TECHNICAL REPORT SERIES

DESIGN AND PERFORMANCE OF THE CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM AT PHILLIPS HIGH SCHOOL, BEAR CREEK, ALABAMA

TVA/WR/WQ--90/5
May 1990
Water Resources
River Basin Operations
Resources Development
Tennessee Valley Authority

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May 1990

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ACKNOWLEDGMENTS

The constructed wetlands demonstration at Phillips High School is a team effort involving many individuals and agencies. At the local level key participants include Wayne Phillips, who donated the land for the project; Sonny L. Frix, Principal-Phillips High School, and his staff; Ms. Roberta Goggans, Superintendent-Marion County Schools, and her staff; and the members of the Marion County Board of Education. At the State level the Alabama Department of Environmental Management approved the project plans. At the Federal level the Soil Conservation Service developed the detailed design and was responsible for construction. Key personnel included Gene R. Kearley and Virgil McGuire. The Agricultural Stablization and Conservation Service managed the contracts associated with the project. The Tennessee Valley Authority (Water Quality Department) planned and funded the project using Congressional appropriations for the Bear Creek Floatway projects. Key personnel include Gary L. Springson, Bear Creek Floatway Projects Manager; James T. Watson, Phillips High School Constructed Wetland Project Leader; Johnny S. McFall, Field Engineering; David M. Varnell and Larry O. Hill, Environmental Chemistry Laboratory; and Burline P. Pullin and Donald A. Hammer, Valley Resource Center. Joel Pounders is the Bear Creek Floatway Advisory Committee Field Professional. The project was constructed by the Kenneth Jackson Construction Company, Hamilton, Alabama.

EXECUTIVE SUMMARY

A constructed wetlands wastewater treatment system has been constructed at Phillips High School, Bear Creek, Alabama, to polish the effluent from the school's extended aeration package treatment plant. The project is a demonstration of innovative technology under the Congressionally appropriated Bear Creek Floatway projects.

The constructed wetland is a single gravel cell that is 125 feet wide and 175 feet long. Gravel depth is 12 inches of No. 6 washed river gravel averaging about 1/2 inch. Construction was completed in August 1988 at a cost of $36,266. The design hydraulic loading rate is 25 acres per million gallons per day (acres/mgd). The actual loading rate has been about 33 acres/mgd.

Monitoring results for the period October 1988 through July 1989 reveal that the system has been very effective in polishing the effluent from the package treatment plant. The effectiveness is attributed primarily to maintenance of an overall oxidizing environment within the gravel substrate. Average monthly removals during the first year of operation exceeded 90 percent for BOD, TSS, organic nitrogen, total phosphorus, dissolved phosphorus, and fecal coliforms. Average removal percentages ranged in the 80s for ammonia and total nitrogen and in the 70s for nitrate + nitrite nitrogen and dissolved BOD. The prevalence of oxidizing conditions is probably the result of low carbonaceous demand, the low inlet hydraulic loading rate, and the combination of the shallow gravel depth and the excellent plant coverage and root depths during the first year of operation.

The only time that an NPDES permit limit was not met was during February and March when the effluent pH was 5.8 and 5.9, respectively. These values are slightly below the lower pH limit of 6.

The system is still immature and the long term performance needs to be documented to increase the credibility of this specific system and the technology in general. The performance of the system is expected to remain good as long as the gravel substrate remains in an oxidized state.

DESIGN AND PERFORMANCE OF THE CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM AT PHILLIPS HIGH SCHOOL BEAR CREEK, ALABAMA

OVERVIEW OF THE CONSTRUCTED WETLAND SYSTEM

Phillips High School is located in Bear Creek, Alabama, approximately 40 miles south of Florence on State Route 5 (figure 1). Before the constructed wetland project, the school's wastewater treatment system was only an extended aeration package treatment plant. The facility frequently exceeded its National Pollutant Discharge Elimination System (NPDES) permit limits, and TVA identified it as a potential source of fecal coliform contamination to the Bear Creek Floatway. TVA's Water Quality Department chose the facility as a demonstration project for innovative technology under the Congressionally appropriated Bear Creek Floatway projects.

Constructed wetlands technology was used to polish the effluent from the existing package treatment plant. The Water Quality Department developed the conceptual design. The United States Department of Agriculture Soil Conservation Service (SCS), Bear Creek Water Quality Project Office, Russellville, Alabama, developed the detailed design and was responsible for construction of the project. The contract (appendix A) was awarded to Kenneth Jackson Construction Company, Hamilton, Alabama. Construction began July 8, 1988; planting began August 9 and was completed August 23, 1988. Cost of the project was $36,266.

The constructed wetland is a subsurface flow type, selected to minimize potential vector and odor problems because school and private residences are nearby. The design is based on a flow of 20,000 gallons per day (gpd) for a school population of 800 (25 gpd per person). The design hydraulic loading rate is 25 acres per million gallons per day (acres/mgd), resulting in an area requirement of 0.5 acre. Cell dimensions are 125-feet wide and 175-feet long. Cell width was maximized within siting constraints to reduce the potential for surface flow as the system matures, resulting in an inlet design hydraulic loading rate of 160 gpd/ft. Gravel depth is 12 inches of No. 6 washed river gravel averaging about 1/2 inch. Besides reducing construction costs, the relatively shallow depth should help determine whether nitrification would be enhanced by forcing all flow within the most effective root zone depth. The system was graded flat on both the bottom and top of the cell. Mixed marsh species (predominately cattails and sedges) were planted in the gravel in rows 2 feet apart. The system was constructed in a marshy area containing clay soils with low permeability.

Flow from the package plant is conveyed to the wetlands by a 6-inch PVC (schedule 35) pipe and is uniformly distributed across the inlet area by a 4-inch PVC (schedule 35) pipe with 16 tees 8 feet apart. The joints contain standard elastomeric gaskets so that the discharge elevation of each tee can be adjusted for uniform flow distribution. The distributor pipe is located 1 foot above the surface of the gravel bed to accommodate solids accumulation for many years without affecting flow distribution. The elevated distributor pipe also results in further aeration as the wastewater enters the wetland. The pipe is anchored by concrete pads (1- by 2- by 1-feet) and galvanized steel straps located midway between each tee. Wastewater flows from the tees to an inlet strip (2-feet wide at the base of the cell) containing 2- to 4-inch rock along the width of the wetland. This larger rock strip further distributes flow and reduces the clogging potential in the inlet zone.

A structure to monitor inlet flow was built in October 1989 before the inlet distributor. The flow measuring device is a 60 degree V-notch weir. Table 1 contains a conversion chart for determining flow.

As the wastewater flows horizontally through the bed, pollutants are removed by physical, chemical, and biological treatment mechanisms (Stowell et al., 1980 and Watson et al., 1989). Solids are removed by sedimentation, filtration, and adsorption. Nutrients and trace metals are removed by adsorption, absorption, complexation, and precipitation. Organics are removed by decomposition, biological metabolism, and absorption. Pathogens are removed by absorption, sedimentation, ultraviolet radiation, chemical reactions, natural dieoff, and predation by zooplankton. Performance is expected to be relatively good from inception because of the physical processes; however, optimal performance will not occur until the system matures (three or more years).

Since it is highly permeable, gravel allows the system to function in a subsurface mode. Gravel also provides a very large surface area on which microorganisms colonize. The efficiency of biological treatment depends largely on the quantity of microorganisms to feed on pollutants. However, colonization of microorganisms, sedimentation, and filtration of solids, and growth of roots reduce spaces within the gravel and eventually could clog the system, limiting flow to the top of the gravel. The marsh vegetation stabilizes the hydraulic conductivity of the gravel and inhibits complete clogging (Brix, 1987, and Watson and Hobson, 1989). The stabilization process is complex and long-term involving the skeletal structures of dead roots, microorganisms, and composted debris that eventually accumulate on top of the bed. The marsh vegetation also supplies oxygen to the heterotrophic microooganisms that colonize the surface of the gravel, roots, and debris (Brix, 1987, and Watson and Hobson, 1989). Oxygen is transferred to the roots where some of it escapes into the surrounding area and is used by the microorganisms.

The water level is normally maintained about 1 to 3 inches below the gravel surface by rotating a standpipe located in a concrete block building at the effluent end of the system. The water level may be changed as needed. The system may be flooded to control weeds and vectors (mosquitoes, flies, etc.), to increase the retention time for treatment purposes, to control ice during winter, and to store water during summer school vacation. The water level may be dropped below the bed surface to stimulate root growth during the fall, to control vectors and odors and to increase the hydraulic gradient so that subsurface flow may continue as the system clogs.

The treated wastewater is collected by 6-inch perforated, corrugated plastic tubing buried in a trench along the outlet end of the system. The trench is 2-feet wide at the base of the system and contains 2 feet of 2- by 4-inch rock. The larger rock minimizes the clogging potential within the trench. From the collector pipe, the wastewater goes to the concrete block outlet sump containing the water level control standpipe. An aluminum cover protects the sump from leaves and debris and discourages vandalism. The outlet to the sump is connected to a burial vault which has been converted to a 30-degree, V-notch weir box for measuring flow. A staff gauge on the side of the box measures the head of water flowing over the weir. Table 1 contains a conversion table for determining flow. A 45-degree V-notch weir is also available for installation if the flow increases. Operation and maintenance procedures are contained in appendix B.

VEGETATION STATUS

Cattails and sedges planted August 9-23, 1988, showed new growth within a few weeks and continued growth until December when cold weather made them dormant until March. The cattails spread quickly during spring of 1989, and by summer, coverage was excellent in the front half and end of the cell. Growth was not as strong from about the middle of the cell. The cattails planted in this area came from a road ditch and apparently were stressed more than those planted in the front and rear of the cell, which were obtained from ponds. During August 1989, the roots of both the cattails and sedges extended almost to the bottom of the gravel (about 10 to 11 inches). There was no evidence of anaerobic conditions within the bed (even in the inlet area). The only potential problem occurred in early summer after the 1988/89 school year when the stems of cattails in the inlet area died. The probable cause was routine use of cleaning or other chemicals at the school when wastewater flow and dilution in the sewerage system was minimal. Only a few of the plant roots appeared to be killed, and the surviving roots quickly established new plants. The inlet zone was revegetated by the beginning of the 1989/90 school year. Consequently, the overall vegetative status was outstanding for the first growing season.

MONITORING STRATEGY

Weekly influent and effluent sampling began October 1988, at the start of the school year as operation of the package treatment plant began stabilizing for typical loading conditions. The 1988/89 school year was August 22, 1988, to May 25, 1989. Sampling was reduced to a monthly basis from November 1988 through April 1989. A final sample set for fiscal year 1989 was taken in July during summer vacation under minimal wastewater loading conditions. All were grab samples collected by TVA's Field Engineering Department using Muscle Shoals personnel. Influent samples were collected in the manhole between the package treatment plant and the wetlands, while effluent samples were collected in the adjustable standpipe. Duplicate samples were collected in April for quality control. Parameters consist of the following:

Laboratory	Field
Biochemical oxygen demand (BOD, total and soluble)	Temperature
Total suspended solids (TSS)	pH
Organic nitrogen	Dissolved oxygen (DO)
Ammonia nitrogen	Conductivity
Nitrate plus nitrite nitrogen	Alkalinity
Phosphorus (soluble and total)	Flow (CW effluent)
Fecal coliforms	

Laboratory parameters were analyzed by TVA's Environmental Chemistry Laboratory in Chattanooga and field parameters were analyzed by Field Engineering during collection of samples. All analytical procedures are Environmental Protection Agency (EPA) approved, and intralaboratory performance is evaluated by systematic checks for precision and accuracy.

FLOW

Instantaneous flow obtained at the effluent weir box during sample collection ranged from 0 to 9,900 gpd. Because of the importance of flow in evaluating wetlands performance, continuous flow recorders were installed in fall 1989. Although data do not cover the report period, the information should still be representative, providing a clearer perspective on the hydraulic loading applied to the wetland. December 1, 1989, through March 31, 1990, the average influent and effluent flows for the wetland were 12,600 and 17,700 gpd, respectively. The higher effluent value probably results from rainfall during this period. Using the average of these values (15,200 gpd), the actual hydraulic loading rate is approximately 33 acres/mgd (the design is 25 acres/mgd).

RESULTS

Table 2 lists data for each sample, including monthly averages, minimum and maximum values, and percent difference between the monthly average influent and effluent. Time series plots for each parameter are contained in figures 3 through 17.

Compliance Parameters

The NPDES permit issued by the Alabama Department of Environmental Management (ADEM) for Phillips High School includes limitations on BOD, TSS, ammonia nitrogen, and pH. Monitoring results reveal that the constructed wetlands is very effective in ensuring that the final system discharge is within appropriate NPDES permit limits. Results for each parameter are presented below.

BOD--Monthly average influent BOD was 13 mg/l and the average effluent value was less than 1 mg/l, resulting in a removal efficiency of 92 percent. Influent ranged from less than 1 mg/l (the detection limit) to 30 mg/l. Effluent ranged from less than 1 mg/l to 1.1 mg/l, never exceeding the NPDES effluent limit of 20 mg/l. The primary removal mechanisms are believed to be filtration of solids and bacterial metabolism of remaining carbonaceous material.

TSS--Monthly average influent TSS was 60 mg/l and the average effluent value was less than 3 mg/l, resulting in a removal efficiency of 95 percent. Influent ranged from 40 to 92 mg/l, indicating that sludge management is the primary operational problem with the extended aeration plant. The package plant does not have a digester, and during the start of the school year, sludge bulking may be a problem because of young sludge, while later in the year pin floc may be a problem because of high sludge age (US EPA, 1977).

Wetlands effluent ranged from 1 to 11 mg/l, never exceeding the NPDES effluent limit of 30 mg/l. Filtration through the gravel substrate is the probable primary removal mechanism.

High influent solids concentrations represent a potential, long-term problem for the constructed wetland system. High suspended solids concentrations have clogged the inlet area of other gravel wetland systems, resulting in surface flow and reduced effectiveness (Watson and Hobson, 1989, and Choate et al., 1989). However, the Phillips High School system is designed with a much lower inlet unit hydraulic loading rate (160 gpd/ft, instead of 600 to 3000 gpd/ft), which may assimilate the suspended solids with little adverse effects. Actual inlet loading rate was about 101 gpd/ft based on influent flows for December 1, 1989, through March 31, 1990. This design should be carefully observed and evaluated over the next few years. Currently recommended TVA design guidelines result in even more conservative inlet loading rates.

Ammonia Nitrogen--Monthly average influent ammonia nitrogen was 10.7 mg/l, and the average effluent value was 1.8 mg/l, resulting in removal efficiency of 83 percent. Influent ranged from 1.3 to 20 mg/l, which, together with usually high nitrate + nitrite and low alkalinity concentrations, indicates that the extended aeration plant is nitrifying but not to the extent required for consistent compliance. Wetlands effluent ranged from 0.02 to 3.6 mg/l, never exceeding the NPDES effluent limit of 8 mg/l. Higher effluent concentrations occurred during the winter when low temperatures reduced nitrification rates.

pH--The median of the monthly influent pH values was 6.0 and the median effluent value was 6.3, resulting in an increase of 5 percent. Influent ranged from 5.1 to 7.8, while the effluent ranged from 5.8 to 7.7, slightly dropping below the NPDES permit lower limit of 6 in February and March. The NPDES upper limit of 9 was never exceeded.

Other Parameters of Interest

Nitrogen--Total nitrogen in the influent to the wetland averaged 48 mg/l and the effluent averaged 9.0 mg/l, resulting in a removal of 82 percent. Removal of all species of nitrogen (organic, ammonia, and nitrate + nitrite) was high: 95 percent for organic nitrogen (from an average of 12 to 0.58 mg/l), 83 percent for ammonia nitrogen (from an average of 10.7 to 1.8 mg/l), and 75 percent for nitrate + nitrite nitrogen (from an average of 26 to 6.5 mg/l).

