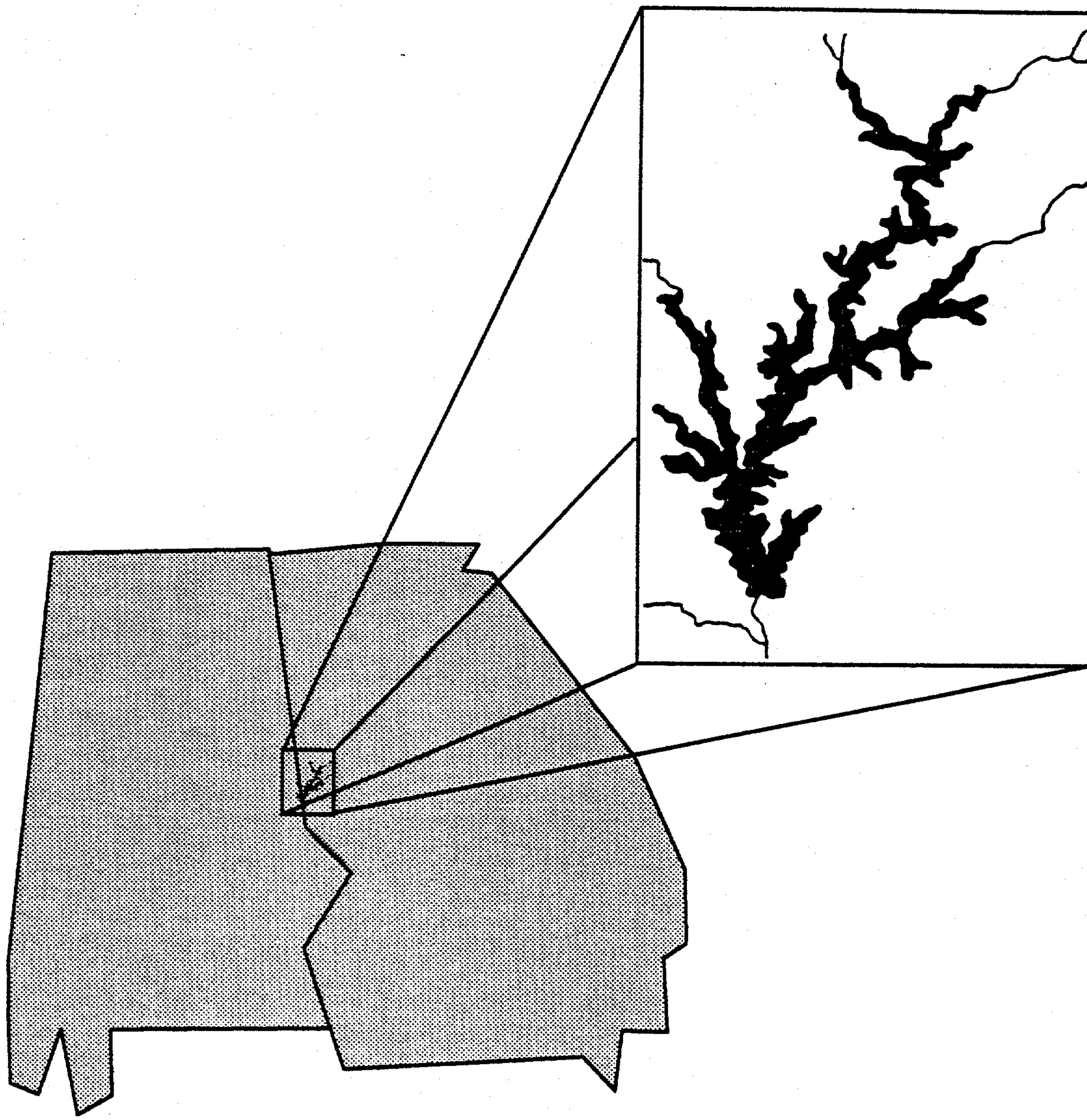
West Point Lake
Phase I Diagnostic /Feasibility Study
Final Report



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WEST POINT LAKE

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Preface

Funding for the study was provided by 70% federal / 30% state matching grants to the states of Alabama and Georgia. These grants were made available through the Clean Water Act Section 314 Nationally Competitive Clean Lakes Program. Federal funding was administered through the United States Environmental Protection Agency and the matching funds were provided by the Fuller E. Callaway Foundation.

This report includes results from a multi-year study. Comments or questions related to the content of this report should be addressed to:

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WEST POINT LAKE

PHASE I DIAGNOSTIC/FEASIBILITY STUDY

FINAL REPORT

30 September 1994

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EXECUTIVE SUMMARY

Diagnostic Study.

West Point Lake was chosen for a Phase I, Clean Lakes, Diagnostic/Feasibility Study based on several studies that showed accelerated eutrophication resulting from excessive nutrient loading. The objectives of this study were to provide historic and current data on West Point Lake, identify water quality problems and determine feasible solutions for their correction.

West Point Dam was constructed by the U.S. Army Corps of Engineers on the Chattahoochee River near West Point, Georgia. The 10,481 ha lake first reached full pool in June 1975 and in addition to generating hydroelectric power, served as a potable water supply, recreational (swimming and boating) resource, fishery and as flood protection. The planning of an impoundment on the Chattahoochee River at West Point, Georgia, 170 river km downstream from metropolitan Atlanta, attracted the attention of resource managers and scientists alike. Two preimpoundment studies were conducted independently, one by the Georgia Water Quality Control Board and the other by the U.S. Environmental Protection Agency. Results of both studies revealed water quality problems associated with the effects of Atlanta-area pollution of the Chattahoochee River. A series of postimpoundment studies revealed degraded water quality conditions in the lake particularly during the mid to late 1980's.

West Point Lake is a warm monomictic reservoir that thermally stratifies in the lacustrine zone from about late April to early September during most years. Stratification was rather weak, seldom involving thermocline temperature gradients in excess of 3 °C and water column temperature gradients in the deeper areas rarely in excess of 10 °C. Chemical stratification always accompanied thermal stratification in West Point Lake. Dissolved oxygen concentration in the lacustrine zone declined to <1.0 mg/l by June of each year and persisted for varying time periods, frequently until fall overturn.

West Point Lake waters are not naturally fertile. Specific conductance, a measure of ionic content of water, and total alkalinity, the concentration of bases in water, are crude indicators of natural fertility. These variables in West Point Lake fell in the lower half of the range expected for Alabama lakes.

Nutrient enrichment of West Point Lake from point and nonpoint sources of pollution greatly increased lake fertility. Nitrogen and phosphorus are plant nutrients that are required in relatively high concentrations to support plant growth. Nitrogen concentrations in West Point Lake were excessive. Bioavailable nitrogen was abundant with seasonal mean concentrations in the headwaters usually exceeding 1.0 mg/l and lacustrine concentrations varying from about 0.3 - 0.5 mg/l. Of the macronutrients, phosphorus is usually in shortest supply and therefore is the element most often limiting to plant growth in freshwater ecosystems. Phosphorus concentrations demonstrated a strong longitudinal gradient in West Point Lake. Upstream concentrations were extremely high with soluble reactive phosphorus concentrations ranging from 46 to 324 μg/l and total phosphorus concentrations ranging from 86 to 372 μg/l. Even though both plant nutrients were abundant, the high concentrations of phosphorus in the upstream areas resulted in nitrogen limitation of plant growth in those areas.

The obvious response to nutrient enrichment of West Point Lake was excessive growth of plankton algae. Sixty-six algal taxa were identified during the study. Phytoplankton communities were indicative of typical, nutrient enriched, southeastern reservoirs. Corrected chlorophyll *a* concentrations in West Point Lake ranged from a high of 39 μg/l in the New River embayment in June of 1990 to a low of 0.0 μg/l at an upstream site in October and in the tailwaters in November of 1990. Mean summer concentrations were generally highest and mean winter concentrations were lowest. Except for the winter of 1991-92, seasonal mean chlorophyll a concentrations were always highest at some mid-reservoir location. During the summers, declining abiogenic turbidity coupled with abundant plant nutrients and annual peaks in solar radiation resulted in optimum conditions for phytoplankton growth in the transition zone of the lake. Mean chlorophyll a concentrations during the growing season remained well above the eutrophic threshold of 6.4 $\mu g/l$. Phytoplankton primary productivity, expressed on an areal basis, was highest in the summer and lowest during winter. Maximum mean productivity during the summer was 3,349 mg $C/m^2 \cdot day$ and during the winter it was 512 mg $C/m^2 \cdot day$ both at downstream locations. Since 1981, summer season production rates have remained well above the eutrophic threshold level (1,000 mg $C/m^2 \cdot day$) and, at times (1985, 1986 and 1989), have reached extremely high levels. The overall trend in phytoplankton primary productivity of West Point Lake since the mid-1980's has been downward. Algal Growth Potential Tests conducted during the growing seasons of 1990-1992 revealed a decline in algal biomass supportable by West Point Lake waters from the 1990 levels to the 1991 and 1992 levels and a tendency for more of the lake to be phosphorus limited during the same time period.

Periods of rainfall and runoff in the Atlanta metropolitan area resulted in elevated densities of fecal coliform bacteria in the upstream reaches of West Point Lake several days following the runoff event. At times, bacterial concentrations exceeded the use designated criterion for lake areas tested. The combined sewer overflow problem in the Atlanta area following rainfall events results in some untreated domestic sewage as well as urban runoff entering the

Chattahoochee River. This is believed to be the primary source of fecal coliform bacteria in West Point Lake.

Mercury was the only one of 115 toxic substances detected in West Point Lake waters. It was found in seven of twenty water samples with a range of 0.18 ppb to 1.46 ppb. This concentration of mercury in water samples is in excess of the Georgia water quality standard of 0.12 ppb. Substances documented at levels greater than detection limits in sediments included As, Se, Hg, Cd, Cr, Ni, Cu, Pb, Zn, phthalates, pyrene, fluoranthene and benzopyrene. There are no Federal or State standards for sediment concentrations. A total of 18 composites of six fish of both carp and largemouth bass were collected and tested for 34 toxic substances. As, Se, Hg, Cr, Cu, Pb, Ni, Zn, PCB, chlordane, PCA and DDT were detected. PCB's (primarily 1260) were detected in fish filets below the FDA action level but in excess of the EPA 10^{-4} risk level. Chlordane was detected in fish filets in excess of the FDA action level and EPA 10^{-4}, 10^{-5} and 10^{-6} risk levels. Other substances detected were below Federal guideline levels where guidelines are available. Additional studies of hybrid bass and black crappie revealed detectable concentrations of Cd, Cr, Ni, Se, Tl, Zn, PCB, DDT, chlordane and dieldrin. None of the substances exceeded FDA action levels. Organohalides called trihalomethanes are known or suspected of being carcinogenic and/or mutagenic agents. Eutrophication of lakes serving as water supplies has been linked to increases in trihalomethane concentrations in finished drinking water. Based on limited data, variations in algal biomass (chlorophyll a) in West Point Lake apparently were not associated with changes in trihalomethanes in the LaGrange, Georgia finished drinking water.

Fish health assessment, based on samples of carp and largemouth bass collected in West Point Lake, revealed generally healthy fish. The method employed to determine fish health may not be sensitive enough for the relatively low level pollution observed at West Point Lake. None of the gross lesions observed appeared to be life-threatening or to be severely compromising the fish. No ulceration, open sores, deformities, fin rot or emaciated fish were observed. The only strong correlation between contaminant level and a measured response was the positive correlation between PCB levels and liver/somatic index. This should be further examined histologically to try to determine the reason.

The dominant macrophytes in West Point Lake, smartweeds and alligator weed, are species that do not require inundation and therefore are not greatly affected by the annual water level fluctuation of the Lake. At full pool in the upstream riverine portion of the reservoir, waters flood overbank areas adjacent to the old river channel creating shallow-water habitat conducive to marginal emergent vegetation. The annual 3 m fall/winter drawdown and relatively high turbidity of lake waters in this upstream area probably have prevented establishment of submersed aquatic macrophytes. Further downstream, the drawdown exposes 2,900 ha of the littoral zone each year and eliminates all but the hardiest species of marginal aquatic plants (grasses, rushes and sedges).

Sedimentation is being monitored in West Point Lake by the Corps of Engineers. The initial survey was performed in 1978 with a resurvey in 1983. From the results of the two surveys, the depletion was 0.04% during the 5 year period. This depletion was considered minimal. A resurvey was scheduled for 1994, contingent upon available funding.

Sediment oxygen demand in West Point Lake ranged from a low of 0.75 to a high of 1.49 g $O_2/m^2 \cdot day$, values similar to those reported for other southeastern reservoirs.

Feasibility Study.

The diagnostic study of West Point Lake revealed three basic problems; cultural eutrophication, bacterial contamination and toxic contamination. All three of the problems were heavily influenced by point and nonpoint sources of pollution of the Chattahoochee River in the vicinity of the Atlanta, Georgia metropolitan area.

The eutrophication of West Point Lake has resulted from the discharge of over 240 MGD of treated municipal wastewater from the Atlanta area, urban stormwater runoff and combined sewer overflow (CSO). The Atlanta area point source dishcargers alone, were responsible for an estimated 66% of the total phosphorus loading of West Point lake. Actions taken to date (phosphate detergent ban and initiation of a 0.75 mg/l phosphorus limitation in treated effluent) have resulted in a decline in phosphorus loading and in decreased total phosphorus and chlorophyll a concentrations in the lake. The question now is how much further reduction, if any, of effluent phosphorus is needed to offset the effects of planned increases in discharge of treated wastewater (a total permitted flow of 358 MGD by the year 2010) and anticipated reduced tributary flows into West Point Lake caused by increased consumptive water use upstream. While water quality models are being developed to help answer this question, West Point Lake must be protected by the immediate establishment of lake water quality standards as called for in Act Number 1274 approved by the Georgia General Assembly in April 1990.

We recommend the following standards.

Chlorophyll a (corrected for phaeopigments). Mean, photic zone, chlorophyll a concentrations measured near the LaGrange water intake structure during the growing season should not exceed 27 μg/l. Maximum instantaneous photic zone chlorophyll a concentrations should never exceed 50 µg/l under 10-year low-flow conditions or 40 µg/l under average-flow conditions.

pH. Lake water pH should not decline below 6.5 nor rise above 9.5.

Dissolved oxygen. The dissolved oxygen of the photic zone or that portion of the epilimnion within the photic zone should remain at or above 5.0 mg/l at all times. These three standards will assure that cultural eutrophication of West Point Lake will be halted without negatively impacting any of the uses of the lake. When agreement can be reached on a water quality model, standards can be established for total phosphorus and total nitrogen as required in the lake standards act. Nutrient limits on tributary streams can be effectively dealt with at that time.

The primary source of fecal coliform bacteria in West Point Lake is believed to be untreated stormwater runoff and CSO's in the Atlanta area. Upstream areas of West Point Lake, primarily a 13-km reach between Franklin, Georgia and the mouth of New River, frequently exceeded the use-designated criterion (a geometric mean of 200 bacterial colonies/100 ml based on at least four samples collected within a 30-day period) for that portion of the lake. Enforcement of the existing standard would solve the problem, however, it is not likely that this can be achieved without improvement in the quality of urban stormwater and CSO's entering the Chattahoochee River. Actions are underway that could result in substantial reductions in solids and bacteria in Atlanta-area storm related discharges. EPD is in the process of issuing NPDES area-wide permits to municipalities within the metro Atlanta area. The permit requires that stormwater not create a nuisance or interfere with legitimate water use of the state. Best management practices are used to address stormwater quality problems. EPD has also issued NPDES permits for the six CSO's. At one of the six CSO's the sewers are being separated. The other five are planning to screen (> 1.0 cm) and disinfect the combined wastewater prior to its entry into the Chattahoochee River. Intensive bacterial testing in the upstream portion of West Point Lake is recommended to determine if these corrective measures will result in compliance with existing bacterial standards.

Mercury, of unknown origin, was detected in seven of twenty water samples at levels exceeding the Georgia water quality standard of 0.12 $\mu g/l$. PCB and chlordane residues in fish tissue were found to exceed EPA or FDA action levels. The industrial chemicals pyrene, fluoranthene and benzopyrene were found in sediments. EPA banned the insecticide chlordane and the industrial chemical PCB and their concentrations in the environment should decline with time. Yearly monitoring of West Point Lake is recommended to insure that: a) chlordane and PCB residue levels do decrease; b) levels of industrial chemicals do not increase and c) mercury concentrations in water do not increase. Given the rapid growth of the Atlanta metro area and increasing demands on the Chattahoochee River that affect both its water quality and water quantity, the environmental quality of West Point Lake should be continuously monitored into the future.

TABLE OF CONTENTS

PART I. DIAGNOSTIC STUDY

PART II. FEASIBILITY STUDY

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX ITEMS

Appendix 1

Appendix 9

Appendix 10

PART I. DIAGNOSTIC STUDY

1.0 LAKE IDENTIFICATION

West Point Lake was impounded in 1974 by construction of hydroelectric generating facilities on the Chattahoochee River, approximately 109 kilometers downstream of the city of Atlanta, Georgia. The major portion of the reservoir lies within Troup and Heard Counties in Georgia with smaller portions of the reservoir in Chambers County, Alabama (Figure 1-1). The project was authorized by the Flood Control Act of 1962 for flood control, power generation, recreation, fish and wildlife enhancement and flow regulation for downstream navigation (EPD 1989a). The reservoir also serves as a water supply reservoir for the city of LaGrange, Georgia.

