

A second rainfall event occurred later in the week that resulted, as mentioned previously, in higher flows at the WWTP and in the stream even though rainfall amounts recorded at the WWTP were less (Figure B4). Plant flow increased to 0.70 mgd and flow in 18 Mile Creek peaked at over 230 cfs. The WWTP again experienced a solids loss from the clarifiers from 1655 on March 16 to 0455 on March 17 (Figure B4). The effluent TSS increased from 10 mg/l to 880 mg/l within 6 hours and T-P increased from 5.1 mg/l to 18.2 mg/l during the same time interval (Table B7). The T-P concentrations in the stream increased from 0.17 mg/l to 0.77 mg/l during the time period when the WWTP effluent quality declined. The WWTP was responsible for 44 percent of the T-P loading to the stream (78 hr. into the event). It should be noted that stream T-P concentrations had begun to increase prior to the decline in WWTP performance for each of these two rainfall periods during the May 12-18 sampling event (Table B6). However, the elevated stream T-P concentrations are due primarily to the contributions of the WWTP during the periods of poor performance. The WWTP contributed an average of 20 percent of the total stream T-P loading for the entire seven day period. It should be noted that the WWTP often has effluent T-P concentrations of 2.0 mg/l or less when the system is not experiencing hydraulic transients.

May 19-24 Sampling Period

The second week of sampling in May was conducted so that both T-P and B-P analyses could be completed on samples collected at the WWTP and 18 Mile Creek. This sampling period was also characterized by rainfall and increased stream flow. The watershed received 0.07 in. of rainfall on May 19, 0.83 ins. on May 20, and 0.43 in. on May 21 in addition to a smaller amount on the 22nd and 0.28 in. again on the 23rd. The peak flow of over 226 cfs occurred at approximately 56 hr. into the event (Figure B5). This peak flow was just below the peak flow from the previous week of over 230 cfs. The hydrograph was similar to those observed in March and the first sampling period in May as indicated by the sharp increase in flow on the rising limb, a peak flow of over 200 cfs, the relatively short duration of elevated flow (usually less than 16 hrs.), and the rapid fall of the descending hydrograph limb (Figure B5).

The WWTP was at a base flow of approximately 0.30 to 0.40 when a flow increase to 0.78 mgd was experienced (Figure B6). Although this flow was well below design the WWTP had been operating at less than 50 percent of this peak of 0.78 mgd (Table B9). The effluent TSS concentration increased from a low of 15 mg/l to over 570 mg/l at 30 hr. into the event. Effluent T-P was 15.6 mg/l during the time of maximum solids loss. The WWTP was contributing 66 percent of the total T-P loading to the stream as compared to 14 percent for the entire six day sampling period. The T-P concentration in the stream increased from 0.14 mg/l to 0.22 mg/l at 18 to 30 hrs. Figure B5 shows these concentrations were below those observed in the stream later in the event when WWTP performance was good and T-P contributions were not significant (Table B8).

The WWTP flow suddenly decreased at 0455 on May 21 (48 hr.) just as the stream flow was increasing towards the peak flow at 56 hr. (Figure B6). Effluent quality remained relatively steady during the remainder of the sampling period with TSS and T-P concentrations in the 25 mg/l and 2.0 mg/l ranges, respectively (Table B9). The WWTP contributed less than 15 percent of the T-P loading to the stream during the remainder of the sampling period. The T-P concentrations and loadings in 18 Mile Creek continued to increase as the stream flow moved towards the peak of the hydrograph. The highest T-P concentration, 0.28 mg/l, and loading, 319 lb/d, coincided with the peak of the hydrograph. Nonpoint sources, and to a lesser degree upstream point sources, were responsible for the T-P loading increase observed from 42 hr. to 60 hr. into the event (Figure B5).

The WWTP was not achieving a high degree of nitrification during this sampling period as NH_3 concentrations ranged from 7.5 mg/l to 17.5 mg/l when the solids washout occurred (Table B9). The WWTP was not nitrifying earlier in May but did achieve significant NH_3 reductions in March and April.

The WWTP contributed from 20 to 30 percent of the stream TKN loading during the six day sampling period with a peak of 59 percent at the 30 hr. mark.

June 30 - July 6 Sampling Period

The sampling event in June-July occurred during a period of low flow. The base flow at the beginning of the week was less than 48 cfs at a stage of 0.58 ft. (Table B14). The stream flow responded to the rainfall on July 1 of 0.88 in. by increasing to over 78 cfs at the peak of the hydrograph (30 hr. into the event). The WWTP effluent T-P was higher during low flow at the plant than observed during the previous months. T-P concentrations were between 15 and 17 mg/l prior to the flow increase at the WWTP (Figure B8). The stream T-P levels were impacted as the T-P concentration at base flow was 0.44 to 0.46 mg/l (Table B14). The stream T-P concentrations at the majority of flows during the study were less than 0.20 mg/l. The reason for the higher T-P values in the stream during this event can be traced to the fact that less dilution of the immediate upstream point source (Pendleton-Clemson WWTP) was being provided during the low flow periods in June, July, and August.

The percentage of the T-P loading to the stream contributed by the WWTP could not be determined because the plant flow meter was out of service during the early period of this sampling event. Assuming the WWTP flow was 0.40 mgd the plant would have been contributing approximately 40 to 45 percent of the T-P loading. Note that the contribution of the WWTP during a similar low flow period in August (37 cfs) was 42 to 47 percent. The stream T-P concentration during the August sampling period was 0.50 and 0.60 mg/l. These August T-P concentrations were among the highest observed during the study period and they occurred during the period of lowest flow. The T-P concentration in the stream decreases as the stream flow increases and more dilution of the WWTP point source is available. However, the stream concentrations were shown to increase at higher flows if WWTP performance declined. The WWTP effluent quality remained relatively unchanged during the initial period of the event (0-18 hrs).

The WWTP experienced two periods of solids loss during this sampling event. The first was apparently flow related, however the second occurred when plant flow had decreased to 0.45 mgd (Table B15). The peak T-P concentrations were 28 to 30 mg/l during the time of solids loss from the clarifiers. The stream T-P concentrations never reached the high values observed at the low flow in August even when the WWTP performance declined.

TABLE B-1

PR#018 MILE CREEK STUDY

DATE: MARCH LOCATION: WQ STATION

STATION	DATE	TIME	BOTTLE NO	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	D-P (MG/L)	D-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
EC-1	3/19-20	1200-0600	9-12	0	0.86	65.10	0.11	39	.041	14	0.28	98	0.60	211	.05	18	43	15088
EC-1	3/20	1200	13	6	0.81	61.60	0.09	36	.032	11	0.21	70	0.61	203	.05	17	160	53124
EC-1	3/20	1800	14	12	0.82	62.30	0.10	34	.029	10	0.37	124	0.62	208	.05	17	210	70517
EC-1	3/20	2400	15	18	1.38	115.30	0.19	118	.048	30	0.53	329	0.55	342	.05	31	210	130508
EC-1	3/21	0600	16	24	1.75	173.20	0.50	467	.035	33	1.70	1587	0.53	495	.05	47	390	364084
EC-1	3/21	1200	17	30	1.80	183.10	0.35	345	-	0	1.10	1086	0.47	464	.08	79	350	345418
EC-1	3/21	1800	18	36	1.48	128.70	0.31	215	-	0	0.81	562	0.49	340	.08	55	210	145676
EC-1	3/21	2400	19	42	1.26	101.10	0.20	109	.016	9	0.47	256	0.51	278	.05	27	200	108986
EC-1	3/22	0600	20	48	1.16	90.60	0.15	73	.063	31	0.38	186	0.56	273	.05	24	78	38090
EC-1	3/22	1200	21	54	1.10	84.80	0.13	59	.073	33	0.19	87	0.58	265	.05	23	130	59419
EC-1	3/22	1800	22	60	1.07	82.00	0.14	62	.063	28	0.28	124	0.61	270	.07	31	280	123754
EC-1	3/22	2400	23	66	1.03	78.50	0.12	51	.056	24	0.15	63	0.59	250	.05	21	120	50774
EC-1	3/23-24	0600-0600	24-28	72	0.96	72.70	0.11	43	.033	13	0.15	59	0.60	235	.05	20	54	21160

TABLE B-2

18 MILE CREEK STUDY

DATE: MARCH LOCATION: PENDLETON-CL EMSON WWTP

STATION	DATE	TIME	BOTTLE NO	TIME	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	D-P (MG/L)	D-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
CP-001	3/19-20	1140-0540	9-12	0	0.39	0.60	4.40	14	3.93	13	1.00	3	0.10	0.33	0.15	0.49	4	13
CP-001	3/20	1140	13	6	0.31	0.48	5.20	13	-	0	1.10	3	0.08	0.21	0.15	0.39	5	13
CP-001	3/20	1740	14	12	0.42	0.65	4.70	16	-	0	0.88	3	0.08	0.28	0.05	0.18	3	11
CP-001	3/20	2340	15	18	0.65	1.01	4.30	23	2.46	13	1.00	5	0.09	0.49	0.10	0.54	5	27
CP-001	3/21	0540	16	24	1.35	2.09	24.00	270	-	0	68.00	766	0.23	2.59	0.92	10.36	1100	12385
CP-001	3/21	1740	18	36	0.65	1.01	5.70	31	-	0	7.00	38	0.15	0.81	0.90	4.90	98	531
CP-001	3/21	2340	19	42	0.67	1.04	4.50	25	3.02	17	3.50	20	0.05	0.28	0.94	5.30	37	207
CP-001	3/22	0540	20	48	0.25	0.39	3.60	8	-	0	1.60	3	0.08	0.17	0.68	1.40	6	13
CP-001	3/22	1140	21	54	0.60	0.93	2.90	15	2.36	12	1.20	6	0.05	0.25	0.24	1.20	NA	0
CP-001	3/22	1740	22	60	0.52	0.80	1.80	8	-	0	1.10	5	0.12	0.52	0.15	0.65	NA	0
CP-001	3/22	2340	23	66	0.57	0.88	2.00	10	3.1	15	1.20	6	0.11	0.52	0.21	0.99	NA	0
CP-001	3/23-24	2400-2400	24-28	72	0.43	0.67	2.30	8	3.27	12	1.20	4	0.15	0.54	0.15	0.54	6	22

TABLE B-3

18 MILE CREEK STUDY

DATE: APRIL LOCATION: NQ STATION

STATION	DATE	TIME	BOTTLE NO	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	B-P (MG/L)	B-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)
EC-1	4/14-20	1030-1030	1-24	1.24 (6 DAY AVG.)	98.90 (6 DAY AVG.)	0.09	47.79	-	-	0.39	207	0.61	323.00	0.13	69.00	49

TABLE B-4

18 MILE CREEK STUDY

DATE: APRIL LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	B-P (MG/L)	B-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	BOD5 (MG/L)
CP-001	4/14-20	1010-1010	0.44 (6 DAY AVG.)	0.68 (6 DAY AVG.)	2.6	10	3.1	11	3.3	12.10	.18	0.66	1.4	5.13	NA	NA

18 MILE CREEK STUDY

DATE: APRIL LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	B-P (MG/L)	B-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	BOD5 (MG/L)
CP-001	4/19-20	1100-1100	0.37	0.58	3.00	9	-	-	4.70	69.00	0.22	0.69	3.40	10.63	3	4.3

TABLE B-5

18 MILE CREEK STUDY

DATE: APRIL STORM LOCATION: NQ STATION

STATION	DATE	TIME	BOTTLE NO	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	B-P (MG/L)	B-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)
EC-1	4/23	0900	1	0	0.90	68.00	0.10	37	.032	12	0.47	172	0.59	216	<0.05	18	54
EC-1	4/23	1700	9	9	1.15	89.60	0.10	48	.042	20	0.46	222	0.61	294	<0.05	24	42
EC-1	4/23	2100	13	13	1.38	115.35	0.13	80	.175	109	0.42	259	0.60	369	<0.05	30	56
EC-1	4/24	0100	17	17	1.47	127.35	0.13	89	.065	45	0.50	343	0.56	383	<0.05	34	92
EC-1	4/24	0900	25	25	1.32	107.90	0.13	88	.122	71	NA	NA	0.57	334	<0.05	29	110

TABLE B-6

10 MILE CREEK STUDY

DATE: MAY (1) LOCATION: WQ STATION

STATION	DATE	TIME	BOTTLE NO	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
EC-1	5/12-13	1115-1115	1-5	0	0.77	59.00	-	-	0.22	70	0.05	16	0.17	54	8	2544
EC-1	5/13	1715	6	6	0.80	60.80	0.14	46	0.52	170	0.48	157	0.46	151	34	11142
EC-1	5/13	2315	7	12	1.20	94.60	0.21	107	0.77	393	NAI	0	0.07	36	160	81583
EC-1	5/14	0515	8	18	1.15	89.60	0.35	169	1.08	522	NAI	0	0.05	24	140	67612
EC-1	5/14	1115	9	24	1.36	112.80	0.36	219	1.34	815	NAI	0	0.05	30	200	121598
EC-1	5/14	1715	10	30	1.13	87.60	0.26	123	0.92	434	0.43	203	0.05	24	110	51938
EC-1	5/14	2315	11	36	1.00	75.90	0.18	74	0.82	335	0.43	176	0.06	25	79	32319
EC-1	5/15	0515	12	42	0.92	69.60	0.20	75	0.69	259	NAI	0	0.06	23	94	35264
EC-1	5/15	1115	13	48	0.91	68.80	0.19	70	0.53	197	0.47	174	0.05	19	64	23733
EC-1	5/15	1715	14	54	0.89	67.30	0.15	54	0.53	192	0.36	131	0.06	22	50	18137
EC-1	5/15	2315	15	60	0.85	64.40	0.18	62	0.55	191	0.33	115	0.14	49	50	17356
EC-1	5/16	0515	16	66	0.85	64.40	0.17	59	0.51	177	0.44	153	0.07	24	50	17356
EC-1	5/16	1115	17	72	1.87	197.70	0.77	821	1.87	1993	NAI	0	0.10	107	570	607394
EC-1	5/16	1715	18	78	1.90	204.40	0.35	386	1.32	1454	NAI	0	0.05	55	270	297463
EC-1	5/16	2315	19	84	1.52	134.60	0.32	232	1.20	871	NAI	0	0.06	44	200	145099
EC-1	5/17	0515	20	90	1.24	98.90	0.23	123	0.82	437	NAI	0	0.06	32	130	69299
EC-1	5/17	1115	21	96	1.13	87.60	0.21	99	0.73	345	0.55	260	0.12	57	47	22192
EC-1	5/17	1715	22	102	1.06	81.10	0.11	48	0.55	240	NAI	0	0.05	22	65	28413
EC-1	5/17	2315	23	108	1.02	77.60	0.19	79	0.53	222	0.34	142	0.14	59	62	25932
EC-1	5/18	0515	24	114	0.97	73.50	0.11	44	0.48	190	NAI	0	0.05	20	53	20997

TABLE B-7

18 MILE CREEK STUDY

DATE: MAY (1) LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	BOTTLE NO	TIME	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
CP-001	5/12-13	1055-1055	1-5	0	0.43	0.67	0.22	1	0.45	2	0.46	1.65	0.37	1	31	111
CP-001	5/13	1655	6	6	0.40	0.62	2.20	7	21.00	70	0.05	0.17	16.00	53	7	23
CP-001	5/13	2255	7	12	0.64	0.99	5.10	27	20.00	107	0.05	0.27	18.00	96	8	43
CP-001	5/14	0455	8	18	0.45	0.70	27.00	101	100.00	375	0.05	0.19	18.00	68	780	2927
CP-001	5/14	1055	9	24	0.51	0.79	6.90	29	20.00	85	0.05	0.21	14.50	62	73	310
CP-001	5/14	1655	10	30	0.50	0.77	4.20	18	17.00	71	0.05	0.21	14.20	59	11	46
CP-001	5/14	2255	11	36	0.46	0.71	6.50	25	18.00	69	0.05	0.19	15.50	59	18	69
CP-001	5/15	0455	12	42	0.21	0.32	7.00	12	18.00	32	0.05	0.09	14.00	25	15	26
CP-001	5/15	1055	13	48	0.35	0.54	4.20	12	20.00	58	0.05	0.15	13.00	38	7	20
CP-001	5/15	1655	14	54	0.40	0.62	5.20	17	19.00	63	0.06	0.20	15.00	50	10	33
CP-001	5/15	2255	15	60	0.40	0.62	1.90	6	21.00	70	0.05	0.17	16.50	55	11	37
CP-001	5/16	0455	16	66	0.18	0.28	1.40	2	21.00	32	0.05	0.08	15.10	23	10	15
CP-001	5/16	1055	17	72	0.50	0.77	5.10	21	19.00	79	0.05	0.21	17.50	73	10	42
CP-001	5/16	1655	18	78	0.50	0.77	18.20	76	100.00	417	0.05	0.21	15.00	63	880	3670
CP-001	5/16	2255	19	84	0.70	1.08	17.50	102	82.00	479	0.05	0.29	12.00	70	620	3620
CP-001	5/17	0455	20	90	0.40	0.62	10.60	35	40.00	133	0.05	0.17	12.00	40	600	2002
CP-001	5/17	1055	21	96	0.40	0.62	1.20	4	18.00	60	0.05	0.17	12.00	40	18	60
CP-001	5/17	1655	22	102	0.40	0.62	1.93	6	17.00	57	0.05	0.17	12.50	42	42	140
CP-001	5/17	2255	23	108	0.40	0.62	1.20	4	17.00	57	0.05	0.17	12.00	40	8	27
CP-001	5/18	0455	24	114	0.40	0.62	2.70	9	17.00	57	0.05	0.17	12.50	42	8	27

TABLE B-8

18 MILE CREEK STUDY

DATE: MAY (2) LOCATION: HO STATION

STATION	DATE	TIME	BOTTLE NO	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	D-P (MG/L)	D-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
EC-1	5/18	1115-2315	1-3	0	0.90	68.00	0.14	51	.057	21	0.67	246	0.92	337	0.06	22	52	19059
EC-1	5/19	0515	4	6	0.87	65.80	0.13	46	.038	13	0.56	199	0.92	326	0.05	18	55	19506
EC-1	5/19	1115	5	12	0.95	71.90	0.14	54	.044	17	0.62	240	0.97	376	0.05	19	75	29066
EC-1	5/19	1715	6	18	1.20	94.60	0.20	102	.082	42	0.74	377	1.00	510	0.14	71	140	71385
EC-1	5/19	2315	7	24	1.36	112.80	0.20	122	-	0	0.74	450	0.91	553	0.05	30	124	75391
EC-1	5/20	0515	8	30	1.30	105.60	0.22	125	-	0	0.86	489	0.85	484	0.05	28	110	62610
EC-1	5/20	1115	9	36	1.31	106.80	0.17	98	.009	5	0.67	386	0.84	484	0.05	29	100	57565
EC-1	5/20	1715	10	42	1.46	126.00	0.24	163	.073	50	0.86	584	0.92	625	0.06	41	90	61123
EC-1	5/20	2315	11	48	1.60	146.90	0.24	190	.028	22	1.00	792	0.92	728	0.21	166	100	79179
EC-1	5/21	0515	12	54	1.90	204.40	0.26	286	.022	24	0.85	936	0.85	936	0.05	55	120	132206
EC-1	5/21	1115	13	60	1.93	211.20	0.28	319	.023	26	1.00	1138	0.79	899	0.06	68	150	170755
EC-1	5/21	1715	14	66	1.55	139.10	0.23	172	.022	16	0.78	585	0.80	600	0.07	52	80	59980
EC-1	5/21	2315	15	72	1.35	111.60	0.20	120	.012	7	0.69	415	0.80	481	0.10	60	160	96244
EC-1	5/22	0515	16	78	1.28	103.30	0.16	89	.015	8	0.67	373	0.88	490	0.06	33	100	55679
EC-1	5/22	1115	17	84	1.25	100.00	0.16	86	.104	56	0.60	323	0.88	474	0.05	27	90	485[illegible]
EC-1	5/22	1715	18	90	1.17	91.60	0.17	84	.008	4	0.65	321	0.90	444	0.05	25	90	44435
EC-1	5/22	2315	19	96	1.20	94.60	0.15	76	.005	3	0.60	306	0.85	433	0.05	25	96	48950
EC-1	5/23	0515	20	102	1.28	103.30	0.15	84	.007	4	0.59	329	0.85	473	0.05	28	97	54008
EC-1	5/23	1115-2315	21-22	108	1.15	89.60	0.13	63	.007	3	0.52	251	0.77	372	0.05	24	81	39118

TABLE B-9

18 MILE CREEK STUDY

DATE: MAY (2) LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	BOTTLE NO	TIME	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	B-P (MG/L)	B-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
CP-001	5/18	1055-2255	1-3	0	0.40	0.62	3.00	10	4.07	14	21.00	70	0.45	1.50	11.70	39	28	94
CP-001	5/19	0455	4	6	0.31	0.48	2.90	7	5.24	14	23.00	59	0.45	1.16	13.50	35	28	72
CP-001	5/19	1055	5	12	0.31	0.48	3.40	9	5.1	13	24.00	62	0.43	1.11	12.00	31	15	39
CP-001	5/19	1655	6	18	0.65	0.99	2.90	16	-	0	22.00	119	0.40	2.17	14.00	76	24	128
CP-001	5/19	2255	7	24	0.78	1.21	4.60	30	6.1	40	18.00	117	0.49	3.19	14.50	94	48	313
CP-001	5/20	0455	8	30	0.63	0.97	15.60	82	14.93	78	55.00	289	0.52	2.73	17.50	92	570	2980
CP-001	5/20	1655	10	36	0.55	0.85	3.50	16	4.93	23	12.00	55	0.12	0.55	11.00	50	6	27
CP-001	5/20	2255	11	42	0.70	1.08	2.00	12	.81	5	17.00	99	0.33	1.93	10.70	62	2	12
CP-001	5/21	0455	12	48	0.22	0.34	2.00	4	.21	•0	13.00	24	0.06	0.11	10.90	20	2	4
CP-001	5/21	1055	13	54	0.25	0.39	2.00	4	.44	1	16.00	33	0.06	0.13	9.00	19	16	34
CP-001	5/21	1655	14	60	0.25	0.39	1.50	3	.77	2	13.00	27	0.13	0.27	7.50	16	18	38
CP-001	5/21	2255	15	66	1.03	1.59	1.10	9	.52	4	10.00	86	0.05	0.43	8.50	73	21	180
CP-001	5/22	0455	16	72	0.48	0.74	2.40	10	9.16	37	9.20	37	0.05	0.20	7.50	30	24	96
CP-001	5/22	1055	17	78	0.30	0.46	3.40	9	4.28	11	11.00	28	0.37	0.93	7.50	19	21	52
CP-001	5/22	1655	18	84	0.55	0.85	2.50	11	3.66	17	18.00	83	0.37	1.70	8.00	37	24	110
CP-001	5/22	2255	19	90	0.58	0.90	1.70	8	.83	4	15.00	73	0.37.	1.79	9.00	44	24	116
CP-001	5/23	0455	20	96	0.45	0.70	2.30	9	4.13	15	16.00	60	0.48	1.80	8.50	32	26	98
CP-001	5/23	1055-1655	21-22	102	0.40	0.62	3.00	10	4.27	14	10.00	33	0.45	1.50	9.00	30	29	97

TABLE B-10

10 MILE CREEK STUDY

DATE: MAY (C) LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	BOTTLE NO	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	D-P (MG/L)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)	BOD5 (MG/L)	BOD5 (LB/D)
CP-001	5/17-18	1100-1100	C	0.40	0.62	1.00	3.34	-	18	60	0.06	0.20	14	47	6	20	7	23

TABLE B-11

10 MILE CREEK STUDY

DATE: MAY LOCATION: WEST FIELD DRAINAGE

STATION	DATE	TIME	T-P (MG/L)	D-P (MG/L)	TKN (MG/L)	NO3 (MG/L)	NH3 (MG/L)	TSS (MG/L)
CFR-1	5/16	1220	0.67	.15	3.00	1.00	1.35	310
CFR-1	5/20-24	1200-1400	1.00	.63	0.98	1.65	0.38	23

TABLE B-12

10 MILE CREEK STUDY

DATE: JUNE LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	FLOW (MGD)	FLOW (CFS)	TSS (MG/L)	BOD5 (MG/L)
CP-001	7/6-7	0800-0800	0.41	0.63	20	2

TABLE B-13

10 MILE CREEK STUDY

DATE: JUNE (BYE) LOCATION: WQ STATION

STATION	DATE	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	D-P (MG/L)	TKN (MG/L)	NO3 (MG/L)	NH3 (MG/L)	TSS (MG/L)
A1.2D	6/1	1235			0.08	.007	0.34	0.17	0.15	11
A1.2	6/1	1230			0.03	.004	0.25	0.08	0.10	2
EC-1	5/31	1345	0.78	59.60	0.20	.073	0.28	0.36	0.43	20
EC-2	5/31	1409	0.78	59.60	0.27	.078	0.24	0.73	0.43	37
EC-3	5/31	1438	0.78	59.60	0.24	.091	0.51	0.69	0.41	41
EC-4	5/31	1522	0.78	59.60	0.20	.122	0.32	0.69	0.27	41
EC-5	5/31	1615	0.78	59.60	0.18	.142	0.25	0.71	0.32	37
EC-6	5/31	1904	0.78	59.60	0.14	.086	0.25	0.60	0.12	15
EC-7	5/31	2124	0.78	59.60	0.11	.119	0.56	0.16	0.48	17
P-1	5/31	1355			0.02	.002	0.16	3.90	0.06	6
CP-001	5/31	1320			6.40	2.59	29.00	0.23	19.00	15

TABLE B-14

18 MILE CREEK STUDY

DATE: JUNE-JULY WQ LOCATION: WQ STATION

STATION	DATE	TIME	BOTTLE NO	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	D-P (MG/L)	D-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
EC-1	6/30	1130	1	0	0.58	47.85	0.46	119	.49	126	1.40	361	0.75	193	0.70	181	58	14958
EC-1	6/30	1730	2	6	0.58	47.85	0.44	113	.55	142	1.65	426	0.74	191	0.50	129	43	11089
EC-1	6/30	2330	3	12	0.59	48.38	0.56	146	.752	196	2.20	574	0.74	193	0.50	130	57	14863
EC-1	7/1	0530	4	18	0.70	54.60	0.28	82	.109	32	1.22	359	0.72	212	0.23	68	110	32371
EC-1	7/1	1130	5	24	1.01	76.78	0.28	116	.26	108	0.87	360	0.89	368	0.08	33	160	66219
EC-1	7/1	1730	6	30	1.03	78.49	0.32	135	.774	327	0.95	402	0.78	330	0.31	131	150	63461
EC-1	7/1	2330	7	36	0.83	62.99	0.30	102	.135	46	0.89	302	0.56	190	0.37	126	120	40743
EC-1	7/2	0530	8	42	0.75	57.69	0.21	65	.05	16	1.00	311	0.58	180	0.31	96	78	24252
EC-1	7/2	1730	10	54	0.65	51.68	0.22	61	.164	46	0.84	234	0.63	175	0.45	125	54	15041
EC-1	7/2	2330	11	60	0.64	51.11	0.22	61	.138	38	0.93	256	0.69	190	0.38	105	50	13774
EC-1	7/3	0530	12	72	0.62	50.00	0.18	49	.19	51	1.21	326	0.54	146	0.31	84	44	11858

TABLE B-15

18 MILE CREEK STUDY

DATE: JUNE-JULY LOCATION: PENDLETON-CLEMSON WWTP

STATION	DATE	TIME	BOTTLE NO	TIME	FLOW (MGD)	FLOW (CFS)	T-P (MG/L)	T-P (LB/D)	D-P (MG/L)	D-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
CP-001	6/30	1100	1	0	-	0.00	15.20	0	-	0	46.00	0	0.06	0.00	28.00	0	31	0
CP-001	6/30	1710	2	6	-	0.00	17.80	0	-	0	26.00	0	7.60	0.00	17.00	0	-	0
CP-001	6/30	2310	3	12	-	0.00	28.00	0	.87	0	72.00	0	0.05	0.00	30.00	0	-	0
CP-001	7/1	0510	4	18	-	0.00	16.80	0	1.29	0	47.00	0	0.05	0.00	29.00	0	36	0
CP-001	7/1	1100	5	24	0.70	1.08	30.00	175	-	0	110.00	642	0.05	0.29	43.00	251	790	4612
CP-001	7/1	1710	6	30	0.55	0.85	30.00	138	.44	2	91.00	417	0.05	0.23	39.00	179	800	3670
CP-001	7/1	2310	7	36	0.52	0.80	18.00	78	3.53	15	44.00	191	0.05	0.22	32.00	139	50	217
CP-001	7/2	0510	8	42	0.30	0.46	28.00	70	2.2	6	68.00	170	0.05	0.13	38.00	95	-	0
CP-001	7/2	1100	9	48	0.50	0.77	15.40	64	1.48	6	36.00	150	0.06	0.25	29.00	121	36	150
CP-001	7/2	1710	10	54	0.50	0.77	13.60	57	1.75	7	44.00	183	0.05	0.21	30.00	125	34	142
CP-001	7/2	2310	11	60	0.45	0.70	26.00	98	2.2	8	110.00	413	0.05	0.19	40.00	150	890	3340
CP-001	7/3-7	0510-0510	12-28	72	0.45	0.70	5.10	19	.87	3	38.00	143	0.05	0.19	27.00	101	40	150

TABLE B-16

18 MILE CREEK STUDY

DATE: NOVEMBER DYE LOCATION: WATER QUALITY STATION AND LAKE HARTWELL

STATION	DATE	TIME	STAGE (FT)	FLOW (CFS)	T-P (MG/L)	D-P (MG/L)	TKN (MG/L)	NO3 (MG/L)	NH3 (MG/L)	TSS (MG/L)
A1.1	11/15	1932			0.17	.128	0.65	0.45	0.44	15
A2.5 (4')	11/16	1322			0.03	.007	0.50	0.06	0.09	4
A2.5 (11')	11/16	1320			0.07	.042	0.70	0.20	0.11	10
EC-1	11/15	1225	1.12	86.66	0.21	.149	0.65	0.45	0.17	96
EC-2	11/15	1245	1.14	88.59	0.27	.231	1.00	0.52	0.28	85
EC-3	11/15	1310	1.16	90.56	0.28	.225	0.90	0.47	0.21	110
EC-5	11/15	1426	1.20	94.63	0.31	.224	0.82	0.50	0.23	100
EC-6	11/15	1458	1.23	97.81	0.30	.216	0.85	0.52	0.23	110
EC-7	11/15	1516	1.24	98.89	0.34	.216	1.10	0.47	0.10	130
EC-8	11/15	1538	1.28	103.34	0.36	.239	1.00	0.50	0.34	120