These results indicate that the nitrogen processes of ammonification, nitrification, and denitrification are very effective even though the wetland is still immature. In other young wetland systems, nitrification is typically a limiting process because of inadequate DO (Choate et al., 1989). As indicated in table 1, DO in both influent and effluent is relatively high, averaging 6.2 in influent and 5.0 in effluent. Minimum effluent value was 2.8 mg/l, which is still higher than the range normally considered to be severely limiting [less than 2 mg/l (US EPA, 1975; Sharma and Ahlert, 1977; and Surampalli and Baumann, 1989)]. These data suggest that the wetland is functioning in an overall oxidized state. However, reducing conditions also occur within the wetland because of the relatively high loss of nitrate + nitrite (denitrification).

Nitrification is also enhanced by the low dissolved BOD in the effluent from the package treatment plant (see the next section). Nitrifiers are out-competed by heterotrophs at dissolved BODs greater than about 20 mg/l (Horan, 1990). Since this is not a limiting factor in this system, most of the oxygen is available for degradation of nitrogenous compounds.

Alkalinity and pH appear to have the potential to limit complete nitrification within the system. At times, influent alkalinity and pH are low (probably as a result of nitrification and production of organic acids within the extended aeration plant); however, both increase significantly as wastewater flows through the wetland (because of denitrification and destruction of organic acids).

In an effort to improve nitrification, two design modifications were used for this system. The modification reduced (1) hydraulic loading rate in the wetland inlet area (160 gpd/ft instead of 600 to 3,000 gpd/ft, leading to a corresponding reduction in the unit organic and nitrogen loading rate in the inlet area), and (2) gravel depth (1 ft instead of 2 ft, increasing contact of the wastewater with the oxygenated root zone particularly in immature wetland systems). Although these changes appear to have been very successful, additional data from this and other systems are needed for confirmation.

Also cyclic loading may be important in maintaining an overall oxidized state in gravel. Very little loading occurs when school is not in session (daily during evenings and weekends and seasonally during summer vacation).

Phosphorus--Total and dissolved phosphorus in the influent to the wetland averaged 6.2 and 4.6 mg/l, respectively. Effluent concentrations averaged 0.29 and 0.23 mg/l, respectively, resulting in removals of 95 percent for each form of phosphorus. Maximum effluent concentration was only 0.61 mg/l for both forms. Most phosphorus in both the influent and effluent is dissolved.

These removal efficiencies are very high for constructed wetland systems, unless they are designed specifically for phosphorus removal (Watson et al., 1989; Brix, 1987; and Boon, 1985). The primary removal mechanisms are normally considered to be complexation and co-precipitation/adsorption based on reactions with multivalent cations (iron, aluminum, calcium, etc.) associated with the substrate. The amount of these cations is typically limited in most systems and, consequently, the removal efficiencies are normally time limited. It is too early in the life of the Phillips High School system to determine whether it will continue to provide high removal of phosphorus.

Dissolved BOD--Dissolved BOD was normally low in both the wetlands influent and effluent. As expected, the most variability occurred in the influent with concentrations ranging from less than 1 to 14 mg/l, averaging 4.4 mg/l. Effluent concentrations were normally less than detectable (1 mg/l) and the maximum was only 1.5 mg/l. The average removal was at least 76 percent.

These data indicate that the extended aeration plant has converted essentially all the available food (carbonaceous material) to biomass and gaseous by-products. As indicated previously, the high TSS concentrations in the plant effluent (the wetlands influent) and the occasional high total BOD values suggest that sludge management is the primary operational problem with the facility.

Fecal Coliforms--Fecal coliforms varied widely in the wetland influent, ranging from 1,050,000 to less than 100 organisms per 100 ml, with geometric mean about 15,000. Effluent concentrations were always below detection limits (10 organisms per 100 ml) except for one sample which had 10 organisms per 100 ml. The average removal efficiency approached 100 percent, which is excellent performance for a system without a disinfection system. Filtration and natural dieoff are probably the two primary removal mechanisms.

Conductivity--Specific conductance decreases by an average of 53 percent as the wastewater flows through the wetland (from 610 to 288 µmhos/cm), indicating that about the same percentage of dissolved solids may be removed within the system. Losses occur in utilization of organic and nitrogenous materials, reduction of sulfates, and complexation of phosphates and chlorides.

Temperature, Dissolved Oxygen, and Total Alkalinity--These parameters are important in interpreting the data for other parameters, and, consequently, they are not discussed separately.

CONCLUSIONS

The constructed wetland at Phillips High School has been very effective in polishing the effluent from the extended aeration package treatment plant, even though the system is still immature. The effectiveness may be attributed primarily to maintenance of an overall oxidizing environment within the gravel substrate. Average monthly removals during the first year of operation exceeded 90 percent for BOD, TSS, organic nitrogen, total phosphorus, dissolved phosphorus, and fecal coliforms. Average removal percentages ranged in the 80s for ammonia and total nitrogen and in the 70s for nitrate + nitrite nitrogen and dissolved BOD. The prevalence of oxidizing conditions is probably the result of low carbonaceous demand, the low inlet hydraulic loading rate, and the combination of the shallow gravel depth and the excellent plant coverage and root depths during the first year of operation.

The only times that an NPDES permit limit was not met was during February and March when the effluent pH was 5.8 and 5.9, respectively. These values are slightly below the lower pH limit of 6.

The system is still immature, and documentation of the long-term performance is needed to enhance the credibility of this specific system and the technology in general. The performance is expected to remain good as long as the gravel substrate remains in an oxidized state. Maturation of the root zone over the next two to three years should help maintain and even improve the oxidation potential, but high solids concentrations discharged from the package plant may cause problems in at least the inlet area. Since these factors need to be further evaluated, no changes in operation of the package plant or the wetland are recommended during the 1989/90 school year.

The monitoring program should be expanded to include dye studies which would determine performance as the wastewater flows through the system, define reaction kinetics for nitrification, and evaluate flow hydraulics. Other key aspects that should be quantified include system flow (influent and effluent), plant stem and root biomass, root depth, and gravel permeability and porosity.

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TABLES

Table 1. V-Notch Weir Discharge Table

30° V-Notch Weir Discharges					60° V-Notch Weir Discharges				
Head feet	cfs	gps	gpm	mgd	Head feet	cfs	gps	gpm	mgd
0.01	0.0000	0.0001	0.0030	0.0000	0.01	0.0000	0.0001	0.0065	0.0000
0.02	0.0000	0.0003	0.0172	0.0000	0.02	0.0001	0.0006	0.0362	0.0001
0.03	0.0001	0.0008	0.0473	0.0001	0.03	0.0002	0.0017	0.0993	0.0001
0.04	0.0002	0.0016	0.0971	0.0001	0.04	0.0005	0.0034	0.2034	0.0003
0.05	0.0004	0.0028	0.1696	0.0002	0.05	0.0008	0.0059	0.3548	0.0005
0.06	0.0006	0.0045	0.2675	0.0004	0.06	0.0012	0.0093	0.5593	0.0008
0.07	0.0009	0.0066	0.3933	0.0006	0.07	0.0018	0.0137	0.8217	0.0012
0.08	0.0012	0.0092	0.5492	0.0008	0.08	0.0026	0.0191	1.147	0.0017
0.09	0.0016	0.0123	0.7372	0.0011	0.09	0.0034	0.0257	1.539	0.0022
0.10	0.0021	0.0160	0.9594	0.0014	0.10	0.0045	0.0334	2.002	0.0029
0.11	0.0027	0.0203	1.218	0.0018	0.11	0.0057	0.0423	2.540	0.0037
0.12	0.0034	0.0252	1.513	0.0022	0.12	0.0070	0.0526	3.157	0.0045
0.13	0.0041	0.0308	1.849	0.0027	0.13	0.0086	0.0643	3.856	0.0056
0.14	0.0050	0.0371	2.225	0.0032	0.14	0.0103	0.0773	4.640	0.0067
0.15	0.0059	0.0441	2.644	0.0038	0.15	0.0123	0.0919	5.513	0.0079
0.16	0.0069	0.0518	3.107	0.0045	0.16	0.0144	0.1080	6.477	0.0093
0.17	0.0081	0.0603	3.615	0.0052	0.17	0.0168	0.1256	7.537	0.0109
0.18	0.0093	0.0695	4.170	0.0060	0.18	0.0194	0.1449	8.694	0.0125
0.19	0.0106	0.0796	4.774	0.0069	0.19	0.0222	0.1659	9.951	0.0143
0.20	0.0121	0.0905	5.427	0.0078	0.20	0.0252	0.1886	11.31	0.0163
0.21	0.0137	0.1022	6.131	0.0088	0.21	0.0285	0.2130	12.78	0.0184
0.22	0.0153	0.1148	6.887	0.0099	0.22	0.0320	0.2393	14.35	0.0207
0.23	0.0172	0.1283	7.697	0.0111	0.23	0.0357	0.2674	16.04	0.0231
0.24	0.0191	0.1427	8.561	0.0123	0.24	0.0398	0.2974	17.84	0.0257
0.25	0.0211	0.1580	9.481	0.0137	0.25	0.0440	0.3293	19.76	0.0284
0.26	0.0233	0.1743	10.46	0.0151	0.26	0.0486	0.3632	21.79	0.0314
0.27	0.0256	0.1916	11.49	0.0165	0.27	0.0534	0.3991	23.95	0.0345
0.28	0.0280	0.2098	12.59	0.0181	0.28	0.0584	0.4371	26.22	0.0378
0.29	0.0306	0.2290	13.74	0.0198	0.29	0.0638	0.4772	28.63	0.0412

Table 1 (Continued)

30° V-Notch Weir Discharges					60° V-Notch Weir Discharges				
Head feet	cfs	gps	gpm	mgd	Head feet	cfs	gps	gpm	mgd
0.30	0.0333	0.2493	14.96	0.0215	0.30	0.0694	0.5194	31.16	0.0449
0.31	0.0362	0.2706	16.23	0.0234	0.31	0.0754	0.5637	33.82	0.0487
0.32	0.0392	0.2929	17.57	0.0253	0.32	0.0816	0.6103	36.61	0.0527
0.33	0.0423	0.3164	18.98	0.0273	0.33	0.0881	0.6591	39.54	0.0569
0.34	0.0456	0.3409	20.45	0.0294	0.34	0.0949	0.7101	42.60	0.0613
0.35	0.0490	0.3665	21.99	0.0317	0.35	0.1021	0.7635	45.80	0.0660
0.36	0.0526	0.3932	23.59	0.0340	0.36	0.1095	0.8192	49.14	0.0708
0.37	0.0563	0.4211	25.26	0.0364	0.37	0.1173	0.8772	52.63	0.0758
0.38	0.0602	0.4502	27.01	0.0389	0.38	0.1253	0.9377	56.25	0.0810
0.39	0.0642	0.4804	28.82	0.0415	0.39	0.1338	1.001	60.03	0.0864
0.40	0.0684	0.5117	30.70	0.0442	0.40	0.1425	1.066	63.95	0.0921
0.41	0.0728	0.5443	32.66	0.0470	0.41	0.1516	1.134	68.02	0.0980
0.42	0.0773	0.5781	34.68	0.0499	0.42	0.1610	1.204	72.24	0.1040
0.43	0.0820	0.6132	36.78	0.0530	0.43	0.1707	1.277	79.62	0.1103
0.44	0.0868	0.6494	38.96	0.0561	0.44	0.1808	1.353	81.15	0.1169
0.45	0.0918	0.6870	41.21	0.0593	0.45	0.1913	1.431	85.84	0.1236
0.46	0.0970	0.7258	43.54	0.0627	0.46	0.2021	1.512	90.69	0.1306
0.47	0.1024	0.7659	45.95	0.0662	0.47	0.2132	1.595	95.69	0.1378
0.48	0.1079	0.8073	48.43	0.0697	0.48	0.2247	1.681	100.9	0.1453
0.49	0.1136	0.8500	50.99	0.0734	0.49	0.2366	1.770	106.2	0.1529
0.50	0.1195	0.8940	53.63	0.0772	0.50	0.2489	1.862	111.7	0.1609

Note: 30° V-Notch Weir Discharges Formulas: cfs = $0.6760H^{2.5}$ gps = cfs x 7.481
gpm = cfs x 448.8; mgd = cfs x 0.6463

60° V-Notch Weir Discharges Formulas: cfs = $1.443H^{2.5}$ gps = cfs x 7.481
gpm = cfs x 448.8; mgd = cfs x 0.6463

Table 2. Phillips High School Constructed Wetlands Data, Bear Creek, Alabama

Date	Temperature (°C)		Conductivity (µmhos/cm)		Dissolved oxygen (mg/l)		pH (s.u.)		Total alkalinity (mg/l)		TSS (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
10/06/88			440	380			7.8	6.4	16	38	54	<1
10/11/88		15.0	407	228	5.0	8.1	6.4	7.0	6	40	42	<1
10/18/88	19.2	18.0	660	260	4.8	7.4	6.2	6.0	4	29	88	<1
10/26/88	16.2	12.2	790	372	5.3	5.8	5.6	7.7	1	56	46	<1
10/88 Avg	17.7	15.1	574	310	5.0	7.1	6.5	6.8	7	41	58	<1
11/01/88	15.8	12.2	743	399	3.9	5.9	5.7	6.7	7	19	42	2
12/06/88	11.2	6.0	740	340	3.8	4.5	6.2	7.1	5	22	40	<1
01/10/89	11.3	6.5	518	166	9.4	4.5	5.2	6.0	3	20	65	6
02/15/89	15.6	12.6	889	335	7.3	5.1	6.7	5.8	58	25	56	<1
03/07/89	10.0	7.4	333	160	7.2	4.1	6.8	5.9	31	19	82	1
04/12/89	13.1	10.9	756	279	7.0	5.7	5.1	6.1	12	26	86	<1
04/12/89	13.1	10.9	756	279	7.0	5.7	5.1	6.1	12	26	98	<1
04/89 Avg	13.1	10.9	756	279	7.0	5.7	5.1	6.1	12	26	92	<1
07/10/89	27.6	23.2	329	315	5.8	2.8	5.5	6.5	0.2	14	46	11
Avg (month)	15.3	11.7	610	288	6.2	5.0	6.0	6.4	15	23	60	<3
Change (%)[a]		23.2		52.8		19.7		-6.7		-51.1		95.0
Minimum	10.0	6.0	329	160	3.8	2.8	5.1	5.8	0.2	14	40	<1
Maximum	27.6	23.2	889	399	9.4	8.1	7.8	7.7	58	56	92	11

Table 2 (Continued)

Date	BOD (mg/l)		Dissolved BOD (mg/l)		Total nitrogen (mg/l)		Organic nitrogen (mg/l)		Ammonia nitrogen (mg/l)		Nitrate+nitrite-N (mg/l)	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
10/06/88	6	<1	3.6	<1.0	5.7	1.7	1.1	0.26	2.3	0.02	2.3	1.4
10/11/88	3	<1	<1.0	1.5	16	2.6	2.4	0.36	1.8	0.08	12	2.2
10/18/88	29	<1	1.4	<1.0	42	2.6	10.2	0.23	1.9	0.05	30	2.3
10/26/88	1.1	<1	1.0	<1.0	55	5.1	3.2	0.42	15	0.04	37	4.6
10/88 Avg	9.8	<1	1.8	<1.1	30	3	4.2	0.32	5.3	0.05	20	2.6
11/01/88	28	<1	14	<1.0	65	14	15	0.25	20	0.23	30	14
12/06/88	18	1	2.8	<1.0	80	7.2	18	0.34	13	1.4	49	5.5
01/10/89	1	<1	<1.0	<1.0	65	9.5	13	0.06	18.5	2.2	33	7.2
02/15/89	30	<1	7.2	<1.0	56	16	28	1.1	2.0	3.6	26	11
03/07/89	9.5	<1	3.5	<1.0	24	7.1	5.4	0.4	9.1	2.6	9.7	4.1
04/12/89	7	1.0	3.4	1.2	60	12	9.5	0.8	16	3.3	34	7.5
04/12/89	8	1.2	4.0	1.3	59	12	9.5	0.8	16	3.3	33	7.5
04/89 Avg	7	1.1	3.7	1.3	59	12	9.5	0.8	16	3.3	34	7.5
07/10/89	1	<1	<1.0	<1.0	7.8	2.8	4.2	1.4	1.3	1.3	2.3	0.06
Avg (month)	13	<1	<4.4	<1.1	48	9.0	12	0.58	10.7	1.8	26	6.5
Change (%)[a]		92.2		75.9		81.5		95.2		82.8		74.6
Minimum	1	<1	<1	<1.0	5.7	1.7	1.1	0.06	1.3	0.02	2.3	0.06
Maximum	30	1.1	14	1.5	80	16	28	1.4	20	3.6	49	14