Morphometric characteristics of West Point Lake appear in Table 1-1. The reservoir is normally maintained at a full pool level of 194 m surface altitude from mid-May through September and is lowered to 191 m from October to mid-May, exposing 2,900 ha of littoral area.

Water-use classifications for the Georgia portion of the reservoir are as follows:

a) Franklin to New River: Fishing

b) New River to West Point Dam: Recreation

Water-use classifications for the Alabama portion of the reservoir are as follows:

a) West Point Dam to reservoir limits in Alabama:
Swimming/Fish and Wildlife

Water quality criteria for the classifications appears in Appendix 1.0.

WEST POINT LAKE

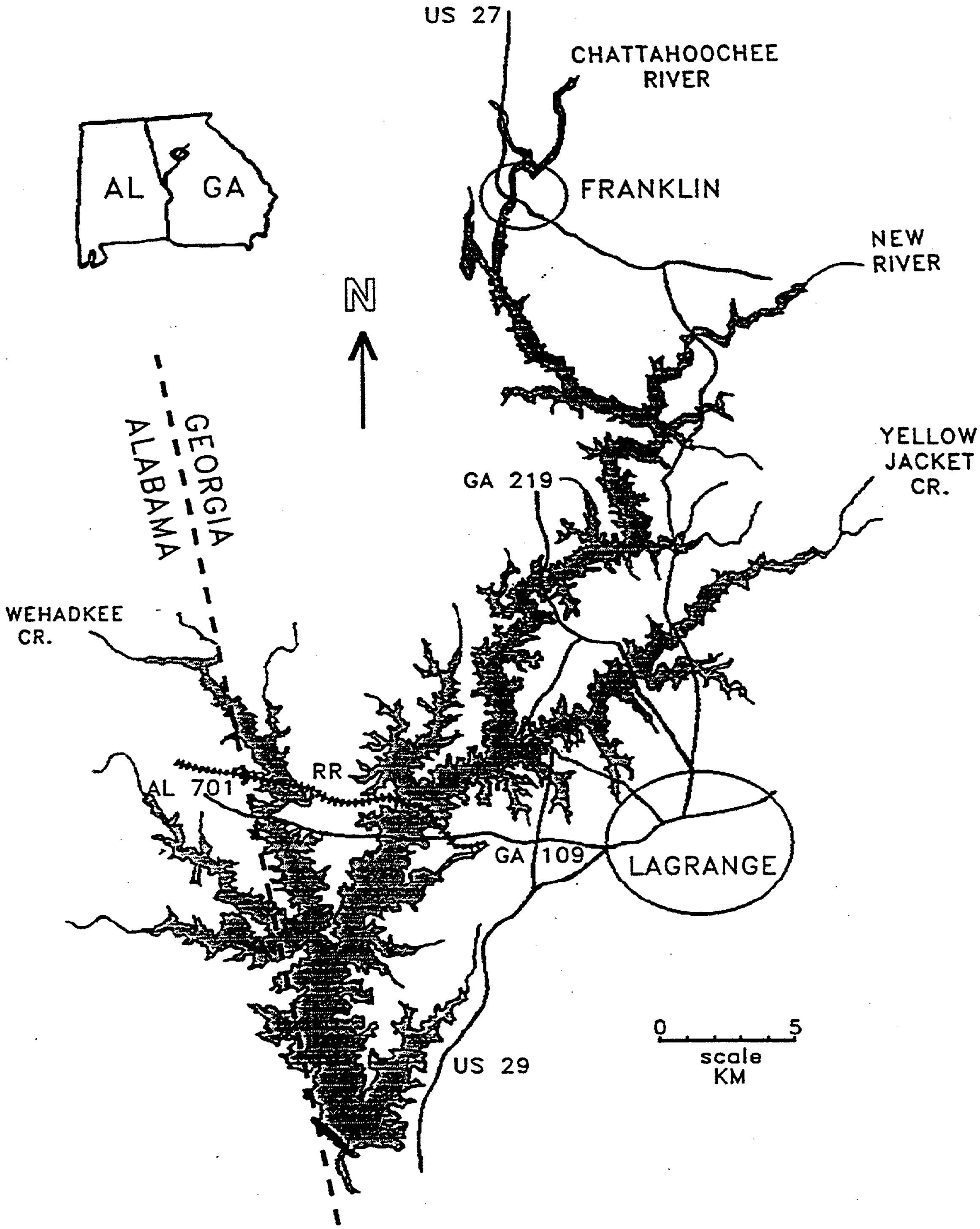

Figure 1-1. Map of West Point Lake, Alabama and Georgia.

Table 1-1. Morphometric characteristics and dam specifications of West Point Lake.

	Morphometric Characteristics
Drainage area	8,745 square kilometers
Surface area	10,467 hectares
Shoreline length	840 kilometers
Mean depth	7 meters
Maximum depth	26 meters
Normal pool elevation	194 meters
Normal pool volume	45,700,000 cubic meters
Mean retention time	55 days
	Dam Specifications
Type	Gravity concrete
Length	2,211 meters
Height	29.6 meters
Completion date	1977
Hydraulic turbines	4
Electrical generation	108,375 kilowatts

2.0 BASIN DRAINAGE AND GEOLOGY

The upper Chattahoochee River originates on the southern slopes of the Blue Ridge Mountains in northeast Georgia and flows generally southwestward through the Atlanta area to West Point Lake at the Alabama-Georgia state line. Runoff from the upper third of the Chattahoochee River basin is controlled by Buford Dam at Lake Sidney Lanier. The Chattahoochee River is the principal tributary to West Point Lake and contributes 96% of the mean annual water loading. Minor tributaries to the reservoir include Yellowjacket, Wehadkee, Whitewater, Potato and Maple Creeks and the New River (Davies et al. 1979a).

The drainage area of the Chattahoochee River upstream of West Point Dam lies entirely within the Piedmont physiographic province. In the vicinity of the reservoir the province is a nearly level plateau whose generally smooth surface lies 244 to 275 meters above sea level. Southwestward the plateau descends to 152 meters at the margin of the Coastal Plain. Except in the Pine Mountain area, the plateau is almost unbroken by isolated ridges. It is not deeply dissected except along the valley of the Chattahoochee River (Radtke et al. 1984).

Metamorphic and igneous rocks underlie the drainage area and generally occupy broad belts. The comparatively uniform lithology is reflected in the uniform topography. Parent materials of the soils have generally been derived from sedimentary and igneous rocks. Geological formations, soil series and their characteristics appear in Table 2-1 (U.S. Army Corps of Engineers, 1977).

Table 2-1. Geological formations, soils series and their characteristics in the drainage area of the Chattahoochee River and West Point Lake.

	Characteristics
<u>Geological Formations</u>	
Ashland mica schist	Consists of two types of sedimentary rocks; garnetiferous biotite schist and a siliceous muscovite schist.
Wedowee formation	Consists of slate, phyllite, quartzite and schist.
Igneous schist and gneiss	Consists of hornblende gneiss, granite and gneiss.
<u>Soils Series</u>	
Buncombe series	Deep, light-textured, well-drained to excessively drained soils formed generally from alluvium.
Louisa series	Shallow to very shallow, gravelly, sandy loams, well-drained, strongly acid upland soils.
Altavista series	Moderately deep, well-drained, sandy loam soils which have developed on low stream terraces with strong acid profiles.
Cecil series	Shallow to deep, well-drained, sandy loam soils developed on the Piedmont uplands with strongly acid subsoils.

3.0 PUBLIC ACCESS

Public access areas are well distributed throughout the entire reservoir area but are most numerous on the lower reaches. There are a total of 52 recreational parks around West Point Lake, 43 of which provide boat launching areas. Thirty-five boat launching areas are operated by the U.S. Army Corps of Engineers. Two launching areas are operated by marinas while the city of Franklin, Heard County, Troup County, and the Georgia Department of Natural Resources each maintain one launching area (personal communication, Darren Kelly). A survey conducted in 1982-1983 determined that the most frequently used reservoir access area was Yellowjacket Creek followed by Highland Marina, Rocky Point, Holiday Marina and Sunny Point (Davies et al. 1984).

For anglers without boats, bank and pier access is available at many Corps recreational areas. Banks and slopes of highway bridge areas are also frequently used by anglers as are shoreline areas of inundated roadways.

4.0 SIZE AND ECONOMIC DISTRIBUTION OF POTENTIAL USER POPULATION

West Point Lake is surrounded by Chambers County, Alabama, Troup County, Georgia and Heard County, Georgia. The area surrounding the reservoir is historically agricultural and textile oriented though industry is increasingly diversified.

The potential user population of West Point Lake is of considerable size because of the reservoir's proximity to metropolitan areas and interstate highways. The reservoir is within 15 km of interstates 85 and 185. Columbus, Georgia, with a metropolitan statistical area population of 250,000 is 72 km from the reservoir. Atlanta, Georgia, with a metropolitan statistical area population of 2,700,000, is 100 km from the reservoir.

Surveys conducted in 1982-1983 determined that counties contributing the greatest number of anglers to West Point Lake were, in descending order, Troup, Fulton, Clayton, Douglas and Muscogee Counties of Georgia and Chambers and Lee Counties of Alabama (Davies et al. 1984). Population and income data for each of these counties appear in Table 4-1, business and employee data in Tables 4-2 and 4-3 and agricultural production data in Table 4-4 (U.S. Department of Commerce, 1987, 1990).

Table 4-1. Total population and income characteristics of Alabama and Georgia counties in the vicinity of West Point Lake.

State	County	Population	Income	Poverty Level (%)
Georgia	Clayton	182,052	$13,577	7.3
	Douglas	71,120	14,096	4.9
	Fulton	648,951	18,452	15.4
	Muscogee	179,278	11,949	14.9
	Troup	55,536	11,581	13.1
Alabama	Chambers	36,876	10,000	13.4
	Lee	87,146	11,409	13.2

Table 4-2. Number of business establishments of Georgia and Alabama counties in the vicinity of West Point Lake.[1]

State	County	Total	Agricultural Forestry Fishing	Mining	Construction	Manufac-turing	Transportation, Public Utilities	Wholesale Trade	Retail Trade	Finance, Insurance, Real Estate	Services	Unclassified Establishments
Georgia	Clayton	3,768	29	3	365	163	205	313	1,083	268	1,190	133
	Douglas	1,421	23	2	204	86	42	94	345	83	478	64
	Fulton	24,476	163	17	1,222	1,152	894	2,585	5,038	2,847	9,424	1,134
	Muscogee	4,301	48	4	405	172	144	268	1,205	462	1,395	198
	Troup	1,305	11	1	122	100	46	95	379	117	375	59
Alabama	Chambers	531	7	--	45	55	23	23	453	24	178	23
	Lee	1,611	30	--	169	85	65	92	456	147	488	79
Total		37,413	311	27	2,532	1,813	1,419	3,470	8,659	3,948	13,528	1,690

[1]Excludes most government employees, railroad employees and self-employed persons.

Table 4-3. Number of employees of Georgia and Alabama counties in the vicinity of West Point Lake.[1]

State	County	Total	Agricultural Forestry Fishing	Mining	Construction	Manufac-turing	Transportation, Public Utilities	Wholesale Trade	Retail Trade	Finance, Insurance, Real Estate	Services	Unclassified Establishments
Georgia	Clayton	53,662	214	B	3,273	5,286	7,206	5,574	17,637	1,800	12,413	C
	Douglas	15,957	82	B	1,633	1,330	1,057	1,022	5,148	633	4,920	B
	Fulton	535,485	1,341	284	19,354	59,030	77,390	46,179	90,234	57,884	181,940	1,849
	Muscogee	71,067	287	B	4,945	17,507	2,578	2,928	17,165	5,766	19,615	C
	Troup	26,405	B[2]	B	1,431	11,433	663	1,102	4,883	910	5,806	106
Alabama	Chambers	11,815	44	--	231	6,960	683	327	1,586	208	1,770	6
	Lee	27,683	156	--	1,566	9,546	1,090	2,955	6,357	1,136	4,900	67
Total		742,074	--	--	32,433	111,002	90,667	60,087	143,010	68,337	230,914	--

[1]Excludes most government employees, railroad employees and self-employed persons.
[2]Employment-size classes indicated as follows: A = 0 to 19; B = 20 to 99; C = 100 to 249; E = 250 to 499.

Table 4-4. Agricultural production of Georgia and Alabama counties in the vicinity of West Point Lake.

State	County	Total Farms	Total Farm Acreage	Total Cropland Acreage	Cattle Sold x 1000	Hogs Sold x 1000	Broilers Sold x 1000	Corn Bushels x 1000	Wheat Bushels x 1000	Soybeans Bushels x 1000	Cotton Bales
Georgia	Clayton	73	8,028	3,242	0.9	D	--	D	D	--	--
	Douglas	134	10,770	3,994	1.3	0.3	D	7.8	--	--	--
	Fulton	344	32,832	12,471	2.3	1.3	1.4	15.6	D	11.4	D
	Muscogee	49	5,304	1,856	0.4	D	--	D	D	--	--
	Troup	281	52,513	21,425	5.7	0.4	D	2.1	D	D	D
Alabama	Chambers	365	102,153	32,905	9.4	D	D	8.3	2.9	D	D
	Lee	402	79,836	33,628	6.3	5.4	D	18.9	2.1	1.9	2.6
Total		1,648	291,436	109,521	26.3	---	---	---	---	---	---

[1]D denotes withheld data.
-- unknown

5.0 HISTORY OF LAKE USES

West Point Lake has been used for recreation, flood control, power generation and the water supply for the city of LaGrange since its impoundment in October 1974. Recreational use of the reservoir has increased consistently. In 1976, visitor days numbered approximately 870,000. By 1989, recreational use had increased to 8.2 million visitor days. Though the number of visitor days has not been diminished by the degradation of the reservoir, awareness of the pollution and of the contamination of fish has resulted in decreased utilization of the facilities by swimmers, skiers, and anglers.

6.0 USER POPULATION AFFECTED BY LAKE DEGRADATION

At the peak of its popularity, West Point Lake supported 25-30 fishing guides, eleven active bait shops, one marina and several boat dealerships. However, bait producers, convenience stores, restaurants and motels have documented a reduction in business since 1988. Several bait shops in the area were forced to close while several others experienced severe financial difficulty. A sixty percent decrease in fishing reduced the number of active guides to 10-12 during the normally busy spring and summer seasons. The number of bass angler tournaments declined as did the number of crappie fishermen visiting the reservoir. Several large real estate developments initiated before the disclosure of the reservoir's degradation experienced a substantial reduction in sales. A fish consumption advisory for West Point Lake issued by the Georgia Department of Natural Resources in February 1991 is expected to further damage business interests associated with the reservoir.

7.0 LAKE USE COMPARISON WITH NEARBY LAKES

Lake Harding is a 2,367 ha reservoir located on the Chattahoochee River, immediately downstream of West Point Lake. Impounded in 1926 for hydroelectric power generation, Lake Harding is much smaller than West Point Lake and receives only a fraction of the recreational use that West Point Lake receives.

8.0 POINT SOURCE POLLUTION INVENTORY

A one year, point source pollution inventory was compiled using discharge monitoring reports (DMR) furnished by the Georgia Department of Natural Resources and the Alabama Department of Environmental Management. The Chattahoochee River Basin Water Quality Management Plan (EPD 1992) was used as a guide to identify the major point sources from West Point Dam to Buford Dam for November 1990 through October 1991. Efforts were made to include all permitted dischargers but some minor dischargers were not included. Minor dischargers were defined as:

1) Municipal and privately-owned facilities discharging less than 10,000 gallons/day; and
2) Industrial facilities with no discharge system, discharge consisted of uncontaminated cooling water, groundwater, and/or rainfall runoff, or discharge with no significant organic (less than 2.5 lbs. of BOD_5 per day) or chemical contaminants.

Flows for the Georgia Power Company fossil fuel plants, Yates, Wamsley and McDonough-Atkinson, were obtained from the 1990 and 1991 flow monitoring and characterization studies. A 2.5 mg/l total phosphorus concentration for municipal effluent was assumed when municipal facilities were not required to monitor total phosphorus in their effluent (personal communication, D. Kamps, Georgia EPD, 1992).

Estimated total loading (point and nonpoint) for total phosphorus (TP), total suspended solids (TSS), total nitrogen (TN) and biochemical oxygen demand (BOD) were determined by using FLUX (Walker 1986). FLUX is a computer program designed to estimate nutrient loadings from grab-sample concentration data and continuous flow records using various calculation methods and stratification schemes which permit quantification of potential errors.

Estimates of annual point source flow and annual point source loads of BOD, TP, TSS, orthophosphate and ammonia-nitrogen were calculated using the daily average for the month and extrapolating to a monthly load. Monthly loads were summed to obtain an annual load. Some dischargers did not report data for all months; values for the missing months were assumed to be the average from the months that were reported.

The river basin was partitioned into the following four areas (Figure 8-1):

1) Buford Dam to Gwinnett County water intake;

2) Gwinnett County water intake to Fairburn, Georgia;

3) Fairburn, Georgia to Franklin, Georgia; and

4) Franklin, Georgia to West Point Dam.

Permitted municipal and industrial dischargers for each of the four areas were listed in Tables 8-1 and 8-2 along with discharge data. Subtotals are shown for each area and are summed to obtain a total load.