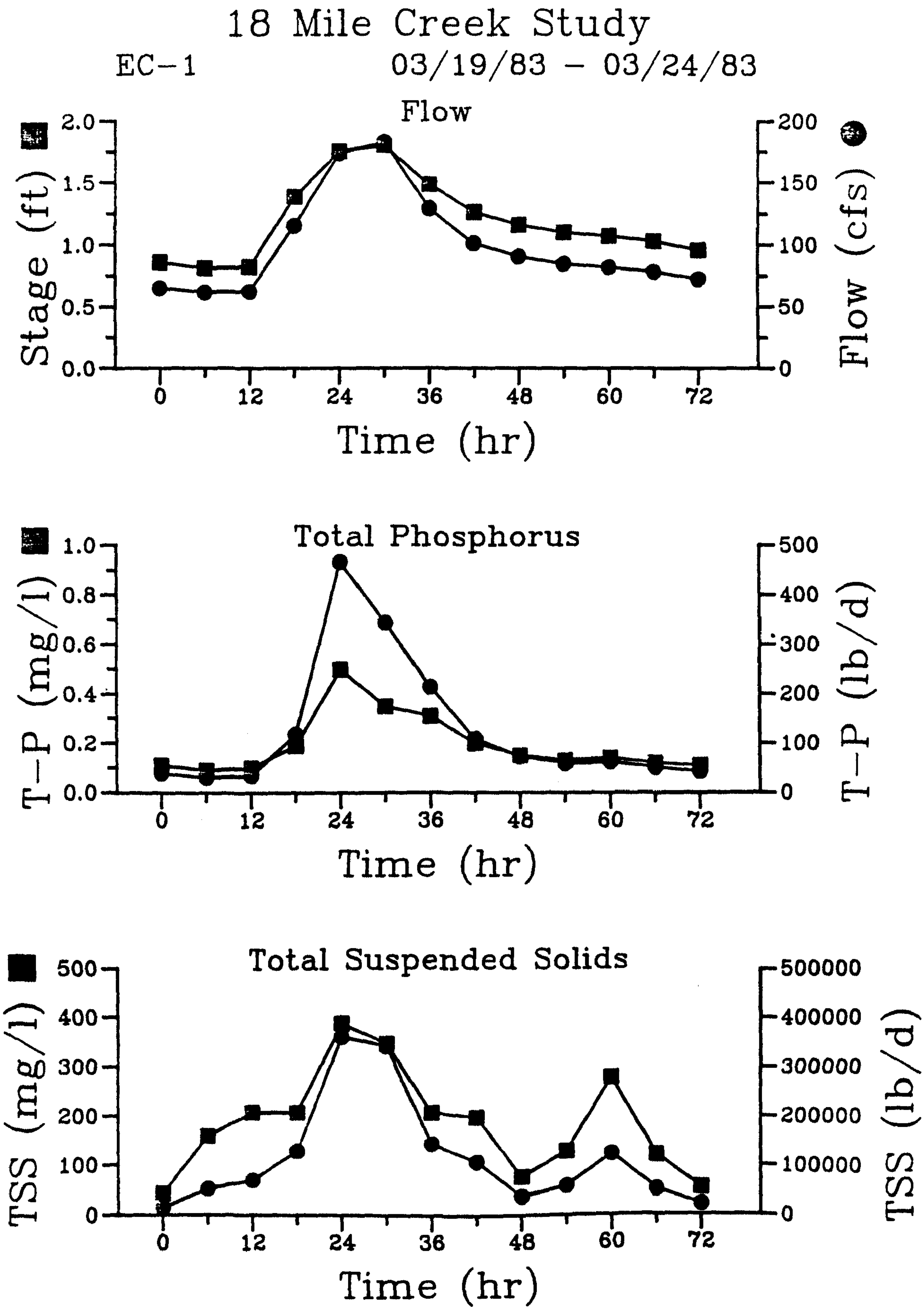
TABLE B-17

18 MILE CREEK STUDY

DATE: NOVEMBER WWTP LOCATION: CLEMSON-PENDLETON WWTP

STATION	DATE	TIME	BOTTLE NO	TIME	FLOW (MGD)	T-P (MG/L)	T-P (LB/D)	TKN (MG/L)	TKN (LB/D)	NO3 (MG/L)	NO3 (LB/D)	NH3 (MG/L)	NH3 (LB/D)	TSS (MG/L)	TSS (LB/D)
CP-001	11/14	1230	1	1	0.60	14.60	47	25.00	81	0.31	1.00	10.00	32	8	26
CP-001	11/14	1330	2	2	0.60	13.00	42	24.00	78	0.08	0.26	21.00	68	12	39
CP-001	11/14	1430	3	3	0.55	9.80	29	26.00	77	0.08	0.24	19.00	56	10	30
CP-001	11/14	1530	4	4	0.55	8.70	26	25.00	74	0.07	0.21	19.00	56	12	36
CP-001	11/14	1630	5	5	0.52	7.70	22	20.00	56	0.07	0.20	17.00	48	9	25
CP-001	11/14	1730	6	6	0.49	6.80	18	25.00	66	0.07	0.18	16.00	42	10	26
CP-001	11/14	1830	7	7	0.48	6.30	16	24.00	62	0.07	0.18	16.00	41	12	31
CP-001	11/14	1930	8	8	0.50	5.70	15	26.00	70	0.07	0.19	18.00	49	9	24
CP-001	11/14	2030	9	9	0.53	5.20	15	25.00	71	0.07	0.20	17.00	49	9	26
CP-001	11/14	2130	10	10	0.55	4.70	14	26.00	77	0.07	0.21	16.00	47	12	36
CP-001	11/14	2230	11	11	0.62	4.30	14	25.00	84	0.07	0.23	20.00	67	9	30
CP-001	11/14	2330	12	12	0.65	4.00	14	21.00	74	0.07	0.25	19.00	67	11	39
CP-001	11/14	0030	13	13	0.60	3.80	12	22.00	71	0.07	0.23	16.00	52	14	45
CP-001	11/14	0130	14	14	0.50	3.40	9	23.00	62	0.07	0.19	14.00	38	11	30
CP-001	11/15	0230	15	15	0.45	3.30	8	22.00	53	0.07	0.17	18.00	44	10	24
CP-001	11/15	0330	16	16	0.40	3.10	7	26.00	56	0.07	0.15	15.00	32	10	22
CP-001	11/15	0430	17	17	0.40	2.90	6	26.00	56	0.07	0.15	14.00	30	8	17
CP-001	11/15	0530	18	18	0.61	2.80	9	35.00	115	0.10	0.33	20.00	66	9	30
CP-001	11/15	0630	19	19	0.70	2.70	10	24.00	91	0.07	0.26	14.00	53	9	34
CP-001	11/15	0730	20	20	0.65	2.60	9	24.00	84	0.07	0.25	17.00	60	9	32
CP-001	11/15	0830	21	21	0.85	2.50	11	25.00	115	0.07	0.32	19.00	87	10	46
CP-001	11/15	0930	22	22	0.75	2.50	10	21.00	85	0.07	0.28	16.00	65	17	69
CP-001	11/15	1030	23	23	0.65	2.30	8	21.00	74	0.07	0.25	19.00	67	7	25
CP-001	11/15	1130	24	24	0.60	2.30	7	20.00	65	0.07	0.23	14.00	45	7	23
CP-001	11/15	1230	25	25	0.52	2.20	6	20.00	56	0.07	0.20	15.00	42	7	20
CP-001	11/15	1330	26	26	0.55	2.20	7	16.00	47	0.07	0.21	15.00	44	5	15
CP-001	11/15	1430	27	27	0.55	2.20	7	21.00	62	0.07	0.21	17.00	50	10	30
CP-001	11/15	1530	28	28	0.55	2.40	7	20.00	59	0.10	0.30	12.00	36	8	24
CP-I	11/14	1230	1	1		9.00									
CP-I	11/15	0830	2	2		2.20									
CP-I	11/15	0930	3	3		4.70									
CP-I	11/15	1030	4	4		6.60									
CP-I	11/15	1130	5	5		4.60									
CP-I	11/15	1230	6	6		4.10									
CP-I	11/15	1330	7	7		3.50									
CP-I	11/15	1430	8	8		3.90									
CP-I	11/15	1530	9	9		3.20									

FIGURE B-1



18 Mile Creek Study
EC-1
03/19/83 - 03/24/83
Flow
Stage (ft)
Flow (cfs)
Time (hr)
Total Phosphorus
T-P (mg/l)
T-P (lb/d)
Time (hr)
Total Suspended Solids
TSS (mg/l)
TSS (lb/d)
Time (hr)

FIGURE B-2

18 Mile Creek Study

CP-001 03/19/83 - 03/24/83

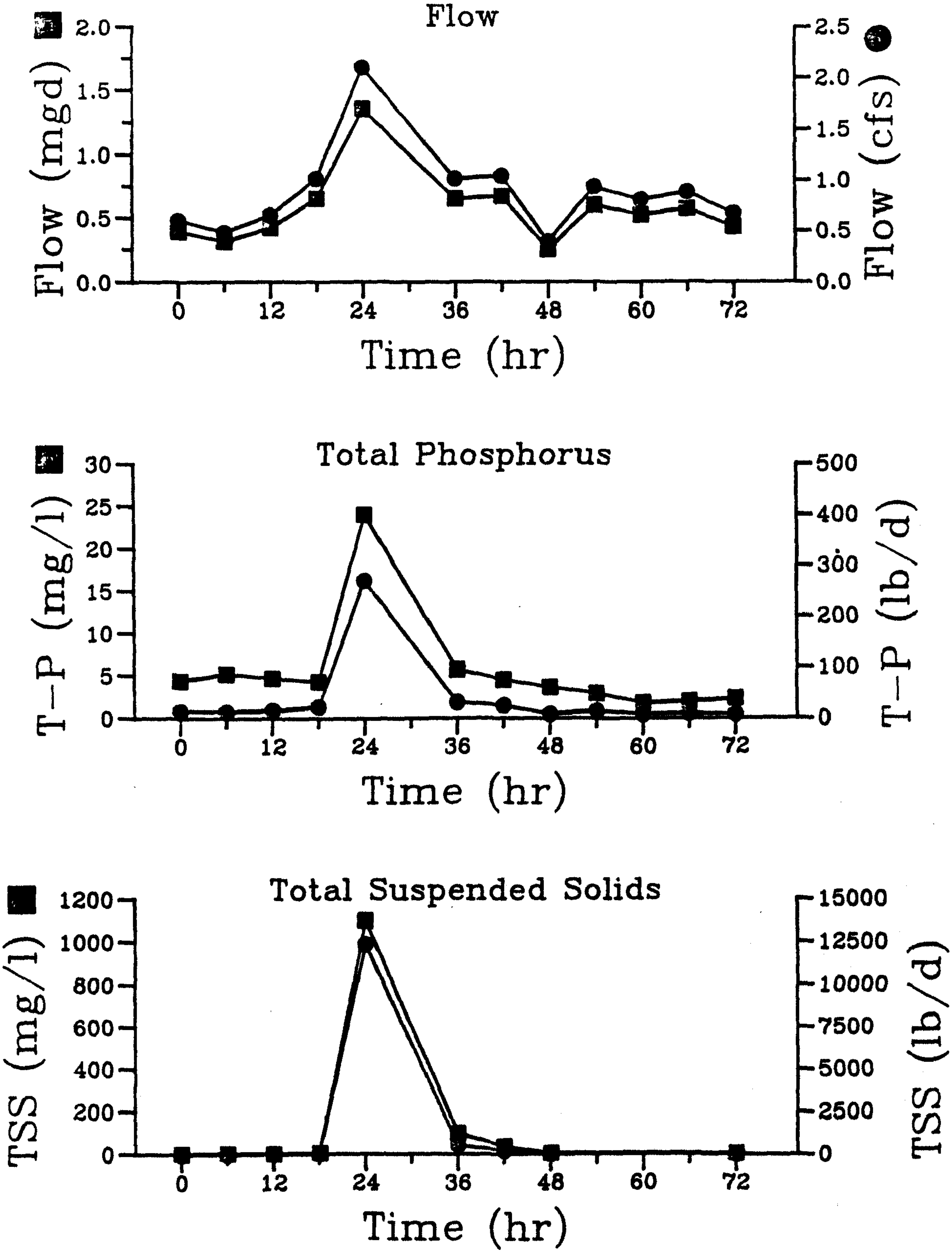
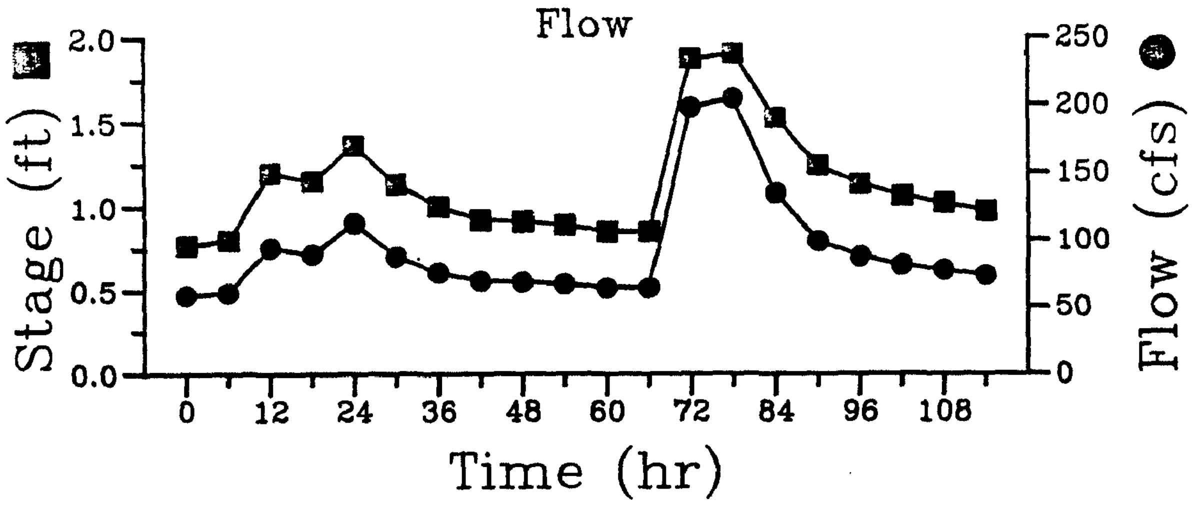
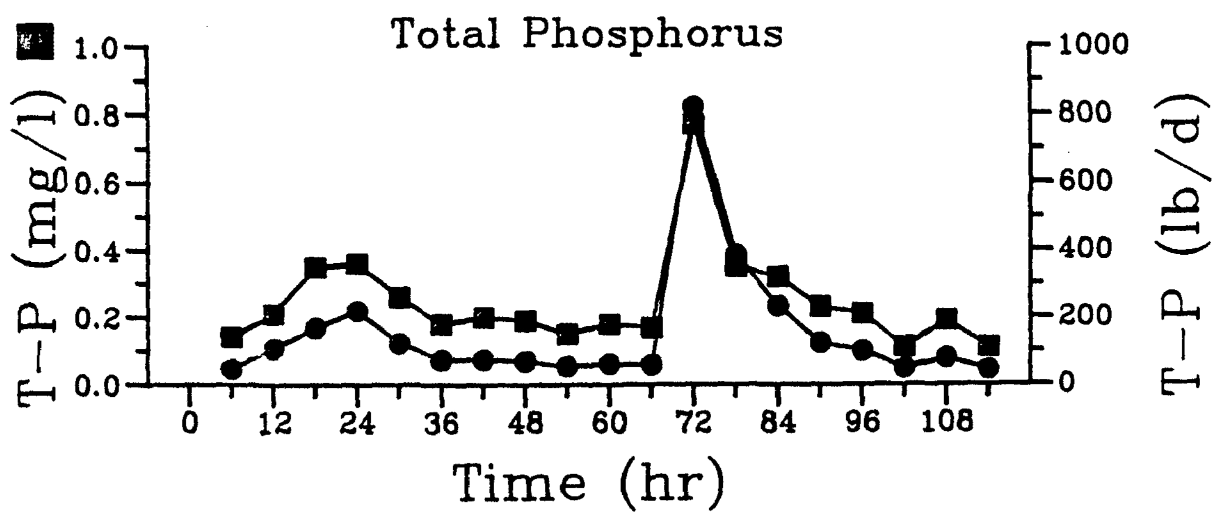


FIGURE B-3

18 Mile Creek Study

EC-1 05/12/83 - 05/18/83





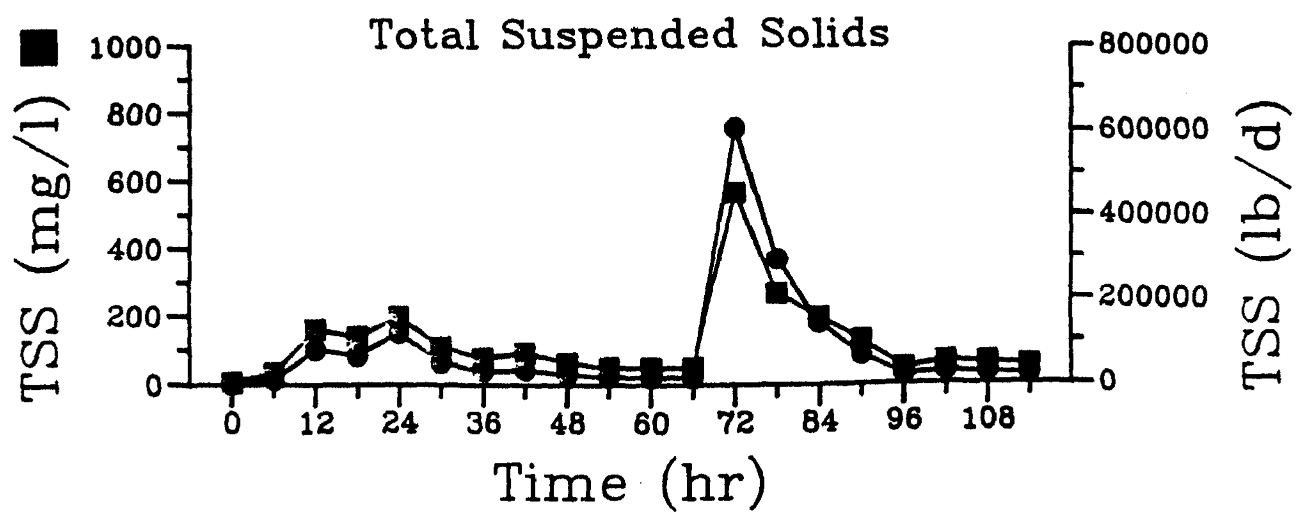
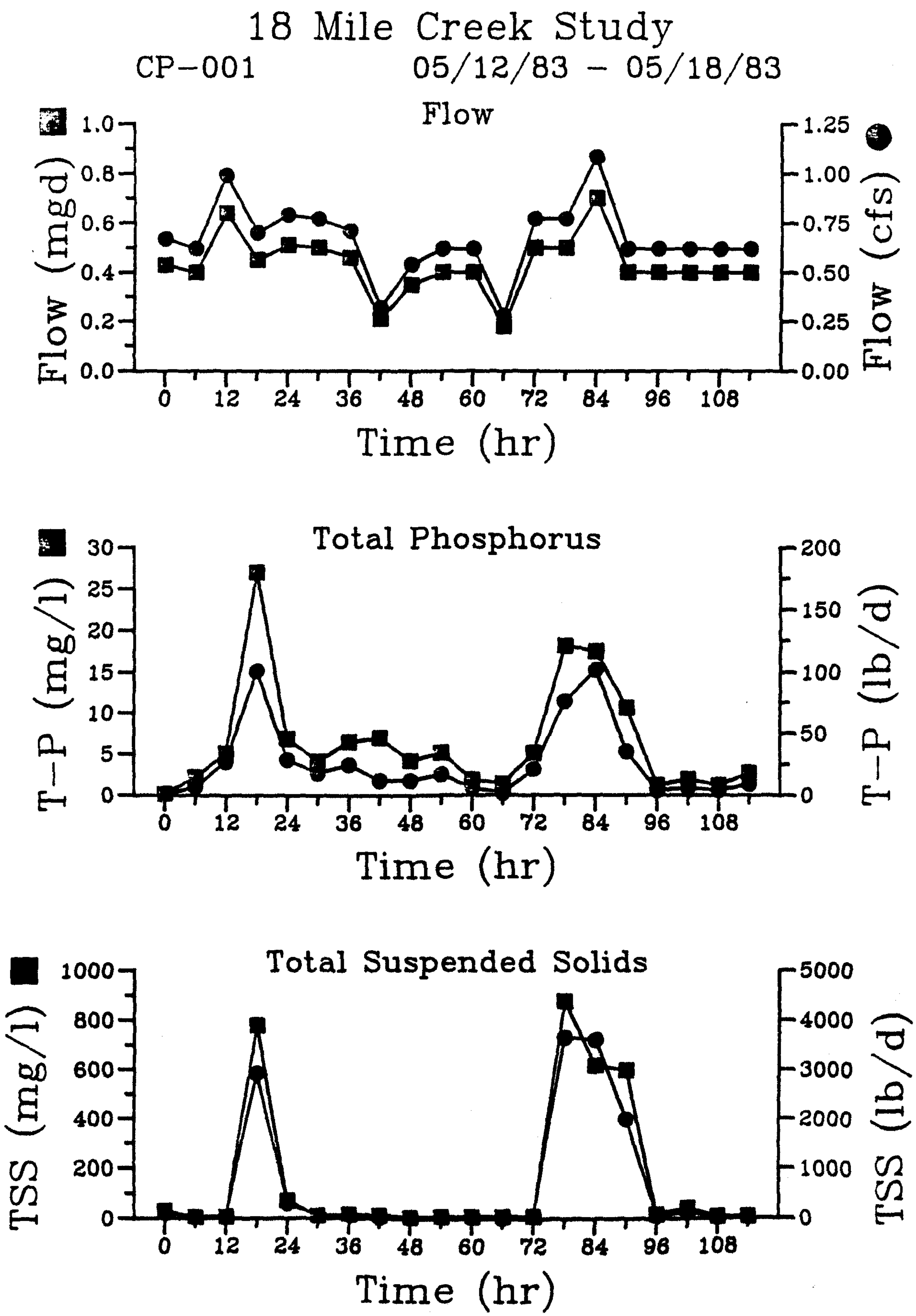
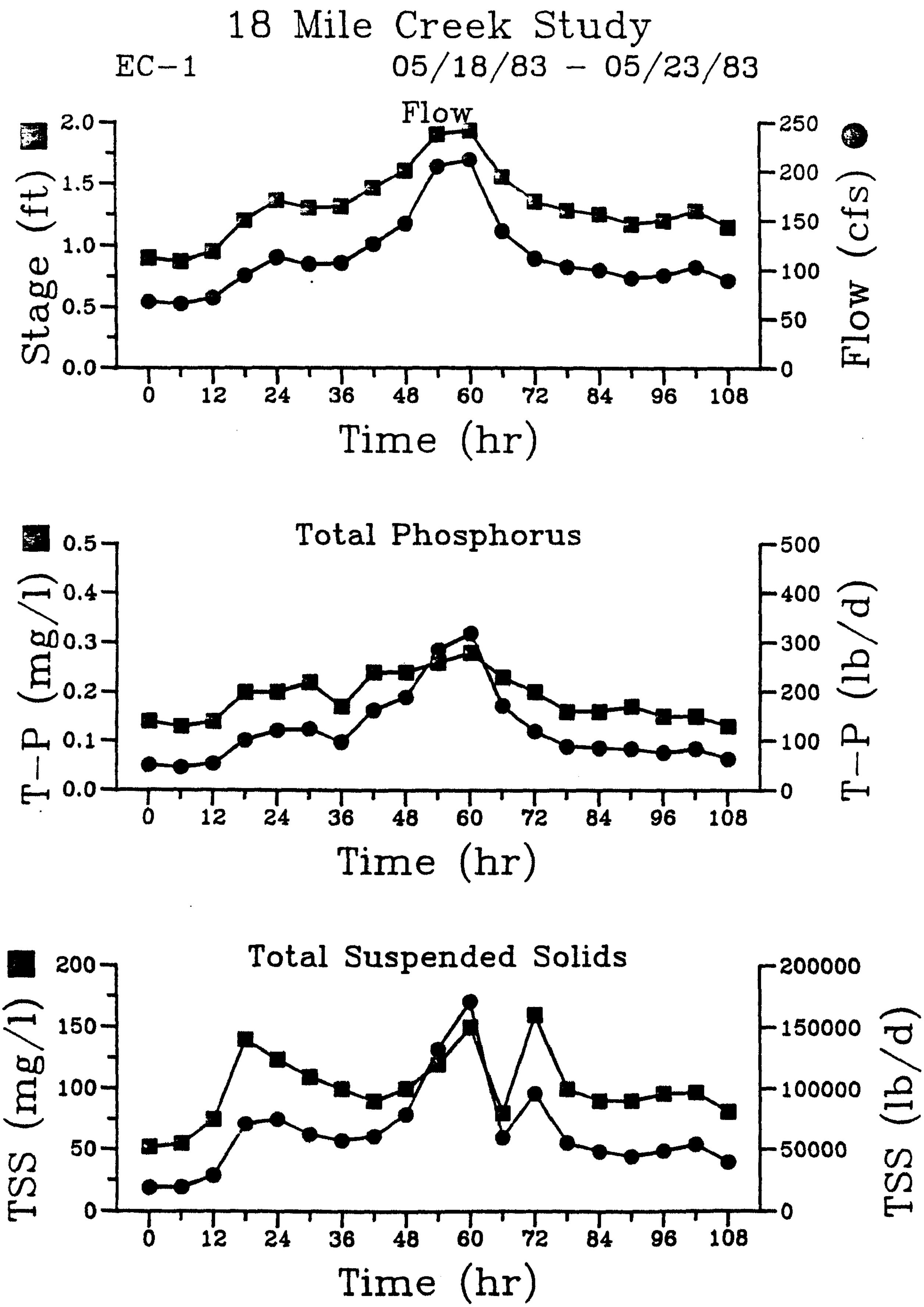


FIGURE B-4



18 Mile Creek Study
CP-001
05/12/83 - 05/18/83
Flow
Flow (mgd)
Flow (cfs)
1.0
0.8
0.6
0.4
0.2
0.0
1.25
1.00
0.75
0.50
0.25
0.00
0
12
24
36
48
60
72
84
96
108
Time (hr)
Total Phosphorus
T-P (mg/l)
T-P (lb/d)
30
25
20
15
10
5
0
200
150
100
50
0
0
12
24
36
48
60
72
84
96
108
Time (hr)
Total Suspended Solids
TSS (mg/l)
TSS (lb/d)
1000
800
600
400
200
0
5000
4000
3000
2000
1000
0
0
12
24
36
48
60
72
84
96
108
Time (hr)

FIGURE B-5



18 Mile Creek Study
EC-1
05/18/83 - 05/23/83
Flow
Stage (ft)
Flow (cfs)
2.0
1.5
1.0
0.5
0.0
250
200
150
100
50
0
0
12
24
36
48
60
72
84
96
108
Time (hr)
Total Phosphorus
T-P (mg/l)
T-P (lb/d)
0.5
0.4
0.3
0.2
0.1
0.0
500
400
300
200
100
0
Time (hr)
Total Suspended Solids
TSS (mg/l)
TSS (lb/d)
200
150
100
50
0
200000
150000
100000
50000
0
Time (hr)

FIGURE B-6

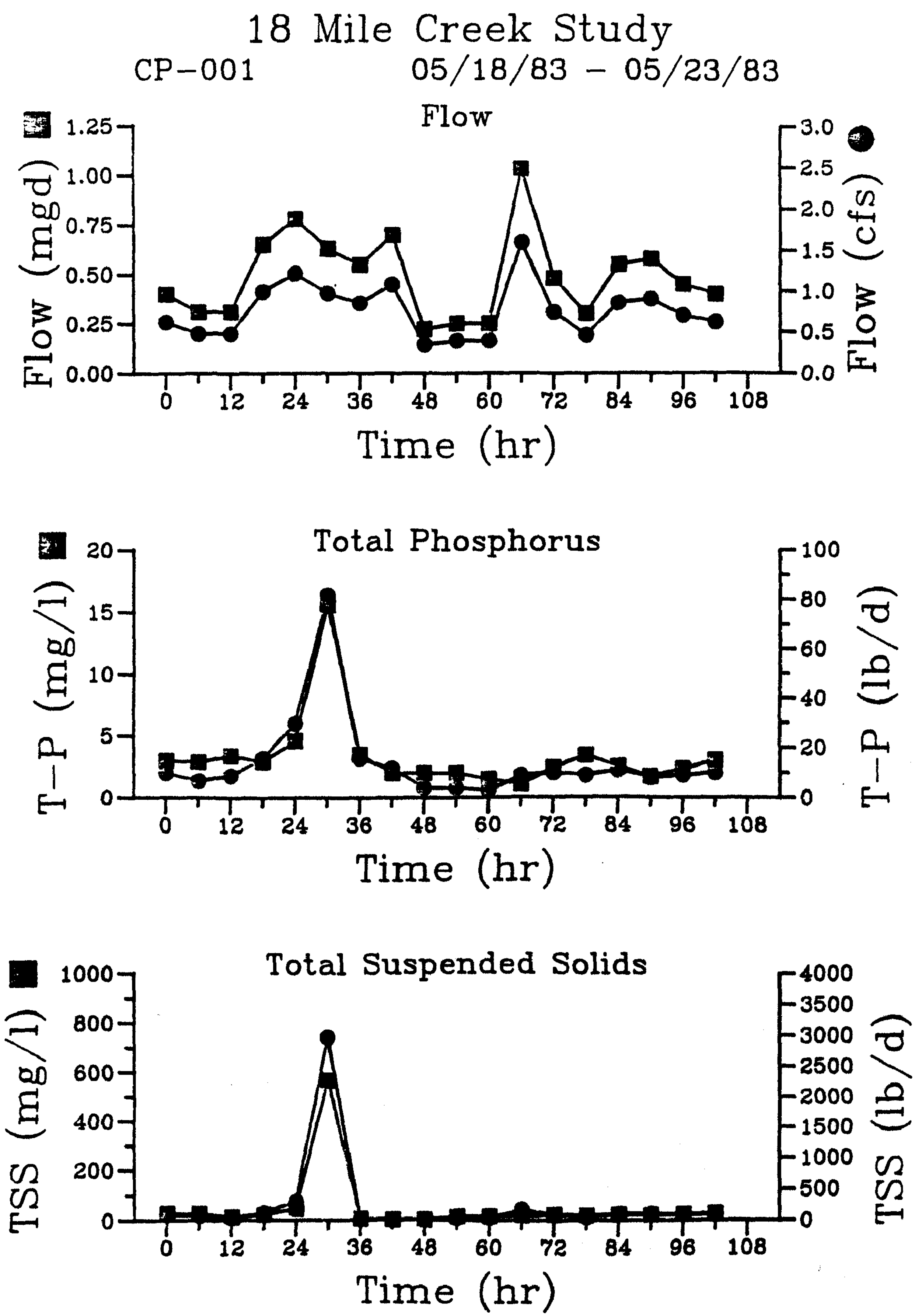

18 Mile Creek Study
CP-001
05/18/83 - 05/23/83
Flow
Flow (mgd)
Flow (cfs)
1.25
1.00
0.75
0.50
0.25
0.00
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
12
24
36
48
60
72
84
96
108
Time (hr)
Total Phosphorus
T-P (mg/l)
T-P (lb/d)
20
15
10
5
0
100
80
60
40
20
0
0
12
24
36
48
60
72
84
96
108
Time (hr)
Total Suspended Solids
TSS (mg/l)
TSS (lb/d)
1000
800
600
400
200
0
4000
3500
3000
2500
2000
1500
1000
500
0
0
12
24
36
48
60
72
84
96
108
Time (hr)