Table 2 (Continued)

Date	Total phosphorus (mg/l)		Dissolved phosphorus (mg/l)		Fecal coliforms (No./100 ml)		Flow (gpd)
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Effluent
10/06/88	3.9	0.11	3.9	0.07	22,000	<10	3,800
10/11/88	4.9	0.07	3.9	0.05	2,800	<10	100
10/18/88	6.6	0.04	0.01	0.02	3,200	<10	0
10/26/88	3.7	0.05	3.3	0.01	900	<10	0
10/88 Avg	4.8	0.07	2.8	0.04	3,600[b]	<10[b]	975
11/01/88	6.8	0.04	5.2	0.02	93,000	<10	100
12/06/88	6.7	0.11	5.6	0.05	50,000	<10	2,700
01/10/89	7.0	0.20	6.2	0.12	900	<10	7,800
02/15/89	5.6	0.49	3.5	0.41	1,050,000	<10	1,500
03/07/89	3.4	0.55	1.4	0.52	120,000	<10	9,900
04/12/89	9.0	0.60	7.5	0.60	16,000	10	2,200
04/12/89	8.0	0.62	6.8	0.61	17,000	10	2,200
04/89 Avg	8.5	0.61	7.2	0.61	16,500[b]	10[b]	2,200
07/10/89	6.4	0.25	4.9	0.09	<100	<10	0
Average (month)	6.2	0.29	4.6	0.23	15,381[b]	<10[b]	3,147
Change (%)[a]		95.3		94.9		99.9	
Minimum	3.4	0.04	0.01	0.01	<100	<10	0
Maximum	9	0.61	7.2	0.61	1,050,000	10	9,900

a. Change between influent and effluent based on unrounded monthly average values
b. Geometric mean

FIGURES

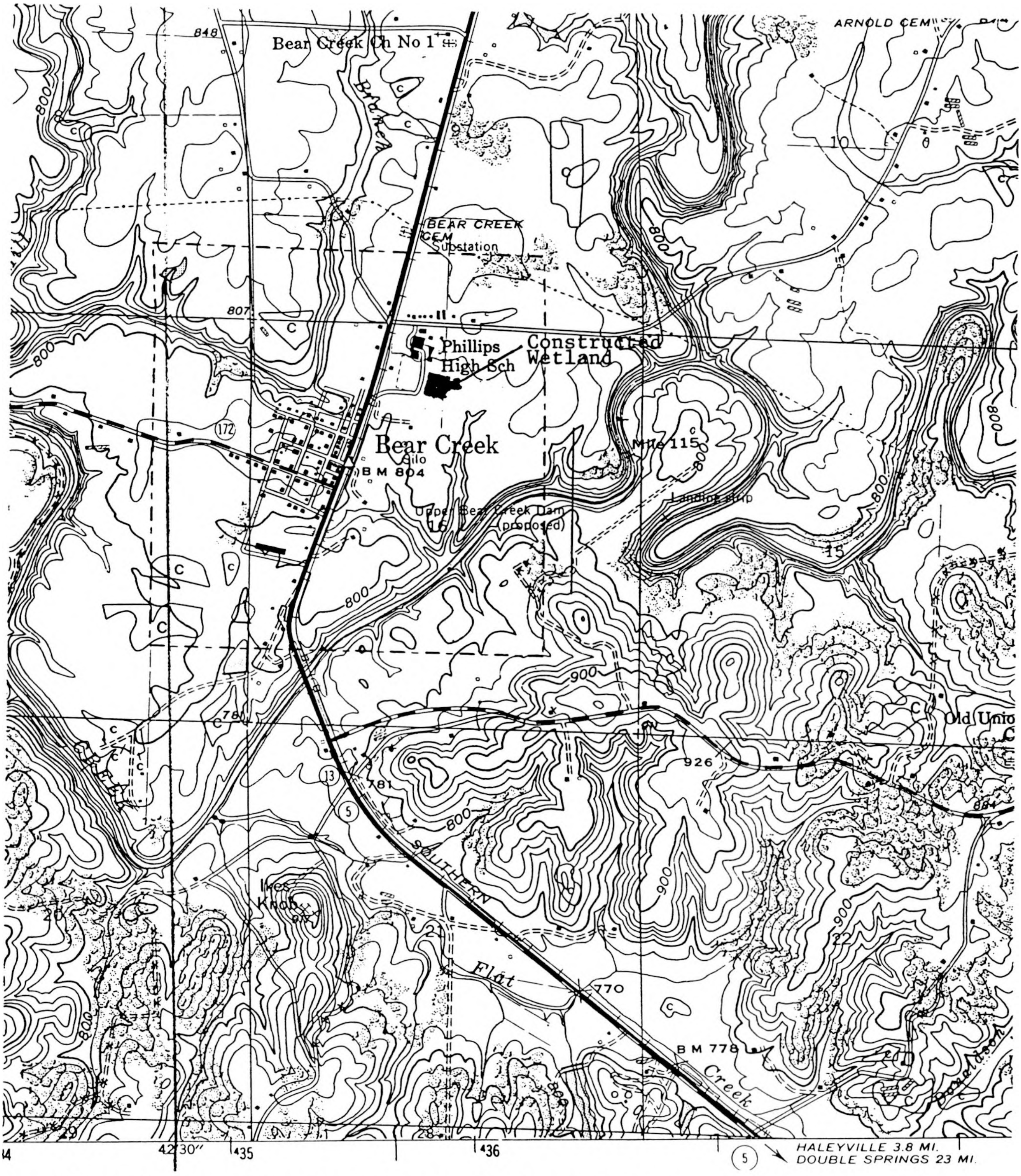


Figure 1. Location of the Constructed Wetland Wastewater Treatment System at Phillips High School, Bear Creek, Alabama

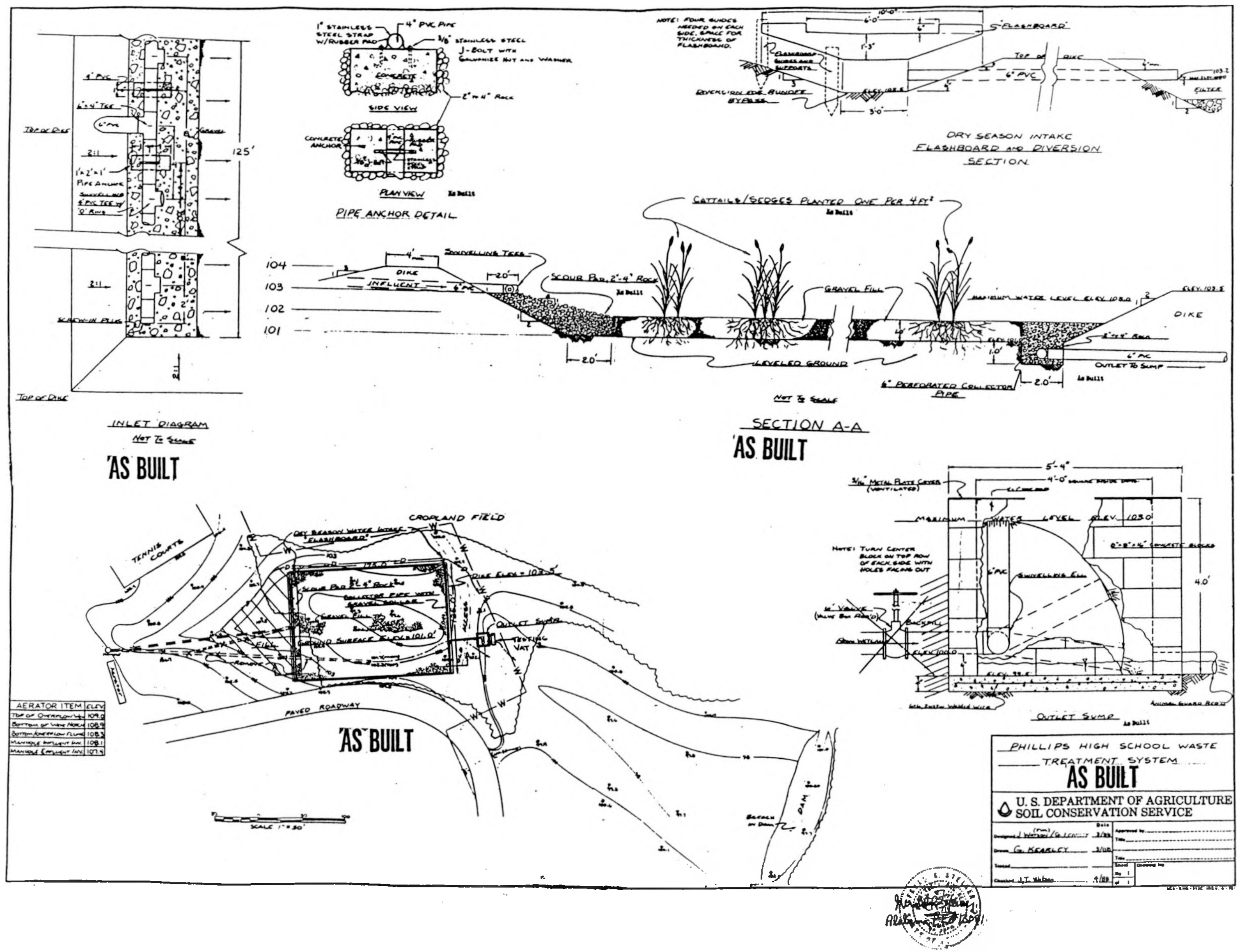


Figure 2. Design of the Constructed Wetland Wastewater Treatment System at Phillips High School, Bear Creek, Alabama

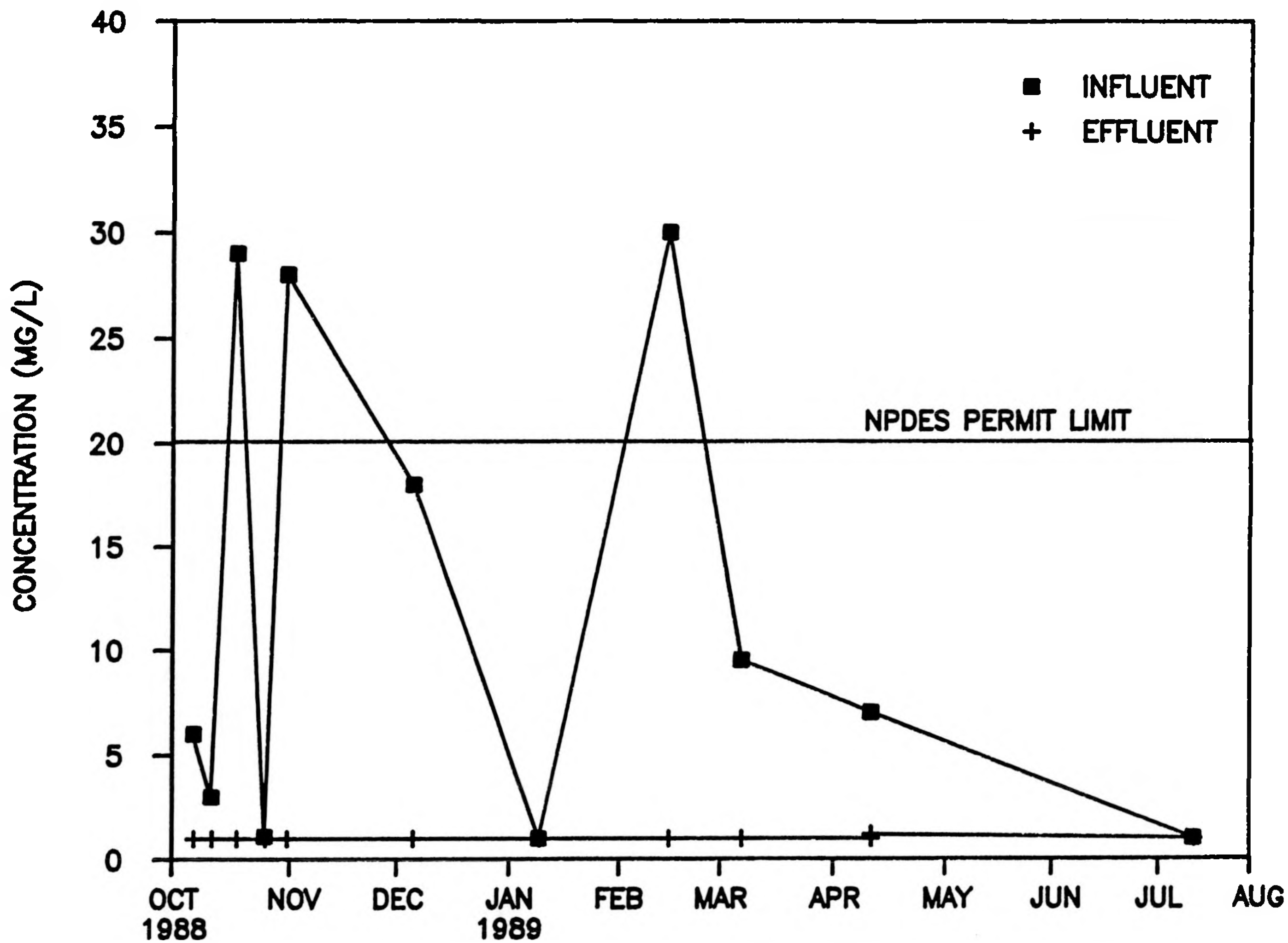


Figure 3. Biochemical Oxygen Demand (BOD), Phillips High School, Bear Creek, Alabama