Point source flow and loading estimates of TP, TSS and BOD are compared for the partitioned areas in Figure 8-2. Municipals comprised 88% and industrials 12% of the total wastewater effluent of 100.04 billion gallons of water per year. The area from the Gwinnett County water intake to Fairburn, Georgia (greater metropolitan Atlanta area) contributed about 88% of the total wastewater discharged. Municipal facilities comprised 98% of that value. The area from Fairburn to Franklin comprised 11% of the total wastewater effluent with 89% of that flow being from industrial sources. The two major industrial dischargers were Georgia Power Company Plants Yates and Wamsley. The area from Franklin to West Point Dam only accounted for 1% of the total wastewater effluent with 50%

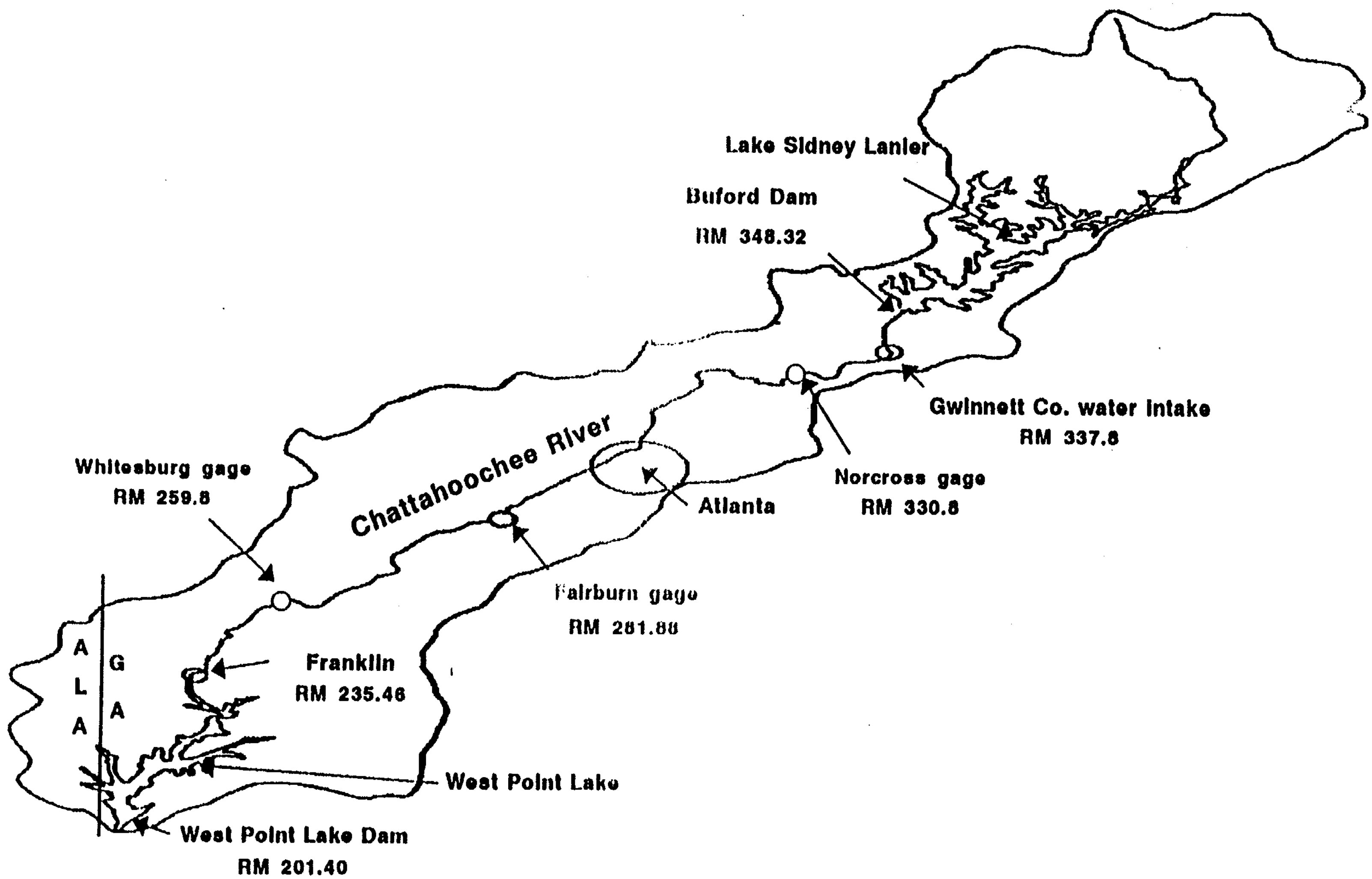

Figure 8-1. Location of partitioned areas in Chattahoochee River basin for point source pollution inventory during diagnostic study of West Point Lake, November 1990 - October 1991.

Table 8-1. Permitted municipal dischargers into West Point Lake during the diagnostic study conducted November 1990 - October 1991.

Facility	NPDES Number	Receiving Stream	Permitted Flow (MGD)	Actual Flow (MGD)	Total Flow (MG)	BOD Loading (lbs/yr)	TSS Loading (lbs/yr)	TP Loading (kg/yr)	NH_3-N Loading (kg/yr)
Gwinnett County Water Intake to Fairburn, Georgia									
Swanee Elem School	GA0035866	Cheatham Creek	0.025	0.001	0.47	89	153	4[1]	*
Cumming WPCP	GA0032115	Big Creek	0.70	0.339	123.83	12,337	15,124	1,172[1]	1,359
Sweetwater WPCP	GA0027171	Town Branch	0.52	0.210	76.65	1,589	4,550	726[1]	171
Doug. North WPCP	GA0030350	Gothard's Creek	0.60	0.306	111.60	4,502	9,755	1,056[1]	403
Doug. Sweetwater	GA0047201	Town Branch	3.0	0.661	241.20	14,502	25,043	509	2,767
South Cobb WPCP	GA0026158	Chattahoochee R.	28.0	20.092	7,333.46	143,015	428,430	20,994	39,818
Camp. Creek WPCP	GA0025381	Chattahoochee R.	13.0	11.63	4,244.95	192,606	328,156	21,856	106,483
St. John Cr. WPCP	GA0030686	Chattahoochee R.	5.0	4.75	1,733.75	40,258	143,858	5,845	2,333
Crooked Cr. WPCP	GA0026433	Chattahoochee R.	6.5	5.167	1,885.83	15,825	33,722	1,618	801
South River WPCP	GA0024040	Chattahoochee R.	41.0	39.575	14,444.88	1,001,739	1,280,184	74,144	56,642
Big Creek WPCP	GA0024333	Chattahoochee R.	11.0	10.567	3,856.83	190,819	610,742	17,425	58,460
R.L. Sutton WPCP	GA0026140	Chattahoochee R.	28.5	28.908	10,551.54	187,810	422,954	60,521	37,646
R.M. Clayton WPCP	GA0021482	Chattahoochee R.	101.0	84.7	30,915.50	2,031,099	5,846,443	246,870	403,282
Utoy Cr. WPCP	GA0021458	Chattahoochee R.	37.0	27.391	9,997.68	399,153	1,120,693	42,114	104,369
C.V. of Lake Lanier	GA0030201	Suwannee Creek	0.125	0.082	29.89	5,121	3,343	283[1]	*
Westside WPCP	GA0023175	Richland Creek	0.25	0.152	55.30	5,789	4,193	523[1]	864
DOT SRA #75	GA0023663	Suwannee Creek	0.035	0.004	1.52	89	402	14[1]	*
DOT SRA #76	GA0023604	Ivy Creek	0.015	0.010	3.51	164	990	33[1]	*
Lanier Mid. School	GA0035068	Suwannee Creek	0.011	0.002	0.67	18	62	6[1]	*
B. Southside WPCP	GA0023167	Suwannee Creek	1.7	0.781	285.22	31,933	34,344	1,675	5,939
Chattahoochee MHP	GA0050041	Strickland Springs	0.06	0.033	11.95	1,136	1,386	113[1]	*
Countryside Villa	GA0030180	Cooper Creek	0.07	0.060	21.72	2,772	3,467	206[1]	*
Union City WPCP[2]	GA0023094	Deep Creek	0.25	0.213	77.56	9,700	9,700	734[1]	*
Chatt. Health[3]	*	Deep Creek	0.006	0.003	1.23	220	346	12[1]	*
Subtotal			278.367	235.637	86,006.74	4,292,285	10,328,040	498,453	821,337

Table 8-1. (Cont).

Facility	NPDES Number	Receiving Stream	Permitted Flow (MGD)	Actual Flow (MGD)	Total Flow (MG)	BOD Loading (lbs/yr)	TSS Loading (lbs/yr)	TP Loading (kg/yr)	NH_3-N Loading (kg/yr)
			Fairburn, Georgia to Franklin, Georgia						
Brookwood MHP	GA0031521	Little Anneewakee Cr	0.021	0.014	5.08	1,015	1,672	48[1]	*
Palmetto WPCP	GA0025542	Little Bear Creek	0.60	0.536	195.70	9,746	6,249	1,851[1]	*
Pine Lake MHP	GA0035271	Bear Creek	0.05	0.031	11.42	695	1,836	108[1]	*
Bill Arp School	GA0034622	Bear Creek	0.004	0.004	1.47	158	137	14[1]	*
Rebel Trails WPCP	GA0049786	Anneewakee Creek	0.04	0.012	4.50	312	411	42[1]	*
Beaver Est. WPCP	GA0031402	Crooked Creek	0.08	0.066	24.18	1,520	1,540	229[1]	112
Arnwall WPCP	GA0000299	Wahoo Creek	0.06	0.046	16.67	1,620	10,204	158[1]	*
Arnco WPCP	GA0000311	Wahoo Creek	0.10	0.073	26.52	1,775	4,465	251[1]	*
Wahoo Creek WPCP	GA0031721	Wahoo Creek	0.75	0.868	316.76	13,894	20,046	2,998[1]	5,374
Snake Creek WPCP	GA0021431	Snake Creek	0.40	0.296	108.07	15,170	18,530	1,024[1]	*
L. Bear Cr WPCP	GA0047104	Little Bear Creek	0.10	0.006	2.25	95	99	21[1]	6
D. Southside WPCP	GA0030341	Anneewakee Creek	3.25	1.517	553.86	39,356	61,801	861	3,297
Fairplay Mid Sch	GA0035963	Hurricane Creek	0.01	0	0	0	0	0	0
Cedar Hgts MHP	GA0024856	Whooping Creek	0.033	0.005	1.83	204	160	17[1]	*
Garden Terrace	GA0033782	Bear Creek	0.034	0.027	9.76	1,870	2,388	92	*
Subtotal			5.532	3.501	1,278.07	87,430	129,538	7,714	8,789
			Franklin, Georgia to West Point Dam						
Grantville #1	GA0033197	New River	0.05	0.023	8.43	1,455	2,382	79[1]	*
Holiday Inn	GA0022632	New River	0.03	0.013	4.72	608	612	155	49
Mineral Springs	GA0021423	New River	0.75	0.471	171.73	5,680	13,729	1,624[1]	720
Grantville #2	GA0033201	New River	0.04	0.021	7.76	1,245	1,938	74[1]	*
Subtotal			0.87	0.528	192.64	8,988	18,661	1,932	769

Table 8-1. (Cont).

Facility	NPDES Number	Receiving Stream	Permitted Flow (MGD)	Actual Flow (MGD)	Total Flow (MG)	BOD Loading (lbs/yr)	TSS Loading (lbs/yr)	TP Loading (kg/yr)	NH_3-N Loading (kg/yr)
			Franklin, Georgia to West Point Dam						
Hogansville WPCP	GA0032379	Yellowjacket Creek	0.50	0.542	197.71	4,263	9,704	1,873[1]	*
Grantville #3	GA0033219	Yellowjacket Creek	0.05	0	0	0	0	0	0
Grantville #4	GA0033227	Yellowjacket Creek	0.03	0	0	0	0	0	0
Subtotal			0.58	0.542	197.71	4,263	9,704	1,873	*
			Direct Discharge to Lake						
USCOE-Herd	GA0048054	West Point Lake	0.002	0	0	*	*	*	*
USCOE-RMD	GA0048038	West Point Lake	0.002	0	0	*	*	*	*
Franklin WPCP	GA0021148	West Point Lake	0.16	0.108	39.33	9,559	11,309	729	1,195
Subtotal			0.164	0.108	39.33	9,559	11,309	729	1,195
			=======	=======	==========	=========	==========	=======	=======
Total			285.513	240.316	87,714.49	4,402,525	10,497,252	510,701	832,090

[1]Facility not required to monitor phosphorus, assumed 2.5 mg/l as phosphorus concentration.
[2]No DMR available. Figured actual flow was 85% of permitted flow and BOD and TSS concentrations were half of permitted value.
[3]No DMR available. Figured actual flow was 85% of permitted flow and BOD and TSS concentrations were an average of 5 other mobile home parks.
* No information available.

Table 8-2. Permitted industrial dischargers into West Point Lake during the diagnostic study conducted November 1990 - October 1991.

Facility	NPDES Number	Receiving Stream	Permitted Flow (MGD)	Actual Flow (MGD)	Total Flow (MG)	BOD Loading (lbs/yr)	TSS Loading (lbs/yr)	TP Loading (kg/yr)	NH_3-N Loading (kg/yr)
Buford Dam to Gwinnett County Water Intake									
Trout Hatchery	GA0026174	Chattahoochee R.	*	0.004	1.58	121	245	*	*
Subtotal			*	0.004	1.58	121	245	*	*
Gwinnett County Water Intake to Fairburn, Georgia									
Tyson Foods	GA0001074	Oors Creek	*	0.654	238.59	12,729	15,999	*	905
Blue Circle	GA0046850-DSN001	Daves Creek	*	*	*	*	*	*	*
Blue Circle	GA0046850-DSN002	Daves Creek	*	0.00	0.00	*	*	*	*
Williams Bros.	GA0043601	*	*	0.002	0.73	*	40	*	*
General Motors	GA0001767	Nancy Creek	*	*	*	*	*	*	*
Lockheed	GA0001198	Poorhouse Creek	*	1.565	571.35	18,092	5,300	1,056[2]	*
Cargill	GA0000361	Proctor Creek	*	*	*	*	*	*	*
C.W. Matthews	GA0048356-DSN001	Proctor Creek	*	0	0	*	*	*	*
C.W. Matthews	GA0048356-DSN002	Proctor Creek	*	0.002	0.55	*	*	*	*
Tilford Yard	GA0001007	Proctor Creek	*	0	0	*	*	*	*
Chem-Central	GA0001597	Nancy Creek	*	*	*	*	*	*	*
Williams Bros.	GA0046906	North Fork Peachtree Creek	*	0	0.03	*	1	*	*
Williams Bros.	GA0047597	Proctor Creek	*	0.00	0.00	*	*	*	*
Plantation Pipe	GA0030953	Nancy Creek	*	*	*	*	*	*	*
Austell Box	GA0001911-DSN004	Sweetwater Creek	*	0.179	65.36	1,362	1,362	*	*
Austell Box	GA0001911-DSN006	Sweetwater Creek	*	0.048	17.50	1,561	636	*	*
Austell Box	GA0001911-DSN007	Sweetwater Creek	*	0.166	60.52	2,147	5,499	*	*
Austell Box	GA0001911-DSN008	Sweetwater Creek	*	0.059	21.50	701	448	*	*

Table 8-2. (Cont).

Facility	NPDES Number	Receiving Stream	Permitted Flow (MGD)	Actual Flow (MGD)	Total Flow (MG)	BOD Loading (lbs/yr)	TSS Loading (lbs/yr)	TP Loading (kg/yr)	NH_3-N Loading (kg/yr)
Gwinnett County Water Intake to Fairburn, Georgia (Cont.)									
Austell Box	GA0001911-DSN013	Sweetwater Creek	*	0.073	26.66	1,183	555	*	*
Colonial Pipe	GA0048429	Olley Creek	*	*	*	*	*	*	*
Ajay Chemicals	GA0048283	Noses Creek	*	*	*	*	*	*	*
Williams Bros.	GA0025913	Noses Creek	*	0.008	2.92	*	195	*	*
Vulcan Mat.	GA000799	Beaver Run Creek	*	0.0003	0.13	*	24	*	*
Williams Bros.	GA001627	*	*	0.008	2.92	*	361	*	*
Thomas Concrete	GA0046078	*	*	0.0	0.0	*	*	*	*
Williams Bros.	GA0048640	*	*	0.0	0.0	*	*	*	*
Plant McDon-Atk	GA0001431-DSN003	Chattahoochee R.	*	2.782	1,015.31	*	46,849	*	*
Plant McDon-Atk	GA0001431-DSN01, 02, 03A, 03B, 03C, 03D, 03E, 03F	Chattahoochee R.	*	383.35	139,922.75	*	*	*	*
Nat. Starch	GA0003352	*	*	*	*	*	*	*	*
Combustion Eng.	GA0031142	*	*	*	*	*	*	*	*
Subtotal			*	5.55'	2,024.07'	37,775	77,269	1056	905
Fairburn, Georgia to Franklin, Georgia									
Young Refining	GA0001902	Cracker Creek	*	0.025	8.94	3,543	3	*	392
Blue Circle	GA0030899-DSN001	Mobley Creek	*	*	*	*	*	*	*
Blue Circle	GA0030899-DSN002	Mobley Creek	*	*	*	*	*	*	*
Vulcan Mat.	GA0032433	Crawfish Creek	*	0.001	0.06	*	13	*	*
Plant Wamsley	GA0026778-DSN002	Chattahoochee R.	*	8.64	3,153.60	*	183,393	*	*

Table 8-2. (Cont).