FIGURE B-7

18 Mile Creek Study

EC-1 06/30/83 - 07/03/83

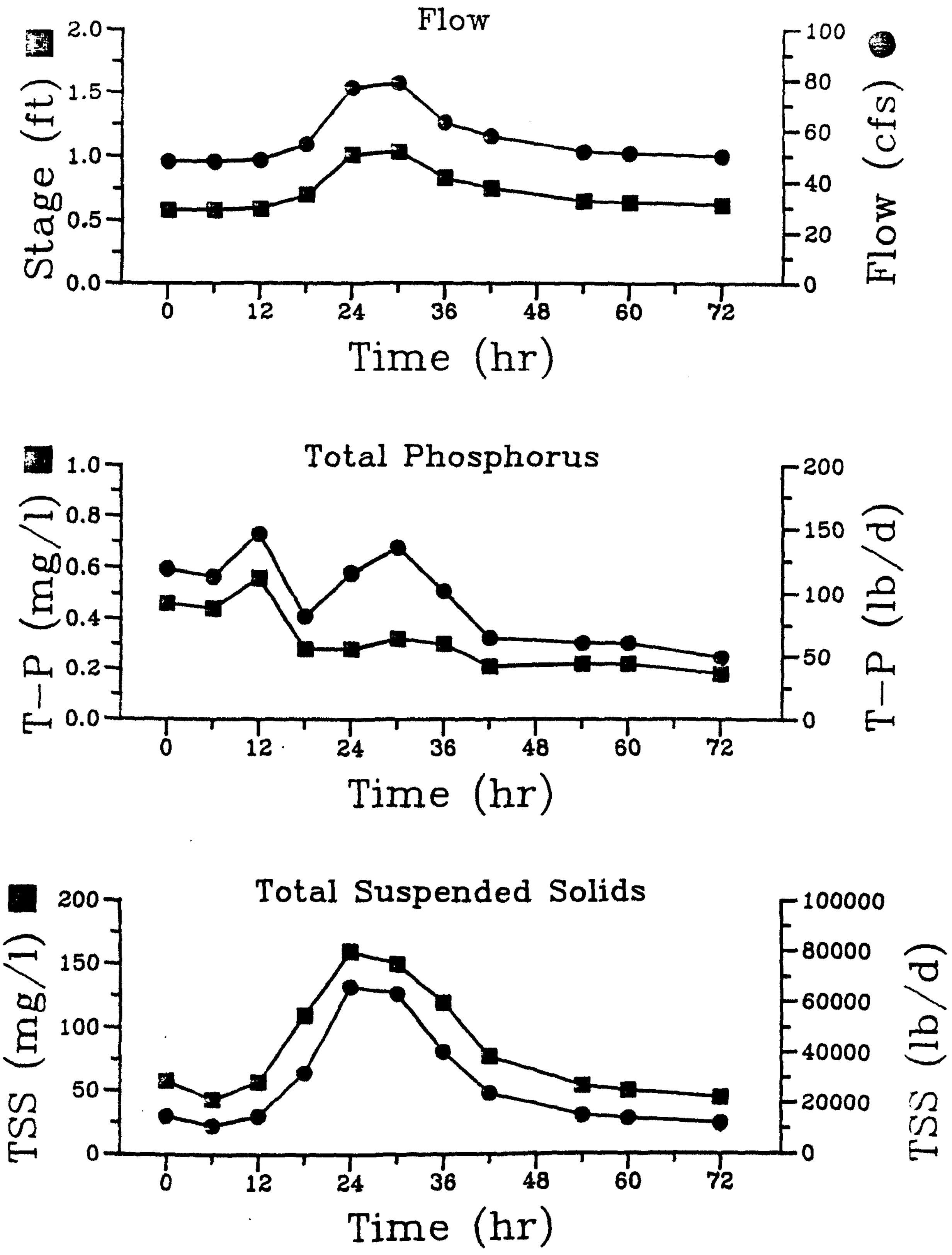
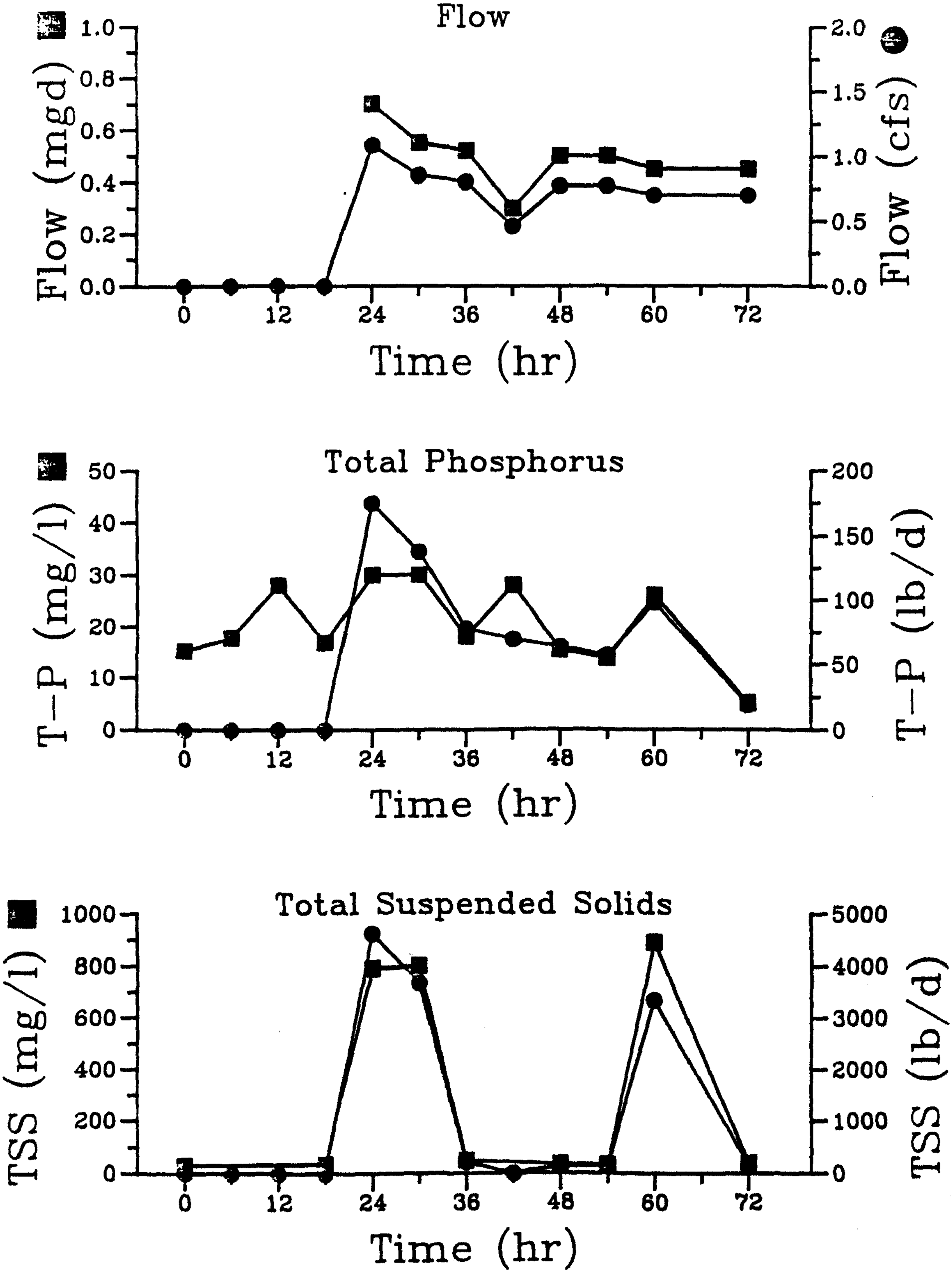


FIGURE B-8

18 Mile Creek Study

CP-001 06/30/83 - 07/03/83



APPENDIX C

AREA-VOLUME DATA FOR 18-MILE CREEK ARM AT 661 msl,

HARTWELL RESERVOIR, S.C., 1983

Appendix C

Area-Volume Data for 18 Mile Creek Arm at 661 msl
Hartwell Reservoir, South Carolina, 1983

Depth (feet)	Area (acres)	Volume (acres-feet)
70.11	.00	.00
69.11	.22	15.30
67.11	.48	37.43
64.11	1.55	125.92
62.11	2.25	169.54
61.11	3.70	252.29
55.11	7.63	472.32
51.11	11.02	651.20
48.11	16.75	912.64
47.11	17.45	944.98
46.11	17.46	945.61
43.11	21.18	1153.78
41.11	22.48	1232.55
40.11	32.31	1576.36
31.11	32.42	1580.42
28.11	47.18	1972.18
26.11	48.03	2001.23
25.11	52.01	2101.04
23.11	53.32	2139.35
21.61	53.35	2140.52
21.11	53.35	2140.53
19.61	66.52	2348.94
17.11	67.46	2371.95
16.11	71.20	2429.91
15.11	80.64	2548.07
14.11	81.98	2571.29
13.61	82.55	2577.97
12.61	85.50	2624.91
12.11	90.99	2716.61
11.11	100.02	2814.15
7.61	129.15	3001.96
7.11	129.38	3004.04
6.11	132.95	3023.74
1.11	161.48	3095.06

APPENDIX D

LIMITING NUTRIENT STATUS OF 18-MILE CREEK ARM, HARTWELL RESERVOIR, S.C., 1983

Appendix D
Limiting Nutrient Status of 18 Mile Creek Arm,
Hartwell Reservoir, South Carolina, 1983.

MONTHS	A5	A4	A3	A2	A1	EC1
2	P	N+P	P	P	P	N
3	P	P	P	P	P	N
4	P	P	N+P	P	N	N
5	P	P	P	P	N	N
6	P	P	P	P	P	N
7	P	P	P	N	N	N
8	P	P	P	N+P	N	N
9	P	N	N	N	N	N

STATIONS

N+P : Optimum Ratio
P : Phosphorous Limited
N : Nitrogen Limited

APPENDIX E

AVERAGE CORRECTED CHLOROPHYLL A FOR DEPTH INTEGRATED SAMPLES, TSI_{chl} AND TSI_{SD}, 18-MILE CREEK ARM, HARTWELL RESERVOIR, S.C., 1983

Table 8-1

Date	No. Stations	Chlor. a (ug/L)	Std. Dev.	% Coef. of Var.	TSI(Chl)
2/24/83	1	5.81	1.71	29.4	48
2/24/83	2	3.44	1.62	47.1	43
2/24/83	3	3.66	1.62	44.3	43
2/24/83	4	21.07	3.72	17.7	60
2/24/83	5	5.87	0.55	9.4	48
3/22/83	1	5.66	0.62	10.9	48
3/22/83	2	16.73	0.68	4.1	58
3/22/83	3	15.46	0.16	1.0	57
3/22/83	4	13.91	1.03	7.4	56
3/22/83	5	19.51	2.05	10.5	60
4/12/83	1	3.73	0.51	13.6	43
4/12/83	2	5.47	0.29	5.3	47
4/12/83	3	7.35	0.26	3.5	50
4/12/83	4	9.17	0.73	8.0	52
4/12/83	5	6.97	0.13	1.9	50
5/17/83	1	6.32	0.55	8.7	49
5/17/83	2	18.06	0.64	3.6	59
5/17/83	3	11.72	1.66	14.1	55
5/17/83	4	6.75	0.36	5.3	49
5/17/83	5	6.45	0.41	6.3	49

Table E-1

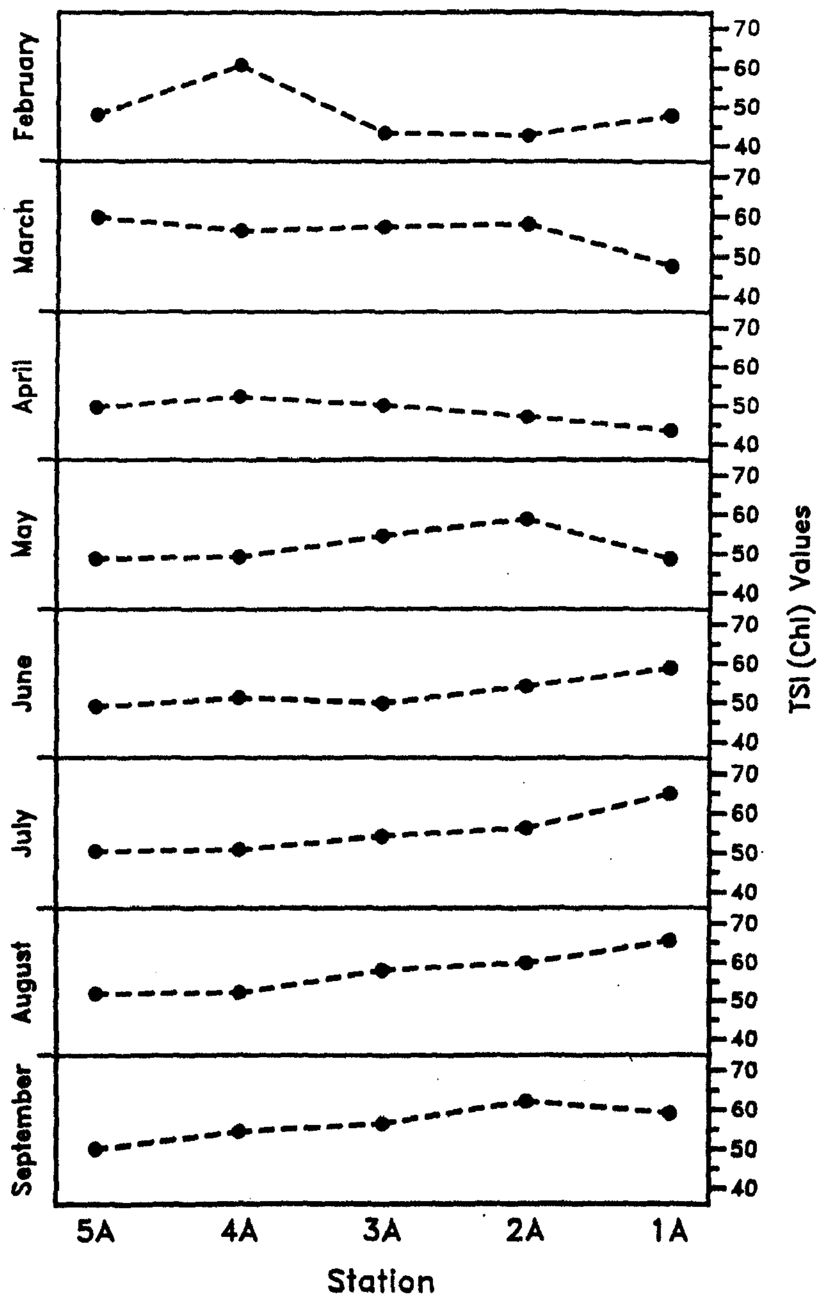
Date	[illegible] Stations	Chlor. a (ug/L)	Std. Dev.	% Coef. of Var.	TSI(Chl)
6/21/83	1	17.80	4.26	24.0	59
6/21/83	2	11.18	0.19	1.7	54
6/21/83	3	7.23	1.84	25.5	50
6/21/83	4	8.28	2.92	35.3	51
6/21/83	5	6.65	1.32	19.9	49
7/19/83	1	33.10	4.53	13.7	65
7/19/83	2	13.98	0.49	3.5	56
7/19/83	3	11.29	2.56	22.7	54
7/19/83	4	8.00	0.55	6.9	51
7/19/83	5	7.61	0.59	7.8	50
8/15/83	1	35.48	0.00	0.0	66
8/15/83	2	19.76	0.21	1.1	60
8/15/83	3	16.47	0.42	2.6	58
8/15/83	4	9.10	0.36	3.9	52
8/15/83	5	8.83	0.30	3.3	52
9/19/83	1	18.40	5.79	31.5	59
9/19/83	2	25.16	0.32	1.3	62
9/19/83	3	14.36	5.63	39.2	57
9/19/83	4	11.50	1.89	16.4	55
9/19/83	5	7.31	0.69	9.4	50

Table E-2

SD(Secchi) Depth in cm

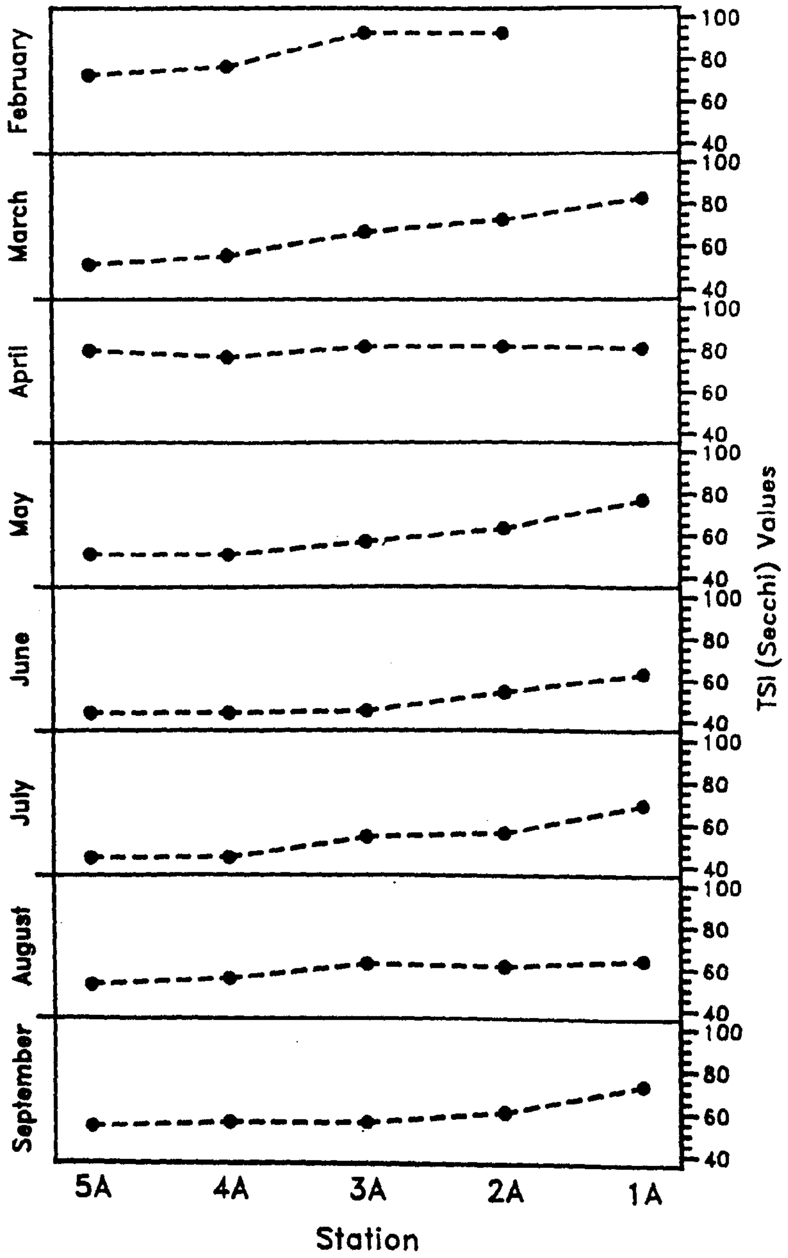
	<----------- Stations				----------->	<-----	Monthly	----->
Date	1A	2A	3A	4A	5A	Avg.	Std. Dev.	% Coef. of Var.
2/24/83		93.0	93.0	77.0	73.0	84.0	10.5	12.5
3/22/83	83.0	73.0	67.0	56.0	52.0	66.2	12.6	[illegible]
4/12/83	81.0	82.0	82.0	77.0	80.0	80.4	2.1	2.6
5/17/83	77.0	63.0	57.0	51.0	51.0	59.8	10.8	18.1
6/21/83	63.0	54.0	45.0	44.0	44.0	50.0	8.4	16.8
7/19/83	69.0	56.0	54.0	44.0	44.0	53.4	10.3	19.4
8/15/83	64.0	61.0	62.0	55.0	52.0	58.8	5.1	8.6
9/19/83	73.0	60.0	55.0	55.0	53.0	59.2	8.1	13.7
Avg.:	72.9	67.8	64.4	57.4	56.1			
Std. Dev.:	7.9	13.8	15.9	13.0	13.2			
% Coef.: of Var.	10.9	20.3	24.7	22.6	23.5			

Figure E-1



February
March
April
May
June
July
August
September
70
60
50
40
TSI (Chl) Values
5A
4A
3A
2A
1A
Station

Figure E-2



February
March
April
May
June
July
August
September
100
80
60
40
TSI (Secchi) Values
5A
4A
3A
2A
1A
Station

APPENDIX F

TEMPERATURE, DISSOLVED OXYGEN, CORRECTED CHLOROPHYLL A

DEPTH PROFILES, 18-MILE CREEK ARM,

HARTWELL RESERVOIR, S.C., 1983

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
09/19	1A	.0	8.50	26.40	---
09/19	1A	2.0	6.70	25.30	---
09/19	2A	.0	5.60	27.40	25.67
09/19	2A	3.0	8.20	27.50	25.80
09/19	2A	6.0	7.50	27.50	26.77
09/19	2A	9.0	4.90	25.40	25.16
09/19	3A	.0	6.70	27.40	12.58
09/19	3A	3.0	6.50	27.40	---
09/19	3A	6.0	5.80	27.40	24.19
09/19	3A	9.0	5.60	27.40	---
09/19	3A	12.0	5.50	27.30	19.03
09/19	3A	15.0	5.30	27.00	---
09/19	3A	18.0	4.20	26.40	14.84
09/19	3A	20.5	3.50	25.90	---
09/19	4A	.0	7.90	27.50	18.38
09/19	4A	3.0	7.80	27.40	23.87
09/19	4A	6.0	---	---	21.93
09/19	4A	9.0	6.80	---	18.38
09/19	4A	12.0	3.40	27.40	19.03
09/19	4A	15.0	2.90	27.30	10.45
09/19	4A	19.0	---	---	7.48
09/19	4A	30.0	2.60	27.20	---
09/19	4A	33.0	2.60	26.80	---
09/19	4A	36.0	2.50	26.90	---
09/19	4A	40.0	---	26.40	---
09/19	4A	43.0	---	26.40	---
09/19	4A	49.0	---	25.90	---
09/19	4A	50.0	1.70	24.50	---
09/19	5A	.0	8.00	27.50	14.84
09/19	5A	3.0	---	---	13.55
09/19	5A	6.0	---	---	14.84
09/19	5A	9.0	8.40	27.40	12.58
09/19	5A	12.0	6.00	27.40	---
09/19	5A	15.0	6.30	27.20	4.32
09/19	5A	18.0	6.30	27.20	---
09/19	5A	21.0	5.80	27.20	5.74
09/19	5A	24.0	5.40	27.20	---
09/19	5A	27.0	5.40	27.20	10.64
09/19	5A	30.0	4.20	27.20	---
09/19	5A	33.0	3.80	27.20	---
09/19	5A	36.0	---	---	---
09/19	5A	40.0	4.30	26.60	---
09/19	5A	47.0	4.10	25.60	7.10
09/19	5A	50.0	.80	23.90	---
09/19	5A	53.0	---	22.90	---
09/19	5A	55.0	---	22.90	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
08/15	1A	.0	7.80	27.70	31.60
08/15	1A	3.3	7.00	27.70	32.25
08/15	1A	6.6	5.10	22.10	40.32
08/15	2A	.0	7.70	29.00	20.25
08/15	2A	3.3	7.50	29.00	17.35
08/15	2A	6.6	7.20	29.00	24.38
08/15	2A	9.8	7.20	29.00	16.90
08/15	3A	.0	7.50	29.20	12.77
08/15	3A	3.3	7.20	29.20	---
08/15	3A	6.6	6.80	29.20	18.06
08/15	3A	9.8	6.70	29.20	---
08/15	3A	13.1	6.60	29.10	15.42
08/15	3A	16.4	6.50	29.20	---
08/15	3A	19.7	5.00	28.50	---
08/15	3A	23.0	3.30	28.00	---
08/15	4A	.0	6.60	29.20	7.74
08/15	4A	3.3	6.30	29.20	---
08/15	4A	6.6	6.40	29.20	12.26
08/15	4A	9.8	5.80	29.20	---
08/15	4A	13.1	4.70	29.20	11.61
08/15	4A	16.4	4.10	29.20	---
08/15	4A	19.7	<1.00	29.00	10.64
08/15	4A	23.0	<1.00	28.50	8.26
08/15	4A	26.2	<1.00	28.20	7.10
08/15	4A	29.5	<1.00	27.20	7.74
08/15	4A	32.8	<1.00	25.70	8.71
08/15	4A	36.1	<1.00	23.70	---
08/15	4A	39.4	<1.00	22.70	5.61
08/15	4A	42.7	<1.00	21.70	---
08/15	4A	45.9	<1.00	21.10	5.03
08/15	4A	49.2	<1.00	20.00	---
08/15	4A	52.5	<1.00	19.20	5.16
08/15	5A	.0	7.40	29.20	6.32
08/15	5A	3.3	---	---	8.58
08/15	5A	6.6	7.10	29.20	9.68
08/15	5A	13.1	7.00	29.20	8.45
08/15	5A	19.7	5.40	29.00	8.39
08/15	5A	23.0	2.70	27.50	5.42
08/15	5A	26.2	<1.00	28.00	5.35
08/15	5A	29.5	<1.00	27.10	---
08/15	5A	32.8	<1.00	25.50	1.94
08/15	5A	36.1	<1.00	24.20	.39
08/15	5A	39.4	<1.00	22.70	---
08/15	5A	42.7	<1.00	21.70	---
08/15	5A	45.9	<1.00	20.70	---
08/15	5A	49.2	<1.00	19.70	1.23
08/15	5A	52.5	<1.00	18.90	---
08/15	5A	55.8	<1.00	18.20	---
08/15	5A	57.4	<1.00	17.70	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
07/19	5A	.0	9.20	30.50	5.16
07/19	5A	9.0	8.80	30.60	---
07/19	5A	12.0	7.60	29.50	[illegible].19
07/19	5A	15.0	2.60	29.50	---
07/19	5A	18.0	1.60	28.90	---
07/19	5A	21.0	4.40	28.00	7.68
07/19	5A	24.0	2.60	27.40	14.84
07/19	5A	27.0	.40	26.50	4.19
07/19	5A	30.0	.40	25.00	---
07/19	5A	33.0	.40	23.70	---
07/19	5A	36.0	.40	22.70	---
07/19	5A	39.0	.40	21.60	---
07/19	5A	42.0	.40	20.60	---
07/19	5A	45.0	.40	19.70	1.71
07/19	5A	48.0	.40	19.00	---
07/19	5A	51.0	.40	18.30	---
07/19	5A	55.0	.40	---	---
07/19	5A	58.0	.40	16.50	12.90