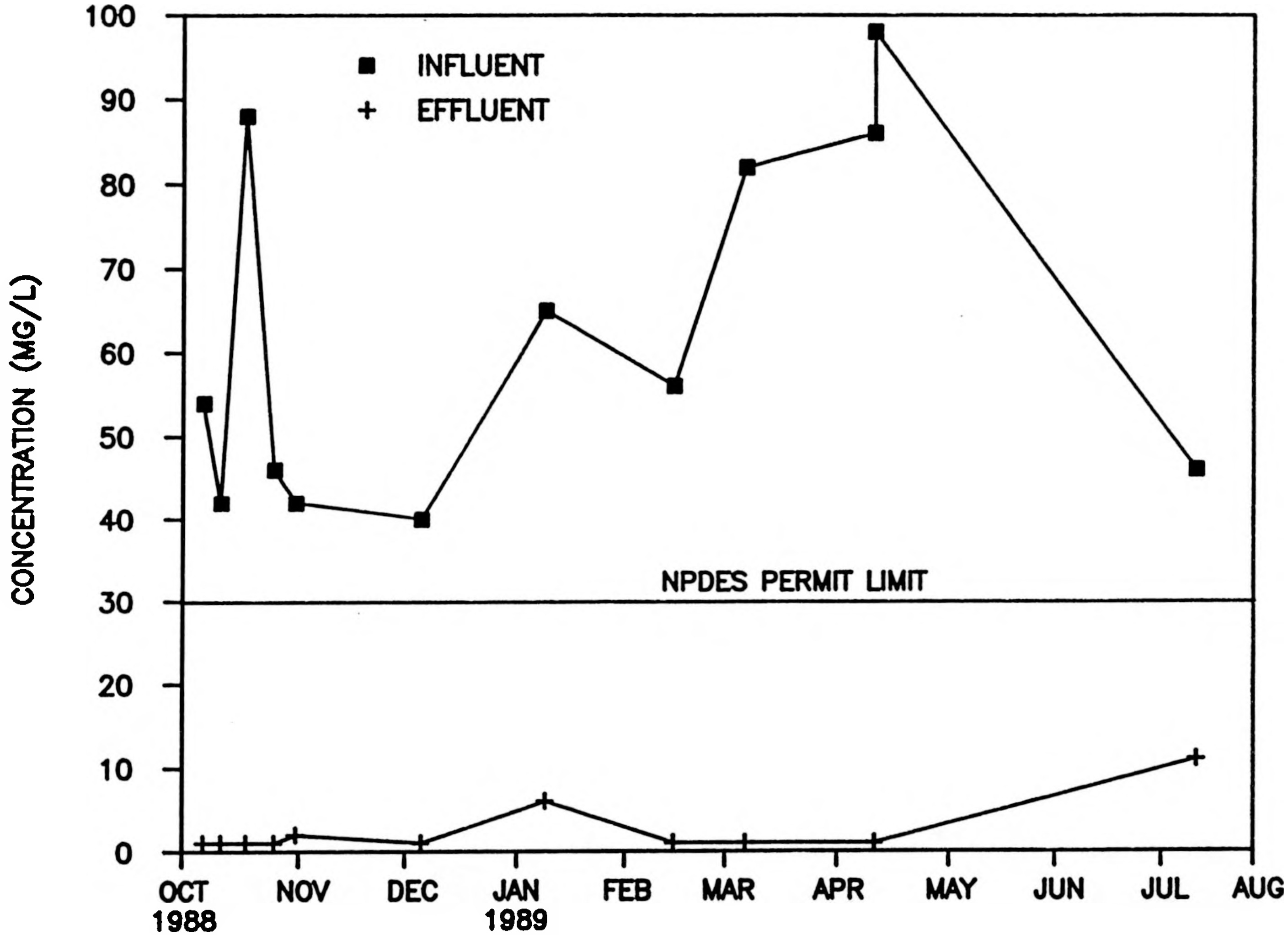


Figure 4. Total Suspended Solids (TSS), Phillips High School, Bear Creek, Alabama