Facility	NPDES Number	Receiving Stream	Permitted Flow (MGD)	Actual Flow (MGD)	Total Flow (MG)	BOD Loading (lbs/yr)	TSS Loading (lbs/yr)	TP Loading (kg/yr)	NH_3-N Loading (kg/yr)
			Fairburn, Georgia to Franklin, Georgia (Cont.)						
Plant Wamsley	GA0026778-DSN01A, 01B, 01C	Chattahoochee R.	*	5.93	1,265.47	*	*	*	*
Plant Yates	GA0001473-DSN01B	Chattahoochee R.	*	18.358	6,700.79	*	183,454	*	*
Plant Yates	GA0001473-DSN01	Chattahoochee R.	*	607.54	221,752	*	*	*	*
Subtotal			*	27.024[3]	9,863.39[3]	3,543	366,863	*	392
			Franklin, Georgia to West Point Dam						
Hoover Alum	GA0000922	Hillabatchee Creek	*	0.090	32.71	*	8,822	16	*
Wm. Bonnell	GA0000507	New River	*	0.482	175.96	*	13,416	95	*
Wehadkee Yarn	AL00057959	Wehadkee Creek	*	0.623	227.55	35,281	37,141	*	3,684
Subtotal			*	1.195	436.22	35,281	59,379	111	3,684
Total			*	33.773[1,3]	12,325.26[1,3]	76,720	503,756	1167	4,981

[1]Does not include Plant McDonough-Atkinson's Discharge Numbers 01, 02, 03A, 03B, 03C, 03D, 03E and 03F.
[2]Reported as ortho-phosphorus.
[3]Does not include Plant Wamsley's discharge number DSN01A, 01B and 01C and Plant Yate's discharge number DSN01.
* = Information not available.

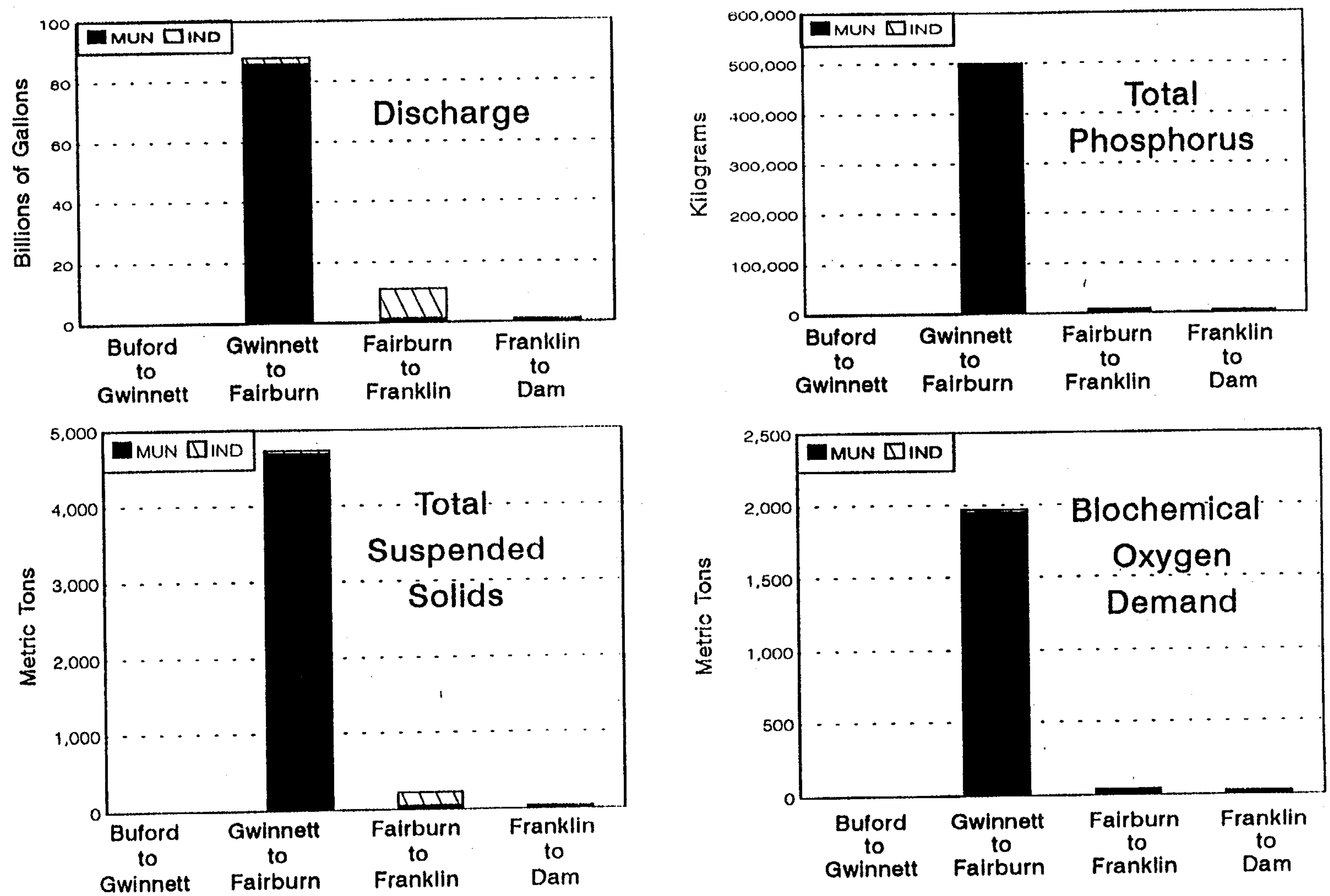

Figure 8-2. Quantification of municipal (MUN) and industrial (IND) discharge and loading of total phosphorus, total suspended solids and biochemical oxygen demand of four partitioned areas during diagnostic study of West Point Lake, November 1990 - October 1991.

being from municipal and 50% from industrial sources. At this time, municipals were discharging 84% of the permitted flow of 278.367 million gallons/day (MGD).

The point source TP load was 511,868 kg with the area from the Gwinnett County water intake to Fairburn contributing about 98% of the TP load (Figure 8-2). Municipals discharged over 99% of the point source phosphorus load. Only three industrial dischargers were required to monitor phosphorus in their effluent.

TSS point source load was 5,000 metric tons with municipals responsible for 95% of the total (Figure 8-2). The area from the Gwinnett County water intake to Fairburn comprised 94% of the TSS load with municipals responsible for over 99% of the load in that area. Five percent of the TSS load was from Fairburn to Franklin. Industrials were responsible for 74% of that load. The two major industrial contributors were Plants Yates and Wamsley.

The point source BOD load was 2,036 metric tons. Municipals discharged 98% of the total load. The area from the Gwinnett County water intake to Fairburn contributed about 97% of the total point source BOD load with municipals responsible for over 99% of the load within that area.

In summary, municipals were responsible for 88% of the total wastewater discharged and at least 95% of the TSS, TP and BOD load. The area from the Gwinnett County water intake to Fairburn contributed 88% of the total wastewater effluent and greater than 95% of the TP, TSS and BOD loads. About 10% of the estimated 1 trillion gallons of water that entered West Point Lake during the study year was point source flow (Figure 8-3).

Point source TP loading from the Atlanta area has been declining since 1988 (Figure 8-4). Data from 1986 through 1990 were from Georgia Department of Natural Resources (EPD 1990). For study year 1991, an estimated 495,518

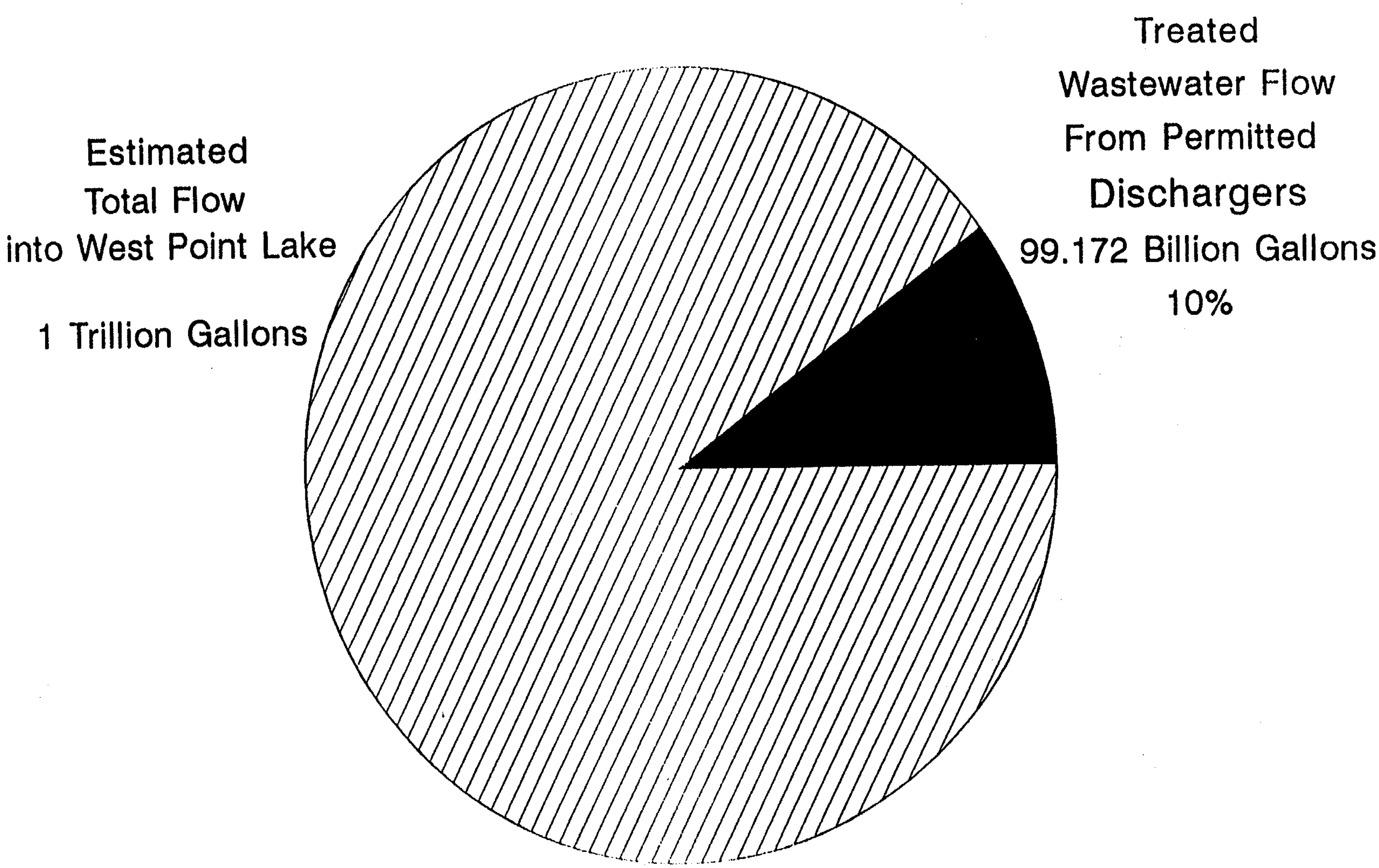

Figure 8-3. Percentage of the total flow into West Point Lake (Franklin, GA) that was from municipal and industrial facilities during the diagnostic study, November 1990 - October 1991.

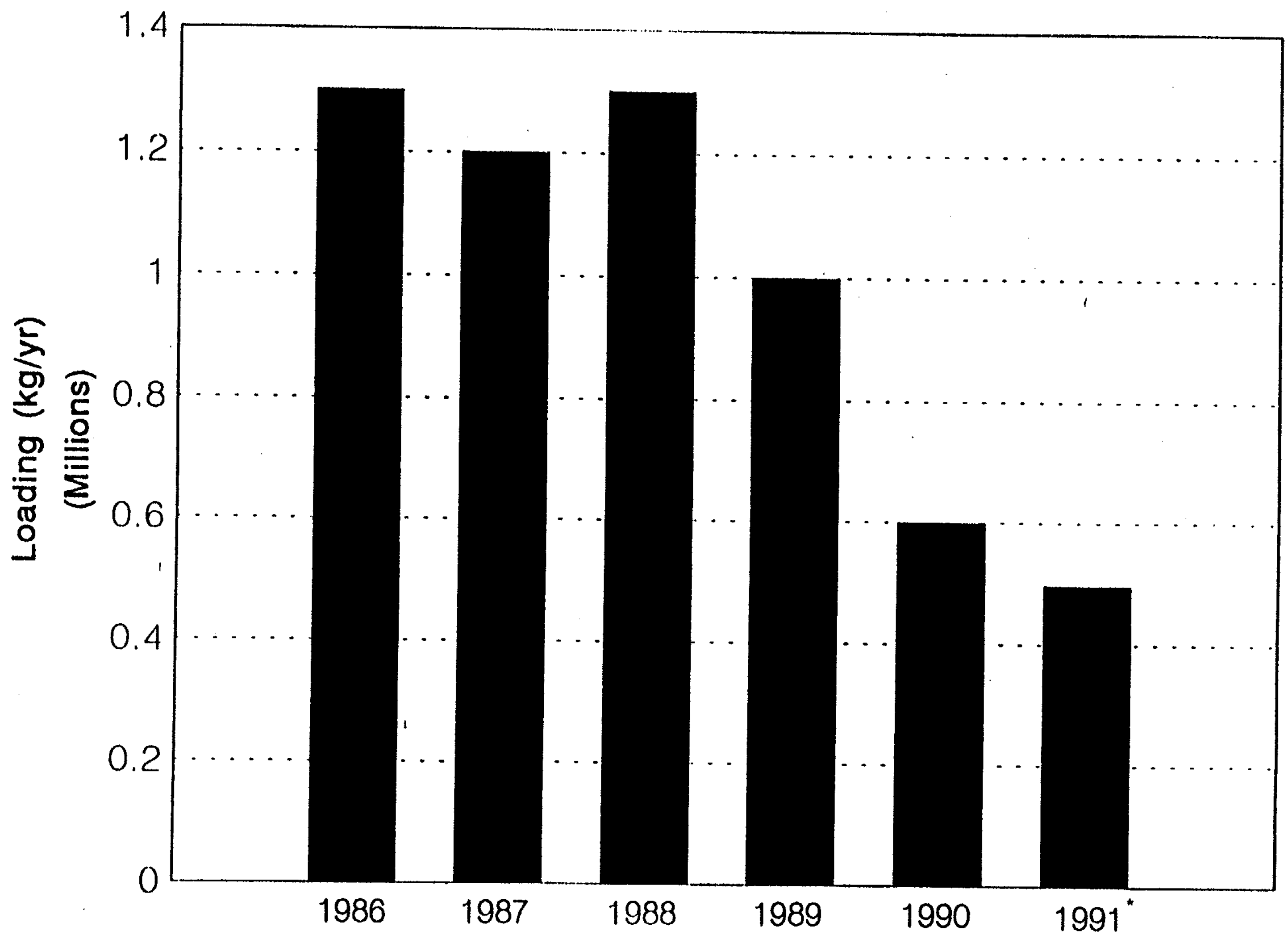

Figure 8-4. Estimated annual total phosphorus loading from major Atlanta area point sources to the Chattahoochee River (* - November 1990 - October 1991.)

kilograms of TP was discharged by municipal and industrial sources from the Atlanta area. The point source TP load has decreased about 63% since 1986 (EPD 1989). This decrease can be attributed to improved wastewater treatment by major dischargers in response to a 0.75 mg/l TP concentration limit imposed on major dischargers by EPD. This limit was to have been in effect by the end of 1991, but some dischargers were provided more time (1996) by the Georgia General Assembly to meet this phosphorus limit. Also contributing to the phosphorus decline was a statewide ban on the sale of high phosphate detergents enacted by the Georgia General Assembly in 1990.

The major municipal discharger of TP was the R. M. Clayton water pollution control plant (WPCP) contributing an estimated 246,870 kilograms of TP during the study year which was 48% of the total point source phosphorus load (Figure 8-5). Two other facilities, R. L. Sutton WPCP and South River WPCP discharged an estimated 12% (60,521 kilograms) and 15% (74,144 kilograms), respectively, of the TP point source load. Forty-one other municipal plants discharged an estimated 129,166 kilograms which was about 25% of the total point source phosphorus load. The mean, flow-weighted, TP concentration for municipal wastewater effluent was 1.50 mg/l during the study year. The three largest municipal facilities, R. M. Clayton WPCP, R. L. Sutton WPCP and South River WPCP had a mean TP concentration during the study year of 2.11, 1.51 and 1.35 mg/l, respectively.