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
07/19	1A	.0	9.00	30.40	46.36
07/19	1A	3.0	8.60	30.40	53.54
07/19	1A	6.0	5.60	30.00	19.57
07/19	1A	9.0	4.40	27.70	---
07/19	2A	.0	8.70	29.60	10.97
07/19	2A	3.0	8.40	30.60	13.55
07/19	2A	6.0	7.50	30.60	---
07/19	2A	9.0	7.60	30.50	17.42
07/19	2A	12.0	3.80	30.30	11.42
07/19	2A	14.0	.80	29.50	---
07/19	3A	.0	8.80	30.60	7.80
07/19	3A	3.0	8.60	30.60	10.64
07/19	3A	6.0	8.40	30.60	---
07/19	3A	9.0	8.20	30.50	---
07/19	3A	12.0	7.60	30.50	11.93
07/19	3A	15.0	3.60	29.60	10.00
07/19	3A	18.0	.85	29.50	---
07/19	3A	21.0	.20	28.60	8.71
07/19	3A	24.0	.20	27.60	---
07/19	4A	.0	9.60	30.70	4.71
07/19	4A	3.0	8.70	30.60	---
07/19	4A	6.0	8.80	30.60	---
07/19	4A	9.0	8.70	30.60	8.77
07/19	4A	12.0	6.50	30.50	11.93
07/19	4A	15.0	.70	29.70	12.58
07/19	4A	18.0	.17	29.30	10.38
07/19	4A	21.0	1.50	28.30	---
07/19	4A	24.0	.17	27.60	---
07/19	4A	27.0	.00	26.60	---
07/19	4A	30.0	.00	25.30	---
07/19	4A	33.0	.00	24.30	---
07/19	4A	36.0	.00	22.90	---
07/19	4A	39.0	.00	21.90	---
07/19	4A	42.0	.00	20.90	---
07/19	4A	45.0	.00	19.90	3.55
07/19	4A	48.0	.00	19.40	---
07/19	4A	51.0	.00	18.40	---
07/19	4A	54.0	.00	17.60	---
07/19	4A	55.0	.00	---	13.55
07/19	4A	58.0	.00	17.50	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
06/21	1A	.0	9.80	27.60	15.87
06/21	1A	3.3	9.50	27.50	14.71
06/21	1A	6.6	7.60	26.36	15.13
06/21	2A	.0	9.80	27.50	7.61
06/21	2A	3.3	9.60	27.50	7.29
06/21	2A	6.6	9.50	27.40	5.93
06/21	2A	9.8	8.90	26.80	15.48
06/21	2A	13.1	4.50	26.30	12.77
06/21	3A	0.0	9.20	27.50	5.87
06/21	3A	3.3	9.00	27.50	---
06/21	3A	6.6	8.80	27.50	9.68
06/21	3A	9.8	8.80	26.80	---
06/21	3A	13.1	6.10	26.10	---
06/21	3A	16.4	3.80	24.90	---
06/21	3A	19.7	1.00	23.90	---
06/21	3A	19.7	2.80	24.50	9.66
06/21	3A	26.2	.40	23.10	13.55
06/21	4A	.0	9.10	27.60	4.06
06/21	4A	3.3	9.00	27.50	---
06/21	4A	6.6	8.90	27.50	5.87
06/21	4A	9.8	9.30	26.80	---
06/21	4A	13.1	7.00	26.40	17.74
06/21	4A	16.4	4.10	25.50	---
06/21	4A	19.7	2.40	24.60	5.16
06/21	4A	23.0	.65	23.60	8.39
06/21	4A	26.2	.60	23.00	---
06/21	4A	29.5	.75	22.00	---
06/21	4A	32.8	.15	21.00	3.61
06/21	4A	36.1	.15	20.00	---
06/21	4A	39.4	.15	18.70	2.71
06/21	4A	42.7	.15	17.60	---
06/21	4A	45.9	.15	16.70	---
06/21	4A	49.2	.15	15.70	---
06/21	5A	.0	9.40	27.60	2.49
06/21	5A	3.3	9.20	27.50	---
06/21	5A	6.6	8.80	27.50	3.58
06/21	5A	9.8	8.80	27.00	---
06/21	5A	13.1	9.30	26.00	9.22
06/21	5A	16.4	4.50	25.60	9.80
06/21	5A	19.7	2.30	24.50	8.06
06/21	5A	23.0	1.00	24.30	---
06/21	5A	26.2	4.35	23.00	5.16
06/21	5A	29.5	3.90	22.00	---
06/21	5A	32.8	2.40	21.30	.77
06/21	5A	36.1	2.50	19.60	---
06/21	5A	39.4	1.60	18.50	---
06/21	5A	42.7	1.20	17.50	---
06/21	5A	45.9	.70	16.50	1.23
06/21	5A	49.2	.70	15.60	1.10
06/21	5A	52.5	.70	15.00	---
06/21	5A	59.1	.70	---	1.03
06/21	5A	69.6	.70	14.00	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/l)
05/17	1A	.0	7.40	22.40	86.13
05/17	1A	3.3	7.30	22.40	13.42
05/17	1A	6.6	5.20	19.50	29.67
05/17	1A	7.4	5.10	19.50	---
05/17	2A	.0	8.00	23.80	24.51
05/17	2A	3.3	8.00	24.20	45.15
05/17	2A	6.6	7.80	24.20	19.35
05/17	2A	9.8	7.20	23.90	10.64
05/17	2A	13.1	5.00	22.60	4.39
05/17	2A	16.4	4.30	22.00	---
05/17	3A	.0	7.80	24.00	---
05/17	3A	3.3	7.80	24.00	18.06
05/17	3A	6.6	7.40	23.80	---
05/17	3A	9.8	5.80	23.50	12.70
05/17	3A	13.1	3.70	22.50	13.00
05/17	3A	16.4	1.30	21.20	15.77
05/17	3A	19.7	.76	19.60	4.39
05/17	3A	23.0	.75	18.70	4.52
05/17	3A	26.2	.15	18.30	---
05/17	4A	.0	9.00	23.60	8.71
05/17	4A	3.3	9.00	23.80	8.26
05/17	4A	6.6	9.00	23.70	---
05/17	4A	9.8	8.80	23.70	8.58
05/17	4A	13.1	4.10	22.50	5.48
05/17	4A	16.4	4.20	21.30	---
05/17	4A	19.7	3.60	20.30	20.64
05/17	4A	23.0	3.80	19.40	---
05/17	4A	26.2	3.90	17.60	2.39
05/17	4A	29.5	3.90	16.50	---
05/17	4A	32.8	4.30	15.60	2.42
05/17	4A	36.1	4.30	15.40	---
05/17	4A	39.4	3.40	14.90	---
05/17	4A	42.7	2.30	14.60	1.42
05/17	4A	49.2	2.00	14.00	---
05/17	4A	55.8	.40	13.50	---
05/17	5A	.0	9.10	23.70	6.67
05/17	5A	3.3	9.00	23.70	4.19
05/17	5A	6.6	8.90	23.60	---
05/17	5A	9.8	8.90	23.40	12.26
05/17	5A	13.1	8.90	22.40	12.26
05/17	5A	16.4	5.50	20.60	5.03
05/17	5A	19.7	5.70	20.30	---
05/17	5A	23.0	8.40	18.70	---
05/17	5A	26.2	8.10	17.60	5.16
05/17	5A	29.5	6.80	16.40	---
05/17	5A	32.8	6.70	15.60	1.29
05/17	5A	36.1	5.90	15.30	---
05/17	5A	49.2	4.30	13.70	---
05/17	5A	65.6	2.90	12.60	.94
05/17	5A	68.9	4.00	12.50	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
04/12	1A	.0	7.30	15.80	5.64
04/12	1A	3.3	7.20	15.50	---
04/12	1A	5.6	6.80	15.50	---
04/12	1A	7.9	6.80	15.60	---
04/12	2A	.0	7.10	16.90	7.73
04/12	2A	3.3	6.80	16.90	---
04/12	2A	6.6	6.70	16.50	---
04/12	2A	9.8	6.00	15.70	---
04/12	2A	13.1	5.70	15.30	---
04/12	2A	15.7	6.70	14.60	4.00
04/12	3A	.0	6.80	16.70	11.82
04/12	3A	3.3	6.50	16.40	---
04/12	3A	6.6	6.00	16.30	---
04/12	3A	9.8	6.40	16.10	---
04/12	3A	13.1	8.30	14.60	---
04/12	3A	16.4	8.20	14.20	4.91
04/12	3A	19.7	8.10	13.90	---
04/12	3A	23.0	7.10	13.80	---
04/12	3A	24.0	6.90	13.80	2.59
04/12	4A	.0	8.80	16.90	10.68
04/12	4A	3.3	7.60	16.10	---
04/12	4A	6.6	6.90	15.60	---
04/12	4A	9.8	8.30	15.90	---
04/12	4A	13.1	9.40	14.70	---
04/12	4A	16.4	9.20	14.20	7.73
04/12	4A	19.7	9.20	14.20	---
04/12	4A	23.0	8.00	13.90	---
04/12	4A	26.2	6.90	13.70	---
04/12	4A	29.5	5.90	13.40	---
04/12	4A	32.8	5.90	12.80	2.27
04/12	4A	39.4	6.60	12.60	---
04/12	4A	45.9	5.90	12.10	---
04/12	4A	52.5	4.30	11.80	4.77
04/12	4A	59.1	4.50	11.70	---
04/12	5A	.0	7.40	16.50	6.27
04/12	5A	3.3	7.20	15.70	---
04/12	5A	6.6	9.20	15.70	---
04/12	5A	9.8	9.80	14.60	---
04/12	5A	13.1	9.80	14.60	5.50
04/12	5A	16.4	9.80	14.50	---
04/12	5A	19.7	9.50	14.20	---
04/12	5A	23.0	9.40	13.90	---
04/12	5A	26.2	7.60	13.60	---
04/12	5A	32.8	7.40	12.70	2.36
04/12	5A	49.2	7.40	11.90	1.11
04/12	5A	65.3	6.60	11.50	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/l)
03/22	1A	.0	8.70	12.60	11.87
03/22	1A	3.3	8.60	12.10	4.39
03/22	1A	6.6	8.50	11.50	4.39
03/22	1A	9.8	8.50	10.70	---
03/22	2A	.0	8.80	13.60	14.51
03/22	2A	3.3	8.60	13.60	12.90
03/22	2A	6.6	8.40	13.40	5.90
03/22	2A	9.8	8.40	13.00	7.35
03/22	2A	13.1	8.00	12.70	---
03/22	2A	14.1	8.00	12.70	---
03/22	3A	.0	9.00	13.70	12.64
03/22	3A	3.3	8.90	13.70	11.43
03/22	3A	6.6	8.80	13.50	10.97
03/22	3A	9.8	8.60	13.00	---
03/22	3A	13.1	8.50	12.90	---
03/22	3A	16.4	8.50	12.70	---
03/22	3A	19.7	8.60	12.70	---
03/22	3A	23.0	8.70	12.60	---
03/22	3A	23.6	8.70	12.60	---
03/22	4A	.0	10.70	13.60	11.18
03/22	4A	6.6	10.60	12.60	12.90
03/22	4A	13.1	10.40	12.50	10.00
03/22	4A	19.7	10.00	12.50	25.80
03/22	4A	26.2	10.00	12.50	3.10
03/22	4A	39.4	7.70	11.60	---
03/22	4A	52.5	6.90	10.50	---
03/22	4A	57.4	5.40	10.30	---
03/22	5A	.0	10.90	13.40	18.38
03/22	5A	6.6	10.60	12.60	14.67
03/22	5A	13.1	10.60	12.50	4.45
03/22	5A	19.7	10.50	12.50	5.59
03/22	5A	26.2	10.40	12.30	---
03/22	5A	32.8	9.60	11.80	---
03/22	5A	49.2	8.70	10.60	---
03/22	5A	65.6	7.60	9.60	---
03/22	5A	67.3	7.00	9.60	---

Table F-1
Depth Profiles

Date	Station	Depth (ft)	DO (mg/L)	Temp. (C)	Corrected Chlorophyll a (ug/L)
02/24	1A	.0	8.50	12.00	11.67
02/24	1A	3.3	8.50	12.00	11.43
02/24	1A	4.9	8.50	12.00	9.03
02/24	1A	6.6	8.40	12.00	10.97
02/24	2A	.0	8.40	13.50	9.03
02/24	2A	3.3	---	---	7.74
02/24	2A	6.6	8.30	13.50	8.39
02/24	2A	9.8	8.20	13.50	10.97
02/24	3A	.0	8.50	14.00	10.32
02/24	3A	3.3	8.50	14.00	10.32
02/24	3A	6.6	8.40	14.00	10.32
02/24	3A	9.8	8.40	13.50	8.39
02/24	3A	13.1	8.40	13.00	9.03
02/24	3A	16.4	8.10	12.50	7.10
02/24	3A	19.7	8.00	12.50	6.39
02/24	4A	.0	9.80	15.00	18.38
02/24	4A	3.3	9.80	14.00	15.91
02/24	4A	6.6	9.40	13.00	9.03
02/24	4A	9.8	9.00	13.00	4.73
02/24	4A	13.1	9.20	12.00	5.59
02/24	4A	16.4	9.00	12.00	3.87
02/24	4A	19.7	9.30	11.50	4.30
02/24	4A	23.0	9.60	11.00	4.73
02/24	4A	26.2	10.20	10.50	3.01
02/24	4A	29.5	10.00	10.00	2.15
02/24	4A	32.8	9.60	10.00	1.72
02/24	4A	36.1	9.40	10.00	---
02/24	4A	39.4	9.20	9.50	---
02/24	4A	49.2	9.00	9.50	---
02/24	4A	52.5	8.00	9.50	---
02/24	4A	55.8	7.40	9.50	---
02/24	5A	.0	9.50	13.50	7.74
02/24	5A	3.3	9.80	13.00	7.31
02/24	5A	6.6	10.20	12.50	7.74
02/24	5A	9.8	10.40	12.50	8.60
02/24	5A	13.1	10.40	12.50	6.88
02/24	5A	16.4	9.60	12.00	6.88
02/24	5A	19.7	9.30	12.00	3.87
02/24	5A	23.0	9.30	11.50	3.01
02/24	5A	26.2	9.80	11.00	3.01
02/24	5A	29.5	10.00	10.50	2.58
02/24	5A	32.8	10.10	10.00	2.58
02/24	5A	36.1	10.10	9.50	---
02/24	5A	39.4	10.10	9.50	---
02/24	5A	42.7	10.10	9.50	---
02/24	5A	45.9	10.10	9.00	---
02/24	5A	49.2	10.00	9.00	---
02/24	5A	55.8	9.60	9.00	---
02/24	5A	62.3	9.10	9.00	---
02/24	5A	67.3	8.00	9.00	---

Figure F-1

Temperature (°C) Longitudinal Depth Profile, February, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

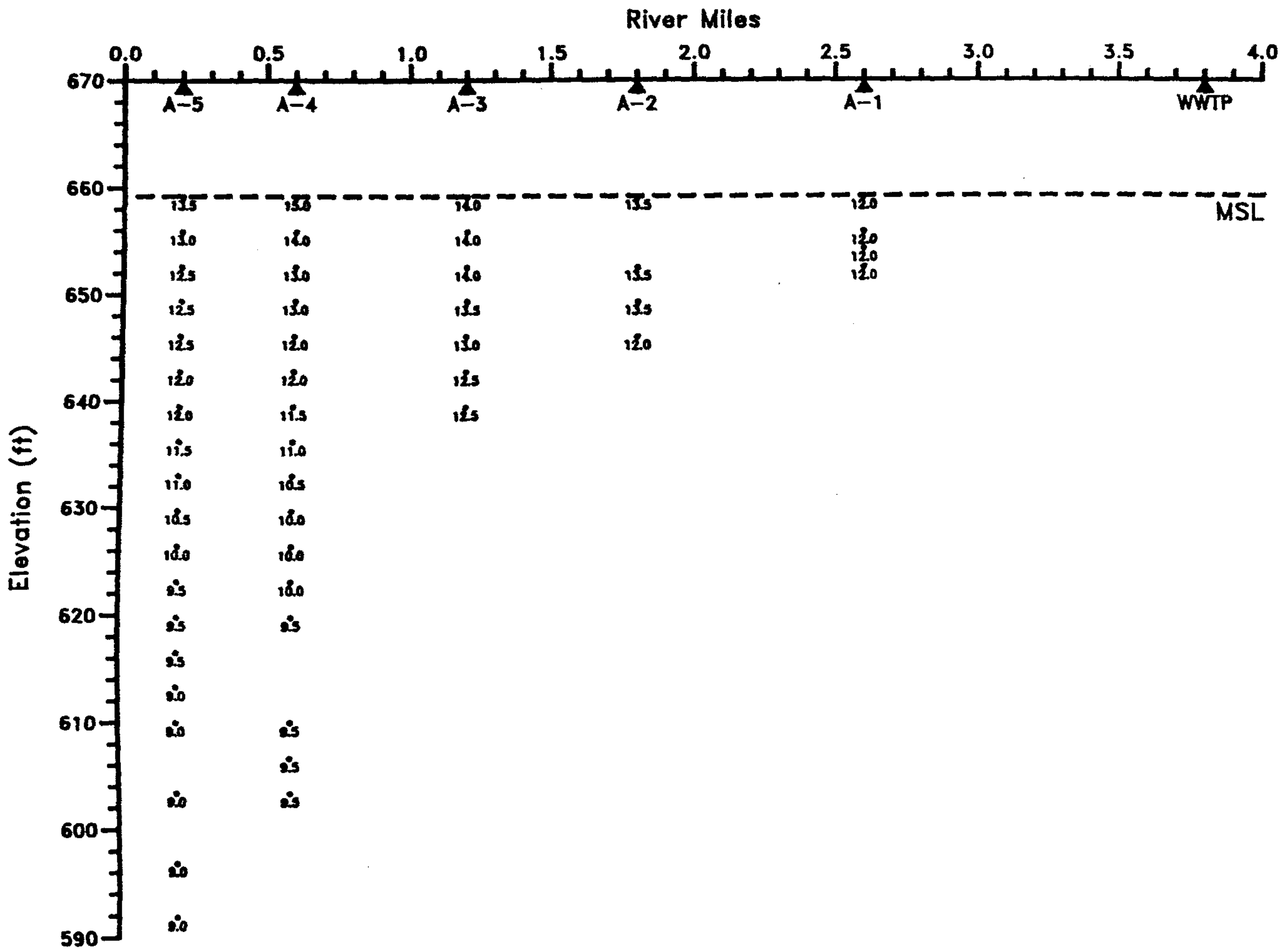


Figure F-2

Temperature (°C) Longitudinal Depth Profile, April, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

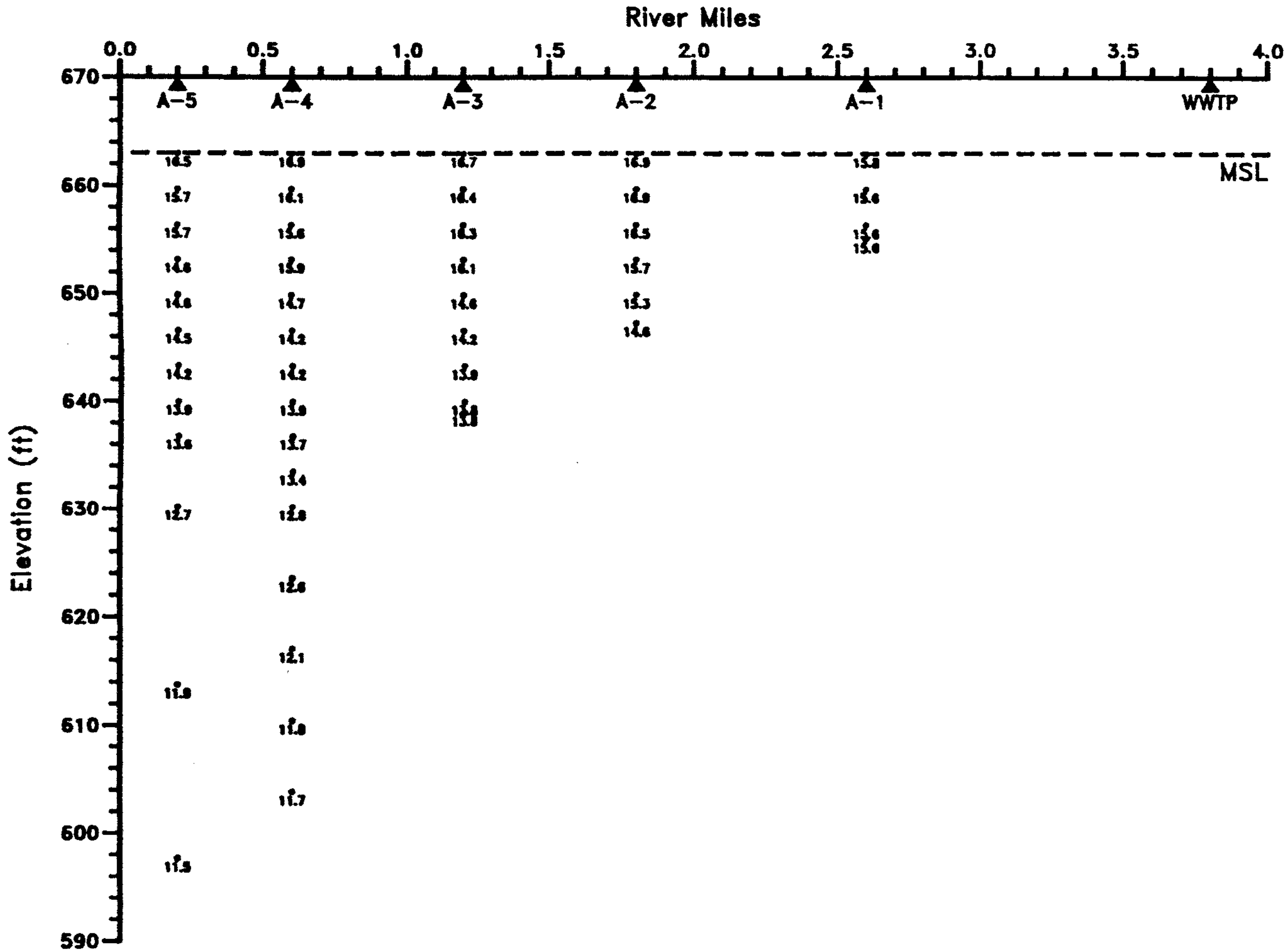


Figure F-3

Temperature (°C) Longitudinal Depth Profile, May, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

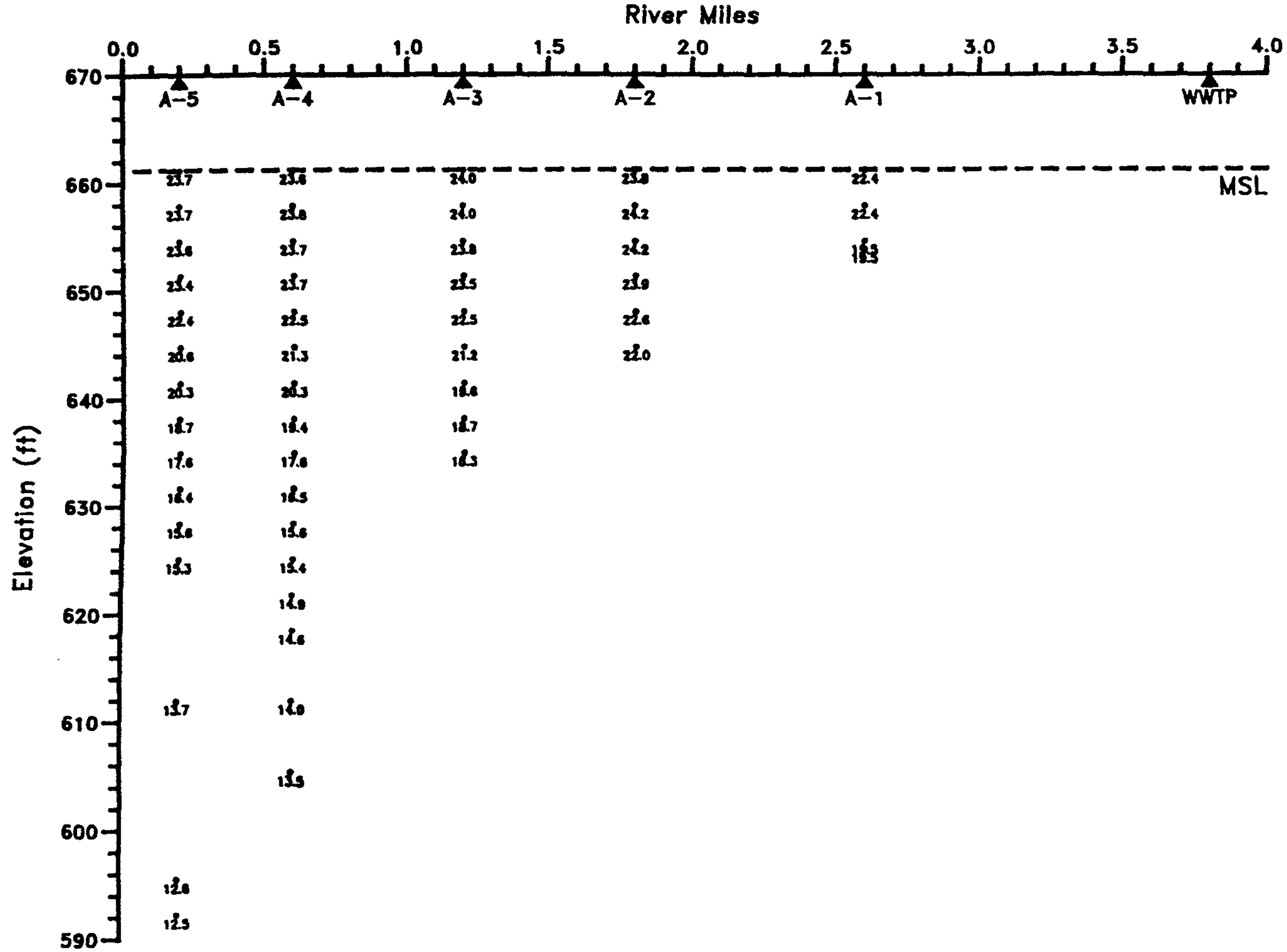


Figure F-4

Temperature (°C) Longitudinal Depth Profile, June, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

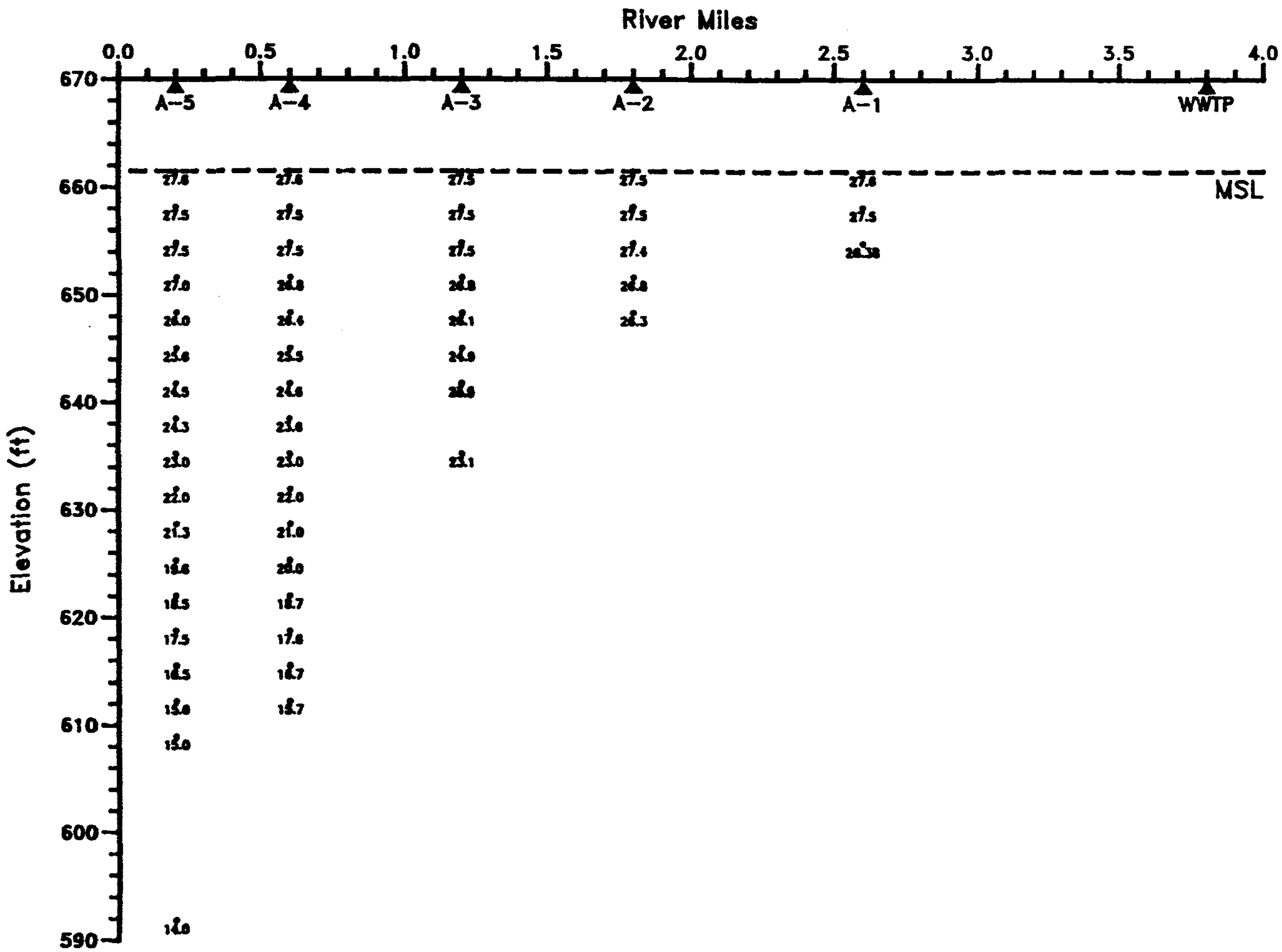


Figure F–5

Temperature (°C) Longitudinal Depth Profile, August, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

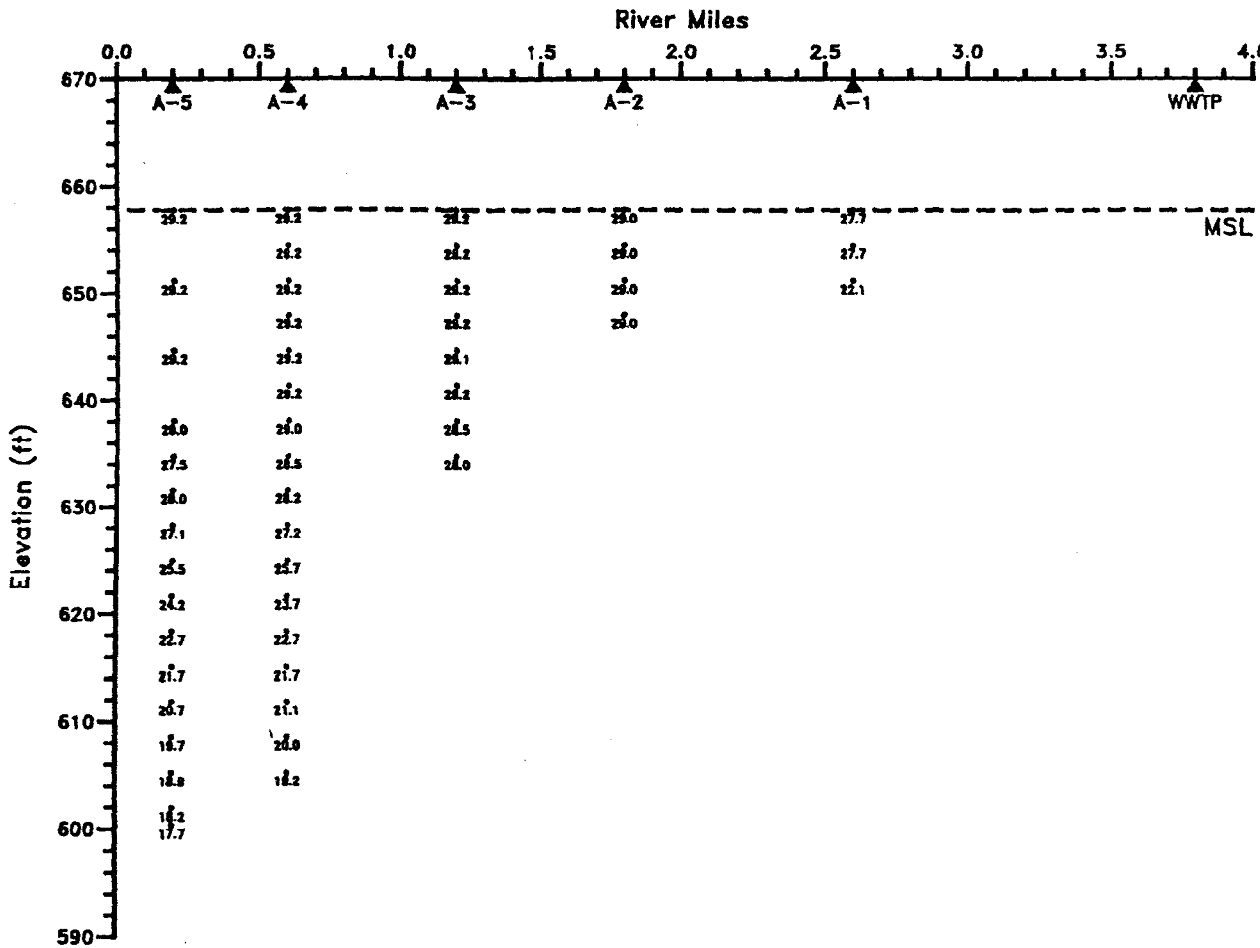


Figure F-6

Temperature (°C) Longitudinal Depth Profile, September, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