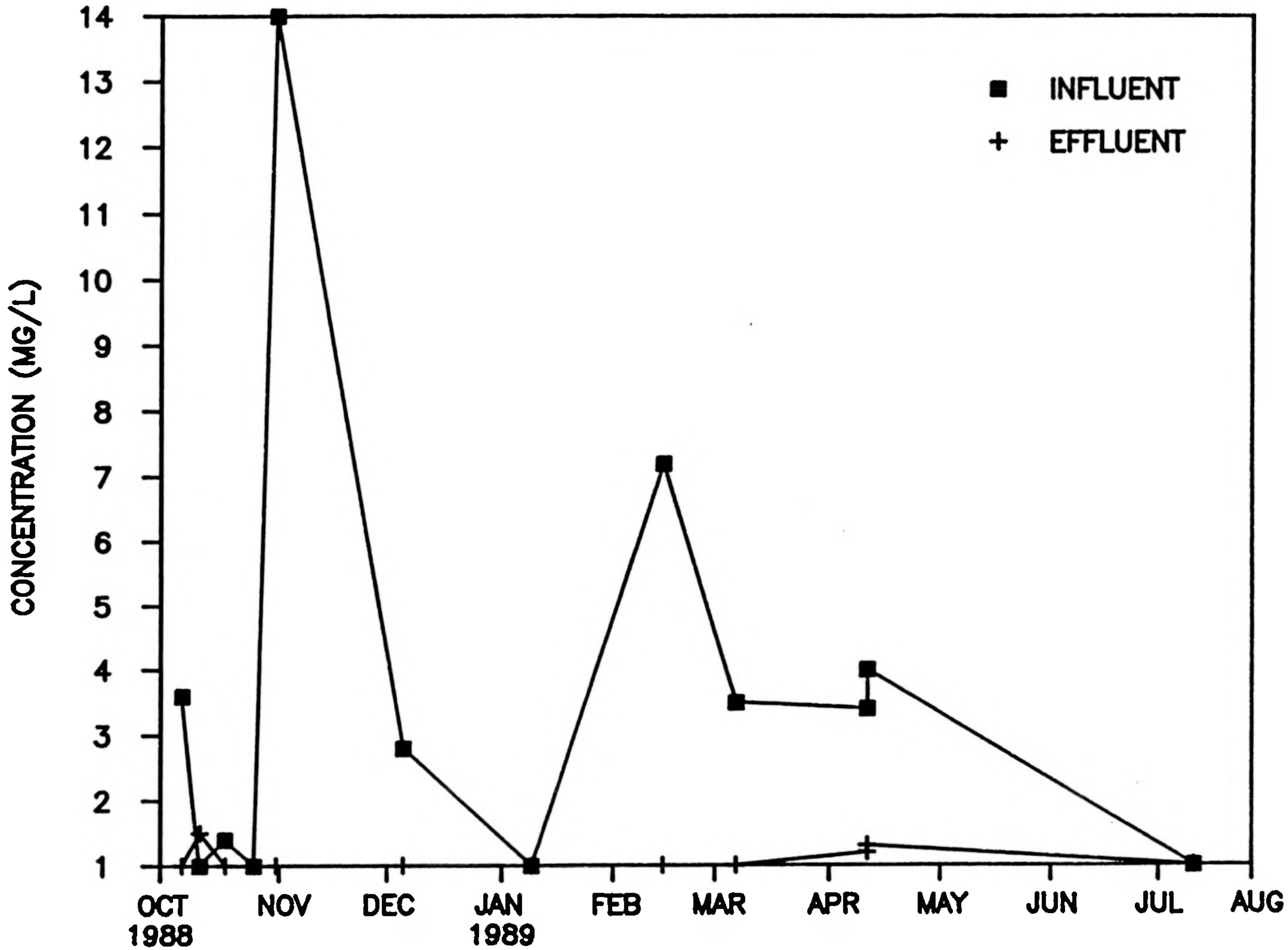


Figure 5. Dissolved BOD, Phillips High School, Bear Creek, Alabama

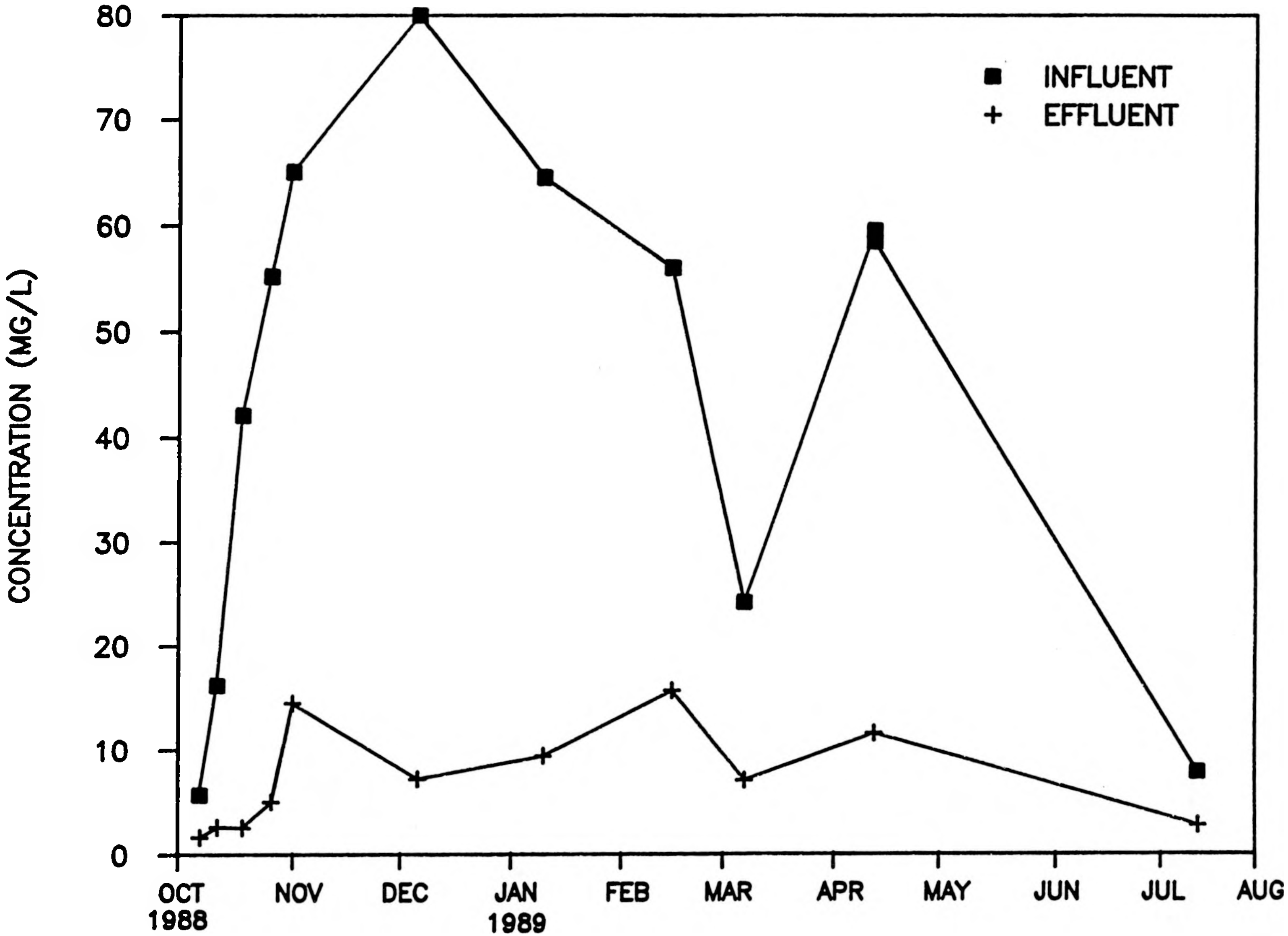


Figure 6. Total Nitrogen, Phillips High School, Bear Creek, Alabama

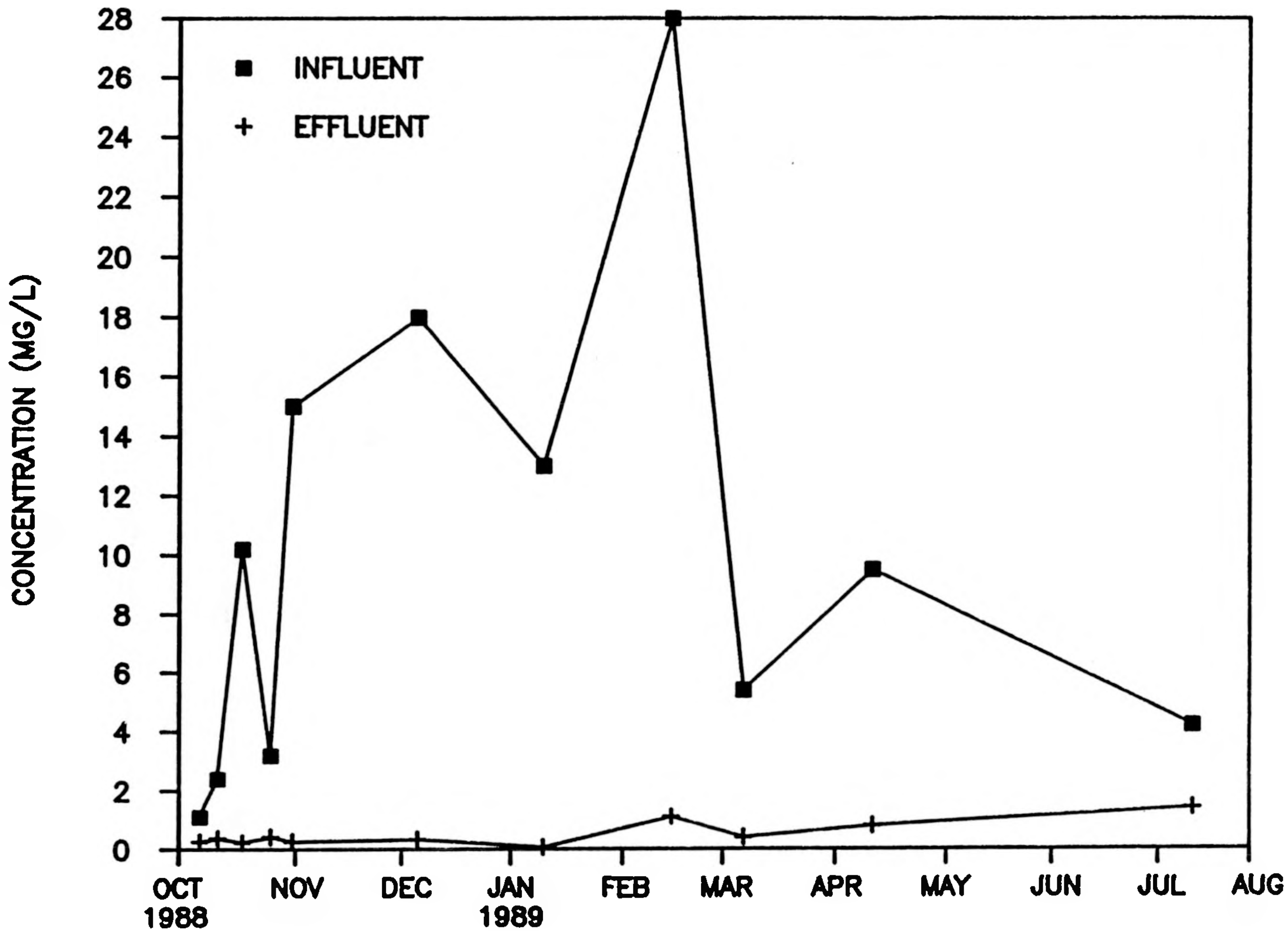


Figure 7. Organic Nitrogen, Phillips High School, Bear Creek, Alabama

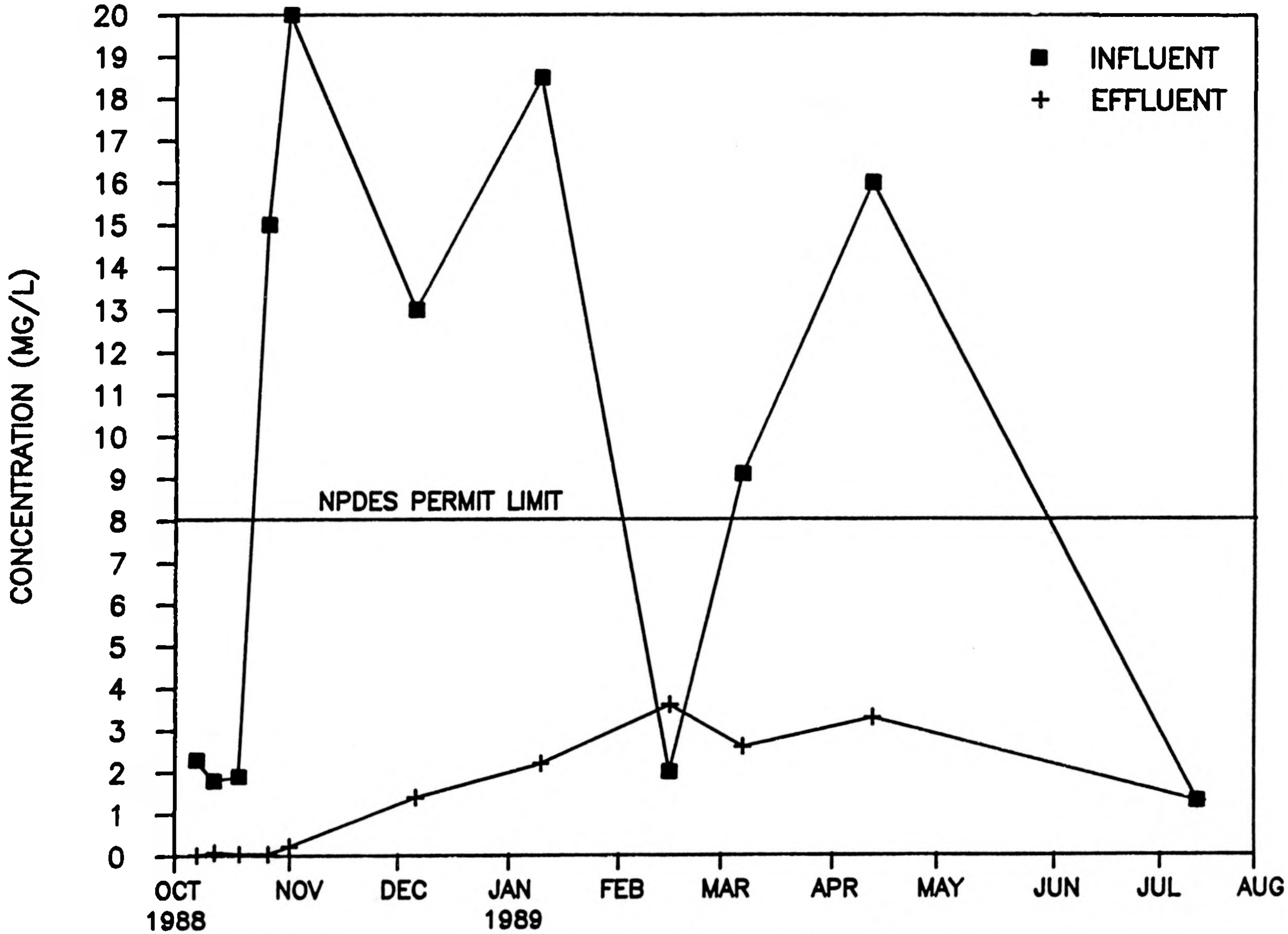


Figure 8. Ammonia Nitrogen, Phillips High School, Bear Creek, Alabama

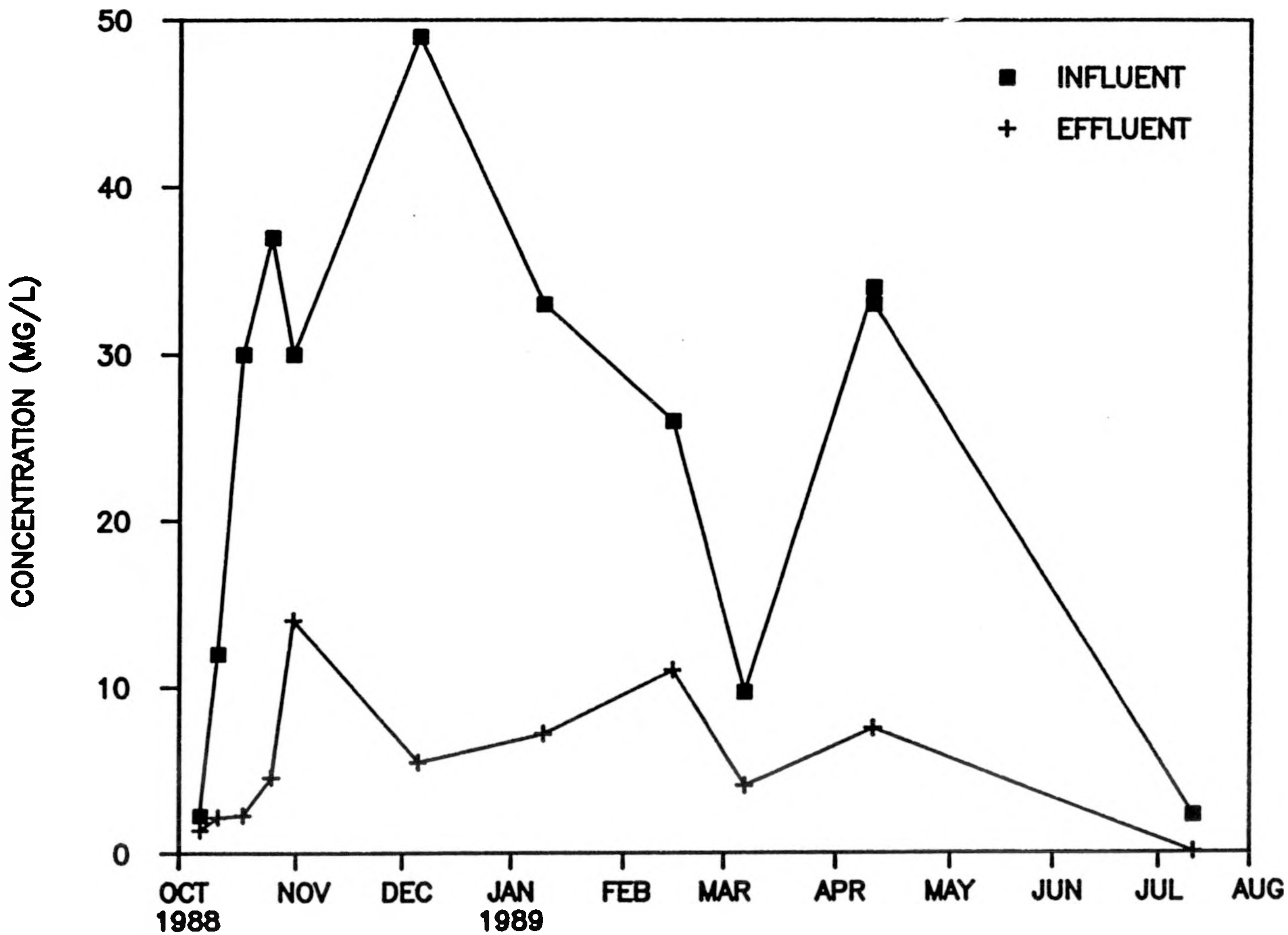


Figure 9. Nitrate+Nitrite Nitrogen, Phillips High School, Bear Creek, Alabama

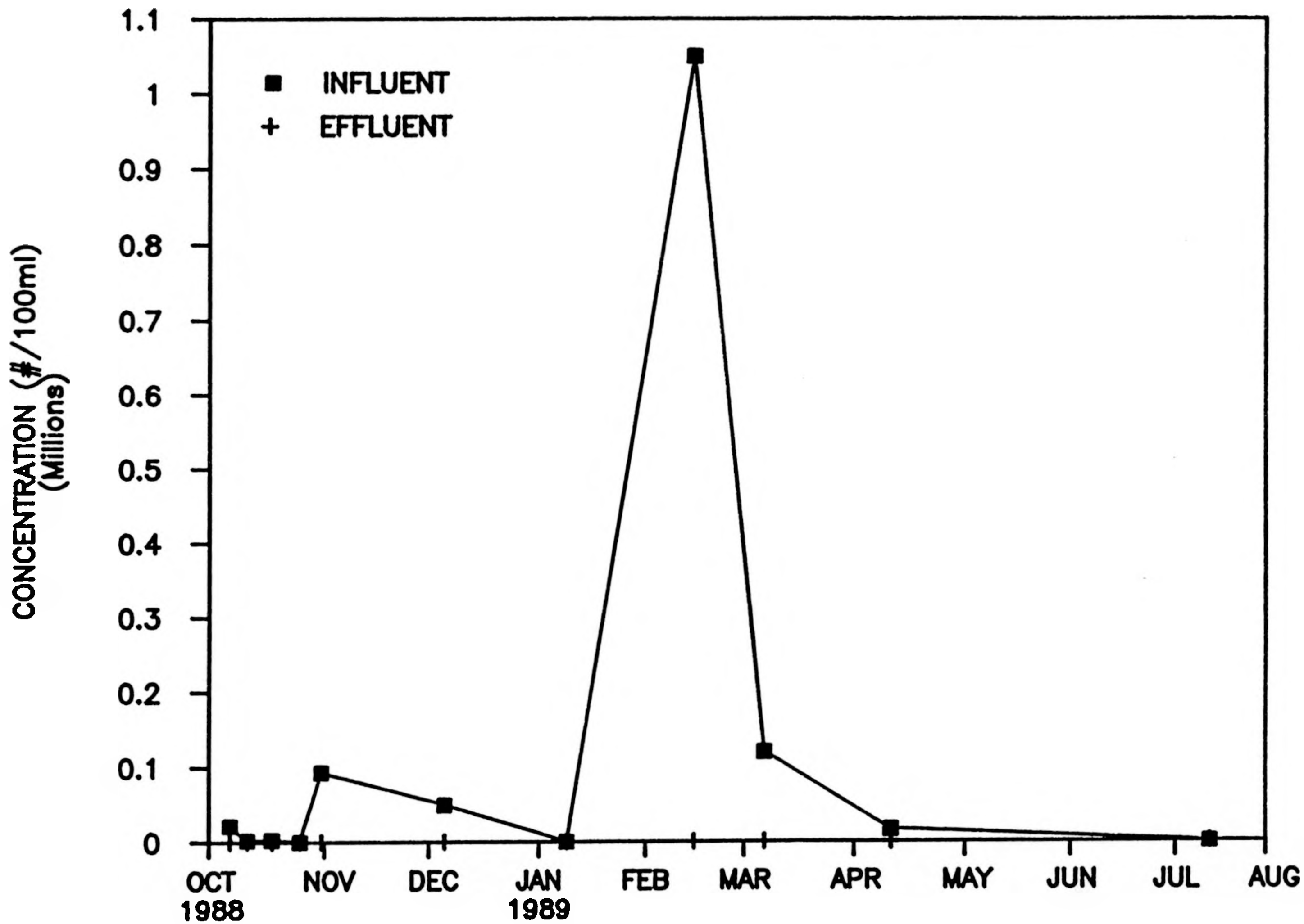


Figure 10. Fecal Coliforms, Phillips High School, Bear Creek, Alabama

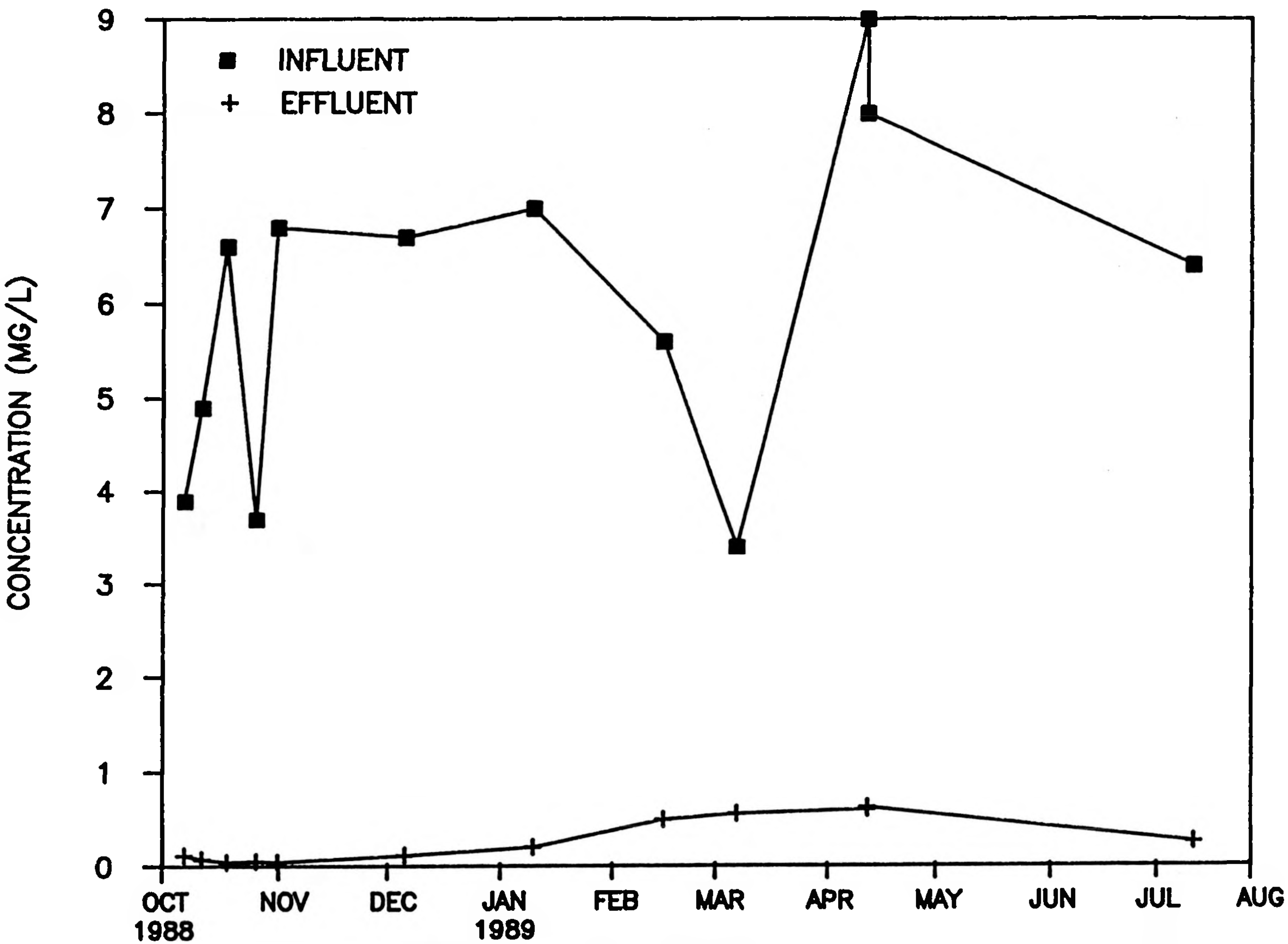


Figure 11. Total Phosphorus, Phillips High School, Bear Creek, Alabama

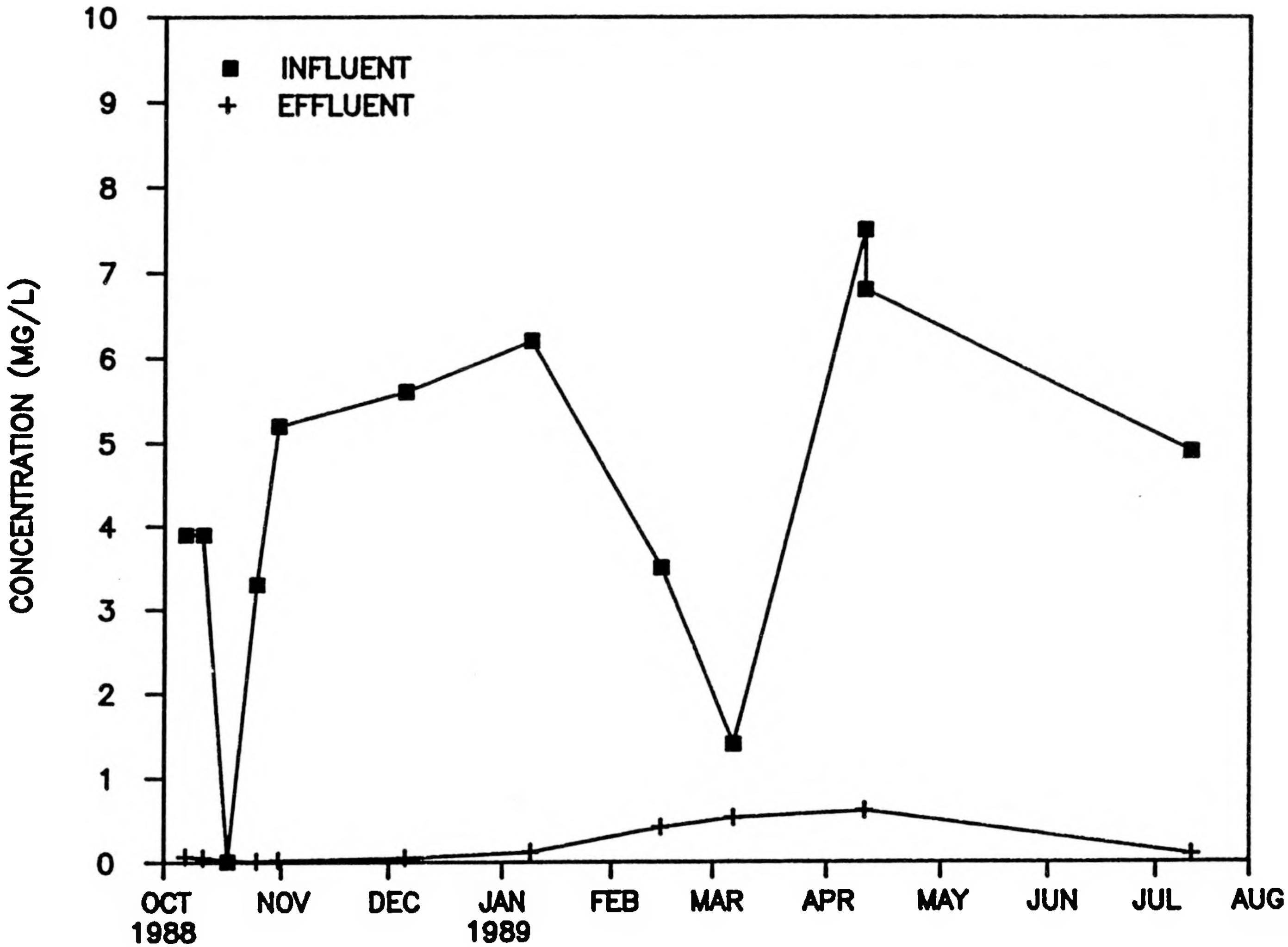


Figure 12. Dissolved Phosphorus, Phillips High School, Bear Creek, Alabama

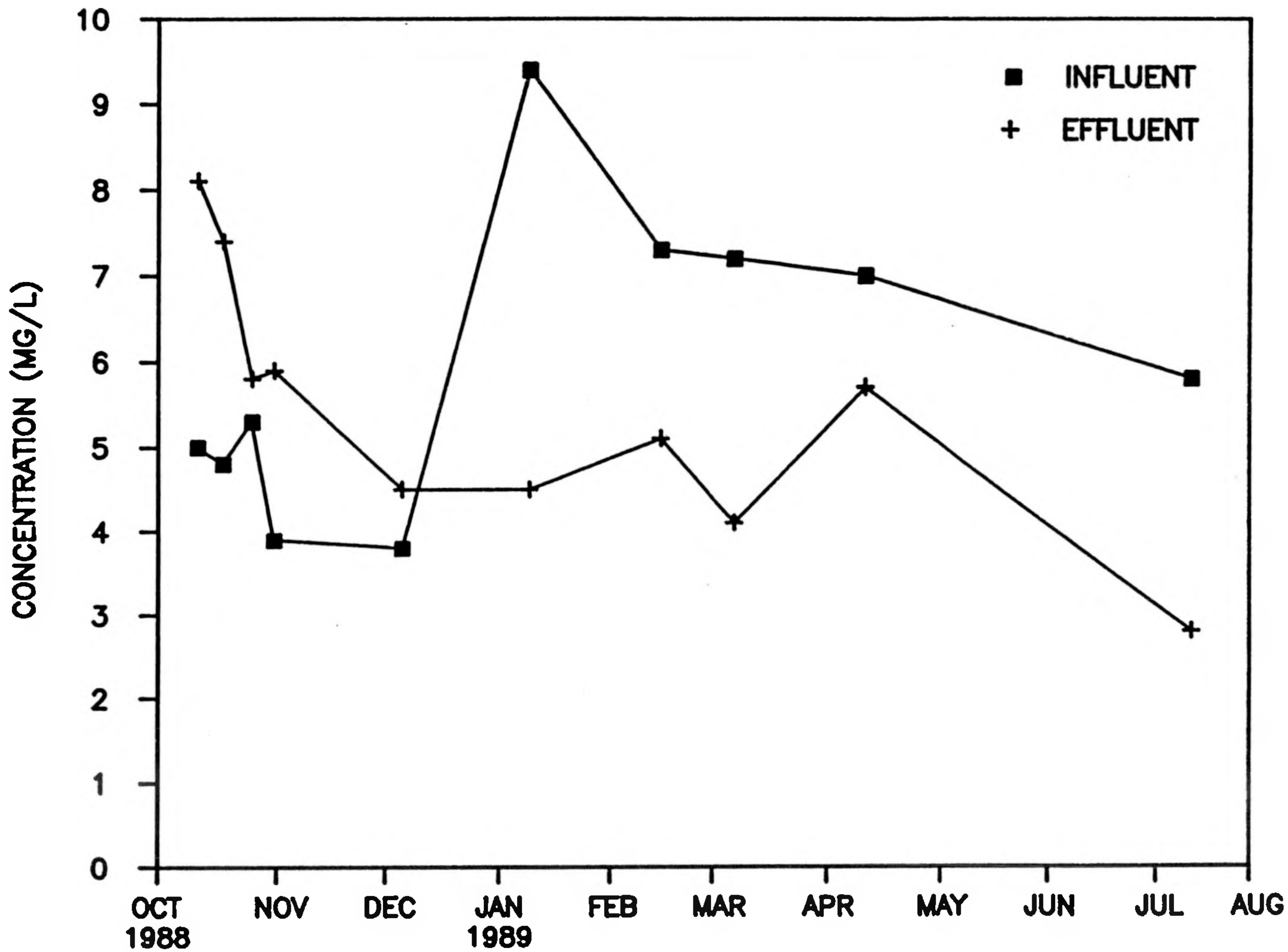


Figure 13. Dissolved Oxygen (DO), Phillips High School, Bear Creek, Alabama

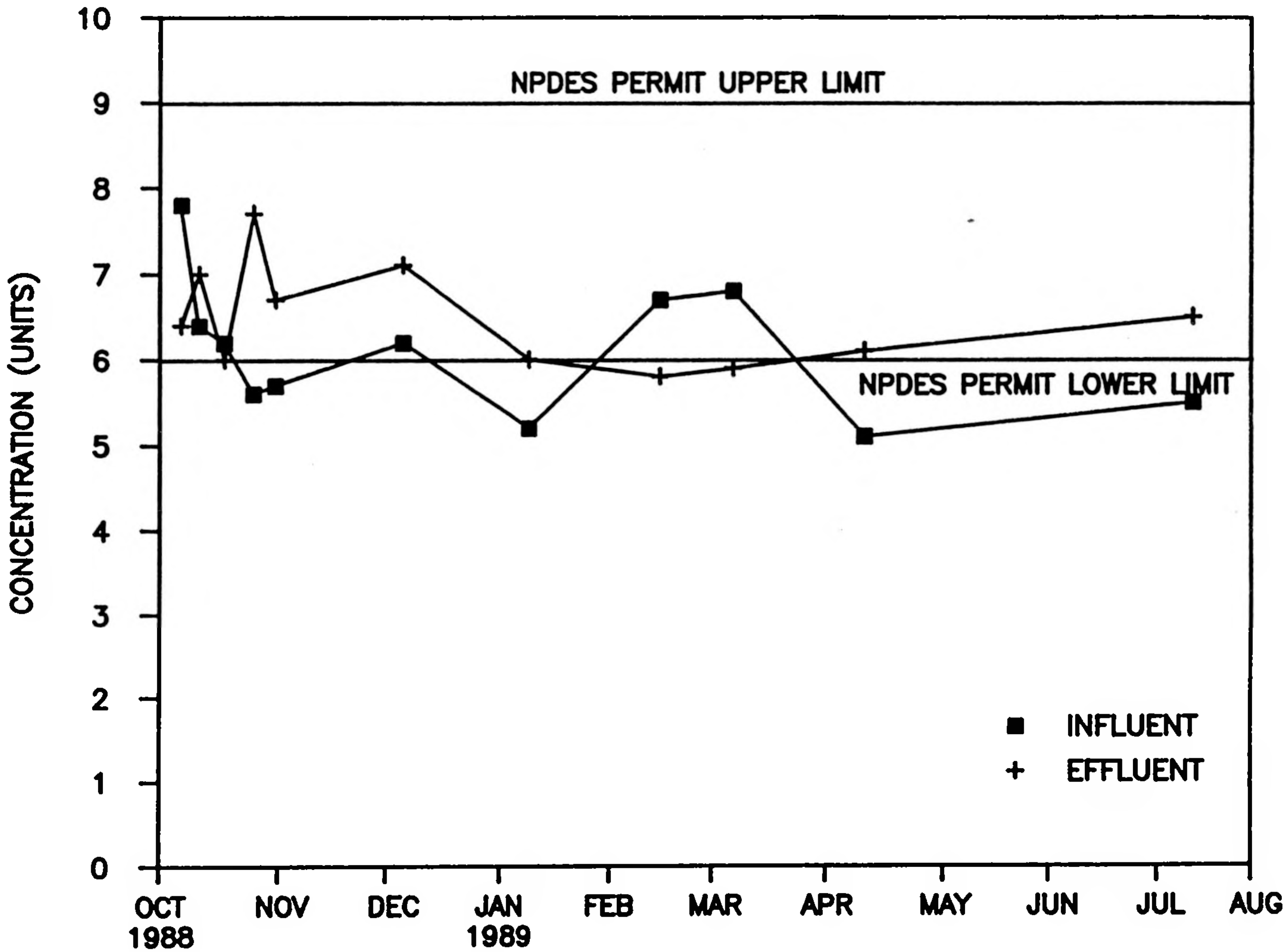


Figure 14. pH, Phillips High School, Bear Creek, Alabama

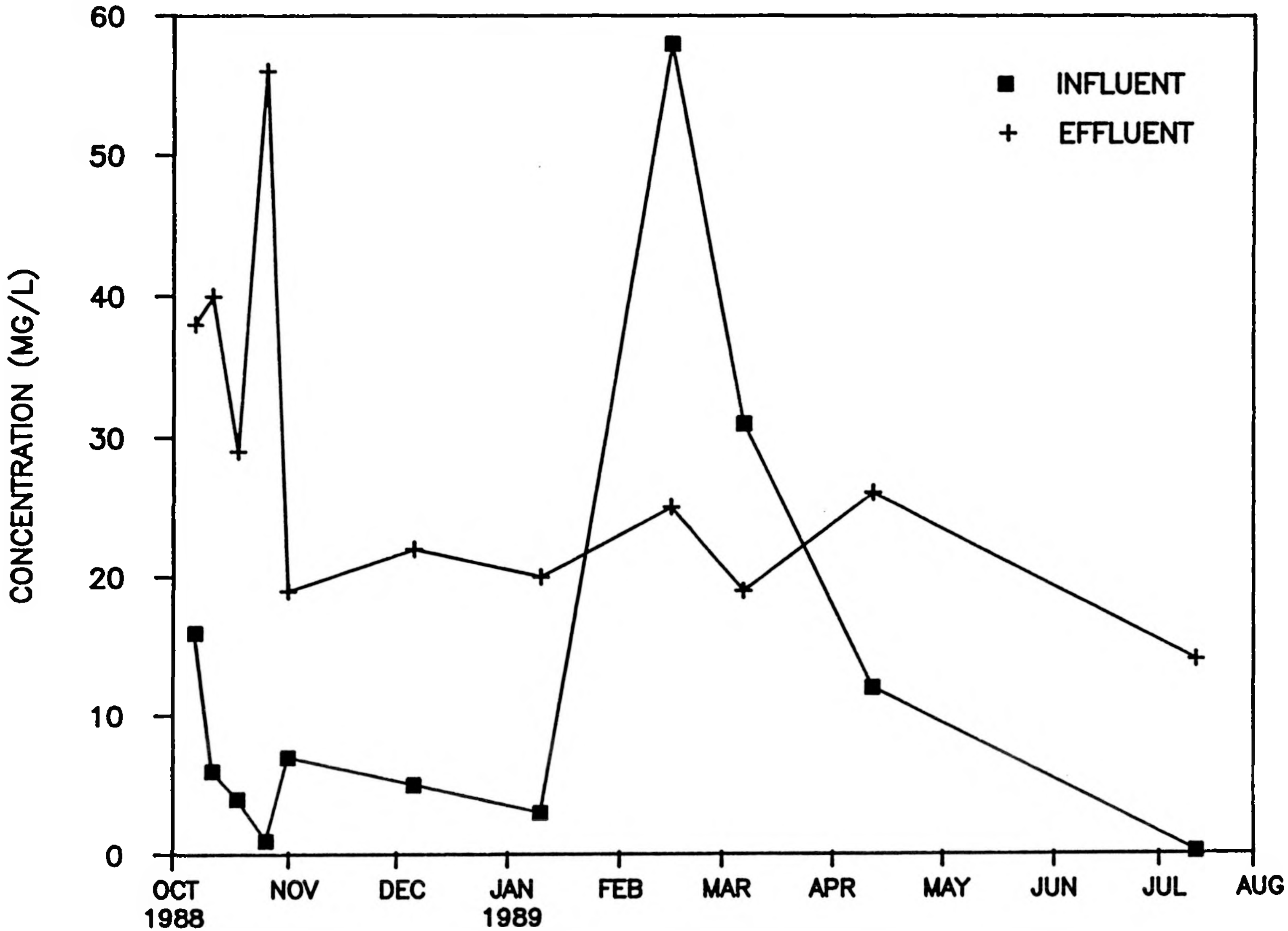


Figure 15. Total Alkalinity, Phillips High School, Bear Creek, Alabama

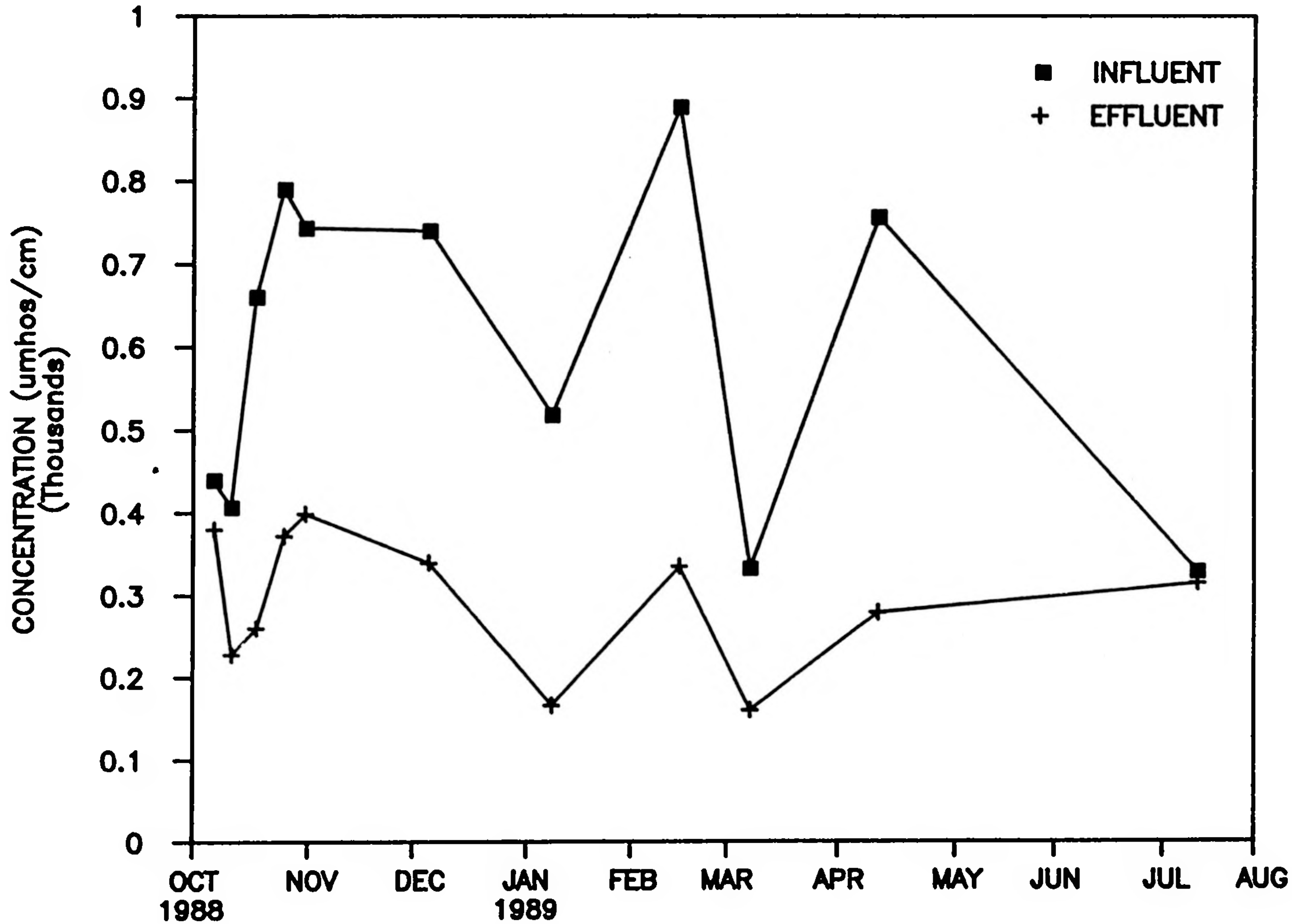


Figure 16. Conductivity, Phillips High School, Bear Creek, Alabama

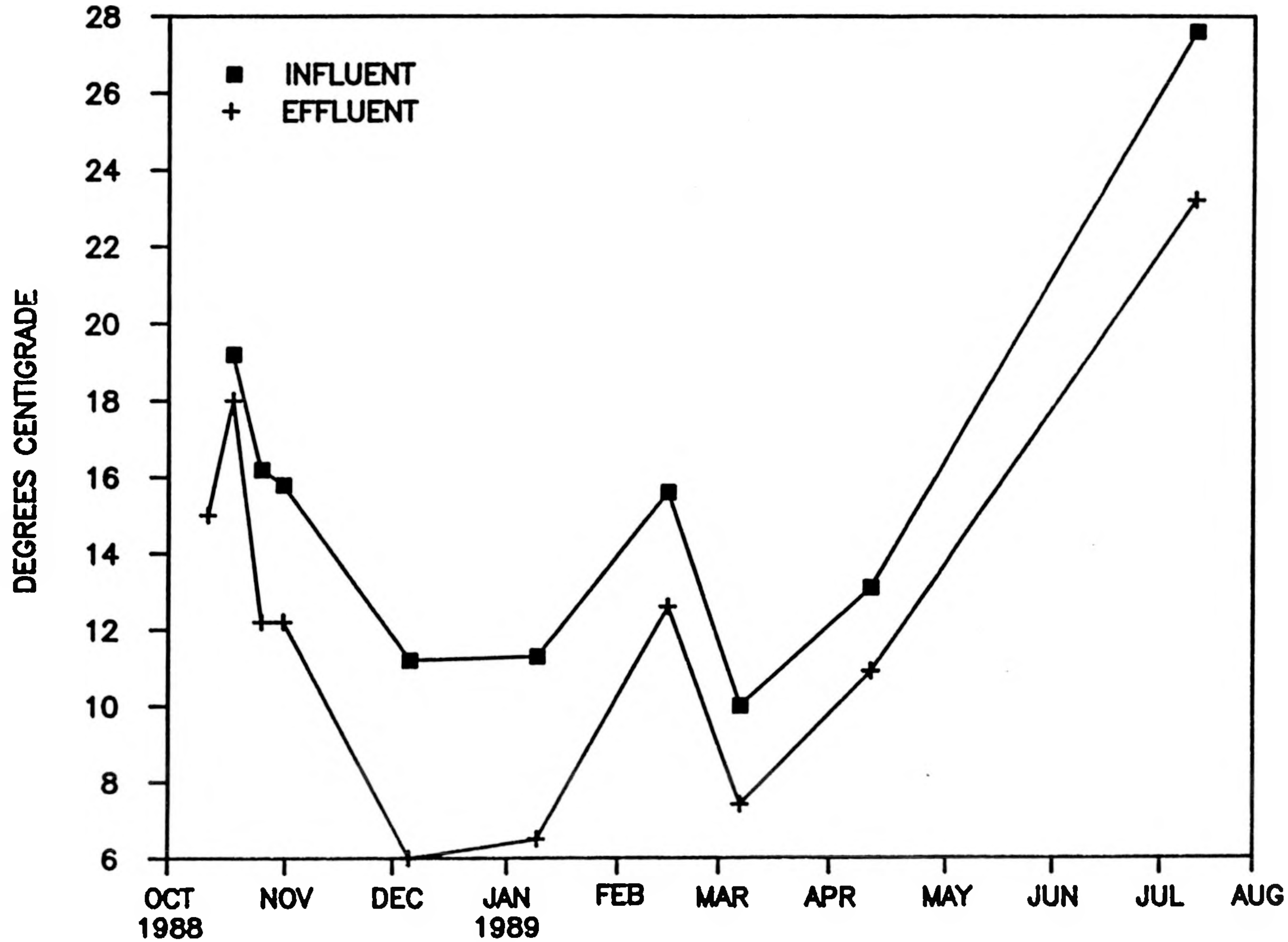


Figure 17. Temperature, Phillips High School, Bear Creek, Alabama

APPENDIXES

APPENDIX A

CONSTRUCTION CONTRACT FOR THE
CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM
AT PHILLIPS HIGH SCHOOL, BEAR CREEK, ALABAMA

MODIFICATION

PHILLIPS HIGH SCHOOL, BEAR CREEK, ALABAMA
WASTE TREATMENT SYSTEM WETLAND

To: Kenneth Jackson Construction Company
Contractor

88-016
XXXXXXXX No.
Bid

P. O. Box 301, Hamilton, AL 35570
Address

You are hereby requested to comply with the following:

Item No.	Change	Increase in Contract Cost	Deacrease in Contract Cost
6	Add concrete footed tie-downs for adjusting the flow regulating tees.	$ 450.00	
7	Add 155 cubic yards due to length and width increases. Price is $14.00/cu. yd.	$2,170.00	
10	Delete 900 L.F. of 11½ gauge chainlink fencing at $4.90 per L.F.		$4,410.00
10A	Add 800 L.F. of 9 gauge chainlink fencing with concrete footed posts and change the gate at sump from 36" to 72". Price is $11.10/L.F. of fencing installed, including gates.	$8,880.00	
13	Add item for diversion and dry season intake construction, concrete test vat pad and storm damage cleanup. Lump sum.	$2,550.00	
	Add 20 calendar days to the contract due to added work and clean-up due to unusually heavy rain storm.		
	TOTAL	$14,050.00	$4,410.00

Net (Increase)(XXXXXXXX) in Contract Cost $9,640.00
The Completion date of the contract is (XXXXXXXXXXXX)(extended)XXXXXXXXX by 20 calendar days.
Revised completion date: August 26 19 88
Original Contract Price $ 26,626.00 Revised Contract Price $36,266.00

THIS MODIFICATION IS HEREBY MADE A PART OF THE CONTRACT.

Roberta D. Goggans 8/23/88 Kenneth Jackson 8-23-

Contracting Officer Date Contractor Date

BID SCHEDULE
FOR
PHILLIPS HIGH SCHOOL
WASTE TREATMENT SYSTEM
WETLAND
MARION COUNTY, ALABAMA

ITEM NO.	WORK OR MATERIAL	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Clearing, Grubbing, and Draining	1 Job	L.S.	$	$ 650.00
2	Land Shaping, Grading and Earthwork	1 Job	L.S.	$	$ 1400.00
3	Loose Rock Fill	56.0	CYD.	$ 16.00	$ 896.00
4	PVC Pipe, 6" Diameter	300	L.F.	$ 4.75	$ 1425.00
5	Outlet Sump	1 Job	L.S.	$	$ 750.00
6	PVC Pipe, Inlet	1 Job	L.S.	$	$ 475.00
7	Loose Gravel Fill	805	CYD.	$ 14.00	$ 11,270.00
8	Vegetation, Seeding and Mulching	0.5	ACRE	$ 600.00	$ 300.00
9	Vegetation, Cattail/Sedge Transplanting	1 Job	L.S.	$	$ 4200.00