A crude estimate of the annual loading of TP, TSS, BOD and TN was calculated using FLUX and the water quality data gathered at Franklin from November 1990 through October 1991 (Table 8-3). The nonpoint source load was estmated by subtracting the known point source load from the estimated total load. Most of the point source load originates about 110 km upstream near Atlanta and under low to normal flow conditions some of those materials,

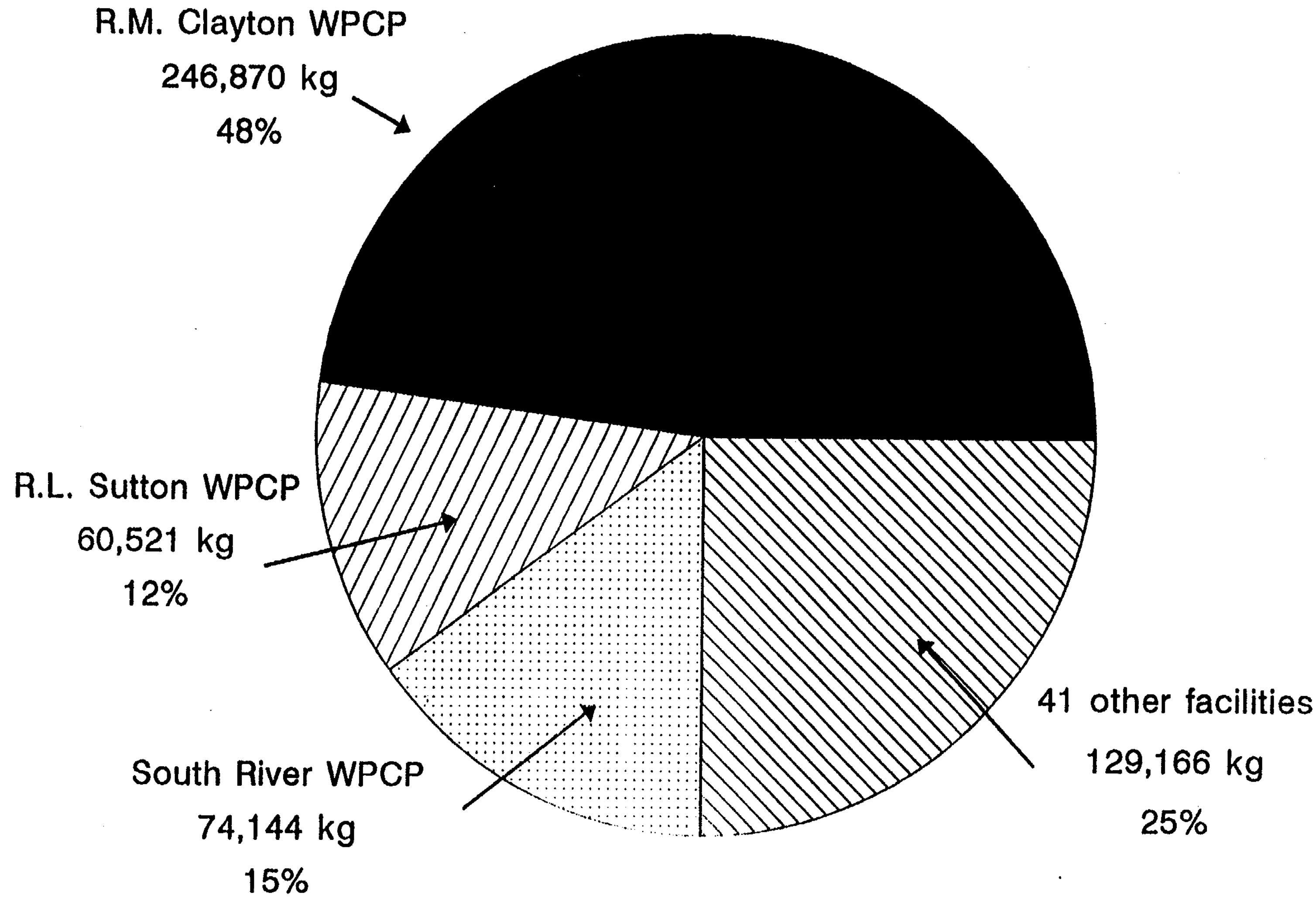

Figure 8-5. Total phosphorus point source loading from municipal facilities during diagnostic study of West Point Lake, November 1990 - October 1991.

Table 8-3. Estimated loading rates using FLUX and estimated point source loading entering the lake from above Franklin, Georgia during the diagnostic study of West Point Lake, November 1990 - October 1991.

Variable	Total Load	Point-source Load	Non-point Source Load
Total Phosphorus (kg/yr)	726,376	507,223	219,153
Total Suspended Solids (Metric tons/yr)	189,987	4,955	185,032
Biochemical Oxygen Demand (Metric tons/yr)	5,680	2,010	3,670
Total Nitrogen (kg/yr)	5,531,844	*	*

* = Information not available.

particularly TP and TSS, would be temporarily stored in stream organisms or stream sediment (Garman et al. 1986). Stream retention of phosphorus is important from the aspect of timing of phosphorus availability to lakes. EPD (1989) estimated TP reduction of about one-third between Atlanta and Franklin due to instream processes occurring under low-flow conditions. Under elevated flows, however, materials are moved swiftly downstream into the lake and any sediment or nutrient accumulation occurring under low-flow would be delivered to the lake. Permanent losses of nutrient or sediment can occur if streams overflow their banks and deposit materials on the floodplain (Garman et al. 1986); however, the Chattahoochee River did not flood during the study year but did maintain flows about six percent above normal.

Point sources accounted for 70% of the phosphorus entering the lake (Table 8-3). Point source BOD accounted for 35% of the total loading and point source TSS comprised only 3% of the total loading. An estimated 5,531,844 kilograms of TN entered the lake during the study year. Dischargers are not required to monitor TN, so no comparison of point source load to total loading could be determined for TN.

Variations in estimated monthly total loading of TP, TSS and BOD were related to changes in Chattahoochee River discharge (Figures 8-6, 8-7 and 8-8). Total loading for all three variables were highest in May and closely correlated with discharge. Point source loading of TP was relatively constant, about 42,000 kilograms per month (Figure 8-6). The TP loading appeared to be point source dominated for 4 months. Point source BOD loading was lower in the summer months probably because some dischargers reduced BOD effluent concentrations during the warmer summer months (Figure 8-8). The TSS point source load was low compared to overall loading. Point source load accounted for about 3% of the total load

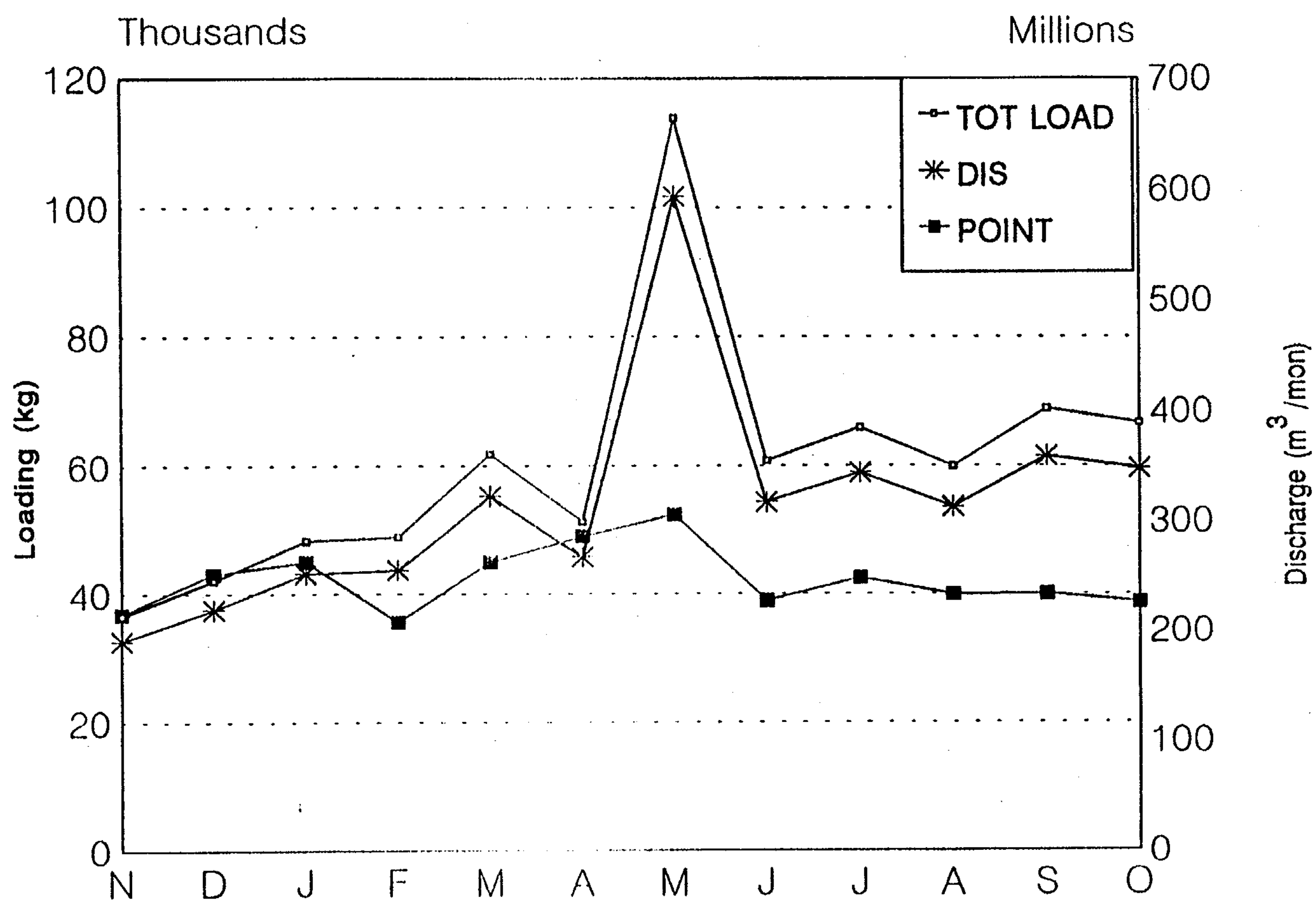

Figure 8-6. Estimated monthly discharge (DIS) and total loading of total phosphorus (TOT LOAD) and point source load (POINT) into West Point Lake (Franklin, GA) during diagnostic study, November 1990 - October 1991.

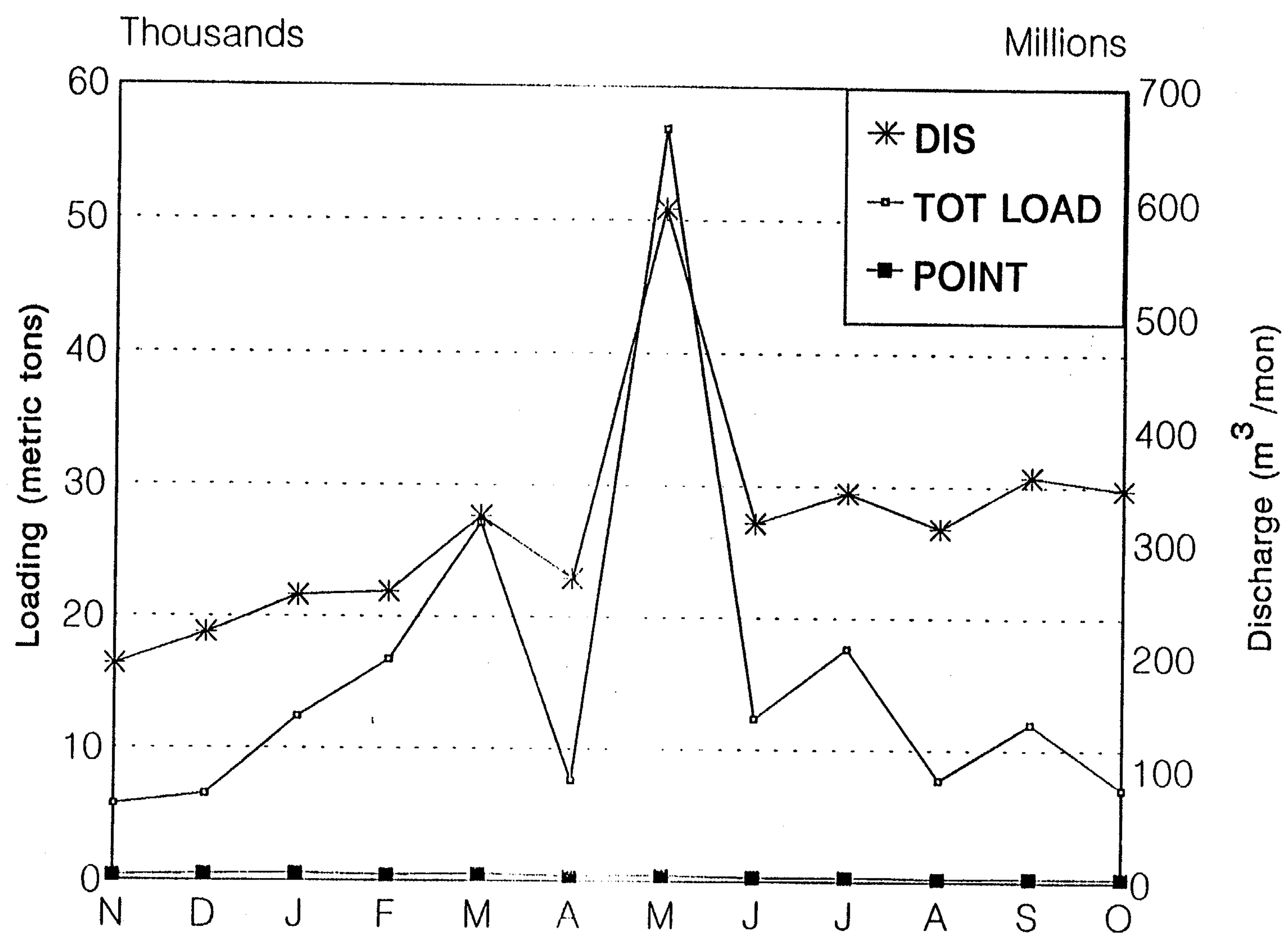

Figure 8-7. Estimated monthly discharge (DIS) and total loading of total suspended solids (TOT LOAD) and point source load (POINT) into West Point Lake (Franklin, GA) during diagnostic study, November 1990 - October 1991.

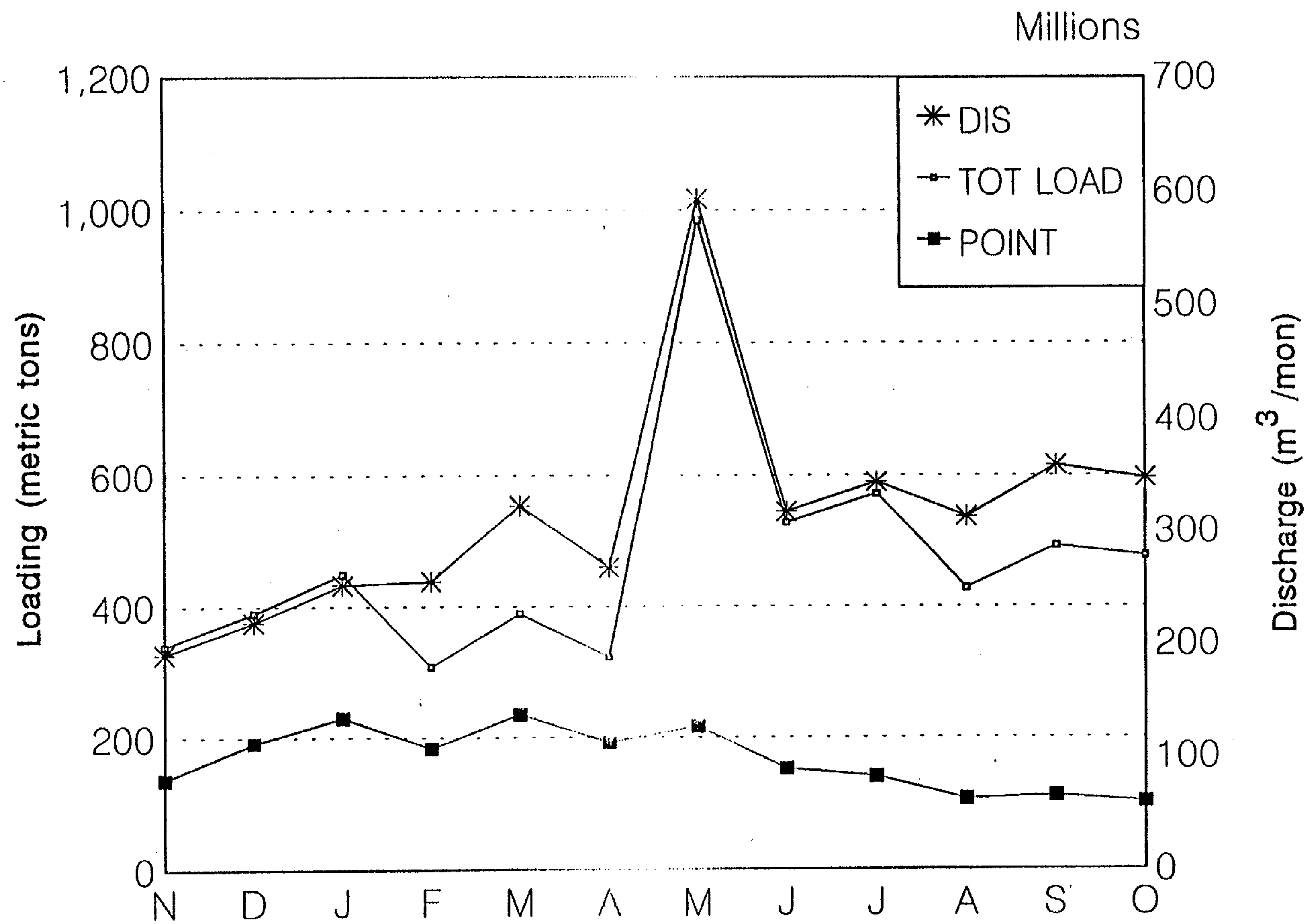

Figure 8-8. Estimated monthly discharge (DIS) and total loading of biochemical oxygen demand (TOT LOAD) and point source load (POINT) into West Point Lake (Franklin, GA) during diagnostic study, November 1990 - October 1991.