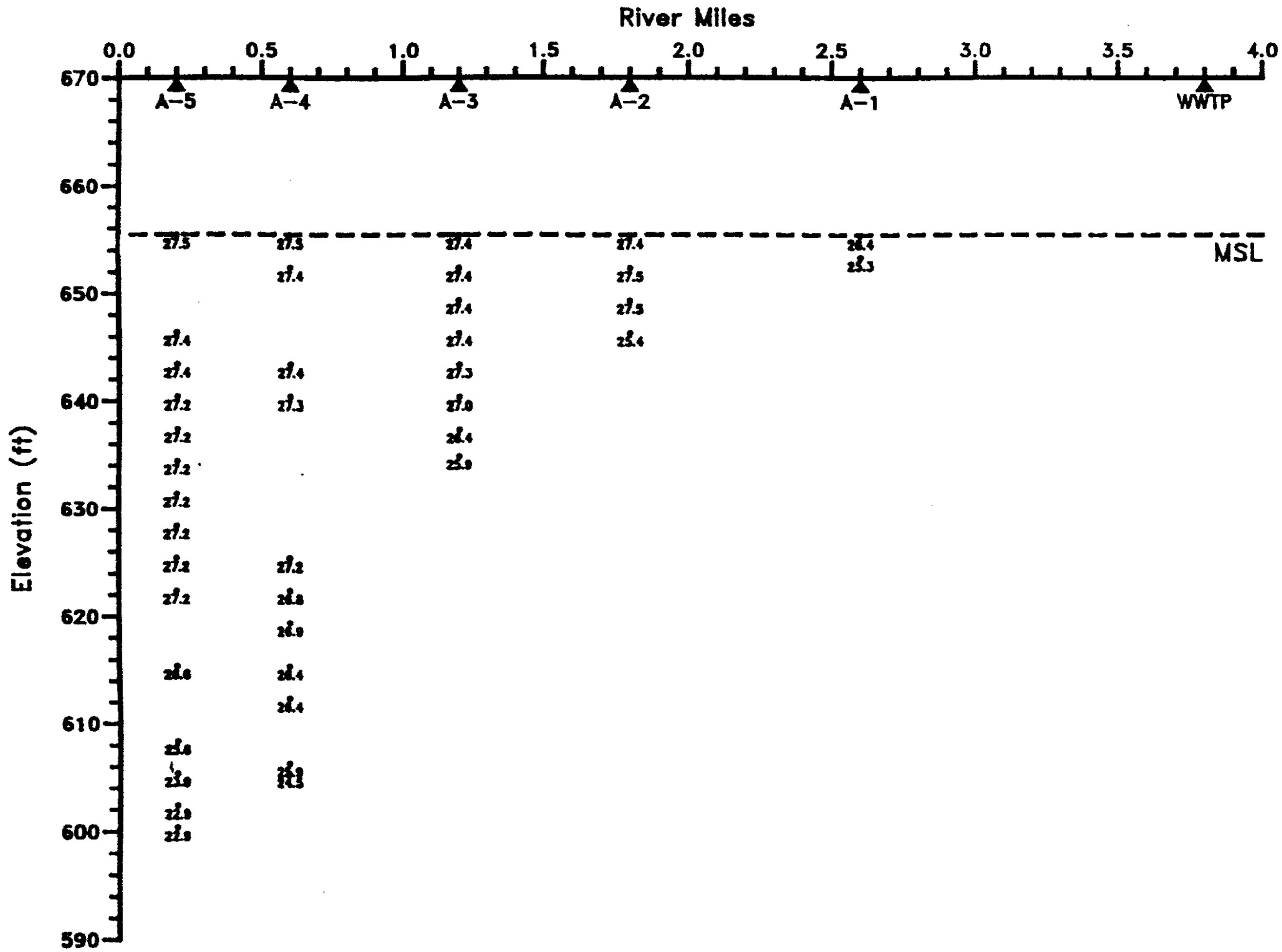


Figure F-7

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, February, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

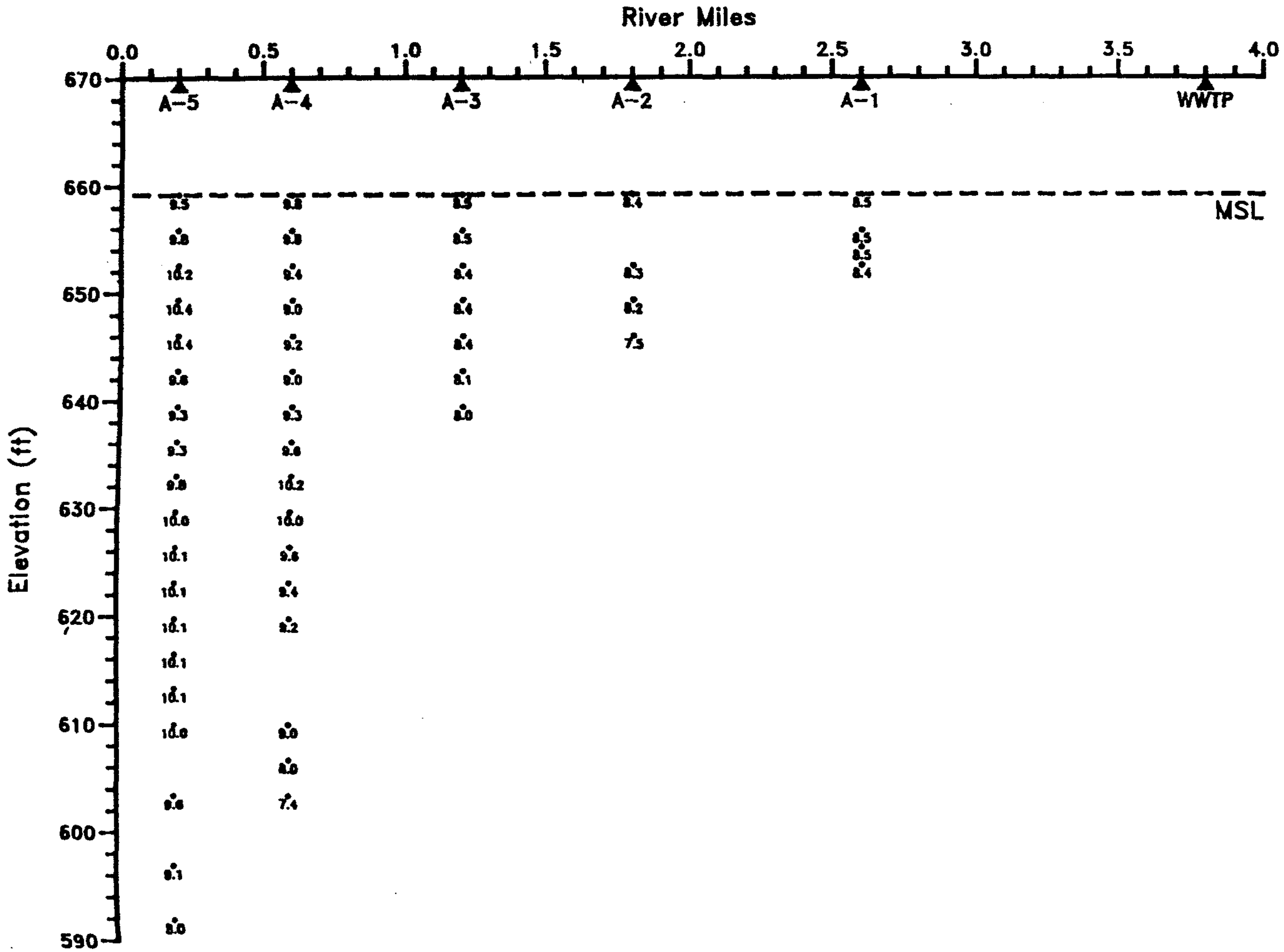


Figure F-8

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, March, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

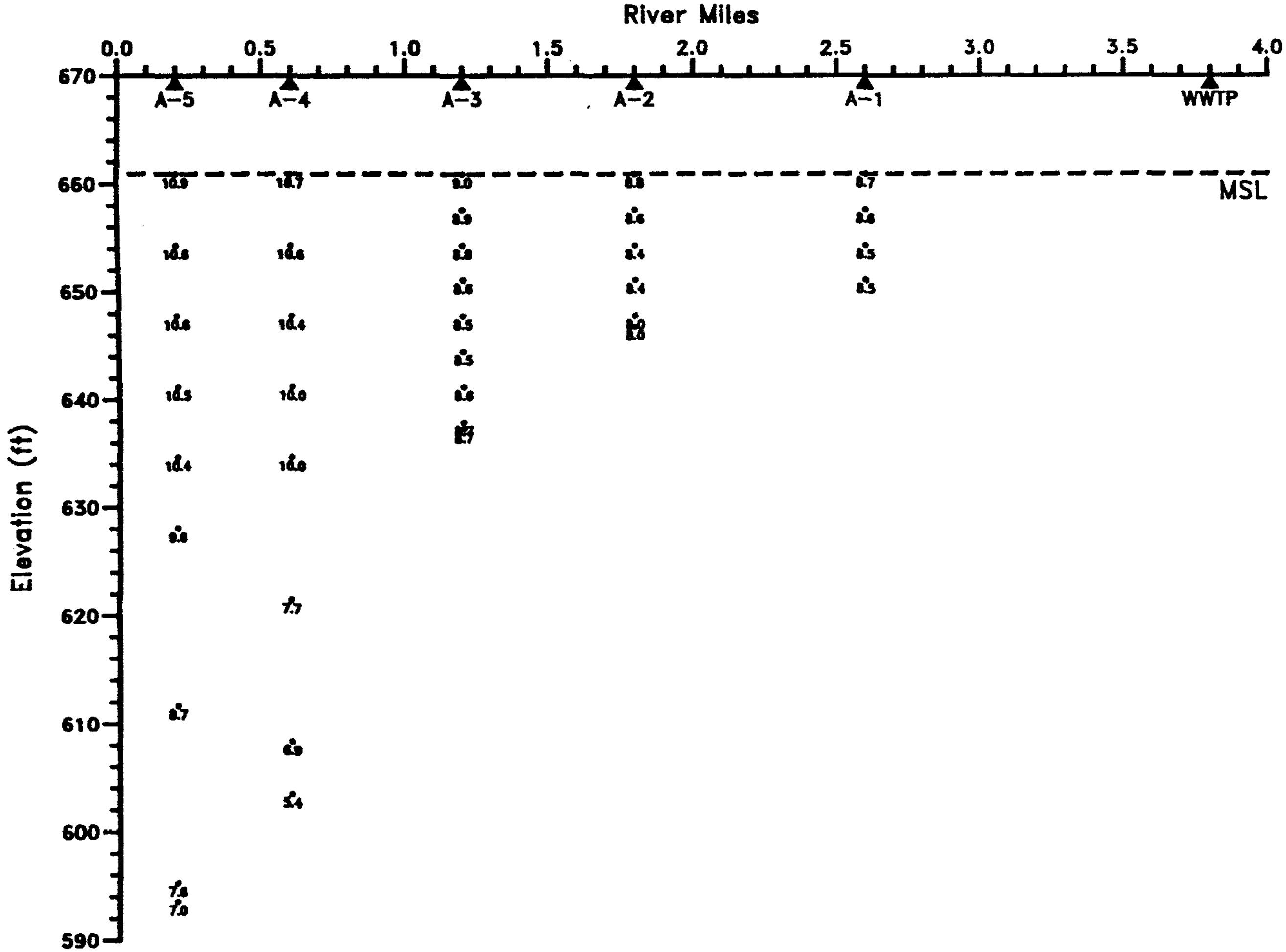


Figure F-9

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, April, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

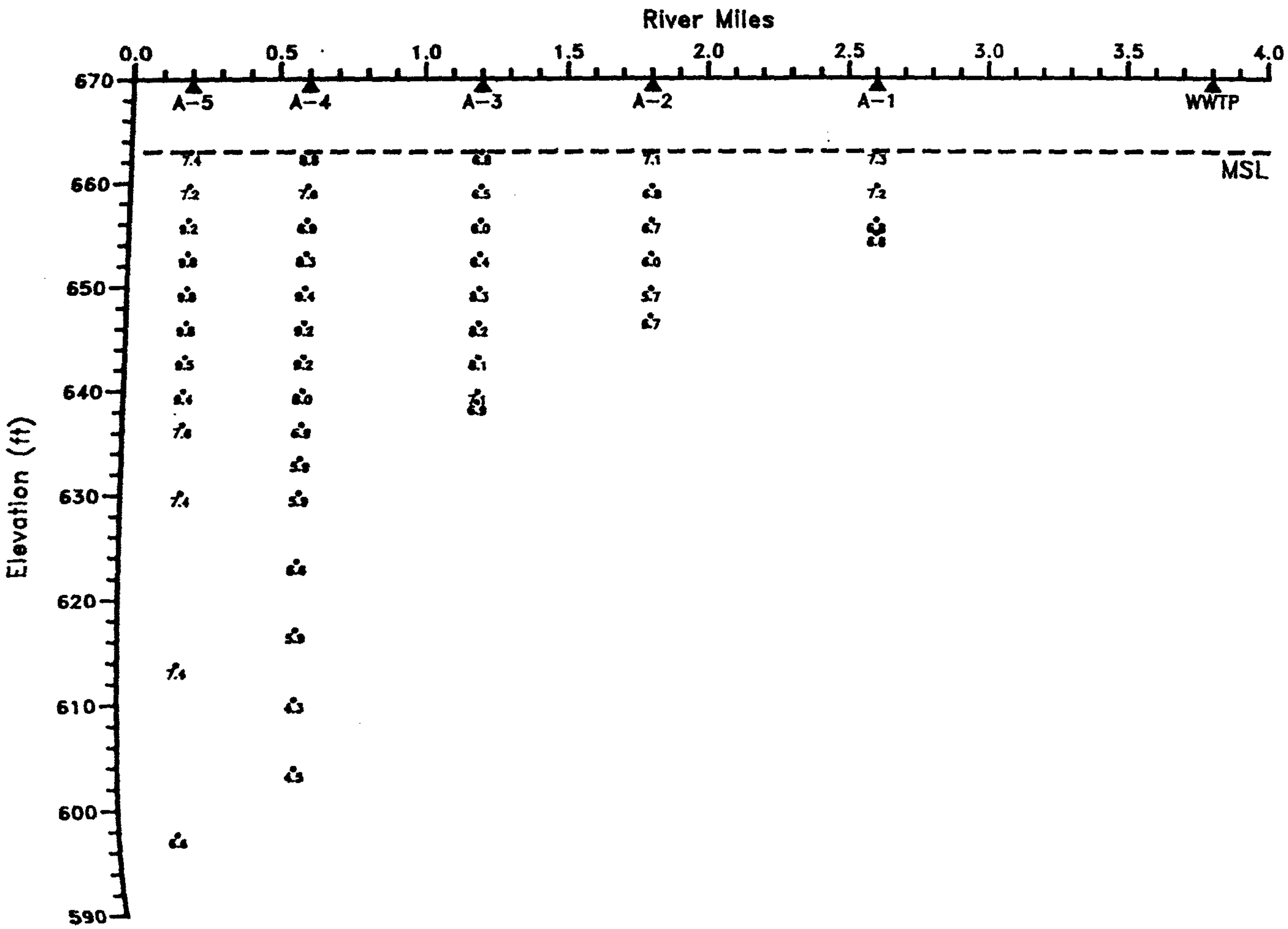


Figure F-10

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, May, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

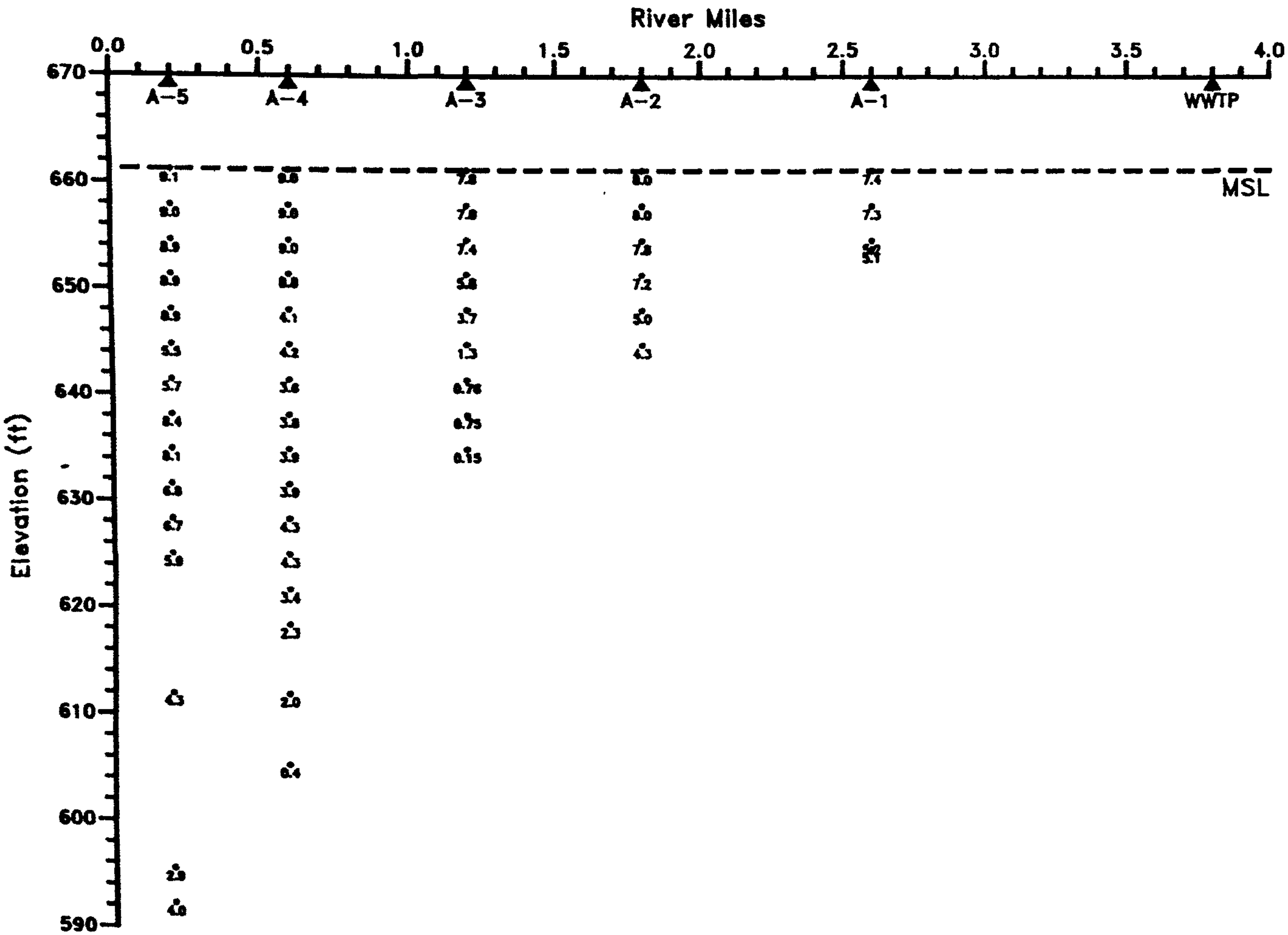


Figure F-11

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, June, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

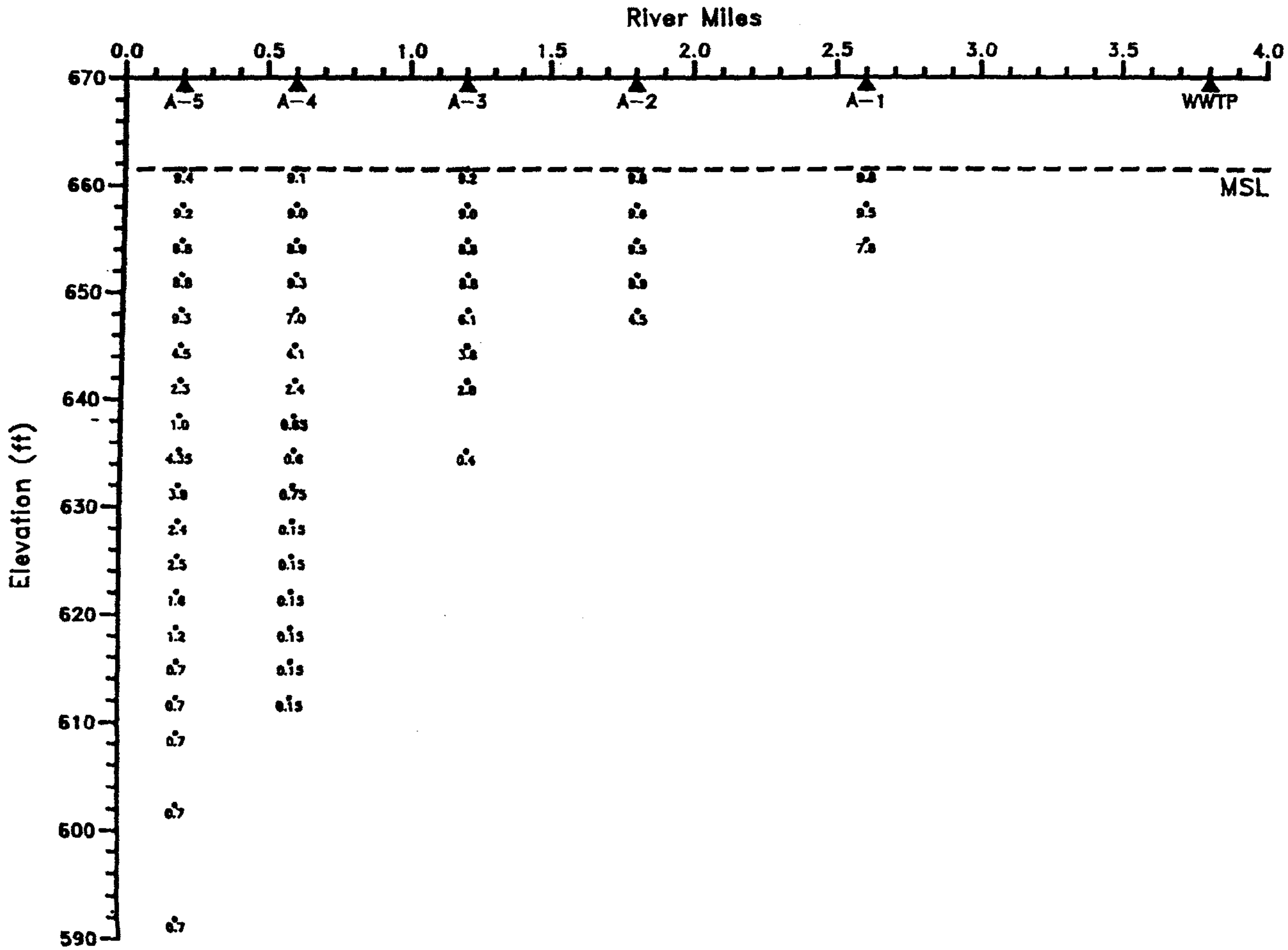


Figure F-12

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, July, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

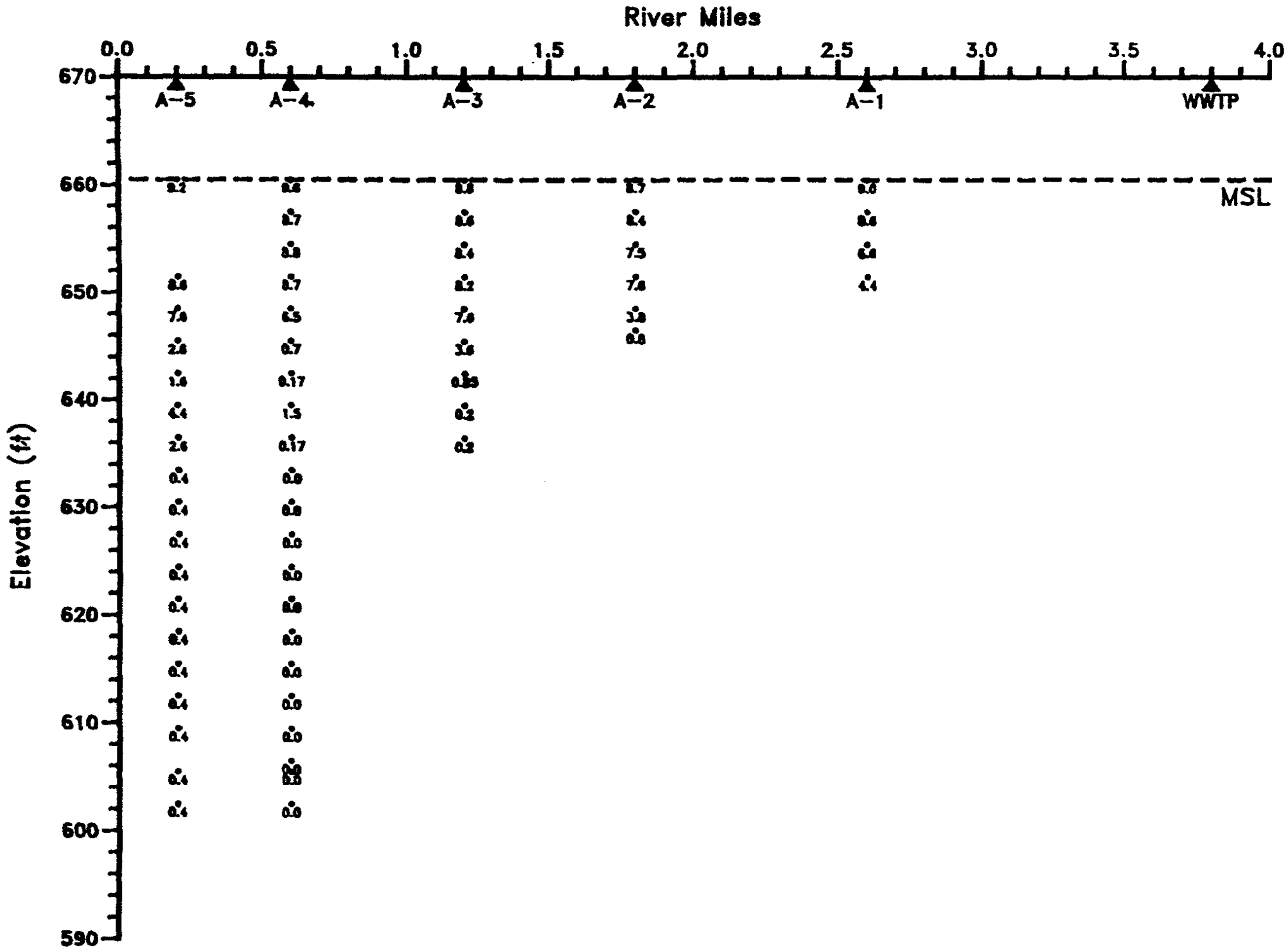


Figure F-13

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, August, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

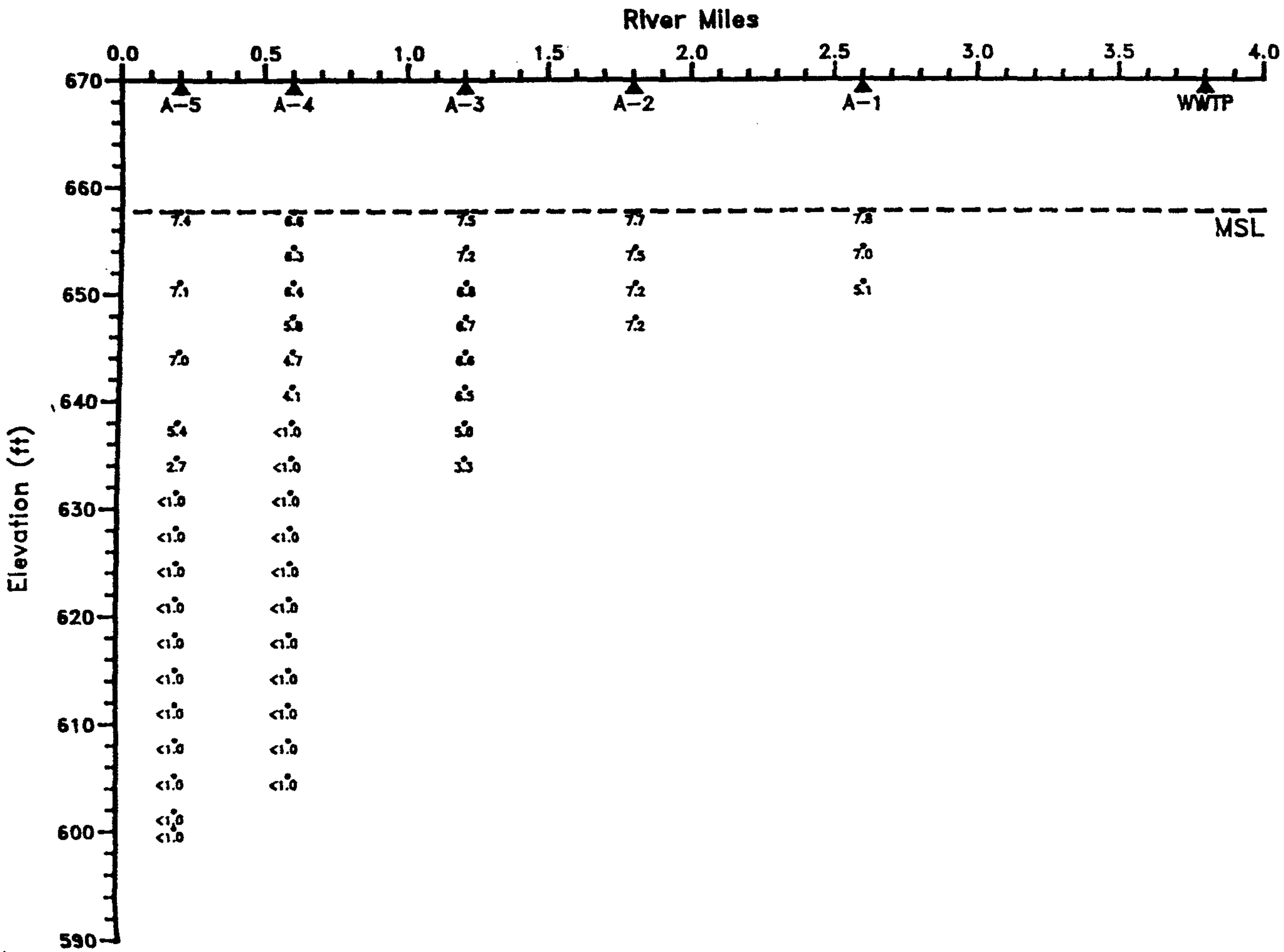


Figure F-14

Dissolved Oxygen (mg/L) Longitudinal Depth Profile, September, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