10	Fencing, Chain Link	900	L.F.	$ 4.90	$ 4410.00
11	Plastic Perf. Pipe, 6" Dia.	125	L.F.	$ 1.60	$ 200.00
12	Testing/Sampling Vat	1 Job	L.S.	$	$ 650.00

921-3357

TOTAL $ 26626.00

SUBMITTED BY: Kenny Jackson
Jackson Const Co

BID SCHEDULE
FOR
PHILLIPS HIGH SCHOOL
WASTE TREATMENT SYSTEM
WETLAND
MARION COUNTY, ALABAMA

ITEM NO.	WORK OR MATERIAL	QUANTITY	UNIT	UNIT PRICE	AMOUNT
1	Clearing, Grubbing, and Draining	1 Job	L.S.	$ XXXXX	$ 600.00
2	Land Shaping, Grading and Earthwork	1 Job	L.S.	$ XXXXX	$ 1,500.00
3	Loose Rock Fill	56.0	CYD.	$ 17.00	$ 952.00
4	PVC Pipe, 6" Diameter	300	L.F.	$ 4.70	$ 1,410.00
5	Outlet Sump	1 Job	L.S.	$ XXXXX	$ 600.00
6	PVC Pipe, Inlet	1 Job	L.S.	$ XXXXX	$ 400.00
7	Loose Gravel Fill	805	CYD.	$ 14.00	$ 11,270.00
8	Vegetation, Seeding and Mulching	0.5	ACRE	$ 200.00	$ 100.00
9	Vegetation, Cattail/Sedge Transplanting	1 Job	L.S.	$ XXXXX	$ 2,000.00
10	Fencing, Chain Link	900	L.F.	$ 4.50	$ 4,050.00
11	Plastic Perf. Pipe, 6" Dia.	125	L.F.	$ 1.40	$ 175.00
12	Testing/Sampling Vat	1 Job	L.S.	$ XXXXX	$ 525.00

TOTAL $ 23,570.00

SUBMITTED BY: Engineer's Estimate*******

Item #1, Clearing, Grubbing, and Draining

1) This item shall consist of draining the surface water from the work site to accomodate construction, and, clearing and grubbing the wooded areas within the work site.

2) Disposal of cleared materials shall be by burning and burying burned material at areas designated by engineer.

3) Burned material shall be covered by a minimum depth of two (2) feet of soil.

4) Tires, heavy oils, and asphalt products are not to be used to burn cleared material.

5) Boundaries of the work site and clearing limits will be marked by SCS.

6) Payment for this work will be made on a lump sum basis.

Item #2, Land Shaping, Grading and Earthwork

1) This item shall consist of lightly shaping and grading the wetland area to the lines and grades shown on the construction drawings, and, constructing the containment dikes of the wetland as shown on the drawings.

2) Grading will generally involve smoothing and leveling the ground surface to grade(± 0.1 foot) by cut and fill operations.

3) Some areas to be shaped may require the use of a backhoe or other machinery in addition to bulldozers or motor graders.

4) Removal of the existing drain pipe shall be subsidiary to this item.

5) The 1 foot by 2 foot rock filled trench at the outlet end shall be paid for under item #3, Loose Rock Fill.

6) Payment for this work will be made on a lump sum basis.

Item #3, Loose Rock Fill

1) This item shall consist of furnishing and placing loose rock fill, D_{50} 2" to 4", as shown on the construction drawings. Maximum rock size shall not exceed 6".

2) Excavation of the 1 foot by 2 foot trench at the outlet end shall be subsidiary to this item.

3) Payment will be made on quantities calculated to the nearest 0.5 cubic yard.

Item #4, PVC Pipe, 6" dia.

1) This item shall consist of furnishing and installing the 6" diameter PVC pipes, including all fittings, for the outlet section of the wetland and outlet sump, and the 6" diameter influent pipe and dry season intake pipe.

2) This item does not include the 6" control valve nor the sump box.

3) Payment for this work will be made on quantities measured to the nearest linear feet of pipe installed.

Item #5, Outlet Sump

1) This item shall consist of furnishing and constructing or installing the outlet sump as shown in the construction drawings. A manufactured reinforced concrete box (ie., septic tank, etc.) may be used in lieu of a concrete block structure, provided it meets TVA design engineer approval and is adequately ventilated.

2) The 6" control valve and valve box are subsidiary to this item.