9.0 NON-POINT SOURCE POLLUTION INVENTORY.

Five tributary streams (Table 9-1 and Figure 9-1) were sampled twenty-one times from November 1990 through October 1991. Streams were sampled twice monthly from December through May, and once monthly from June through October. In addition, samples were collected after three significant rainfall events. Replicate water samples were collected with a van Dorn water sampler and placed in Nalgene bottles for transport to laboratory facilities at Auburn University. Water samples used to estimate total suspended solids concentrations were collected with a depth-integrated, suspended-sediment sampler using methods described by Edwards and Glysson (1988). Water samples were analyzed for total phosphorus (TP), orthophosphate, nitrate-nitrogen, nitrite-nitrogen, total ammonia nitrogen, total Kjeldahl nitrogen (TKN), alkalinity, specific conductance and total suspended solids (TSS) utilizing methods described in Table 10-3. Stream discharge, temperature and dissolved oxygen were measured *in situ* at each stream on all sampling dates. Temperature and dissolved oxygen were measured using a Yellow Springs Instrument model 51B dissolved oxygen meter and current velocity was determined using a Marsh-McBirney model 201D flowmeter. Discharge for ungaged streams was calculated by summing the average velocity times the depth for each transect across the stream.

The Tennessee Valley Authority (TVA) Remote Sensing Unit, Maps and Surveys Department, determined landuse/landcover and livestock operations for the West Point Lake drainage area from U.S. Highway 27 bridge at Franklin, Georgia to the West Point Dam. TVA used 1988 low altitude color infrared aerial photography (nominal scale of 1:24,000) (Appendix 9). The watershed was divided into subwatersheds (nodes) based on tributary drainage patterns (Figure 9-2 and Appendix 9).

Table 9-1. Location of tributary sampling sites for nonpoint source pollution assessment of West Point Lake watershed during the diagnostic study, November 1990-October 1991.

Stream	Station	Description
New River	14	Georgia Highway 100 Bridge
Yellowjacket Creek	13	Hammett Road Bridge
Dixie Creek	12	Georgia Route 219 Bridge
Veasey Creek	16	Alabama Highway 263 Bridge
Wehadkee Creek	15	Bridge off Alabama Highway 16

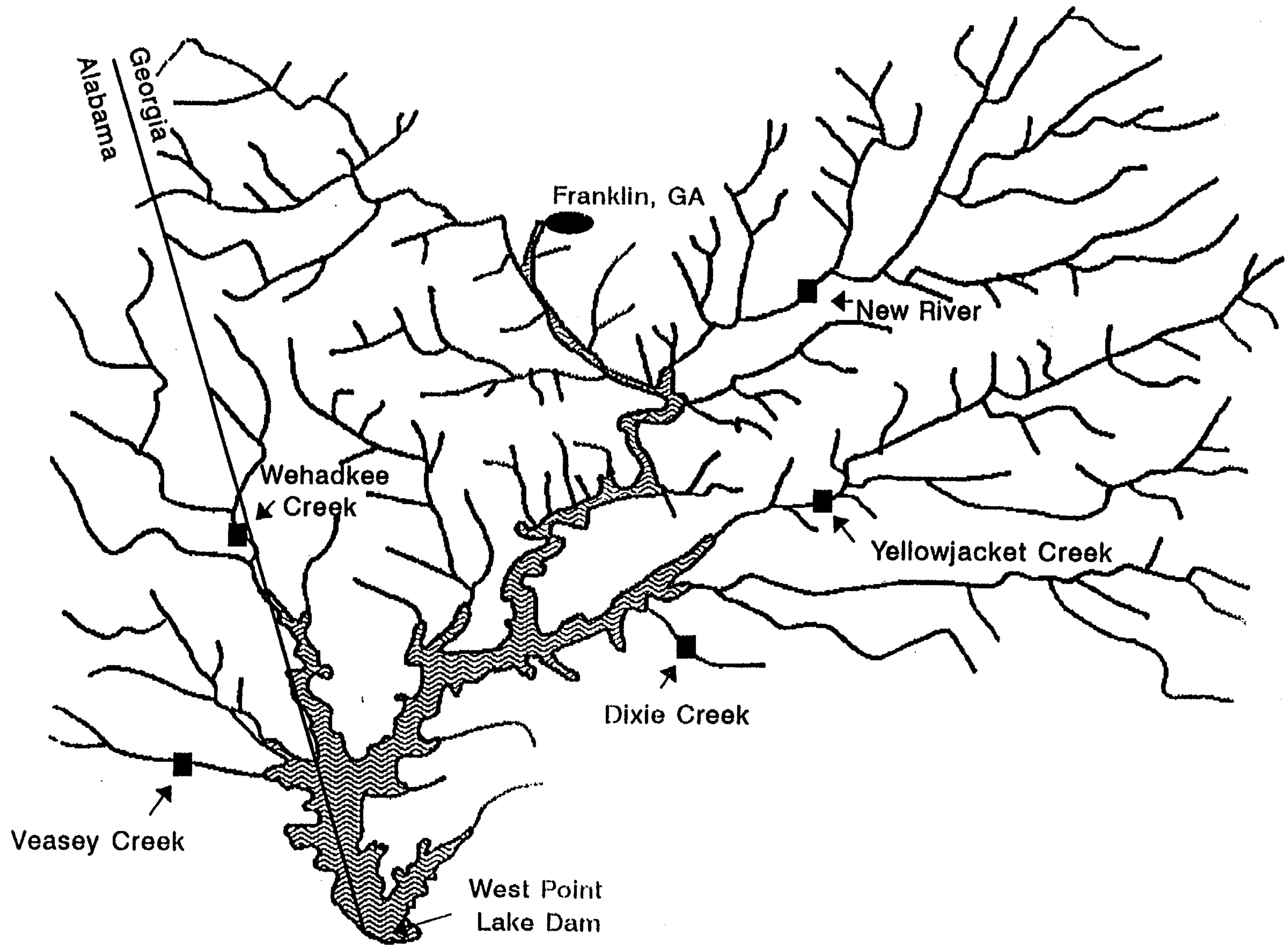

Figure 9-1. Sampling locations (■) of tributary streams on West Point Lake during diagnostic study, November 1990 - October 1991.

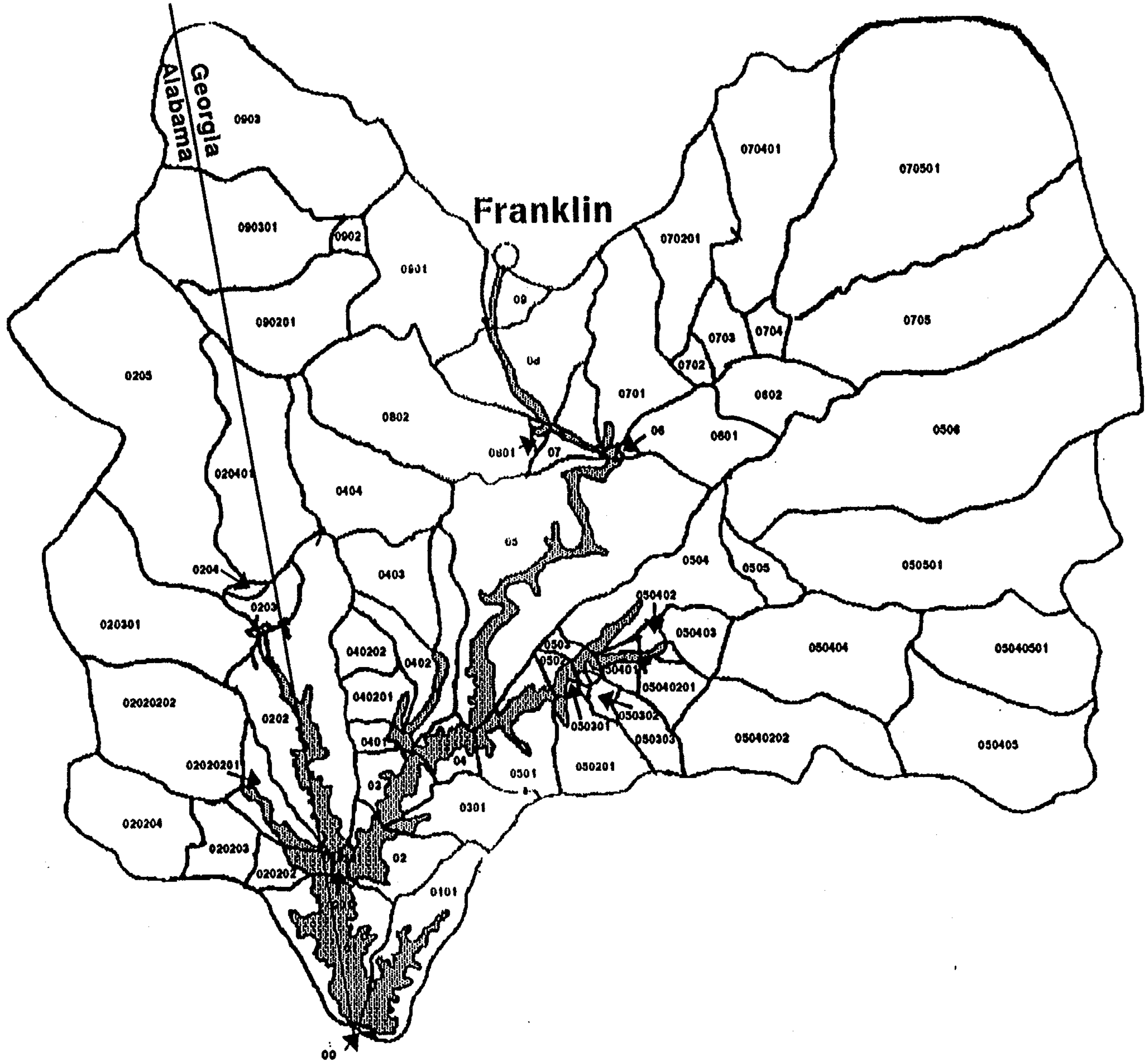

Figure 9-2. Node location of subwatersheds for aerial anaylsis of West Point Lake during diagnostic study, November 1990 - October 1991.

Total loading (point and nonpoint) of five tributary streams for TP, TN, total inorganic nitrogen (TIN) and TSS were determined using FLUX (Walker 1986). FLUX is a computer program designed to estimate nutrient loadings from grab-sample concentration data and continuous flow records using various calculation methods and stratification schemes which permit quantifications of potential errors. To estimate a continuous flow (mean daily discharge) for an ungaged stream, discharge from the ungaged stream was regressed against discharge from a gaged stream for all sampling dates to determine the discharge relationship between the two streams. The mean daily discharges from the gaged stream were then placed into the regression formula to estimate a mean daily discharge for the ungaged stream.

A linear regression model using landuse/landcover and estimated nonpoint source loading for five tributary streams was used to estimate the nonpoint source TP and TSS loading. The twelve landuse/landcover categories (Table 9-2) were consolidated into five categories: urban (1 and 1235), meadow (2, 750, 751, 761 and 762), pasture (21), forest (4 and 45) and agriculture (210) for the analysis. The nonpoint source loadings for each of the five tributary streams were determined by subtracting the point source load from the estimated total load (from FLUX).

Forest land comprised 143,766 hectares (73%) of the total watershed area of 196,678 hectares (Table 9-2). Eleven percent (20,796 hectares) of the landuse was meadow and 3% (6,523 hectares) was pasture. Water accounted for 11,193 hectares (6%) of which 10,200 hectares was the lake. Major tributary watershed area varied from 1,009 hectares in Dixie Creek to 39,909 hectares in New River (Table 9-3). About 83% of the watershed area was in Georgia and 17% was in Alabama.

Table 9-2. Landuse/landcover categories, description and acreage by state for aerial photography analysis of West Point Lake watershed during the diagnostic study, November 1990-October 1991.

Landuse Class Category	Landuse Class Description	Alabama Area (Hectares)	Georgia Area (Hectares)	Total Area (Hectares)
1	Urban and built-up	375	5,364	5,739
1235	Water pollution control plant	0	2	2
2	Meadow	5,740	15,056	20,796
21	Pasture	1,215	5,308	6,523
210	Agriculture	29	148	177
4	Forest	25,109	118,657	143,766
45	Clear-cut forest	580	7,591	8,171
5	Water	1,144	10,049	11,193
750	Barren land-active	3	19	22
751	Barren land-abandoned	13	214	227
761	Disturbed area, little or no cover, non-agricultural area w/o sediment control	0	19	19
762	Disturbed area, little or no cover, non-agricultural area with sediment control	6	37	43
Total		34,214	162,464	196,678

Table 9-3. Landuse/landcover area for major tributaries in West Point Lake watershed during diagnostic study, November 1990-October 1991.

Tributary	Urban (Ha)	Meadow (Ha)	Pasture (Ha)	Agriculture (Ha)	Forest (Ha)	Clear-cut Forest (Ha)	Water (Ha)	Barren Land (active) (Ha)	Barren Land (abandoned) (Ha)	Disturbed Land (Ha)	Total (Ha)
Veasey Cr	4	610	200	1	3,594	5	366	0	0	0	4,780
Wehadkee Cr	448	4,479	773	24	19,880	417	1,189	3	13	4	27,230
Stroud Cr	36	887	209	2	3,942	46	330	0	0	0	5,452
Whitewater Cr	16	298	0	0	7,068	478	373	19	0	0	8,252
Brush Cr	1	417	113	0	4,682	427	93	20	0	0	5,753
Hillabahatchee Cr	39	2,440	391	6	17,029	429	90	194	0	2	20,620
New River	1,594	3,805	1,707	52	28,864	3,206	653	0	0	28	39,909
Yellowjacket Cr	1,337	3,828	1,423	54	20,792	1,232	1,278	0	0	0	29,944
Potato Cr	0	504	130	0	3,225	679	76	0	0	0	4,614
Beech Cr	161	1,215	768	18	12,623	608	333	0	0	0	15,726
Shoal Cr	710	485	90	0	3,344	71	41	19	0	0	4,760
Dixie Cr	463	50	30	0	440	1	25	0	0	0	1,009

A total of 227 livestock operations (75% located in Georgia) were identified (Table 9-4). Non-dairy cattle sites were most numerous, 186, followed by horse and poultry operations with 17 and 19 sites, respectively. Over 30 non-dairy cattle sites were located on each of three watersheds, New River, Yellowjacket Creek and Wehadkee Creek (Table 9-5). New River had the most livestock operation sites with 53 sites.

New River had the highest loading of TP, TN and TIN of the five tributary streams sampled (Table 9-6). TSS loading varied from 11 metric tons for Dixie Creek to 2,119 metric tons for Yellowjacket Creek. The ratio of TN to TP loading varied from about 10:1 for New River, Yellowjacket Creek and Wehadkee Creek to 41:1 for Dixie Creek. The percentage of TIN to TN varied from 37% for New River and Wehadkee Creek to 83% for Dixie Creek.

Estimated monthly loading of TP, TSS, TN and TIN was highest in May for all five tributary streams (Figure 9-3, 9-4, 9-5, 9-6 and 9-7). Loading was closely correlated with stream discharge. TP loading appeared to be point source dominated for 5 of the 12 months in New River and Yellowjacket Creek (Figure 9-3 and 9-4). TSS loading from point sources accounted for less than 3% of the total load in New River, Yellowjacket Creek and Wehadkee Creek (Table 9-7). Point sources accounted for 36% and 46% of the TP load in New River and Yellowjacket Creek, respectively.

Forest land area in the five tributary stream watersheds accounted for most of the variation (R^2 = .99) in nonpoint source TP loading. The formula,

$$TP\ (kg/yr) = \text{area of forest land (hectares)} \times 0.128$$

was used to estimate nonpoint source TP loading of the lake from the watershed. Estimated nonpoint source TP loading from the watershed was 19,402 kg (Table 9-8). An estimated 21% of the nonpoint source TP loading was from the New

Table 9-4. Livestock operation categories, description and number of sites by state for aerial photography analysis of West Point Lake watershed during diagnostic study, November 1990-October 1991.

Livestock Operation Categories	Livestock Operation Description	Alabama		Georgia		Total	
		Number of Sites	Number of Poultry Houses	Number of Sites	Number of Poultry Houses	Number of Sites	Number of Poultry Houses
C	Non dairy cattle	48	*	138	*	186	*
D	Dairy cattle	0	*	5	*	5	*
H	Horse	0	*	17	*	17	*
P	Poultry	9	17	10	13	19	30
Total		57	17	170	13	227	30

* = Not applicable

Table 9-5. Livestock operations for major tributaries in West Point Lake watershed during diagnostic study, November 1990-October 1991.

Tributary	Area (Hectares)	Non-dairy Cattle Sites	Dairy Sites	Horse Sites	Poultry Sites	Number of Poultry Houses
Veasey Creek	4,780	8	0	0	0	0
Wehadkee Creek	27,230	34	0	0	1	2
Stroud Creek	5,452	4	0	0	1	1
Whitewater Creek	8,252	0	0	0	0	0
Brush Creek	5,753	3	0	1	0	0
Hillabahatchee Cr	20,620	17	0	0	4	8
New River	39,909	38	2	13	0	0
Yellowjacket Creek	29,944	36	1	2	1	2
Potato Creek	4,614	2	0	0	4	6
Beech Creek	15,726	15	0	0	4	6
Shoal Creek	4,760	3	0	1	0	0
Dixie Creek	1,009	1	0	0	0	0

Table 9-6. Estimated total loading of TP, TN, TIN and TSS from point and nonpoint sources in five tributary streams entering West Point Lake during the diagnostic study, November 1990-October 1991.