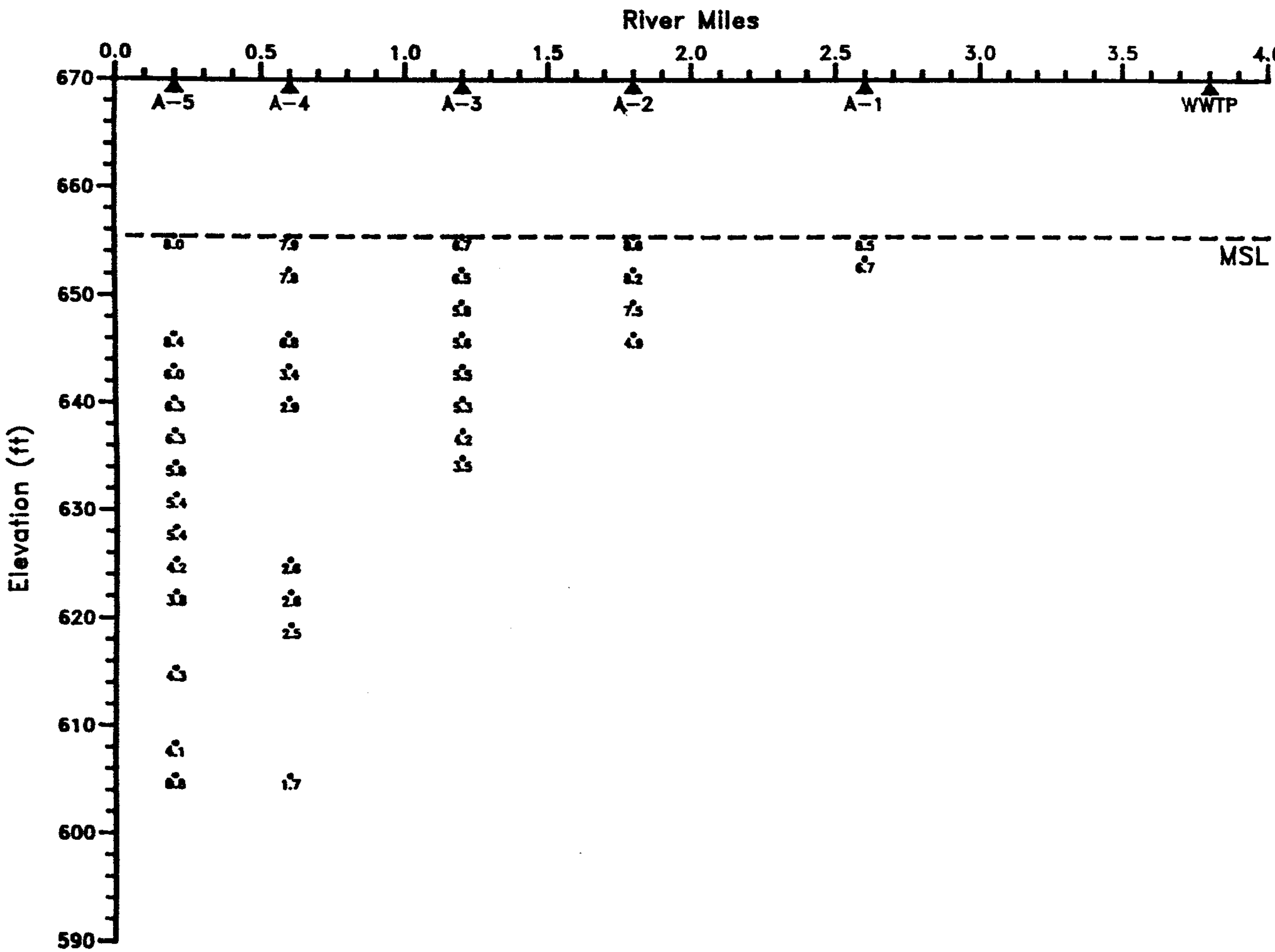


Figure F-15

Chlorophyll a (μg/L) Longitudinal Depth Profile, February, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

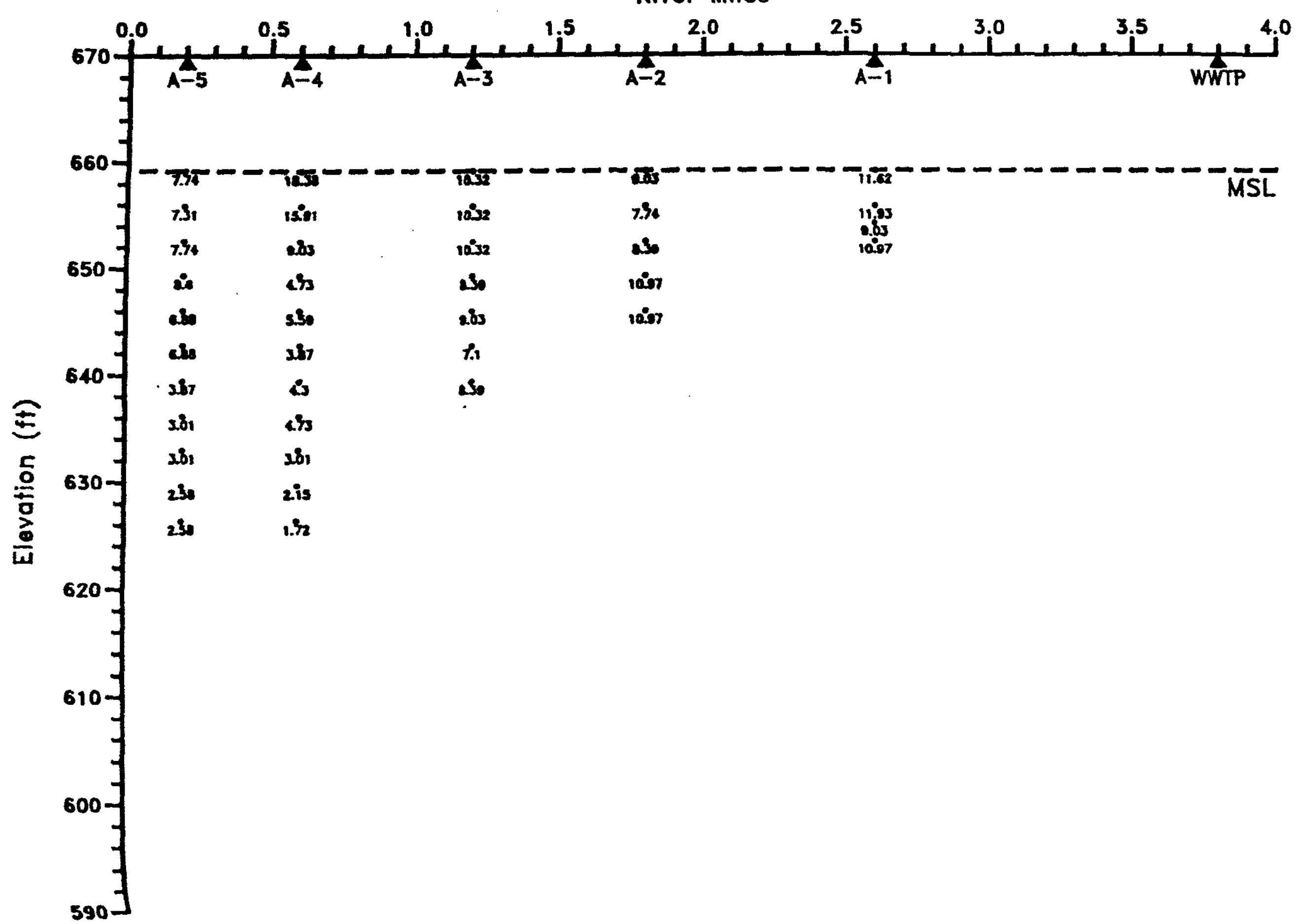


Figure F-16

Chlorophyll a ($\mu g/L$) Longitudinal Depth Profile, March, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

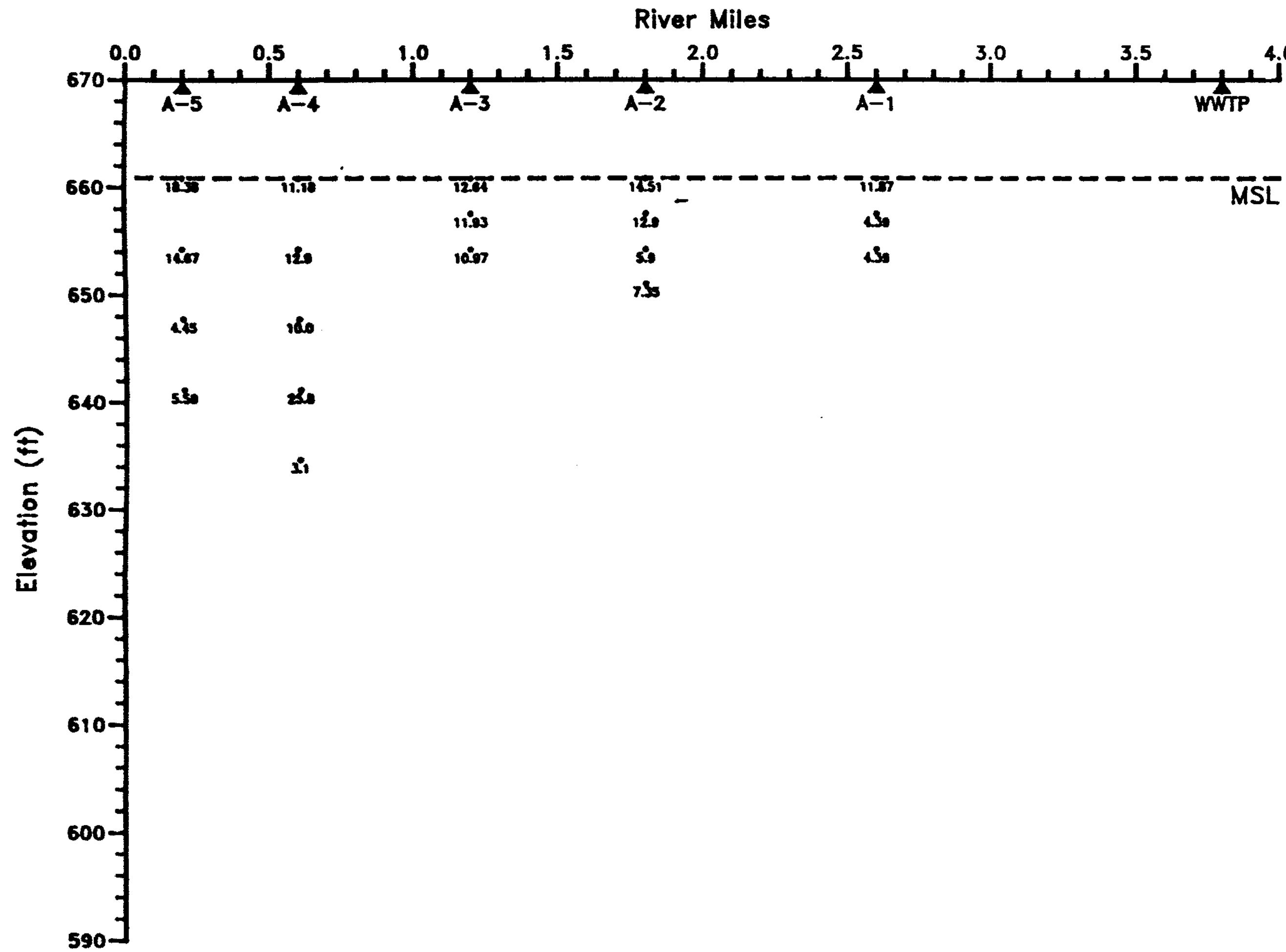


Figure F–17

Chlorophyll a (μg/L) Longitudinal Depth Profile, April, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

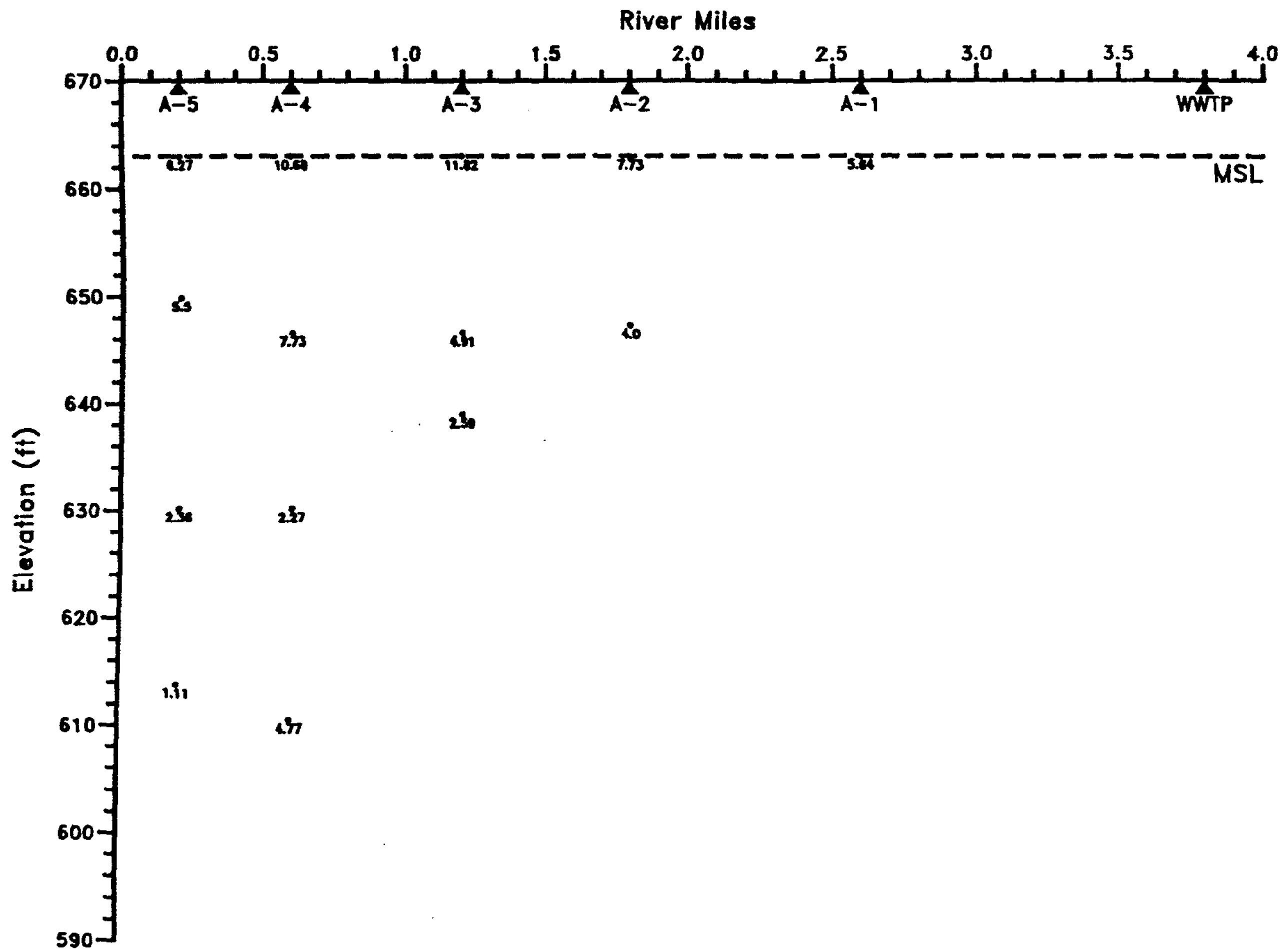


Figure F-18

Chlorophyll a (μg/L) Longitudinal Depth Profile, May, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

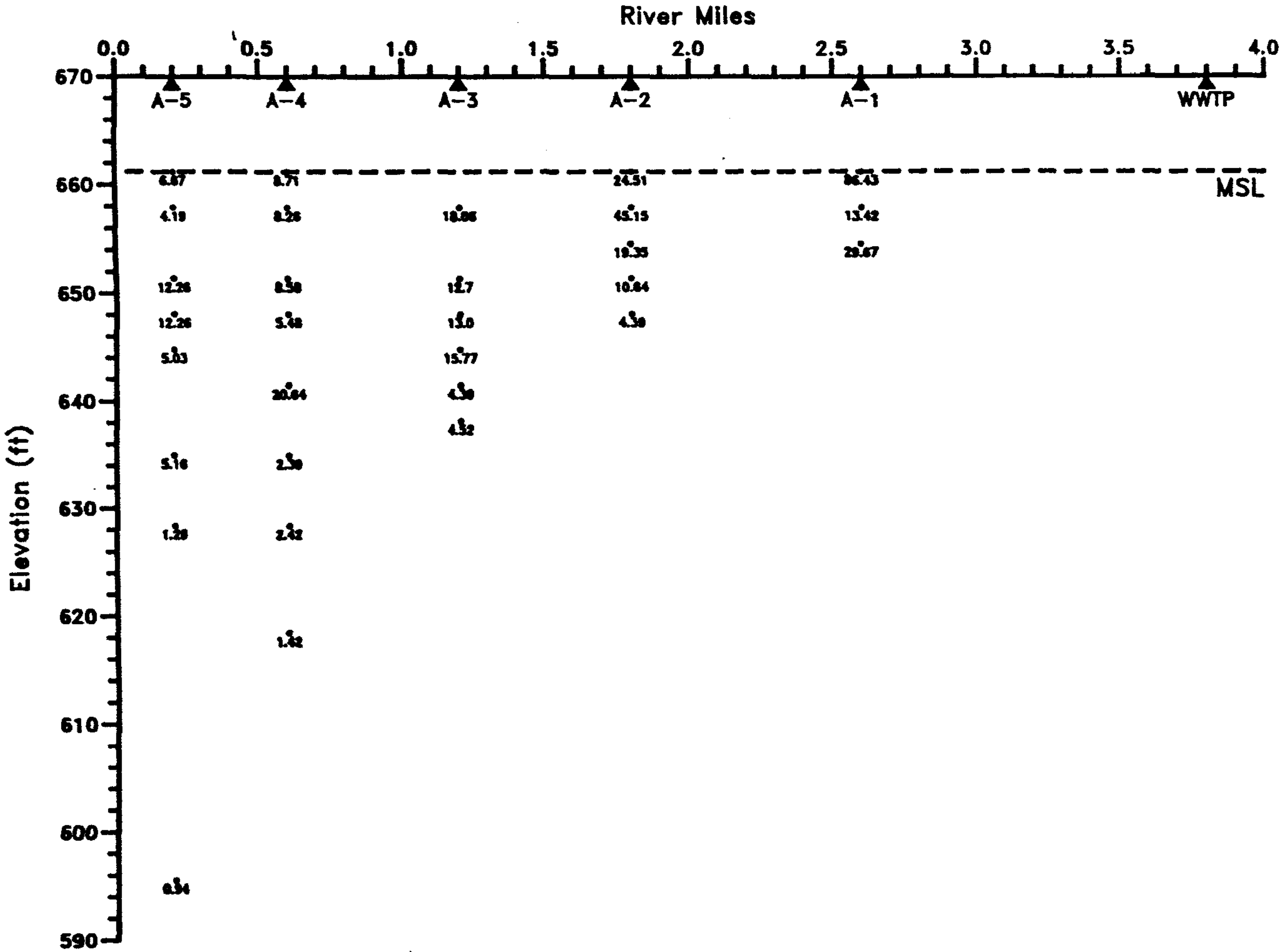


Figure F-19

Chlorophyll a ($\mu g/L$) Longitudinal Depth Profile, June, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

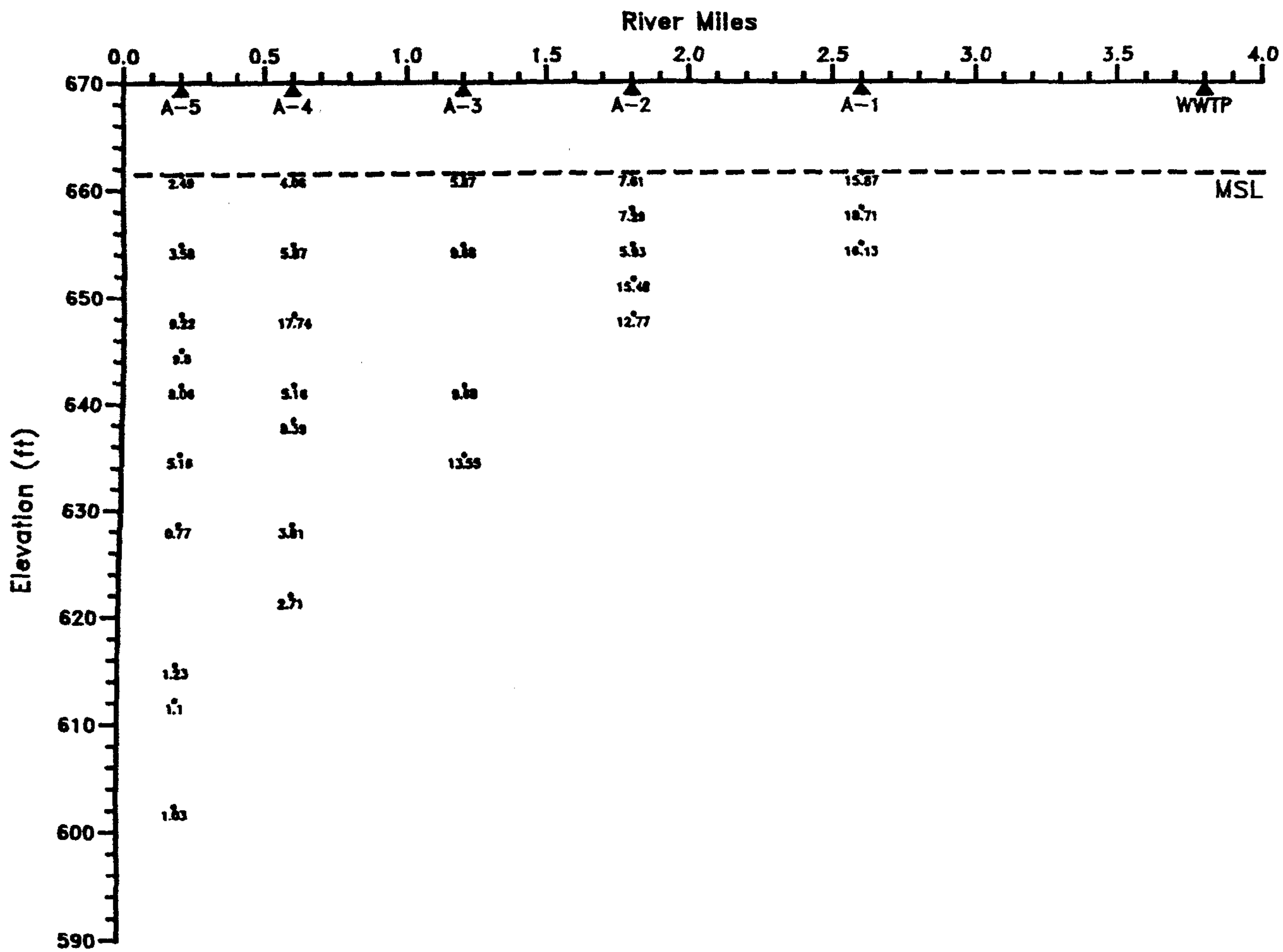


Figure F-20

Chlorophyll a (μg/L) Longitudinal Depth Profile, July, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

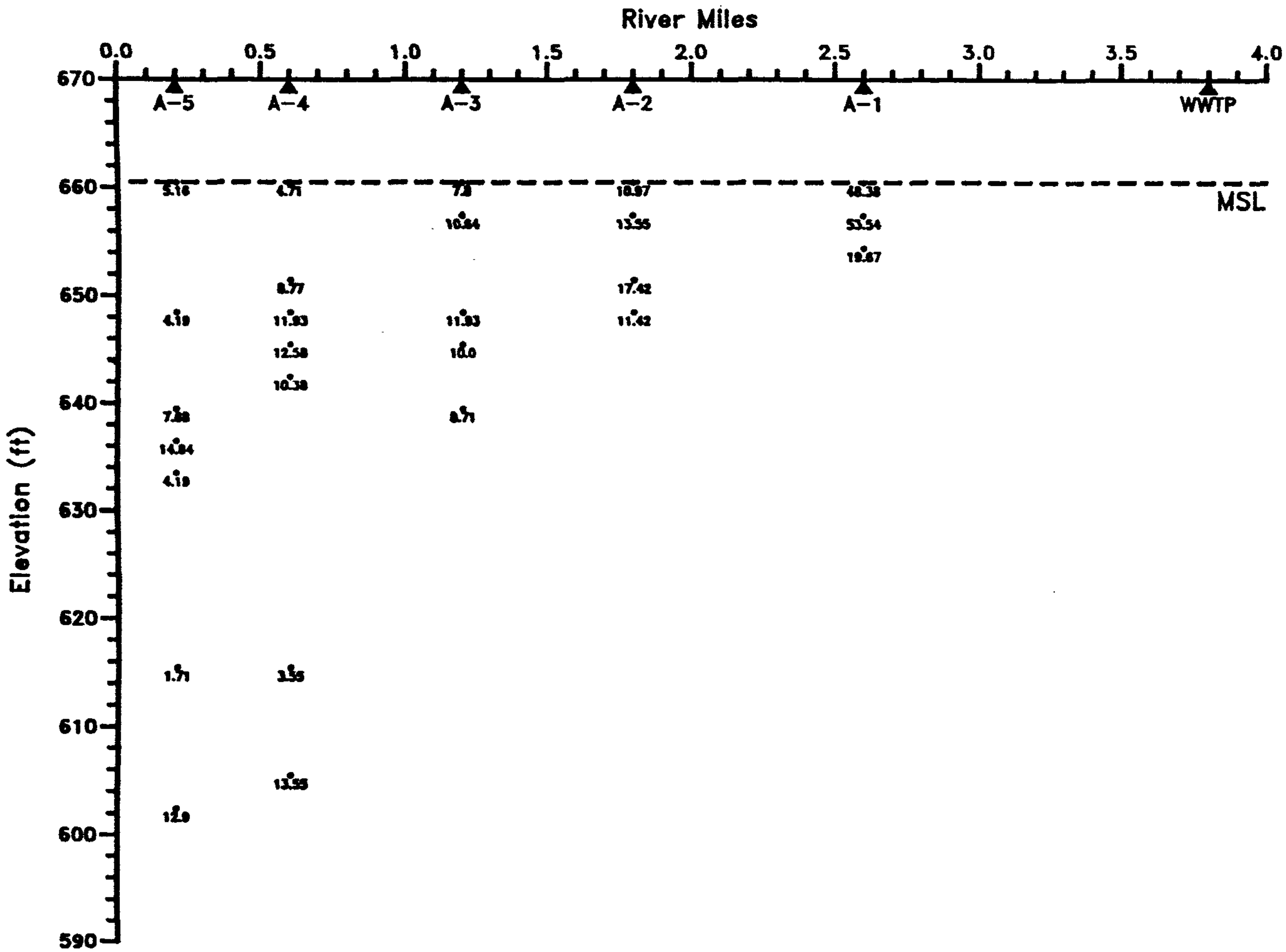


Figure F-21

Chlorophyll a (μg/L) Longitudinal Depth Profile, August, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina

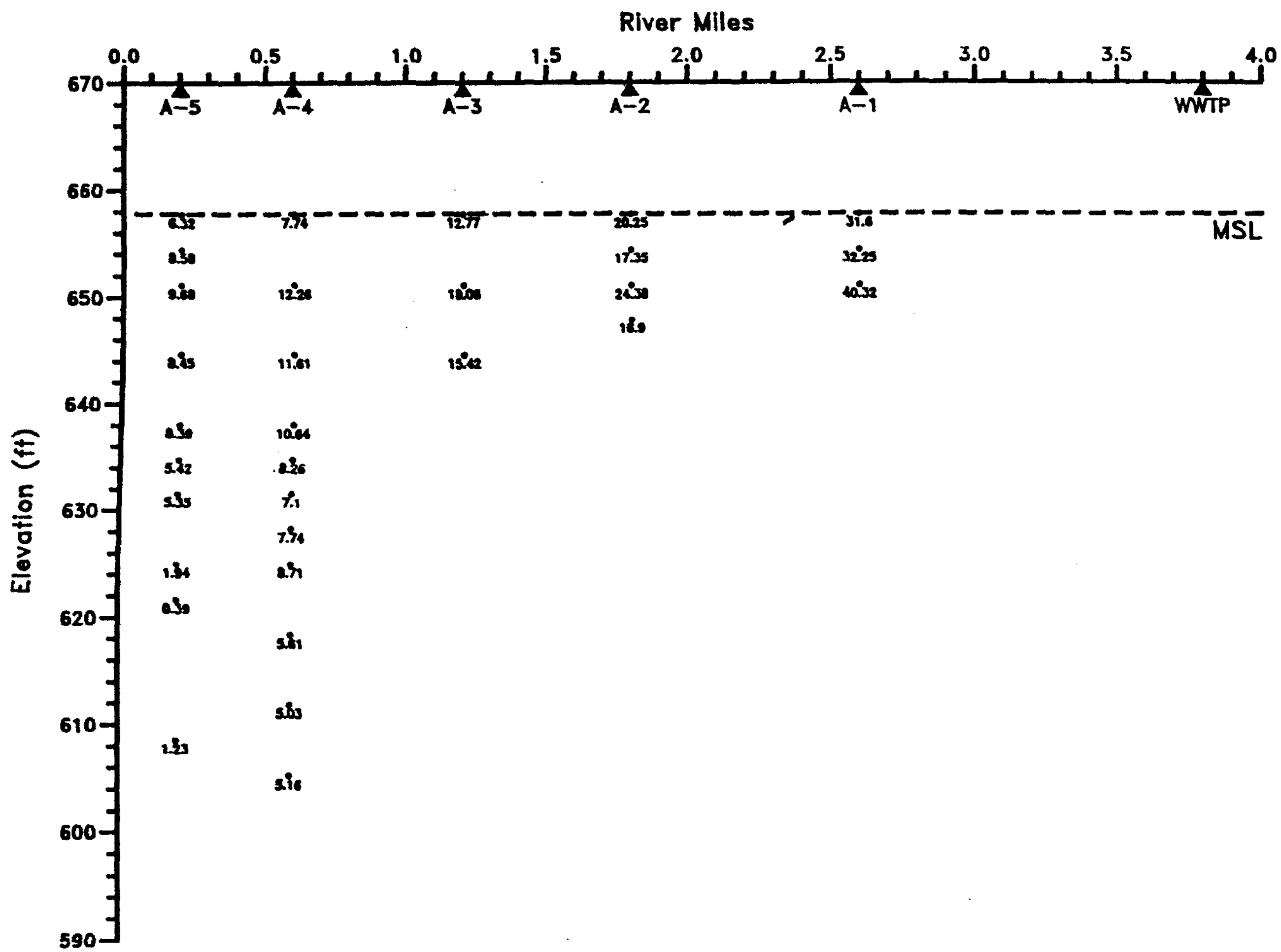
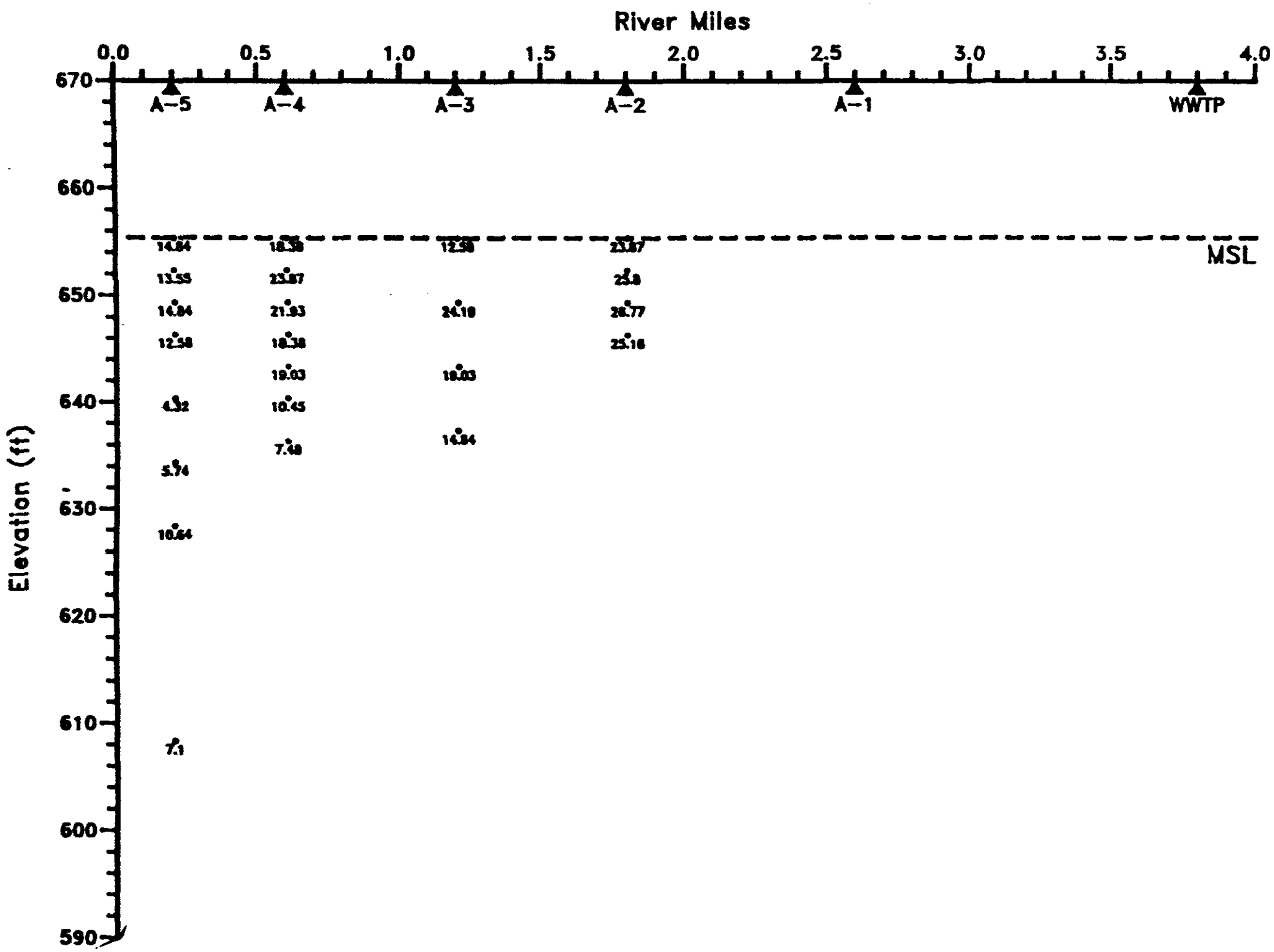