3) Payment for this work will be made on a lump sum basis.

Item #6, PVC Pipe, Inlet

1) This item shall consist of furnishing and installing the 6" x 4" reducing tee, 4" diameter pipes, 4" swivelling 'O' ring tees, and all fittings as shown on the construction drawings. Sixteen (16) 4" tees are required.

2) The ends of the 4" pipe will be closed by screw-in plugs or caps.

3) Payment for this work will be made on a lump sum basis.

Item #7, Loose Gravel Fill

1) This item shall consist of furnishing and installing No. 6 gravel in the wetland as shown on the construction drawings.
2) Gravel depth shall be one (1) foot (± 0.1 foot). The surface of the gravel shall be level and smooth and shall be placed to the elevation shown on the construction drawings.
3) Payment will be made on quantities calculated to the nearest cubic yard.

Item #8, Vegetation, Seeding and Mulching

1) This item shall consist of preparation and treatment with fertilizer, seed, lime, and mulch on the areas disturbed by excavation, shaping, and other construction operations which lie outside the containment dikes of the wetland. This area shall include the containment dikes.
2) Land preparation on the excavated surfaces will include disking to a depth of 6 inches. Lime will be applied prior to disking. The fertilizer will be applied after disking and then incorporated with additional light disking. Seed will be applied after the seebed has been smoothly prepared.
3) Fertilizer shall be designated as 8-24-24 analysis and shall be spread at a rate of 800 pounds per acre. Lime shall be applied at 2 tons per acre.
4) Seeding mixtures, rates, and seeding dates shall be:

MIXTURE	APPLICATION RATE/ACRE	SEEDING DATES
Tall Fescue	15 lbs.	Aug 15 to Nov 1
or		
Bermudagrass (common, hulled)	5 lb.	Apr 15 to June 15

5) Smoothness of the area to be seeded shall be suitable for maintenance with a lawn mower.
6) Seed shall be covered with material ¼ inch deep by cultipacking.
7) Mulch material shall be wheat, oats, barley, or rye straw and shall be evenly spread at a rate of 1½ tons per acre.
8) Payment will be made on quantities measured to the nearest .25 acre.

Item #9, Vegetation, Cattail/Sedge Transplanting

1) This item shall include the excavating, transporting, and planting of live cattail and/or sedge plants. Wild growing cattail/sedge plants will be retrieved from areas found within a 60 mile radius of the work site. TVA and SCS will assist in locating useable plants.

2) Approximately 5,500 plants will be planted in parallel rows running across the 125' width of the wetland. The plants in each row will be spaced 2 feet apart. Each row will be spaced 2 feet apart. Each plant of each successive row will be centered with the gaps of the preceeding row.

3) The root stock of the excavated plants shall be kept moist to prevent them from drying out.

4) The wetland structure shall be complete and mechanically functional before transplanting the cattails/sedges. Also, the water level in the wetland structure will be brought up to the gravel bed surface before transplanting the cattails/sedges. It is anticipated that fresh water will be needed to initially charge the system and furnish water to the transplanted plants.

5) Payment for this work will be made on a lump sum basis.

Item #10, Fencing, Chain Link

1) This item shall consist of furnishing and installing approximately 900 feet of chain-link fencing around the wetland waste treatment facility. The fence will be eight (8) feet high.

2) Two gates will be required. One will be installed at the inlet end of the system, and the other near the sump box outlet. TVA and/or SCS personell will specify gate locations.