Stream	Average Flow (cfs)	Total Phosphorus (kg)	Total Nitrogen (kg)	Total Inorganic Nitrogen (kg)	Total Suspended Solids (Metric tons)
New River	140.87	5,589	55,113	21,348	1,829
Yellowjacket Creek	93.53	4,093	38,137	17,493	2,119
Dixie Creek	2.75	42	1,734	1,427	11
Veasey Creek	8.90	133	2,561	1,040	37
Wehadkee Creek	48.33	1,152	15,019	5,554	560

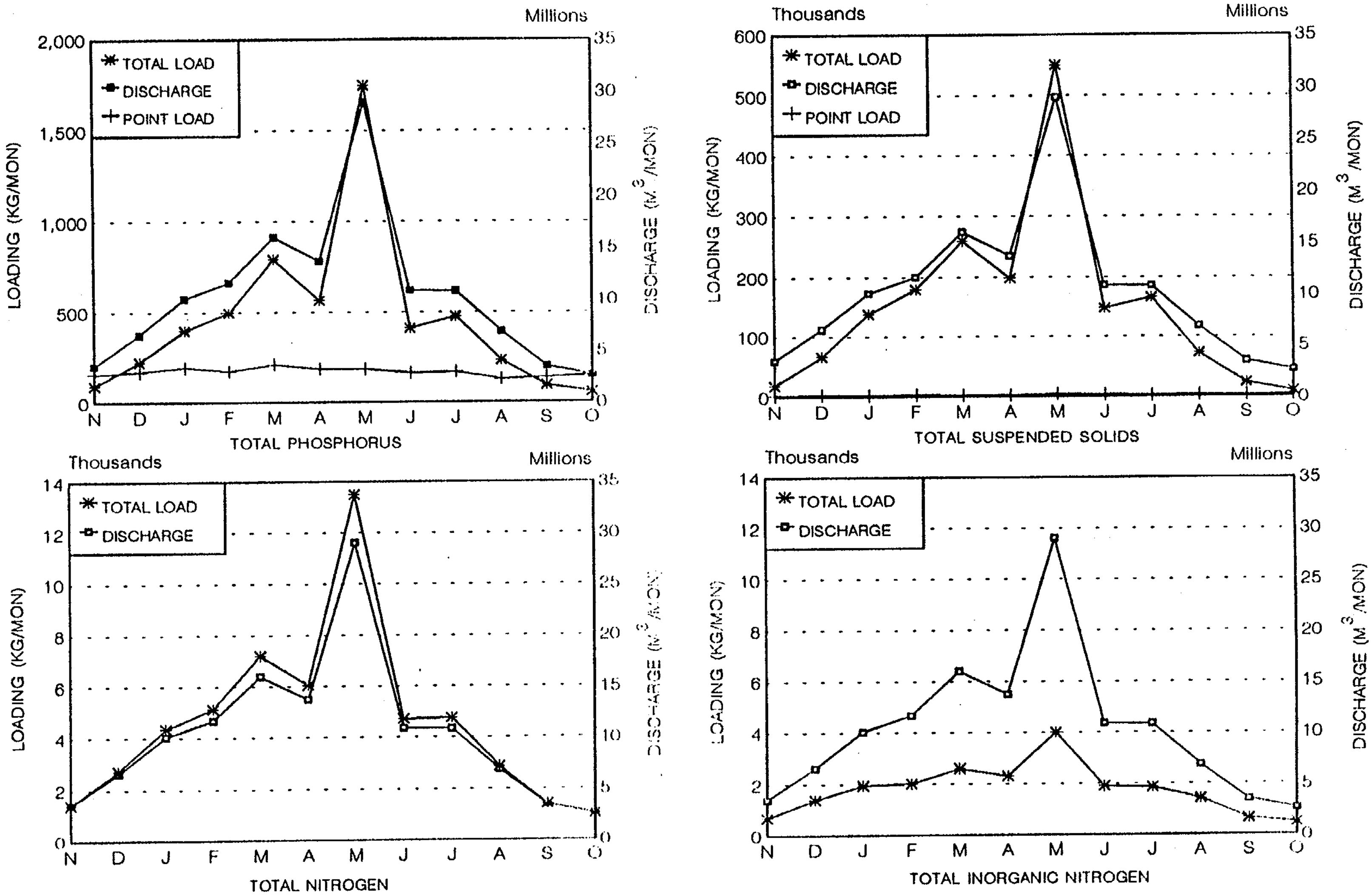

Figure 9-3. Estimated total loading per month of total phosphorus, total suspended solids, total nitrogen and total inorganic nitrogen and point source loads for sampling location at New River during diagnostic study of West Point Lake, November 1990 - October 1991.

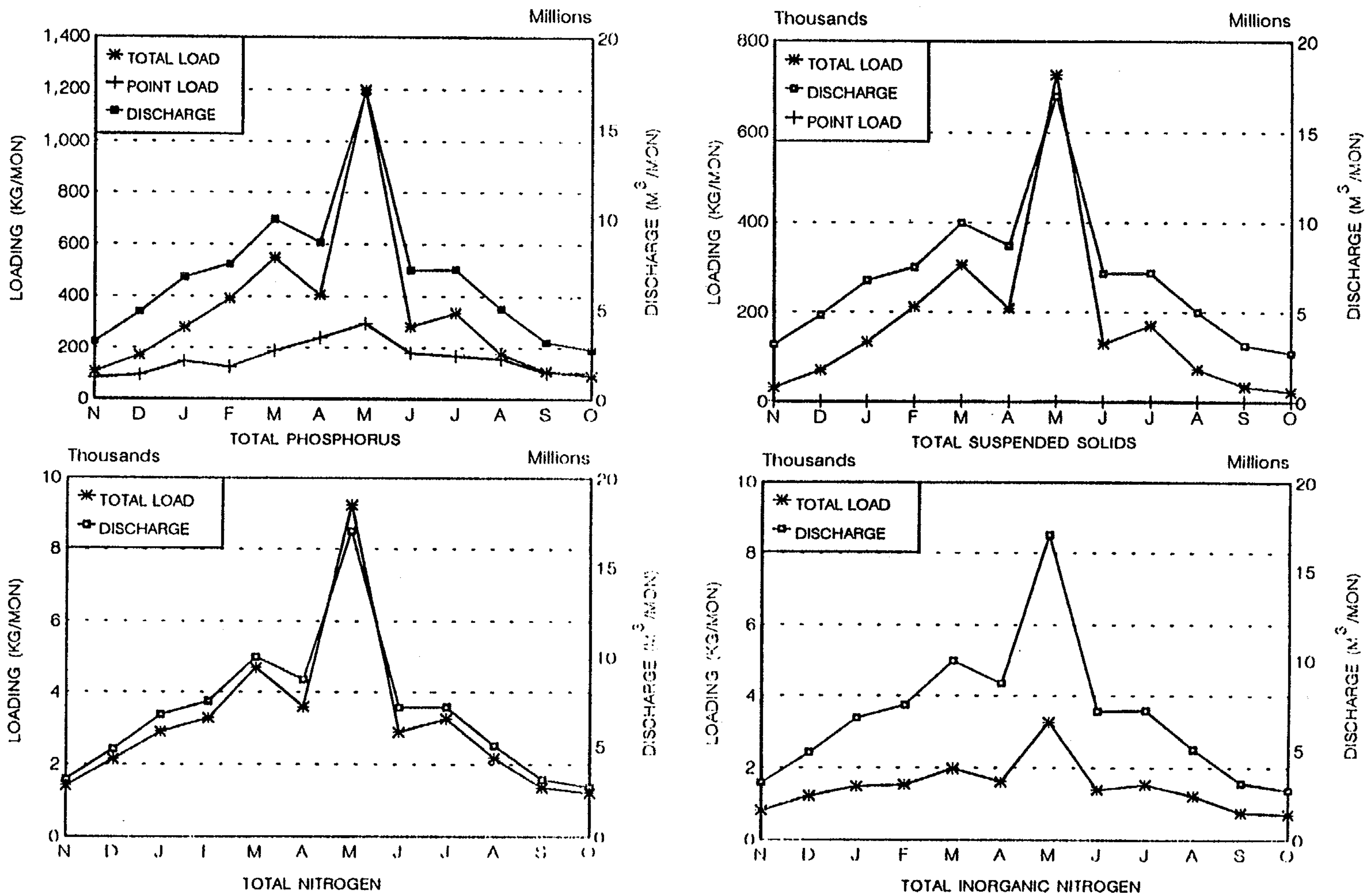

Figure 9-4. Estimated total loading per month of total phosphorus, total suspended solids, total nitrogen and total inorganic nitrogen and point source load for sampling location at Yellowjacket Creek during diagnostic study of West Point Lake, November 1990 - October 1991.

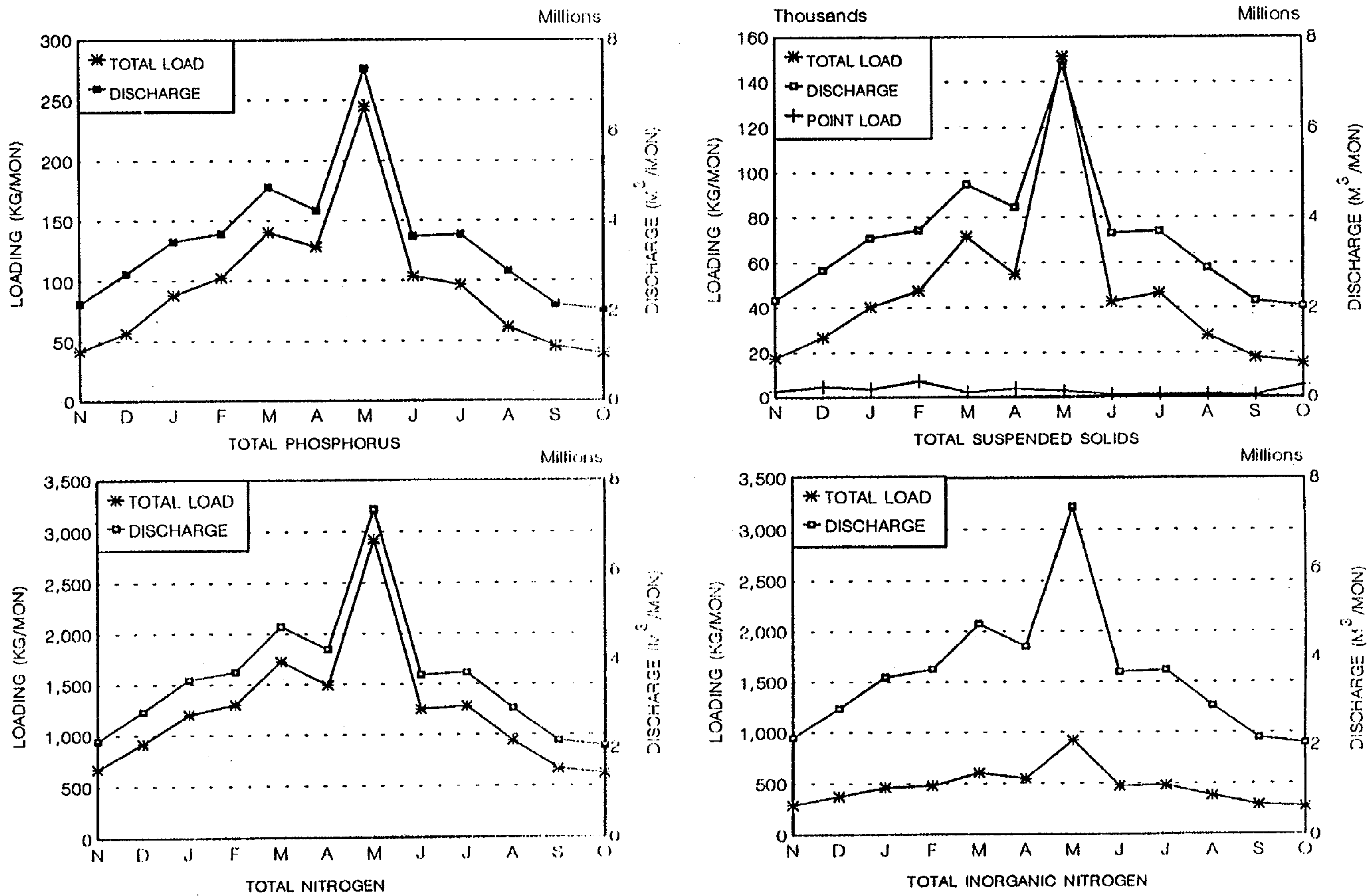

Figure 9-5. Estimated total loading per month of total phosphorus, total suspended solids, total nitrogen and total inorganic nitrogen and point source load for sampling location at Wehadkee Creek during the diagnostic study of West Point Lake, November 1990 - October 1991.

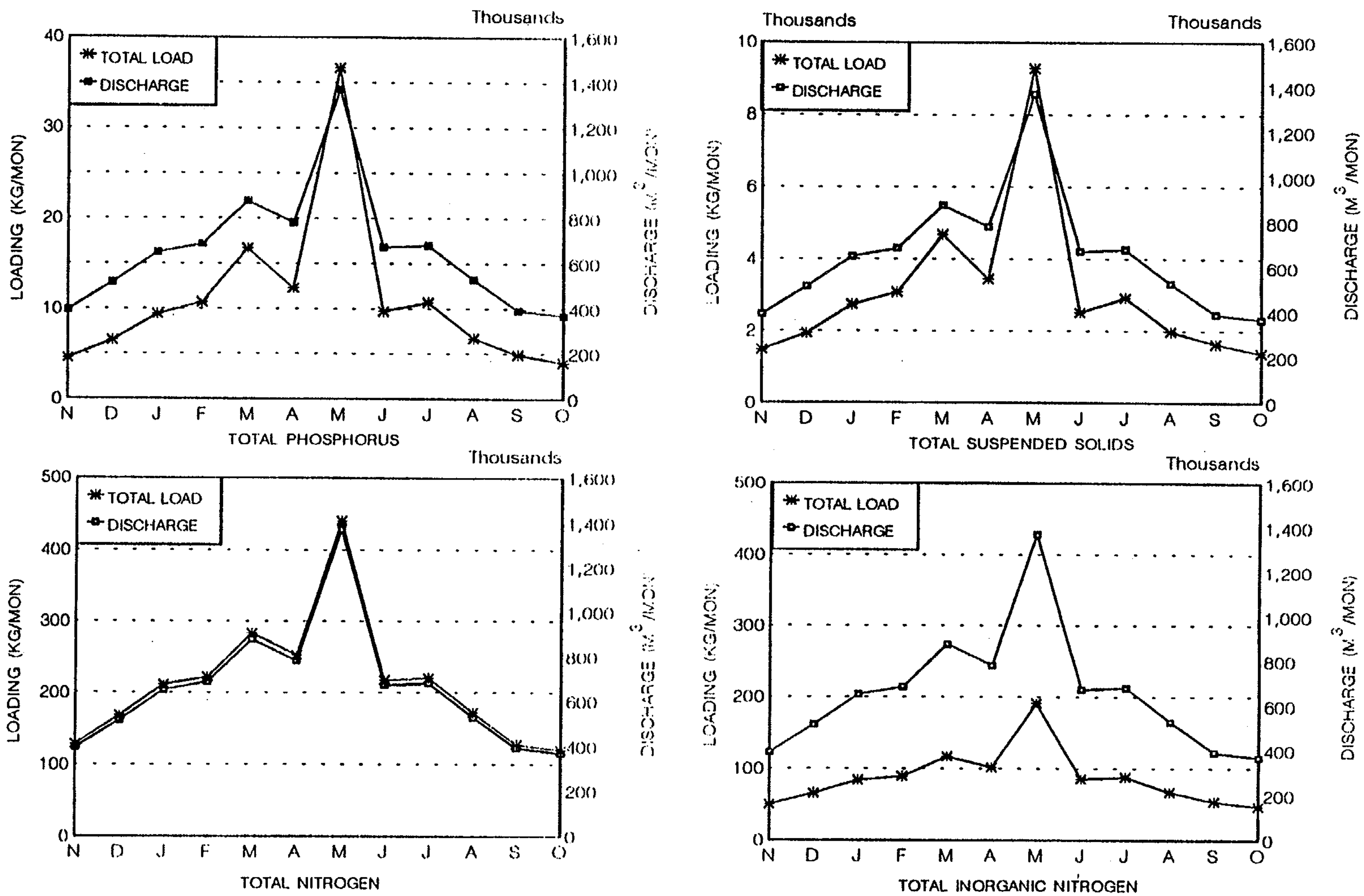

Figure 9-6. Estimated loading per month for total phosphorus, total suspended solids, total nitrogen and total inorganic nitrogen for sampling location at Veasey Creek during diagnostic study of West Point Lake, November 1990 - October 1991.