Figure F-22

Chlorophyll a (μg/L) Longitudinal Depth Profile, September, 1983
18 Mile Creek Embayment, Hartwell Reservoir, South Carolina



APPENDIX G

PHOSPHORUS LIMITED WATERS CHEMICAL AND BIOLOGICAL AVERAGE CONCENTRATIONS OF DEPTH INTEGRATED SAMPLES, 18-MILE CREEK ARM, HARTWELL RESERVOIR, S.C., 1983

Table G-1

Phosphorus Limited Waters Chemical and Biological Average
Concentrations of Depth Integrated Samples,
[illegible]ile Creek Arm, Hartwell Reservoir, South Carolina, [illegible]

Obs	Date	Station	Chlor a Mean	[illegible] Mean	[illegible] Mean
1	2/24	A1	5.8067	9.450	166.667
2	2/24	A2	3.4433	4.500	180.000
3	2/24	A3	3.6567	10.900	200.000
4	2/24	A4	21.0700	48.267	120.000
5	2/24	A5	5.8700	21.533	96.667
6	3/22	A1	5.6567	137.267	123.333
7	3/22	A2	16.7267	51.233	60.000
8	3/22	A3	15.4600	10.357	50.000
9	3/22	A4	13.9100	10.200	.
10	3/22	A5	19.5100	8.700	.
11	4/12	A1	3.7267	65.707	83.333
12	4/12	A2	5.4700	47.003	75.000
13	4/12	A3	7.3500	65.877	80.000
14	4/12	A4	9.1667	43.280	.
15	4/12	A5	6.9733	25.570	50.000
16	5/17	A1	6.3233	78.007	103.333
17	5/17	A2	18.0633	10.427	53.333
18	5/17	A3	11.7200	8.643	40.000
19	5/17	A4	6.7533	2.317	30.000
20	5/17	A5	6.4533	2.010	23.333
21	6/21	A1	17.8033	24.977	96.667
22	6/21	A2	11.1833	7.053	20.000
23	6/21	A3	7.2267	1.453	.
24	6/21	A4	8.2800	5.230	100.000
25	6/21	A5	6.6467	1.633	113.333
26	7/19	A1	33.0967	93.157	203.333
27	7/19	A2	13.9767	21.767	40.000
28	7/19	A3	11.2867	9.710	40.000
29	7/19	A4	8.0000	2.380	20.000
30	7/19	A5	7.6133	1.133	.
31	8/15	A1	35.4800	51.595	106.667
32	8/15	A2	19.7600	1.830	40.000
33	8/15	A3	16.4700	2.030	30.000
34	8/15	A4	9.0967	2.560	20.000
35	8/15	A5	8.8333	1.367	.
36	9/19	A1	18.3967	94.410	170.000
37	9/19	A2	25.1567	37.917	66.667
38	9/19	A3	14.3600	9.110	40.000
39	9/19	A4	11.5000	5.087	26.667
40	9/19	A5	7.3100	8.487	30.000

APPENDIX H

WATER QUALITY DATA AND PERCENT BIOAVAILABLE PHOSPHORUS OF TOTAL PHOSPHORUS, 18-MILE CREEK ARM, HARTWELL RESERVOIR, S.C., 1983

Table B-1

Percent Bioavailable Phosphorus of Total Phosphorus,
Six Mile Creek Arm, Hartwell Reservior, South Carolina, 1983

Obser- vations	Date	Station	Nutr Limit	Sample	Chlor. a	BAP	Total P	% BAP of TP
1	2/24	A1	P	A	7.10	.	180	.
2	2/24	A1	P	B	6.45	7.70	160	4.812
3	2/24	A1	P	C	3.87	11.20	160	7.000
4	2/24	A2	P	A	3.23	4.70	180	2.611
5	2/24	A2	P	B	1.94	.	180	.
6	2/24	A2	P	C	5.15	4.30	180	2.389
7	2/24	A3	P	A	1.94	14.50	200	7.250
8	2/24	A3	P	B	5.15	6.50	200	3.250
9	2/24	A3	P	C	3.87	9.70	200	4.850
10	2/24	A4	NP	A	23.22	40.00	120	33.333
11	2/24	A4	NP	B	23.22	56.50	120	47.083
12	2/24	A4	NP	C	16.77	48.30	120	40.250
13	2/24	A5	P	A	6.45	23.20	110	21.091
14	2/24	A5	P	B	5.81	26.60	80	33.250
15	2/24	A5	P	C	5.35	14.80	100	14.800
16	3/22	A1	P	A	6.26	139.20	140	99.429
17	3/22	A1	P	B	5.03	139.00	110	126.364
18	3/22	A1	P	C	5.68	133.60	120	111.333
19	3/22	A2	P	A	17.35	59.20	80	74.000
20	3/22	A2	P	B	16.83	61.50	80	76.875
21	3/22	A2	P	C	16.00	63.00	80	78.750
22	3/22	A3	P	A	15.61	38.70	50	77.400
23	3/22	A3	P	B	15.48	43.00	50	86.000
24	3/22	A3	P	C	15.29	39.40	50	78.800
25	3/22	A4	P	A	14.19	6.70	.	.
26	3/22	A4	P	B	14.77	11.10	.	.
27	3/22	A4	P	C	12.77	12.80	.	.
28	3/22	A5	P	A	.	8.80	.	.
29	3/22	A5	P	B	20.96	6.50	.	.
30	3/22	A5	P	C	18.06	10.80	.	.
31	4/12	A1	N	A	4.27	72.00	110	65.455
32	4/12	A1	N	B	3.64	48.98	80	61.225
33	4/12	A1	N	C	3.27	76.14	60	126.900
34	4/12	A2	P	A	5.68	44.84	50	89.680
35	4/12	A2	P	B	5.59	46.98	100	46.980
36	4/12	A2	P	C	5.14	49.19	.	.
37	4/12	A3	NP	A	7.50	76.28	.	.
38	4/12	A3	NP	B	7.05	73.95	.	.
39	4/12	A3	NP	C	7.50	47.40	80	59.250
40	4/12	A4	P	A	10.00	51.40	.	.
41	4/12	A4	P	B	8.66	32.23	.	.
42	4/12	A4	P	C	8.64	46.21	.	.
43	4/12	A5	P	A	7.05	24.88	20	124.400
44	4/12	A5	P	B	6.82	26.26	30	87.533
45	4/12	A5	P	C	7.05	.	100	.

Table H-1

Percent Bioavailable Phosphorus of Total Phosphorus,
18 Mile Creek Arm, Hartwell Reservior, South Carolina, 1983

Obser-vations	Date	Station	Nutr Limit	Sample	Chlor. a	BAP	Total P	% BAP of TP
46	5/17	A1	N	A	6.64	76.44	100	76.440
47	5/17	A1	N	B	6.64	65.60	90	72.889
48	5/17	A1	N	C	5.69	91.98	120	76.650
49	5/17	A2	P	A	18.06	7.58	50	15.160
50	5/17	A2	P	B	18.71	9.33	60	15.550
51	5/17	A2	P	C	17.42	14.37	50	28.740
52	5/17	A3	P	A	13.55	8.47	40	21.175
53	5/17	A3	P	B	10.32	10.30	40	25.7500
54	5/17	A3	P	C	11.29	7.16	40	17.9000
55	5/17	A4	P	A	7.10	2.12	30	7.0667
56	5/17	A4	P	B	6.77	2.53	30	8.4333
57	5/17	A4	P	C	6.39	2.30	30	7.6667
58	5/17	A5	P	A	6.00	2.05	20	10.2500
59	5/17	A5	P	B	6.58	2.21	30	7.3667
60	5/17	A5	P	C	6.78	1.77	20	8.8500
61	6/21	A1	P	A	22.58	25.42	60	42.3667
62	6/21	A1	P	B	14.38	25.14	60	41.9000
63	6/21	A1	P	C	16.45	24.37	170	14.3353
64	6/21	A2	P	A	11.29	7.42	20	37.1000
65	6/21	A2	P	B	10.97	1.58	20	7.9000
66	6/21	A2	P	C	11.29	12.16	20	60.8000
67	6/21	A3	P	A	8.19	1.27	.	.
68	6/21	A3	P	B	5.10	0.81	.	.
69	6/21	A3	P	C	8.39	2.28	.	.
70	6/21	A4	P	A	7.10	6.34	20	31.7000
71	6/21	A4	P	B	6.13	4.77	20	23.8500
72	6/21	A4	P	C	11.61	4.58	260	1.7615
73	6/21	A5	P	A	7.68	1.81	20	9.0500
74	6/21	A5	P	B	7.10	1.44	20	7.2000
75	6/21	A5	P	C	5.16	1.65	300	0.5500
76	7/19	A1	N	A	37.41	105.47	410	25.7244
77	7/19	A1	N	B	28.38	81.40	100	81.4000
78	7/19	A1	N	C	33.50	92.60	100	92.6000
79	7/19	A2	N	A	13.55	21.51	40	53.7750
80	7/19	A2	N	B	13.87	17.07	40	42.6750
81	7/19	A2	N	C	14.51	26.72	40	66.8000
82	7/19	A3	P	A	14.19	7.81	40	19.5250
83	7/19	A3	P	B	9.35	13.95	40	34.8750
84	7/19	A3	P	C	10.32	7.37	40	18.4250
85	7/19	A4	P	A	7.61	3.19	20	15.9500
86	7/19	A4	P	B	8.39	1.95	20	9.7500
87	7/19	A4	P	C	.	2.00	20	10.0000
88	7/19	A5	P	A	8.13	1.26	.	.
89	7/19	A5	P	B	6.97	1.05	.	.
90	7/19	A5	P	C	7.74	1.09	.	.

Table B-1

Percent Bioavailable Phosphorus of Total Phosphorus,
Six Mile Creek Arm, Hartwell Reservior, South Carolina, 1983

Obser-vations	Date	Station	Nutr Limit	Sample	Chlor. a	BAP	Total P	% BAP of TP
91	8/15	A1	N	A	35.48	.	130	.
92	8/15	A1	N	B	35.48	51.84	90	57.6000
93	8/15	A1	N	C	35.48	51.35	100	51.3500
94	8/15	A2	NP	A	20.00	1.44	40	3.6000
95	8/15	A2	NP	B	19.61	1.72	40	4.3000
96	8/15	A2	NP	C	19.67	2.33	40	5.8250
97	8/15	A3	P	A	16.06	2.16	30	7.2000
98	8/15	A3	P	B	16.90	2.09	30	6.9667
99	8/15	A3	P	C	16.45	1.84	30	6.1333
100	8/15	A4	P	A	8.71	2.30	20	11.5000
101	8/15	A4	P	B	9.42	3.05	20	15.2500
102	8/15	A4	P	C	9.15	2.33	20	11.6500
103	8/15	A5	P	A	8.51	1.26	.	.
104	8/15	A5	P	B	9.09	1.37	.	.
105	8/15	A5	P	C	8.90	1.47	.	.
106	9/19	A1	N	A	14.19	83.16	150	55.4400
107	9/19	A1	N	B	16.00	98.23	180	54.5722
108	9/19	A1	N	C	25.00	101.84	180	56.5778
109	9/19	A2	N	A	25.48	25.40	70	36.2857
110	9/19	A2	N	B	24.83	56.49	60	94.1500
111	9/19	A2	N	C	25.16	31.86	70	45.5143
112	9/19	A3	N	A	15.48	7.07	40	17.6750
113	9/19	A3	N	B	19.35	13.07	40	32.6750
114	9/19	A3	N	C	8.25	7.19	40	17.9750
115	9/19	A4	N	A	12.90	4.79	30	15.9667
116	9/19	A4	N	B	9.35	5.98	30	19.9333
117	9/19	A4	N	C	12.25	4.49	20	22.4500
118	9/19	A5	N	A	8.06	6.79	30	22.6333
119	9/19	A5	N	B	7.16	9.88	30	32.9333

Table 8-2

Percent Bioavailable Phosphorus of Total Phosphorus, Six Mile Creek Arm, Hartwell Reservior, South Carolina, 1983

Ratio of Bioavailabe Phosphorus to Total Phosphorus

Obs	Date	Station	N	Mean	Std Dev	C.V.	Std Err	Min	Max	Range
1	2/24	A1	2	5.906	1.5468	26.1891	1.0937	4.8125	7.000	2.1875
2	2/24	A2	2	2.500	0.1571	6.2854	0.1111	2.3889	2.611	0.2222
3	2/24	A3	3	5.450	1.5875	29.1275	0.9165	4.2500	7.250	3.0000
4	2/24	A4	3	40.222	6.8750	17.0926	3.9693	33.3333	47.083	13.7500
5	2/24	A5	3	23.047	9.3792	40.6962	5.4151	14.8000	33.250	18.4500
6	3/22	A1	3	112.375	13.4977	12.0113	7.7929	99.4286	126.3[illegible]	26.9351
7	3/22	A2	3	76.542	2.3925	3.1257	1.3813	74.0000	78.750	4.7500
8	3/22	A3	3	80.733	4.6145	5.7157	2.6642	77.4000	[illegible]	[illegible]
9	3/22	A4	0	.	.	.	.	.	.	.
10	3/22	A5	0	.	.	.	.	.	.	.
11	4/12	A1	3	84.527	36.7574	43.4862	21.2219	61.2250	126.900	65.6750
12	4/12	A2	2	68.330	30.1935	44.1877	21.3500	46.9800	89.680	42.7000
13	4/12	A3	1	59.250	.	.	.	59.2500	59.250	0.0000
14	4/12	A4	0	.	.	.	.	.	.	.
15	4/12	A5	2	105.967	26.0687	24.6006	18.4333	87.5333	124.400	36.8667
16	5/17	A1	3	75.326	2.1135	2.8057	1.2202	72.8889	76.650	3.7611
17	5/17	A2	3	19.817	7.7303	39.0090	4.4631	15.1600	28.740	13.5800
18	5/17	A3	3	21.608	3.9429	18.2471	2.2764	17.9000	25.750	7.8500
19	5/17	A4	3	7.722	0.6850	8.8708	0.3955	7.0667	8.433	1.3667
20	5/17	A5	3	8.822	1.4419	16.3436	0.8325	7.3667	10.250	2.8833
21	6/21	A1	3	32.867	16.0509	48.8354	9.2670	14.3353	42.367	28.0314
22	6/21	A2	3	35.267	26.4976	75.1350	15.2984	7.9000	60.800	52.9000
23	6/21	A3	0	.	.	.	.	.	.	.
24	6/21	A4	3	19.104	15.5233	81.2574	8.9624	1.7615	31.700	29.9385
25	6/21	A5	3	5.600	4.4702	79.8246	2.5809	0.5500	9.050	8.5000
26	7/19	A1	3	66.575	35.8180	53.8011	20.6795	25.7244	92.600	66.8756
27	7/19	A2	3	54.417	12.0753	22.1904	6.9717	42.6750	66.800	24.1250
28	7/19	A3	3	24.275	9.1963	37.8840	5.3095	18.4250	34.875	16.4500
29	7/19	A4	3	11.900	3.5096	29.4927	2.0263	9.7500	15.950	6.2000
30	7/19	A5	0	.	.	.	.	.	.	.
31	8/15	A1	2	54.475	4.4194	8.1127	3.1250	51.3500	57.600	6.2500
32	8/15	A2	3	4.575	1.1377	24.8679	0.6569	3.6000	5.825	2.2250
33	8/15	A3	3	6.767	0.5608	8.2870	0.3238	6.1333	7.200	1.0667
34	8/15	A4	3	12.800	2.1231	16.5866	1.2258	11.5000	15.250	3.7500
35	8/15	A5	0	.	.	.	.	.	.	.
36	9/19	A1	3	55.530	1.0058	1.8113	0.5807	54.5722	56.578	2.0056
37	9/19	A2	3	58.650	31.0862	53.0064	17.9488	36.2857	94.150	57.8643
38	9/19	A3	3	22.775	8.5750	37.6508	4.9508	17.6750	32.675	15.0000
39	9/19	A4	3	19.450	3.2686	16.8050	1.8871	15.9667	22.450	6.4833
40	9/19	A5	3	28.289	5.2239	18.4663	3.0160	22.6333	32.933	10.3000

Table 4-3

Percent Bioavailable Phosphorus of Total Phosphorus,
[illegible]ile Creek Arm, Hartwell Reservior, South Carolina, 19[illegible]

Ratio of Bioavailable Phosphorus to Total Phosphorus

Obs	Date	N	Mean	Std Dev	C.V.	Std Err	Min	Max	Range
1	2/24	13	17.1515	16.0000	93.286	4.4376	2.3889	47.083	44.6944
2	3/22	9	89.8834	18.4433	20.519	6.1478	74.0000	126.364	52.3636
3	4/12	8	82.6779	30.1155	36.425	10.6475	46.9800	126.400	79.4200
4	5/17	15	26.6591	26.0732	97.802	6.7321	7.0667	76.650	69.5833
5	6/21	12	23.2095	19.3959	83.569	5.5991	0.5500	60.800	60.2500
6	7/19	12	39.2916	28.4414	72.386	8.2103	9.7500	92.600	82.8500
7	8/15	11	16.4886	19.1517	116.151	5.7744	3.6000	57.600	54.0000
8	9/19	15	36.9388	21.3021	57.669	5.5002	15.9667	94.150	78.1833

Table 8-4

Percent Bioavailable Phosphorus of Total Phosphorus,
18 Mile Creek Arm, Hartwell Reservior, South Carolina, 1993

Ratio of Bioavailable Phosphorus to Total Phosphorus

Obs	N	Mean	Std Dev	C.V.	Std Err	Min	Max	Range
1	95	37.6705	32.6546	86.6847	3.35029	0.55	126.9	126.35

APPENDIX I

PERCENT DIFFERENCE, CHLOROPHYLL A EXPECTED OF CHLOROPHYLL A OBSERVED FOR PHOSPHORUS LIMITED DEPTH INTEGRATED SAMPLES, 18-MILE CREEK ARM, HARTWELL RESERVOIR, S.C., 1983

Table 1-1

Chlorophyll a Expected or Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

			<-- Chlorophyll a -->		
Obser-vations	*Bioavailable Phosphorus	Total Phosphorus	Expected	Observed	**Difference
1	9.45	166.667	44.12	5.81	0.86831
2	4.50	180.000	18.90	3.44	0.81799
3	10.90	200.000	53.06	3.66	0.93102
4	48.27	120.000	287.20	21.07	0.92664
5	21.53	96.667	113.68	5.87	0.94836
6	137.30	123.333	953.40	5.66	0.99406
7	61.23	80.000	377.29	16.73	0.95566
8	40.37	50.000	233.89	15.46	0.93390
9	10.20	.	48.26	13.91	0.71177
10	8.70	.	40.15	19.51	0.51407
11	47.00	75.000	278.48	5.47	0.98036
12	65.88	80.000	410.37	7.35	0.98209
13	43.28	.	253.32	9.17	0.96380
14	25.57	50.000	138.52	6.97	0.94968
15	10.43	53.330	49.39	18.06	0.63434
16	8.64	40.000	39.90	11.72	0.70627
17	2.32	30.000	8.83	6.75	0.23556
18	2.01	23.333	7.42	6.45	0.13073
19	24.98	96.667	134.77	17.80	0.86792
20	7.05	20.000	31.53	11.18	0.64542
21	1.45	.	5.10	7.23	0.41765
22	5.23	100.000	22.40	8.28	0.63036
23	1.63	113.333	5.86	6.65	0.13481
24	9.71	40.000	45.62	11.29	0.75252
25	2.38	20.000	9.03	8.00	0.11406
26	1.13	.	3.89	7.61	0.95630
27	1.83	40.000	6.74	19.76	1.93175
28	2.03	30.000	7.53	16.47	1.18725
29	2.56	20.000	9.85	9.10	0.07614
30	1.37	.	4.82	8.83	0.83195
31	8.49	30.000	39.04	7.31	0.81276

* Derived from AGPT Data

$$** \text{ Difference} = \frac{(\text{Chlorophyll a Expected}) - (\text{Chlorophyll a Observed})}{(\text{Chlorophyll a Expected})}$$

Table I-2

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

General Linear Models Procedure for All Data

Dependent Variable: Bioavailable Phosphorus

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	0.13949861	0.13949861	0.00
Error	29	24897.08628848	858.52021684	PR > F
Corrected Total	30	24897.22578710		0.9899

R-Square	C.V.	Root MSE	BP Mean
0.000006	144.7700	29.30051564	20.23935484

Source	DF	Type I SS	F Value	PR > F
Chlorophyll a Observed	1	0.13949861	0.00	0.9899

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	20.37629370	1.70	0.0992	11.96251236
Chlorophyll a Observed	-0.01316026	-0.01	0.9899	1.03241603

Table 1-3

Chlorophyll a Expected or Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

General Linear Models Procedure for All Data

Dependent Variable: Total Phosphorus

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	6275.38381397	6275.38381397	2.43
Error	23	59435.49486403	2584.15195061	PR > F
Corrected Total	24	65710.87867800		0.1328

R-Square	C.V.	Root MSE	Total_P Mean
0.095500	67.6592	50.83455469	75.13320000

Source	DF	Type I SS	F Value	PR > F
Chlorophyll a Observed	1	6275.38381397	2.43	0.1328

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	106.10157640	4.75	0.0001	22.32243443
Chlorophyll a Observed	-3.02059775	-1.56	0.1328	1.93834810

Table 1-4

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

General Linear Models Procedure for 25% or Less Difference

Dependent Variable: Bioavailable Phosphorus

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	0.30367938	0.30367938	3.93
Error	3	0.23172062	0.07724021	PR > F
Corrected Total	4	0.53540000		0.1417

R-Square	C.V.	Root MSE	BP Mean
0.567201	12.7487	0.27792122	2.18000000

Source	DF	Type I SS	F Value	PR > F
Chlorophyll a Observed	1	0.30367938	3.93	0.1417

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	0.38321004	0.42	0.7034	0.91465757
Chlorophyll a Observed	0.24313802	1.98	0.1417	0.12262159

Table 1-5

Chlorophyll a Expected or Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

General Linear Models Procedure for 25% or Less Difference

Dependent variable: Total Phosphorus

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	1202.62253617	1202.62253617	0.68
Error	3	5344.00813063	1781.33604354	PR > F
Corrected Total	4	6546.63066680		0.4715

R-Square	C.V.	Root MSE	Total P Mean
0.183701	102.1113	42.20587688	41.33320000

Source	DF	Type I SS	F Value	PR > F
Chlorophyll a Observed	1	1202.62253617	0.68	0.4715

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	154.40500487	1.11	0.3474	138.90240144
Chlorophyll a Observed	-15.30065018	-0.82	0.4715	18.62164937

Table 1-6

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

General Linear Models Procedure for 50% or Less Difference

Dependent Variable: Bioavailable Phosphorus

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	0.35139518	0.35139518	2.24
Error	4	0.62808816	0.15702204	PR > F
Corrected Total	5	0.97948333		0.2090

R-Square	C.V.	Root MSE	BP Mean
0.358756	19.2515	0.39626007	2.05833333

Source	DF	Type I SS	F Value	PR > F
Chlorophyll a Observed	1	0.35139518	2.24	0.2090

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	0.13649144	0.11	0.9211	1.29484047
Chlorophyll a Observed	0.26100162	1.50	0.2090	0.17447195

Table I-7

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1983

General Linear Models Procedure for 50% or Less Difference

Dependent Variable: Total Phosphorus

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	1202.62253617	1202.62253617	0.68
Error	3	5344.00813063	1781.33604354	PR > F
Corrected Total	4	6546.63066680		0.4715

R-Square	C.V.	Root MSE	Total P Mean
0.183701	102.1113	42.20587688	41.33320000

Source	DF	Type 1 SS	F Value	PR > F
Chlorophyll a Observed	1	1202.62253617	0.68	0.4715

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	154.40500487	1.11	0.3474	138.90240144
Chlorophyll a Observed	-15.30065018	-0.82	0.4715	18.62164937

Table I-8

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Arm, Hartwell Reservoir, South Carolina, 1985

General Linear Models Procedure for 75% or Less Difference

Dependent Variable: Chlorophyll a Observed

Source	DF	Sum of Squares	Mean Square	F Value
Model	1	0.78317282	0.78317282	0.05
Error	7	109.07422718	15.58203245	PR > F
Corrected Total	8	109.85740000		0.8290

R-Square	C.V.	Root MSE	Chlorophyll a Mean
0.007129	41.2190	3.94740832	9.57666667

Source	DF	Type I SS	F Value	PR > F
Total Phosphorus	1	0.78317282	0.05	0.8290

Parameter	Estimate	T for H0: Parameter=0	PR > |T|	Std Error of Estimate
Intercept	9.98293481	4.46	0.0029	2.23947604
Total Phosphorus	-0.00870583	-0.22	0.8290	0.03883232