3) Payment for this work will be made on quantities measured to the nearest linear foot of fence installed. This includes all gates.

Item #11, Plastic Perforated Pipe, 6" dia.

1) This item shall consist of furnishing and installing the 6" diameter perforated collector pipe, including all fittings, for the outlet section of the wetland.

2) The pipe will be centered in the 1 foot by 2 foot collection trench with a minimum 3" thick bed of rock under the pipe as shwon on the construction drawings. The collector pipe will be laid on a level grade throughout its length and the ends capped with duct tape to privent intrusion of the rock fill.

3) Payment for this work will be made on quantities measured to the nearest linear foot of pipe installed.

Item #12, Testing and Sampling Vat

1) This item shall consist of furnishing, constructing, and installing the designed testing and sampling vat as shown on the construction drawings.

2) The vat may be a standard burial vault or any vat made of sturdy non-corrosive material having the approximate dimensions shown on the construction drawings. The bolt holes, 6 inch pipe entrance, and open end may be pre-cast during manufacture or drilled and cut to the required dimensions. The vat proposed to be used must meet TVA approval prior to installation.

3) Two (2) weir plates are to be furnished; One with a 30 degree (30°) "V" notch and one with a 45 degree (45°) "V" notch. The notches are to be centered on the top side of the weir plates and shall be exactly 0.5 feet deep. The bolt holes in the weir plates are to properly aligned with the holes in the vat so as to insure that the top of the weir plate is level and at the proper elevation in the vat after installation. The 30° notched weir plate shall be installed during construction and the 45° notched weir plate will be furnished to the Marion County Board of Education. The dimensions of the weir plates shall be such that they will not bind against the sides or bottom of the vat during installation and will give a minimum of ½ inch of contact width on both sides of the bolt holes. The notches in the weirs shall be chamfered as shown on the construction drawings. A water-tight gasket is to be furnished and placed between the weir plate and vat upon installation.

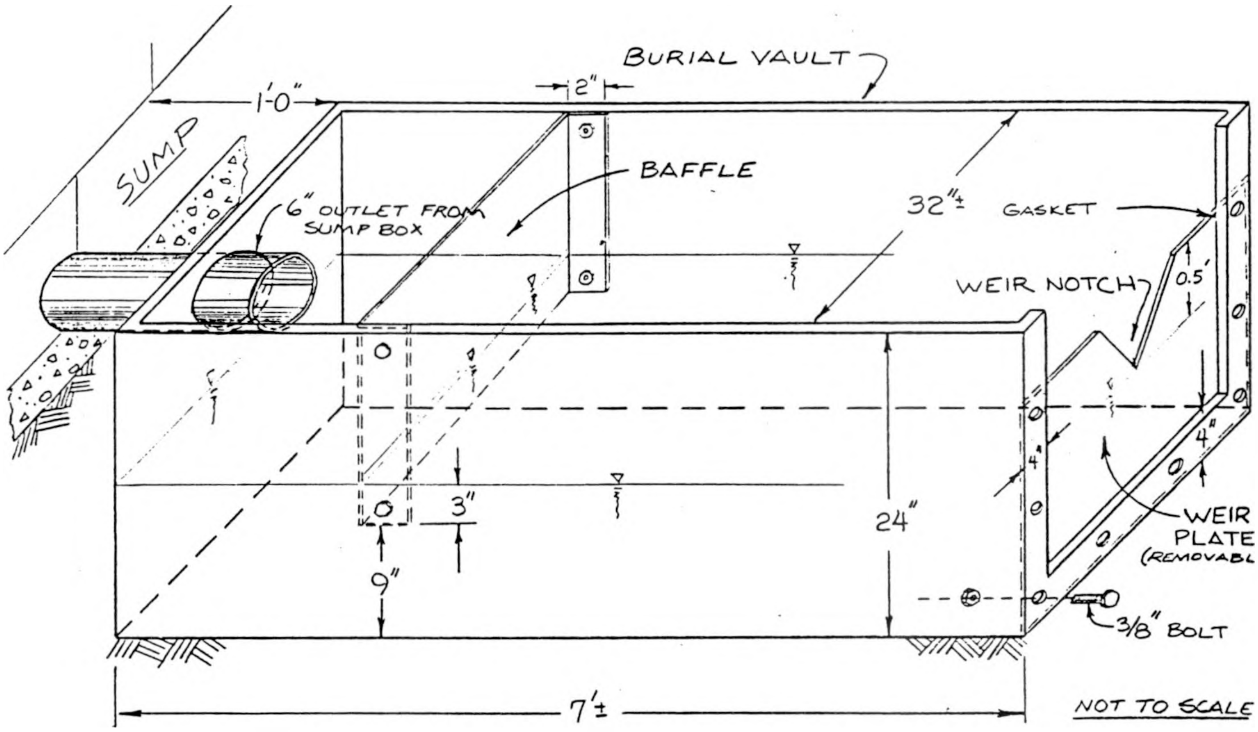
4) A baffle is to be installed 18 inches from the entrance end of the vat and constructed as shown on the construction drawings. Rubber washers shall be placed between the bottom bolt heads and outside wall of vat to prevent leaking.

5) The weir plates, baffle and a cover lid shall be constructed of aluminum, stainless steel, or some other non-corrosive metal. The lid shall be hinged in center.

6) After placement of the vat, the 6" pipe at the entrance will be grouted with a cement grout or other approved sealant on the outside and inside of the vat.

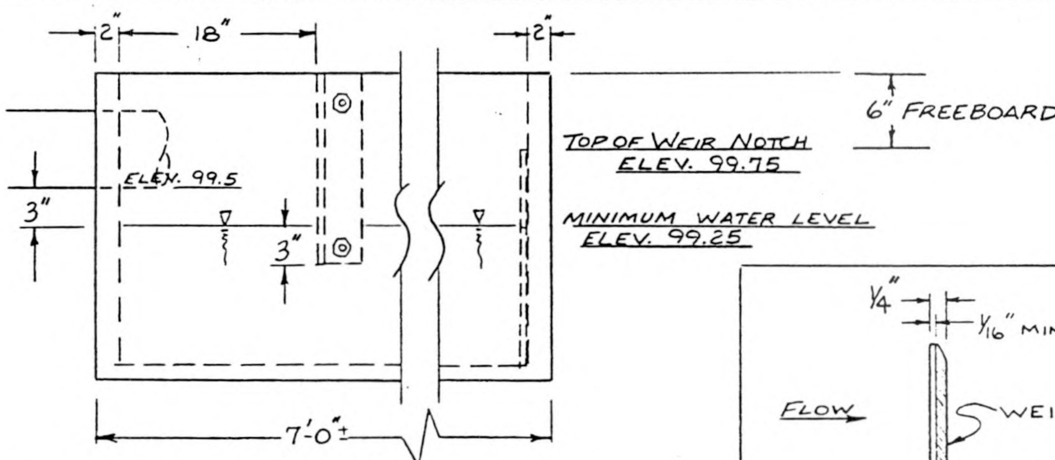
7) The foundation of the vat shall be firm and level with a 1" to 2" bedding of gravel immediately under the vat. The foundation and adjacent area shall be graded so as to allow surface water to readily run off.

8) A one foot staff gauge incremented in hundredths of a foot shall be furnished and mounted to the side of the vat or baffle. The gauge shall be zeroed level with the bottom of the "V" notch and mounted no closer than two (2) feet of the weir. The gauge shall be, or extend, at least 6 inches downstream of the baffle. The gaugé shall allow the lid to close without hitting the gauge.

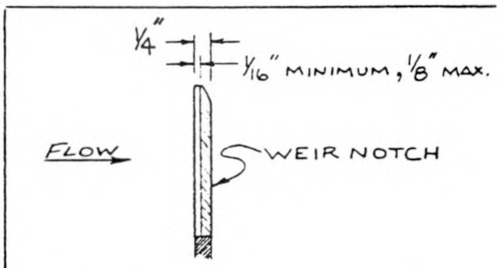


NOTE: A STAFF GAUGE IS TO BE MOUNTED INSIDE THE VAULT

ISOTROPIC VIEW



SCALE 1"=1' SIDE VIEW



CHAMFER DETAIL OF WEIR NOTCH

NOTE : THE TEST VAT WILL BE COVERED WITH A METAL LID HINGED IN THE CENTER OF ITS LENGTH.

PHILIPS HIGH SCHOOL WASTE TREATMENT SYSTEM

G. KEARLEY 3/88 | USDA-SCS

APPENDIX B

OPERATION AND MAINTENANCE PROCEDURES FOR THE CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM AT PHILLIPS HIGH SCHOOL, BEAR CREEK, ALABAMA

OPERATION AND MAINTENANCE PROCEDURES FOR THE CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM AT PHILLIPS HIGH SCHOOL, BEAR CREEK, ALABAMA

INITIAL ADJUSTMENTS

1. Adjust each tee on the inlet distributor pipe to obtain about equal flow from each one. This is a trial and error procedure accomplished by inserting a lever into each tee and gently rotating the tee to the proper elevation. The lever should be a short (3 to 6 ft) section of 4 inch PVC pipe. Remove the gasket from the tee to ease insertion and removal of the lever. The initial overflow elevations will be set so that the distributor pipe will be about half full of water. Care must be used in rotating the tees to assure that they are not cracked or broken.
2. Adjust the water level standpipe in the outlet sump to an elevation where the water in the wetlands will be about 1 inch above the gravel surface for the first month or two of plant growth. This should minimize any stress to the new plants from solar heating of the gravel. As new plant growth progresses, lower the water depth to the routine operational depth of about 1 to 3 inches below the gravel at the outlet. The water level should never be above the top of the newly transplanted vegetation or below its roots.
3. Remove the logs from the stormwater diversion weirs so that stormwater runoff will not enter the wetlands. The logs should be inserted in the weirs only at the end of the school year or when special operations are needed as directed by one of the contacts listed below.

ROUTINE WEEKDAY OPERATIONS

1. Operate and maintain the package plant to produce the best possible effluent quality. Suspended solids released from the package plant will be the greatest potential problem, particularly during the first couple of years when the vegetation is maturing. High quantities of solids will plug the gravel, smother the young plants, and quickly result is anaerobic conditions throughout the gravel substrate.
2. Check and maintain the inlet distributor tees so that flows out of each are approximately equal. Assuming the tees have been set at a proper elevation, unequal flow should be a result of solids settling in the distributor pipe or paper or other materials snagged within the tee. Check to see if this is the case. If the pipe contains obvious quantities of settled solids, remove the cleanout cap from both ends of the distributor pipe and flush the solids from the pipe. Use a water hose, bucket of water, or other means of cleaning any stubborn sections. Remove paper, rags, or other materials that are caught within the distributor system. About once a month brush the inside of the tees to remove algal growth.
3. Check the water level at the front, middle, and end of the wetland. The objective of water level control is to maintain subsurface flow throughout the cell with the water level a few inches (1 to 3 inches) below the top of the gravel. If surface flow is occurring in the inlet area of the bed, gradually lower the water level by rotating (down) the standpipe in the water level control structure. This must be done gradually over a period of weeks to avoid unnecessary stress

on the plants in the lower end of the cell. The roots of the plants will tend to follow the declining water level if given adequate time. Slight wilting and browning of the top of the plants during this procedure is acceptable, but severe stress must be avoided. If severe wilting occurs, the water level must be quickly raised to revive the plants. If severe clogging occurs, it may not be possible to obtain complete subsurface flow within the cell for typical flows; however, the amount of surface flow should be minimized by using the above procedure. Inform one of the TVA contacts listed below any time adjustments are made in the water level during the first three years of operation.

4. Check the water level control standpipe in the sump box to see if water is leaking from the joints or if the elbow has crept down the pipe. Slippage of the joint can be corrected by carefully tapping the joint back in place. Place a board against the elbow and hit the board with a sledge hammer.
5. Check the vegetation around the periphery of the cell and along a middle transect for signs of disease (yellowing/browning, spots, wilting, etc.), infestation of insects, or stress. Call one of the contacts listed below if anything unusual is detected.
6. Collect effluent samples and record flow at the frequency specified in the NPDES permit. Send a copy of reports to James T. Watson, TVA, HB 2S 270C-C, 311 Broad St., Chattanooga, TN. 37402-2801.
7. If algal growth covers either side of the weir plates or staff gauges at the inlet and outlet of the wetland, clean by brushing.

8. Maintain a log book to record any adjustments, repairs, etc. This record will be important in evaluating the performance of the system and identifying factors that affect the performance.

MODIFICATIONS DURING FREEZING WEATHER

1. Check the water in the distributor pipe each morning during severe freezing weather to determine the extent of icing. If icing occurs, remove the caps at each end of the distributor pipe so that flow enters the wetland from the end of the distributor. Replace the caps after the icing problem is over.
2. If ice forms over most of the wetland, initiate draw and fill operations (drain the cells and then fill them, continue until the icing period is over). Reestablish normal water levels as soon as possible.
3. Break up any ice buildup in the effluent weir box.

OPERATIONS DURING SUMMER VACATIONS

During the first three to four years of operation, it is essential that the water level be maintained near or above the gravel surface during summer periods when little or no wastewater flow is available in order to assure an adequate water supply for the marsh vegetation. This can be done by:

1. About two to three weeks before school ends, raise the water level control standpipe to its extreme vertical position to flood the

wetlands. Leave the standpipe in this vertical position until school begins again, unless specifically instructed otherwise by one of the contacts listed below.

2. Install the boards to the storm runoff diversion structures so that stormwater will be diverted to the wetlands. These boards should be installed on about the last day of school and removed on the first day of the following school year, unless instructed otherwise by one of the personnel listed below. After each rain, check for silt buildup in front of the boards and blockage of the diversion pipe; clean as needed.
3. If the water level drops more than 6 inches below the gravel surface, or the plants begin to wilt, add water to the system by opening faucets within the school, trucking water to the wetlands, or by other means. (This should not be necessary after the roots of the marsh vegetation grow into the soil beneath the layer of gravel. TVA will determine when this occurs.)

MISCELLANEOUS OPERATIONS AND PRECAUTIONS

1. Cut the grass inside the fence whenever the school yard is mowed. Herbicides may be used along the bottom of the fence so long as they are very carefully applied.
2. Cut and remove any trees or shrubs that appear in the wetland.
3. Do not apply any pesticides or chemicals to the wetland without TVA approval.
4. Be careful in using cleaning chemicals within the school and disposing of any chemicals to the sewer system.

5. Repair any dike erosion immediately after it occurs.
6. Be alert to animals burrowing into dikes, outbreaks of mosquitoes or other nuisance insects, and other situations that may become a problem.
7. Do not trample the vegetation and the debris layer that builds up over the years.
8. Keep the gate locked and control access to the system. Welcome visitors but always provide supervision.
9. Control nonwetland plants by flooding the cells about 6 inches above the gravel for about two weeks. Use this method as needed by adjusting the water level control standpipes.
10. Periodically check for solids accumulating in front of the weirs and remove as necessary.
11. Destroy slimes that may clog the inlet rock filter beneath the adjustable tees by temporarily installing 4-inch caps on every other tee until the slime layer dries (one to two weeks). After drying the rock under the first group of tees, switch the caps to the remaining tees and repeat the process.
12. Contact one of the personnel listed below if there is doubt as to how to handle any matter.

PERSONNEL TO BE CONTACTED FOR GUIDANCE

Contact the first available person:

Bear Creek Floatway Advisory Committee Field Professional: Joel Pounders, 205-332-1172 (Russellville)

TVA Personnel:

1. Johnny McFall, 205-386-3426 (Muscle Shoals)
2. James T. Watson, 615-751-7316 (Chattanooga)
3. Kim Choate, 615-751-3255 (Chattanooga)
4. Jerry Steiner, 615-751-7314 (Chattanooga)
5. Gary Springston, 615-751-7336 (Chattanooga)

SCS Personnel:

1. Gene Kearley, 205-353-6632 (Decatur)
2. Virgil McGuire, 205-332-0274 (Russellville)