Figure I-1

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983

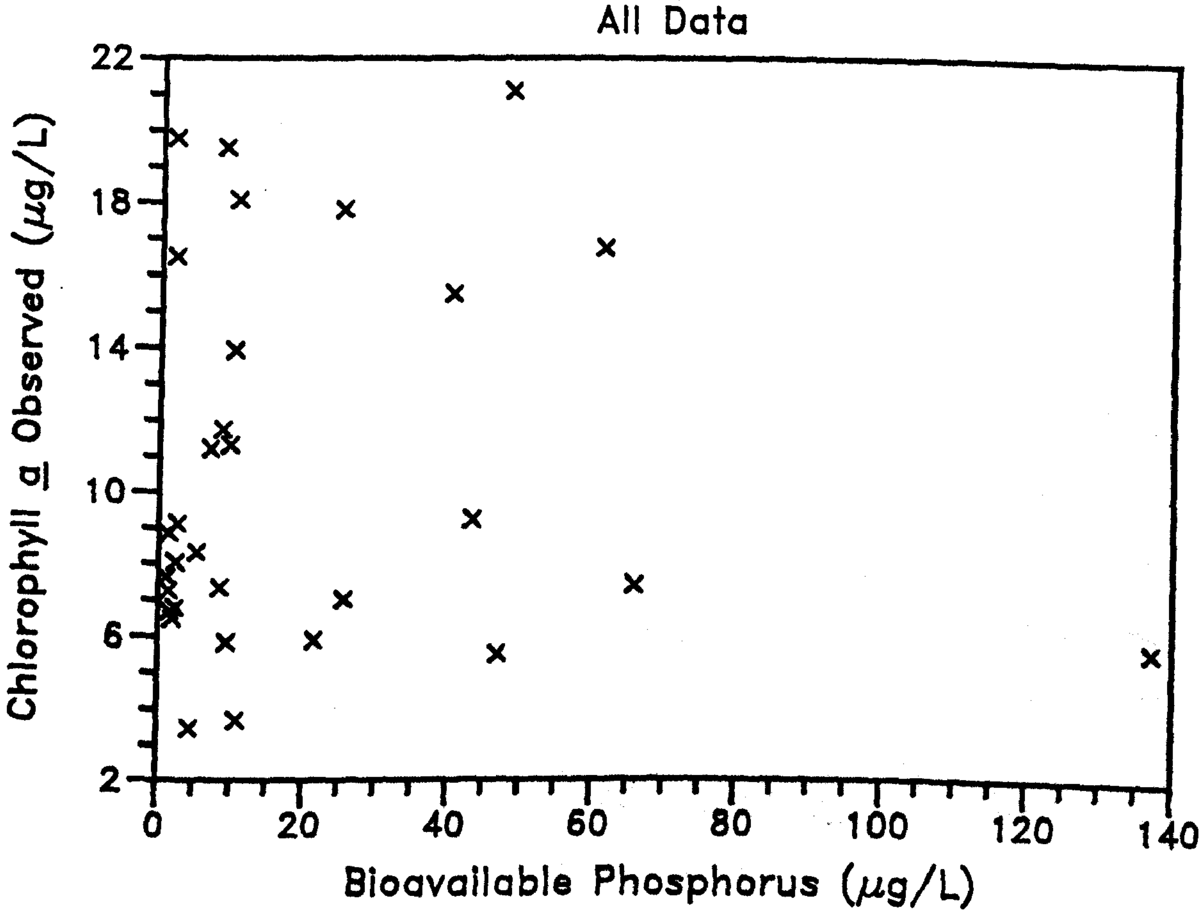


Figure I-2

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983

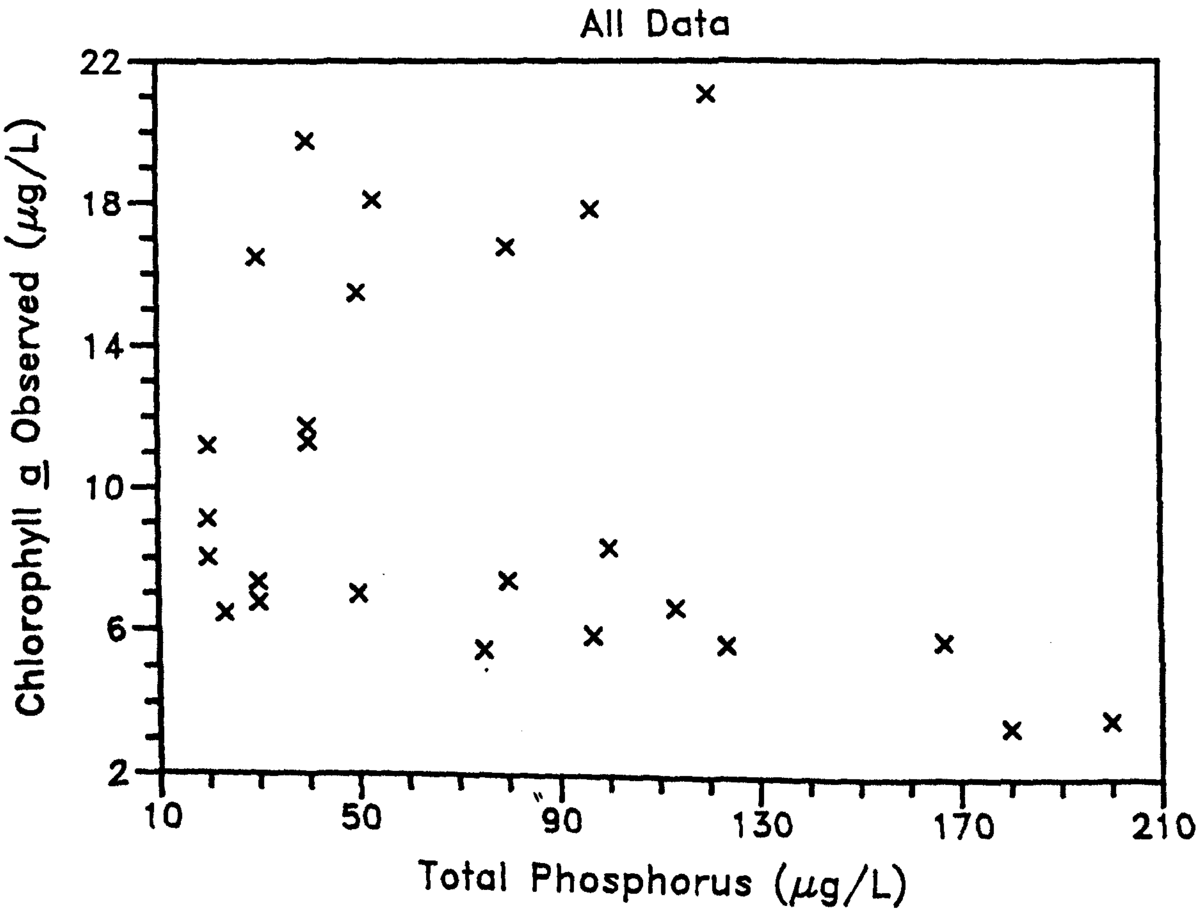


Figure I–3

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983

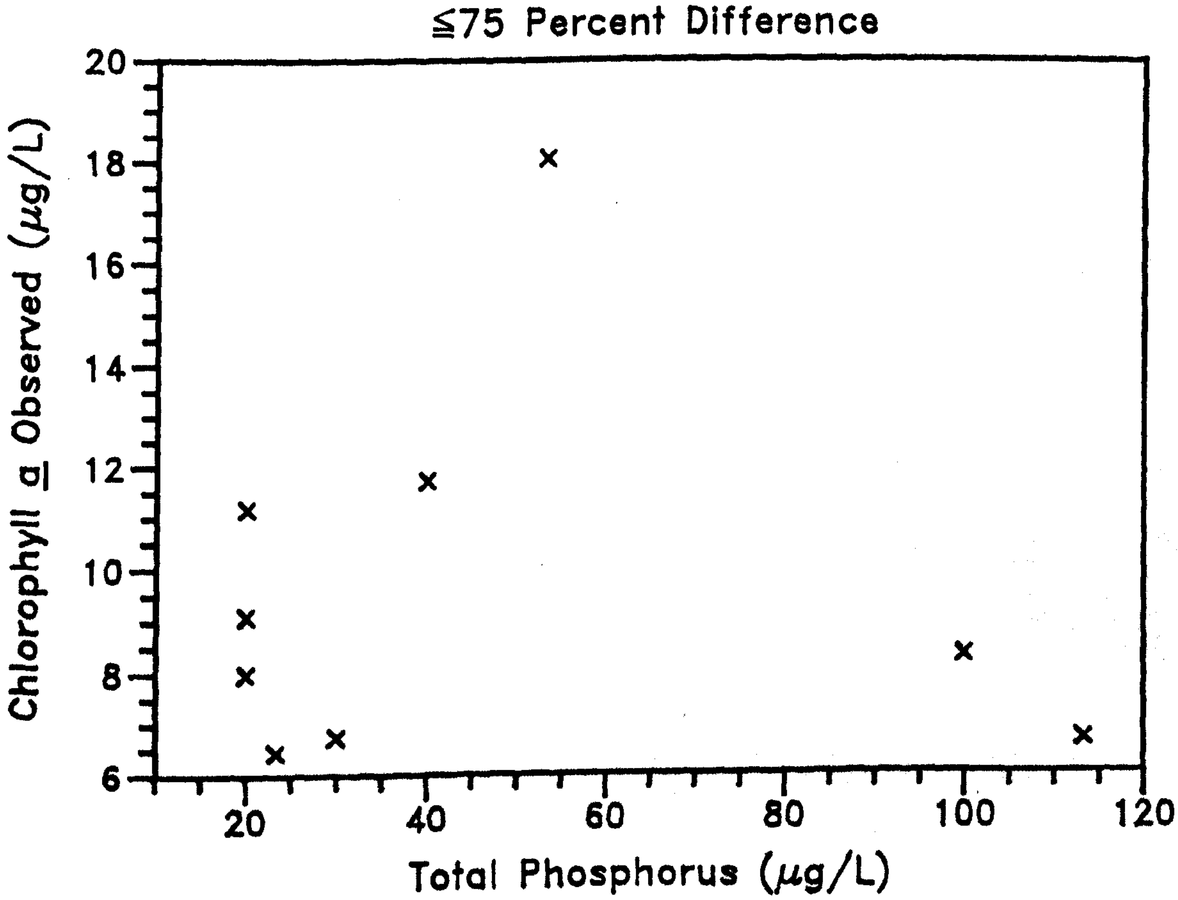


Figure I–4

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983

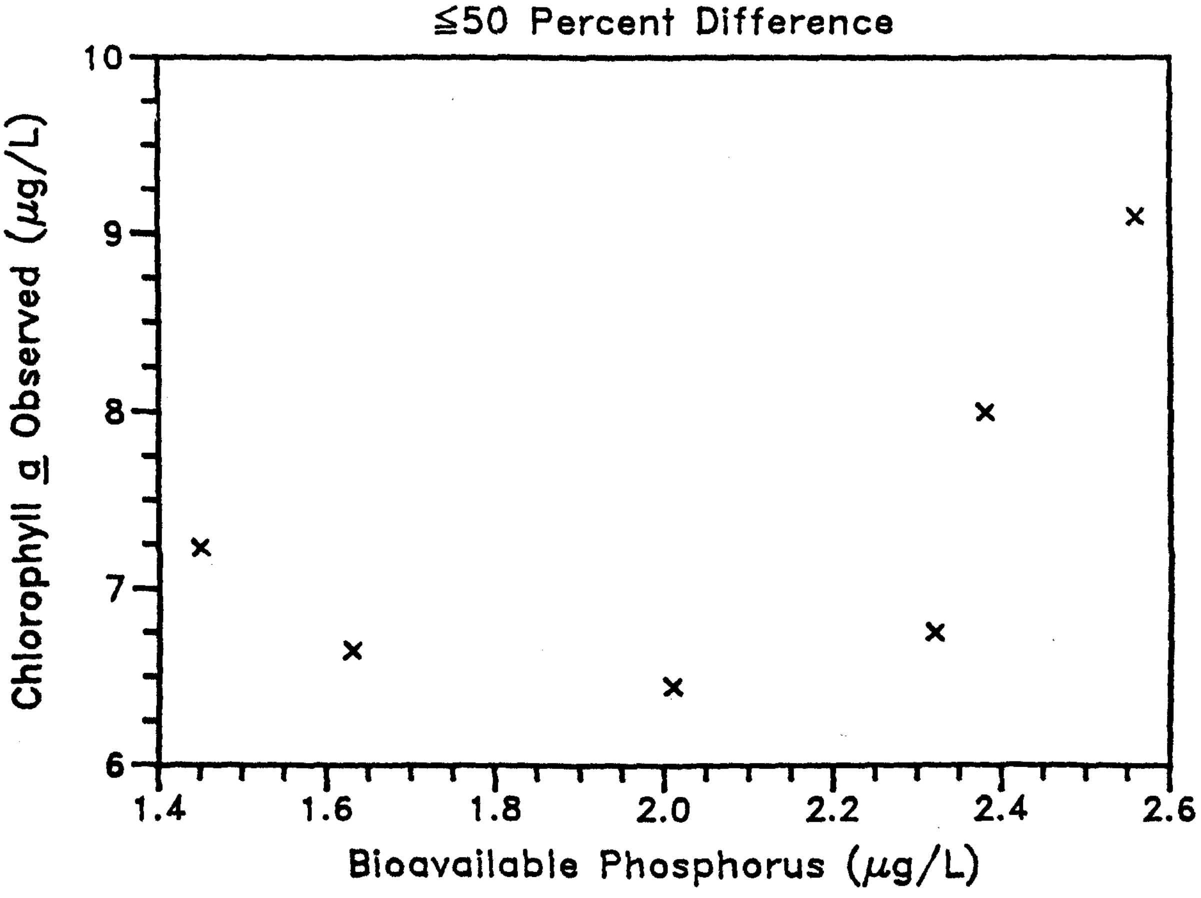


Figure I–5

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983

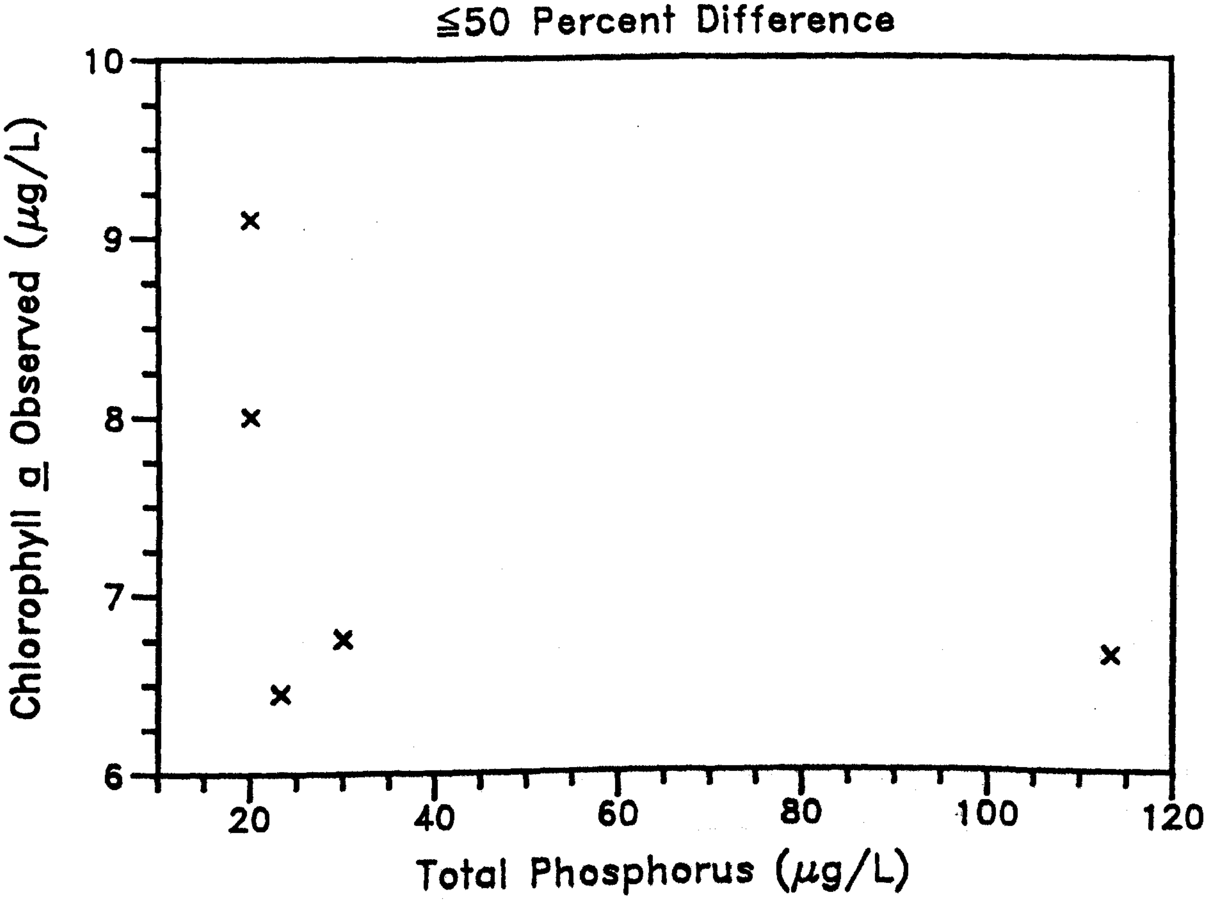


Figure I–6

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983

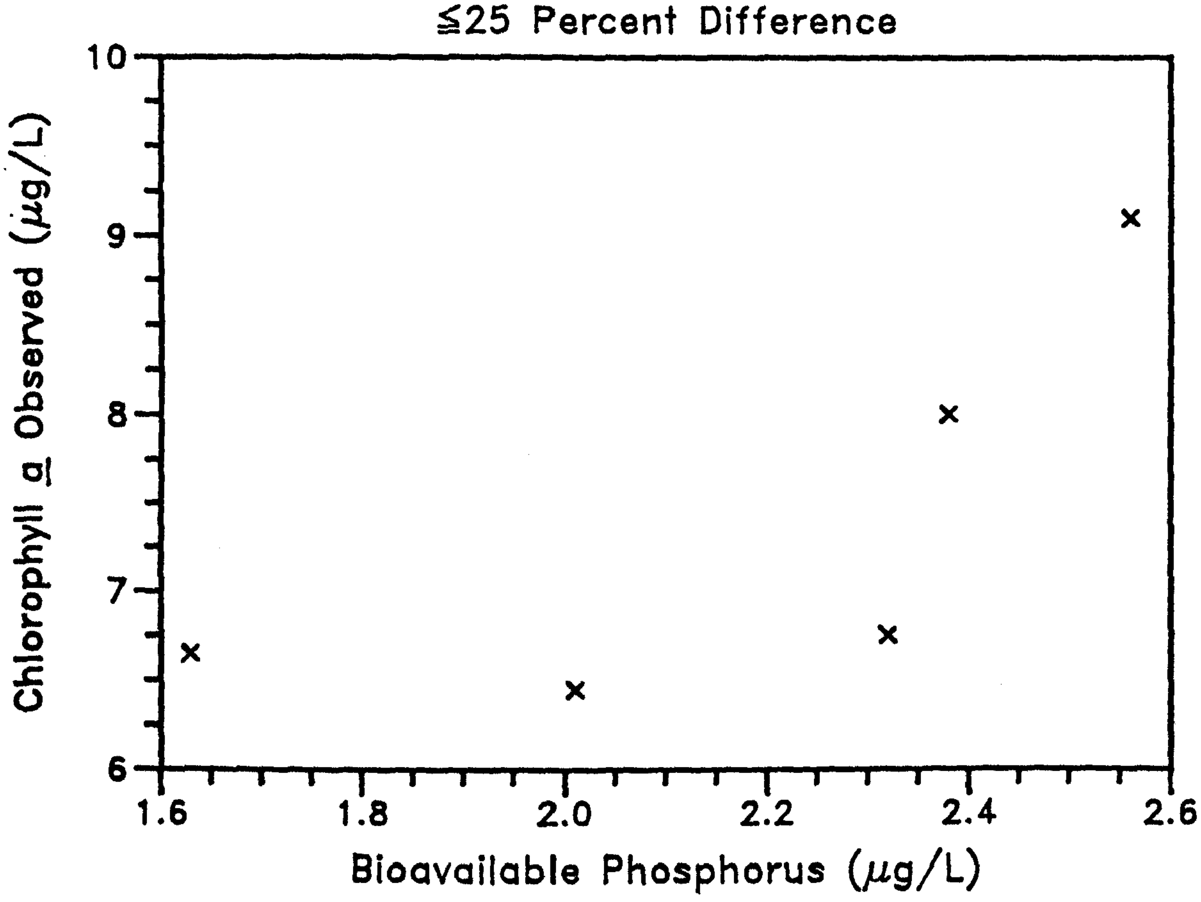
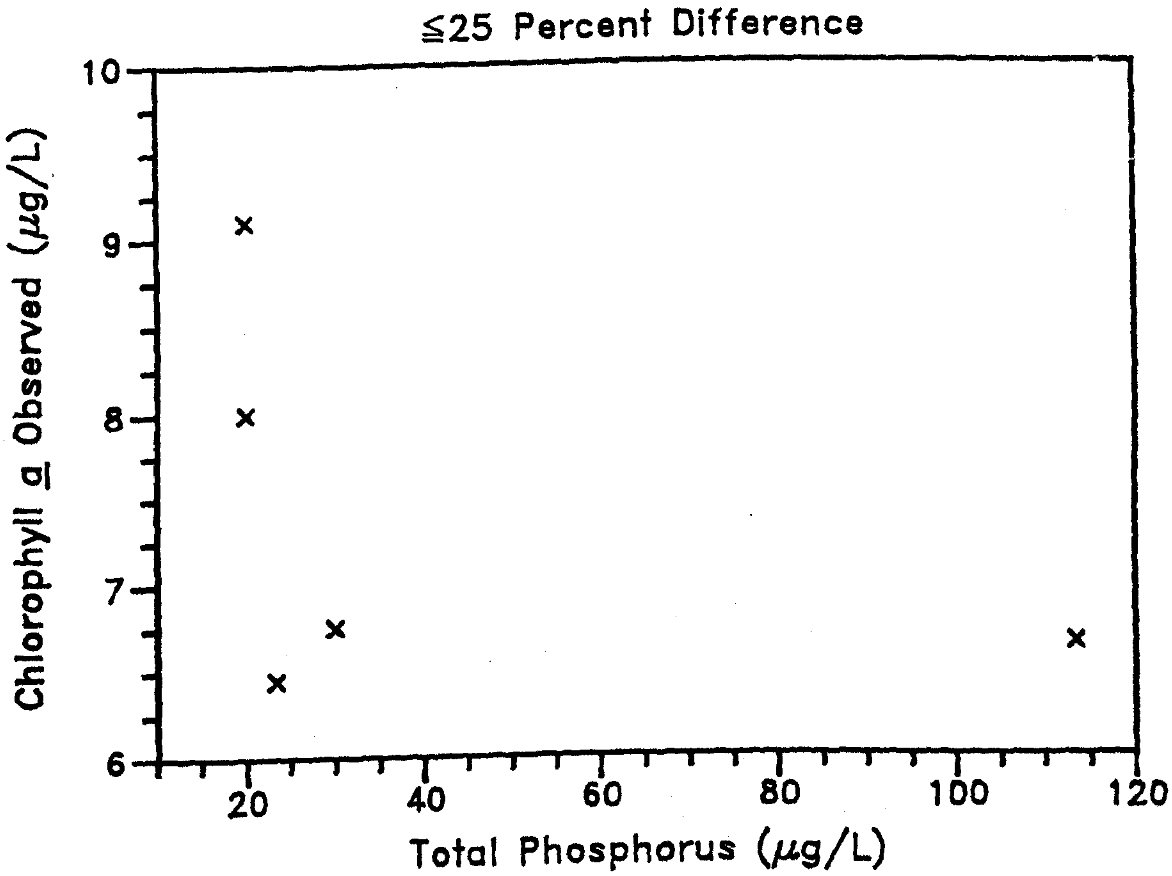


Figure I-7

Chlorophyll a Expected of Chlorophyll a Observed for Phosphorus Limited Depth Integrated Samples, 18 Mile Creek Embayment, Hartwell Reservoir, South Carolina, 1983



APPENDIX J

WATER QUALITY DATA FOR PENDLETON-CLEMSON WWTP AND 18-MILE CREEK, HARTWELL RESERVOIR, S.C., 1983

SEE APPENDIX TABLES B-1 TO B-17

APPENDIX K

EXPLANATION OF PHOSPHORUS LOADING ADJUSTMENTS

APPENDIX K

SUMMARY OF ADJUSTMENT CALCULATIONS
FOR T-P LOADINGS

1. ADJUSTMENT FOR SAMPLING BIAS

An estimate of the total days (based on the six hour sampling periods) of sampling under elevated flow conditions was completed. High flows were defined as flows which exceeded the base flow for the event by 150 percent or more.

Total Sampling Days During Study	Days > 1.5 x Base Flow During Study	Days < 1.5 x Base Flow During Study
32	7.25 (23%)	24.75 (77%)

To estimate the total number of days of high or elevated flow for the entire year (1983) a criteria of 0.30 inches of rain was used as recorded at the Pendleton-Clemson WWTP. The criteria of 0.30 inches was used because this amount approximated the rainfall at which stream flow was elevated for the April event. This is an approximation because antecedent rainfall is an important factor and the rainfall recorded at the WWTP was assumed to represent rainfall which occurred throughout the entire watershed.

Total Days (1983)	Days $\geq$ 0.30 in Rainfall (1983)
365	50 (13%)

ORIGINAL TIME WEIGHTED T-P LOADING AT EC-1 = 82.4 lb/d

Weighted high flow T-P loading = 194.4 lb/d

A. Find average T-P in lb/d for flows <1.5x base flow
(T-P lb/d for flows >1.5 x base Q) (% of flows >1.5 x base Q) + (T-P lb/d for flows < 1.5 x base Q) (% of flows <1.5 x base Q) = 82.4 lb/d

(194.4 lb/d) (.23) + (X lb/d) (0.77) = 82.4 lb/d

where X = lb/d average at low flow (<1.5 x base flow)

X = 48.9 lb/d

(194.4 lb/d) (.13) + 48.9 = 74.2 lb/d is average T-P loading adjusted for sampling

where .13 equals the percentage (13%) of actual days where high flows occurred in the basin (based on rainfall estimator)

2. ADJUSTMENT FOR DEPOSITION/RESUSPENSION

An adjustment for deposition and resuspension of T-P between station EC-1 (where the average T-P loadings were developed) and Lake Station A-1 was made based on the low and high flow dye work. A stream flow of 80 cfs was selected as the cut off between deposition (<80 cfs) and resuspension (>80 cfs) as this slightly exceeds the velocity at which T-P was shown to either deposit (<1.25 ft/sec) or be resuspended (>1.25 ft/sec).

Weighted T-P in lb/d for flows >80 cfs = 119.5 lb/d

A. Find average T-P in lb/d for flows < 80 cfs:

(T-P lb/d for flows >80 cfs) (% of flows > 80 cfs) + (T-P lb/d for flows < 80 cfs) (% of flows < 80 cfs) = 82.4 lb/d

(119.5 lb/d) (.52) + (X lb/d) (.48) = 82.4 lb/d

where X = lb/d average at flows < 80 cfs

X = 42.2 lb/d

B. Find T-P (lb/d) adjusted for deposition/resuspension

(T-P lb/d for flows > 80 cfs) (10% difference between percent (23) of sampling days at flows >80 cfs and percent (10) of days with rainfall >0.30 in.) (15% increase in T-P due to resuspension) + (T-P lb/d for flows < 80 cs) (10% sampling bias) (33% decrease in T-P load due to deposition) = lb/d with deposition/suspension adjustment.

Note: The 15% increase in T-P during resuspension and 33% decrease in FP during deposition were calculated from dye work.
(119.5 lb/d) (.468) (1.15) + (42.2 lb/d) (.532) (.67) = 79.4 lb/d

(decrease of 3.7% from 82.4 lb/d)

C. Find loading adjusted for sampling bias and deposition resuspension

(T-P lb/d adjusted for sampling) - (3.7% adjustment for transport) = T-P lb/d

(74.2 lb/d) - [(74.2 lb/d) (.037)] = 71.5 lb/d

71.5 lb/d was used as the yearly average loading value for T-P to the 18 Mile Creek arm.

3. PROJECTIONS OF T-P LOADINGS FOR INCREASED FLOW AT PENDLETON-CLEMSON WWTP

TOTAL PHOSPHORUS

A. Find the average yearly T-P concentration upstream of EC-1 based on:

1. An average yearly unadjusted loading of 82.4 lb/d
2. An average yearly flow of 91.4 cfs at EC-1 and 0.35 mgd at the WWTP
3. A median T-P concentration in the WWTP effluent of 4.2 mg/l

(Yearly average stream concentration in mg/l) (flow in cfs) (conversion factor to lb/d) + (WWTP effluent concentration in mg/l) (flow in mgd) (conversion factor to lb/d) = 82.4 lb/d

(X mg/l) (91.4 cfs) (5.38) + (4.2 mg/l) (0.35 mgd) (8.34) = 82.4 lb/d

where X = average upstream T-P concentration in mg/l

X = 0.142 mg/l

= 142 ug/l at EC-1

B. Find the projected T-P concentration at A-1 when the flow at the WWTP reaches 75% of the design flow.

(0.142 mg/l) (91.4 cfs) (5.38) + (4.2 mg/l) (1.0 mgd) (8.34) = lb/d at EC-1

where 1.0 mgd is 75% of design

69.8 lb/d + 35.0 lb/d = 104.8 lb/d

Assuming a median T-P of 180 ug/l at EC-1 and an average T-P of 118 at A-1, the average yearly decrease from EC-1 to A-1 is 35%.

lb/d at A-1 = (104.8 lb/d) (.65)

= 68.1 lb/d

$$\text{mg/l} = \frac{68.1 \text{ lb/d}}{(91.4 \text{ cfs})(5.38)}$$

= 0.138 mg/l

= 138 ug/l at A-1

C. Find the projected T-P concentration at A-1 when the flow at the WWTP reaches 100% of the design flow.

(0.142 mg/1) (91.4 cfs) (5.38) + (4.2 mg/1) (1.35 mgd) (8.34) = lb/d at EC-1

where 1.35 mgd is 100% of design

69.8 lb/d + 47.2 lb/d = 117.1 lb/d

lb/d at A-1 = (117.1 lb/d) (.65)

= 76.1 lb/d

$$mg/1 = \frac{76.1 \text{ lb/d}}{(91.4 \text{ cfs})(5.38)}$$

= 0.155 mg/1

= 155 ug/1 at A-1

BIOAVAILABLE PHOSPHORUS

A. Find the average B-P concentration upstream of EC-1 based on:

1. An average yearly loading of 33.8 lb/d
2. An average yearly flow of 91.4 cfs at EC-1 and 0.35 mgd at the WWTP
3. A median T-P concentration in the WWTP effluent of 4.2 mg/1
4. B-P comprising 85% of the T-P

(X mg/1) (91.4 cfs) (5.38) + (4.2 mg/1) (.85) (0.35 mgd) (8.34) = 33.8 lb/d

where X = average upstream B-P concentration in mg/1

X = 0.0475 mg/1

= 48 ug/1 at EC-1

B. Find the projected B-P concentration at A-1 when the flow to the WWTP reaches 75% of the design flow.

(0.048 mg/1) (91.4 cfs) (5.38) + (4.2 mg/1) (.85) (1.0 mgd) (8.34) = lb/d at E<-1

23.6 lb/d + 29.8 lb/d = 53.4 lb/d

The weighted yearly average decrease, via the two dye studies, from EC-1 to A-1 was 23%.

lb/d at A-1 = (53.4 lb/d) (.77)

= 41.1 lb/d

$$mg/1 = \frac{41.1 \text{ lb/d}}{(91.4 \text{ cfs})(5.39)}$$

= 0.084 mg/1

= 84 ug/1

C. Find the projected B-P concentration at A-1 when the flow to the WWTP reaches 100% of the design flow.

$$(0.048 \text{ mg/l})\ (91.4 \text{ cfs})\ (5.38) + (4.2 \text{ mg/l})\ (0.85)\ (1.35 \text{ mgd})\ (8.34) = \text{lb/d at E}$$

$$23.6 \text{ lb/d} \quad + \quad 40.2 \text{ lb/d} \quad = 63.8 \text{ lb/d}$$

$$\text{lb/d at A-1} = (63.8 \text{ lb/d})\ (.77)$$

$$= 49.1 \text{ lb/d}$$

$$\text{mg/l} = \frac{49.1 \text{ lb/d}}{(91.4 \text{ cfs})\ (5.38)}$$

$$= .100 \text{ mg/l}$$

$$= 100 \text{ ug/l at A-1}$$

APPENDIX L

EXPLANATION OF PARTIAL DIFFERENCE BETWEEN SOURCE TOTAL PHOSPHORUS AND STREAM TOTAL PHOSPHORUS LOAD

APPENDIX L

EXPLANATION OF PARTIAL DIFFERENCE BETWEEN SOURCE TOTAL PHOSPHORUS AND STREAM TOTAL PHOSPHORUS LOAD

The transport mode for particulate phosphorus associated with the nine active basin point source discharges was based on stream velocity determinations. A relationship was developed between total phosphorus fate and velocity during the high flow dye study. The corollary held that particulate phosphorus would deposit in sinks whenever the stream velocity was less than 1.25 ft/sec. Likewise a resuspension of particulate phosphorus would occur at velocities greater than 1.25 ft/sec.

Velocity was computed using Manning's equation:

$$V = \frac{1.486}{N} r^{2/3} s^{1/2}$$

where: V = velocity in feet/second

N = a roughness coefficient

r = hydraulic radius in feet, and

s = energy gradient (slope)

Since a stage-discharge relationship exists at long term water quality station EC-1, stream velocity and hydraulic parameters were determinable for any flow rate. During the basin study, the stream flow rate at EC-1 was constant at 37.1 cfs. This flow rate is equivalent to a velocity of 1.16 ft/sec. Manning's coefficient was then computed as follows:

where: $r = .33$

$s = 0.00144$ ft/ft

$V = 1.16$ ft/sec, then

$N = 0.023$

The nine active discharges are located in the upper reach of the basin upstream of long term monitoring Station EC-1. The energy gradient (slope) in these reaches is steeper; therefore, the velocity increases. Predictive velocities for these point source segments showed that deposition of particulate phosphorus occurred through a 5.2 mile segment upstream of EC-1, whereas tributary reaches and main stream segments upstream of the 5.2 mile stretch of creek had velocities sufficient to maintain particulate phosphorus in suspension.

Applying a deposition rate of 0.056 mg/L/mile, developed during the dye study, to the basin stream segments with velocities less than 1.3 ft/sec resulted in 2.92 lb/day deposited as sinks along the stream bottom. This quantity of phosphorus, though not appreciable, accounts for a portion of the difference between source and stream total phosphorus.

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