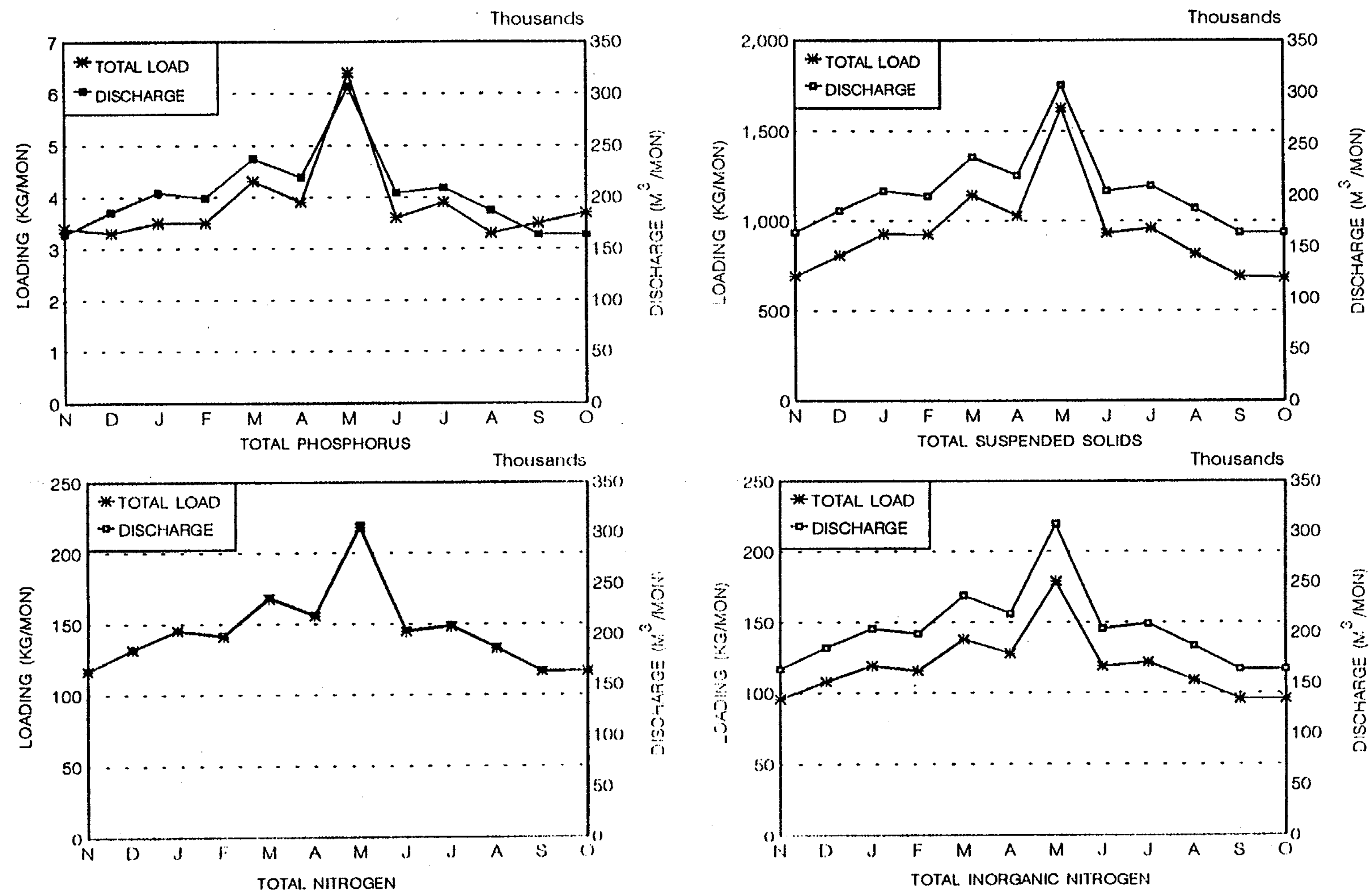

Figure 9-7. Estimated total loading per month of total phosphorus, total suspended solids, total nitrogen and total inorganic nitrogen for sampling location at Dixie Creek during diagnostic study of West Point Lake, November 1990 - October 1991.

Table 9-7. Estimated total loading, point source and nonpoint source loading of tributary streams sampled during the diagnostic study of West Point Lake, November 1990-October 1991.

Tributary	Total Loading	Point Source Pollution Loading	Non-point Source Pollution Loading
		Total Phosphorus (kg)	
New River	5,589	2,027	3,562
Yellowjacket Creek	4,093	1,873	2,220
		Total Suspended Solids (Metric tons)	
New River	1,829	15	1,814
Yellowjacket Creek	2,119	4	2,115
Wehadkee Creek	560	17	543

Table 9-8. Estimated nonpoint source total loading and loading from major tributaries for total phosphorus and total suspended solids in West Point Lake watershed during diagnostic study, November 1990-October 1991.

Tributary	Area (Hectares)	Total Phosphorus (kg)	Total Suspended Solids (Metric tons)
Veasey Creek	4,780	457	38
Wehadkee Creek	27,230	2,592	898
Stroud Creek	5,452	509	75
Whitewater Creek	8,252	964	0
Brush Creek	5,753	652	146[1]
Hillabahatchee Creek	20,620	2,229	224
New River	39,909	4,095	1,945
Yellowjacket Creek	29,944	2,812	2,020
Potato Creek	4,614	498	168[1]
Beech Creek	15,726	1,690	673
Shoal Creek	4,760	436	116[1]
Dixie Creek	1,009	56	39[1]
Others	28,629	2,412	279
Total Loading	196,678	19,402	6,621

[1]Based on alternate regression formula.

River subwatershed. Wehadkee Creek and Yellowjacket Creek accounted for 13% and 14%, respectively, of the total load. All nonpoint sources accounted for 32% of the TP entering West Point Lake (Table 9-9).

The amount of agricultural land in the five tributary basins accounted for most of the variation (R^2 = .99) in nonpoint source TSS loading. The formula,

TSS (metric tons/yr) = area of agriculture land (hectares) x 37.41

was used to estimated nonpoint source TSS loading to the lake from the adjoining watershed. Estimated nonpoint source TSS loading from the watershed was 6,621 metric tons (Table 9-8). Loading from Yellowjacket Creek and New River was 2,020 metric tons and 1,945 metric tons, respectively. On tributary watersheds where no agricultural land was present, an alternate formula,

TSS (metric tons.yr) = acreage of pasture (hectares) x 1.29

was used to estimate TSS load for those tributaries. This equation accounted for 95% (R^2 = 0.95) of the variation in TSS.

Nonpoint sources accounted for 97% of the TSS load entering West Point Lake. Sedimentation within the lake is being monitored by the Corps of Engineers, Mobile District. The initial survey was performed in 1978 with a resurvey in 1983. From the results of the two surveys, the depletion was 0.04% during the 5 year period. This depletion was considered minimal. A resurvey was scheduled for 1994, contingent upon available funding (personal communication, Benton Odom, Jr., Corps of Engineers).

Table 9-9. Estimated total loading, total point source loading and total nonpoint source loading for total phosphorus and total suspended solids during the diagnostic study of West Point Lake, November 1990-October 1991.

Tributary	Total Loading	Point Source Pollution Loading	Non-point Source Pollution Loading
		Total Phosphorus (kg)	
From Franklin, GA to headwaters	726,376	507,223	219,153
West Point Lake watershed	24,047	4,645	19,402
Total	750,423	511,868 (68%)	238,555 (32%)
		Total Suspended Solids (Metric tons)	
From Franklin, GA to headwaters	189,987	4,955	185,032
West Point Lake watershed	6,666	45	6,621
Total	196,653	5,000 (3%)	191,653 (94%)

10.0 WEST POINT LAKE LIMNOLOGY

10.1 WEST POINT LAKE LIMNOLOGICAL HISTORY

The planning of an impoundment on the Chattahoochee River at West Point, Georgia, 170 river km downstream from metropolitan Atlanta, attracted the attention of resource managers and scientists alike. Two preimpoundment studies were conducted independently, one by the Georgia Water Quality Control Board (Georgia Water Quality Control Board 1971) and the other by the U.S. Environmental Protection Agency (Schneider et al. 1972). Results of both studies revealed water quality problems associated with the effects of Atlanta-area pollution of the Chattahoochee River. Schneider et al. (1972) warned of accelerated eutrophication, bacterial contamination and problems associated with thermal and chemical stratification. They recommended a postimpoundment study be conducted.

A postimpoundment study, conducted in 1975, confirmed that nutrient enrichment was a serious problem in West Point Lake (Vick et al. 1976). Algal growth potential test results ranked West Point Lake among the more highly productive lakes in the nation. Predictive models using phosphorus loading indicated that the lake would become highly eutrophic. Elevated iron and manganese concentrations in the tailwaters had created problems for downstream water users. Bacterial quality of the lake and tailwaters was good and pesticide and toxic metals were not considered a major problem at that time.

From 1976 through 1984, the Department of Fisheries and Allied Aquacultures, Auburn University (AU) under contract with the U.S. Army Corps of Engineers (COE) conducted fisheries and limnological studies of West Point Lake. Results of these studies were submitted to the COE in the form of seven final reports (Davies et al. 1979a, Davies et al. 1979b, Shelton et al. 1981, Lawrence et al. 1982, Bayne et al. 1983, Davies et al. 1984 and Bayne et al. 1986). Much of the limnological information gathered as a result of those studies appears in two publications, Bayne et al. (1983) and Bayne et al. (1990). Based on phytoplankton primary productivity, the lake, as a whole, remained mesotrophic (<1,000 $mgC/m^2 \cdot day$) from 1976 through 1981 although areas of the lake during the growing seasons would far exceed eutrophic conditions at times. From 1982 through 1985 the entire lake increased in primary productivity, far exceeding the eutrophic threshold. Since 1985, studies conducted by the U.S. Environmental Protection Agency (EPA), Georgia Department of Natural Resources, Environmental Protection Division (EPD) and AU have revealed accelerated eutrophication of West Point Lake (Raschke 1987, EPA-EPD 1987 and 1988, EPD 1989a and EPD 1989b).

On 19 July, 1988, a fish-kill occurred downstream from West Point Dam. About that same time, taste and odor problems developed in drinking water supplies taken from the Chattahoochee River downstream from the dam. Both problems apparently resulted from anaerobic conditions existing in the lake hypolimnion at the time. EPD and AU personnel documented water quality conditions in the lake near the dam after the fish kill. Penstock openings draw water from a depth of greater than 17m. There was no dissolved oxygen in the water column below a depth of 4 m on 21 July 1988. These events and others focused much public and news media attention on the condition of West Point Lake. In November 1988, Congressman Richard Ray, 3rd District Georgia, called a public meeting for the purpose of presenting information, from many sources, on the condition of West Point Lake. Congressman Ray later formed a West Point Lake Task Force to deal with the issues related to West Point Lake on a continuing basis.

Using various models several efforts have been made to predict the magnitude of nutrient loading reduction necessary to halt the eutrophication of

West Point Lake and improve water quality (Raschke 1987, EPD 1989b and Gaugush 1989). As a result, EPD has recommended a phosphorus effluent limitation of 0.75 mg/l at major wastewater treatment facilities upstream of West Point Lake. This is expected to result in a maximum mean chlorophyll a concentration of 27 μg/l at the LaGrange, GA water intake under low-flow conditions similar to those experienced in 1987 and 1988 (EPD 1989b). Using a different model, Gaugush (1989) predicted that an 80% reduction in phosphorus loads (under 1987 conditions) would be required just to shift the system into phosphorus limitation.

Studies conducted by the U.S. Geological Survey also revealed elevated plant nutrient concentrations and signs of advancing eutrophication (Stamer et al. 1978 and Radtke et al. 1984). In a rather intensive study of West Point Lake conducted from April 1978-December 1979, Radtke et al. (1984) also reported relatively high concentrations of chlordane and PCB's (polychlorinated biphenyls) in sediment samples as well as in young bullhead catfish and largemouth bass. Studies conducted by EPD in 1990 revealed that West Point Lake fish consistently contained concentrations of chlordane, PCB's and DDE (DNR News Release 1991). Concentrations of chlordane in fish edible portions exceeded the Food and Drug Administration standards for that compound and a fish consumption advisory was issued recommending that people not eat certain species of fish taken from the Chattahoochee River south of Atlanta. On 3 March 1991, Alabama, citing the Georgia data, extended the consumption advisory to the Alabama portion of West Point Lake and downstream through Lake Harding (Alabama Department of Public Health, News Release, 3 March, 1991).

In 1989, EPD published a comprehensive action plan to address the problems encountered in the reach of the Chattahoochee River between Buford Dam (Lake

Lanier) and West Point Dam (EPD 1989c). Problem areas discussed included: point source pollution, non-point source pollution, combined sewer overflows, toxic substances, meeting existing water quality standards and future water supply demands.

10.2. CURRENT LIMNOLOGICAL CONDITION

From June 1990 through October 1992, West Point Lake was sampled and monitored to provide data on the current limnological condition of the Lake. Auburn University (AU) conducted independent research from June through October 1990. From November 1990 through October 1991 a Phase I, Clean Lakes, Diagnostic/Feasibility Study was conducted by AU, LaGrange College and the University of Georgia (UGA) under contract with the Georgia Department of Natural Resources (GDNR). A second Phase I Study was carried out from November 1991 through October 1992 by AU under contract with the Alabama Department of Environmental Management (ADEM). The Callaway Foundation of LaGrange, Georgia provided matching funds for both of the Phase I studies. Others providing data used in this lake assessment included the U.S. Environmental Protection Agency (EPA), GDNR-Environmental Protection Division (EPD), ADEM, U.S. Corps of Engineers (COE), the U.S. Geological Survey (USGS) and the LaGrange, Georgia Water Department.

10.2.1 LAKE WATER QUALITY

West Point Lake was visited at least monthly (biweekly during the growing season) from June 1990 through October 1992 (Table 10-1). During the 1990 growing season (April - October) EPD sampled West Point Lake monthly at six locations between Franklin, GA and West Point Dam (Table 10-2). Their findings

Table 10-1. Schedule of activities for the diagnostic study of West Point Lake, June 1990 - October 1992.

	Year																												
	1990							1991												1992									
Variable	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Water Quality	x	x	x	x	x	x	x	x	x	x	xx	xx	xx	xx	xx	xx	xx	x	x	x	x	x	xx	xx	xx	xx	xx	xx	xx
Phytoplankton	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chlorophyll a	x	x	x	x	x	x	x	x	x	x	xx	xx	xx	xx	xx	xx	xx	x	x	x	x	x	xx	xx	xx	xx	xx	xx	xx
Algal Growth Potential											x		x		x		x						x		x	x	x		x
Primary Productivity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fecal coliform						x	x	x	x	x	x	x	x	x	x	x	x												
Sediment Oxygen Demand																													x
Tributary Sampling						x	xx	xx	xx	xx	xx	xx	xx	x	x	x	x	x											
Macrophyte Survey																												x	
Land Use/Cover										----	----	----	----	----	----	----	----	----	----	----	----								
Trihalomethane		x			x				x			x			x			x				x	x						x
Toxics																													x
Fish Health																													

Table 10-2. Location of sampling stations for the diagnostic study of West Point Lake, 1990-1992.

Sampling Station	Description
1*	Chattahoochee River at U.S. Highway 27, Franklin, Georgia - River kilometer 378.0
2	Chattahoochee River just downstream of the confluence with New River - River kilometer 368.1
3	New River embayment
4*	West Point Lake downstream of Georgia Highway 219 bridge - River kilometer 355.0
5*	West Point Lake at City of LaGrange water intake - River kilometer 346.8
6	Yellowjacket Creek embayment
7*	West Point Lake just upstream of Georgia Highway 109 - River kilometer 339.1
8	Wehadkee Creek embayment
9*	West Point Lake near buoy 22 (off Rocky Point)
10*	West Point Lake in the dam forebay - River kilometer 324.1
11	Chattahoochee River below West Point Dam - River kilometer 323.9

* Stations sampled monthly by EPD during the periods April through October of 1991 and 1992.

were presented in an agency report (EPD 1990). From June through October 1990, AU also conducted monthly studies at 11 sampling sites throughout the lake (Table 10-2, Figure 10-1, Appendix 1, Table 10-1). Those data are reported in this document. From November 1990 through October 1992 all limnological data gathered by EPD and AU were included in this document. EPD continued to sample six locations monthly from April through October during 1991 and 1992 (Table 10-2). AU sampled 11 locations monthly during that time as well as sampling stations 1, 2, 3, 6, 8 and 11 (stations not sampled by EPD) coincident with EPD sampling trips during the 1991 growing season.

EPD and AU sampling and analytical methods were similar, although some differences will be noted. Methods used to measure water quality variables appear in Table 10-3.

At each sampling station (except tailwater station 11) *in situ* measurements of temperature, pH, dissolved oxygen (DO) and specific conductance were made throughout the water column with a Hydrolab® Surveyor II (Table 10-3). Sampling was usually conducted from mid-morning to mid-afternoon. Secchi disk visibility was measured and the 1% incident light depth was determined with a submarine photometer (EPD used a radiometer). At station 11 surface water temperature, pH, DO and specific conductance were measured next to the river bank.

Previous studies of West Point Lake have revealed marked seasonal changes in water quality caused by seasonal variations in temperature, precipitation and solar radiation (Bayne et al. 1983 and Bayne et al. 1990). Monthly variations in meteorological conditions and discharge from June 1990 through October 1992 are summarized in Table 10-4 and Figure 10-2. During the 29 month study, the weather was warmer (monthly mean +0.58 °C) and drier (monthly mean -1.40 cm) than normal although monthly and seasonal exceptions to this pattern were common. To

WEST POINT LAKE

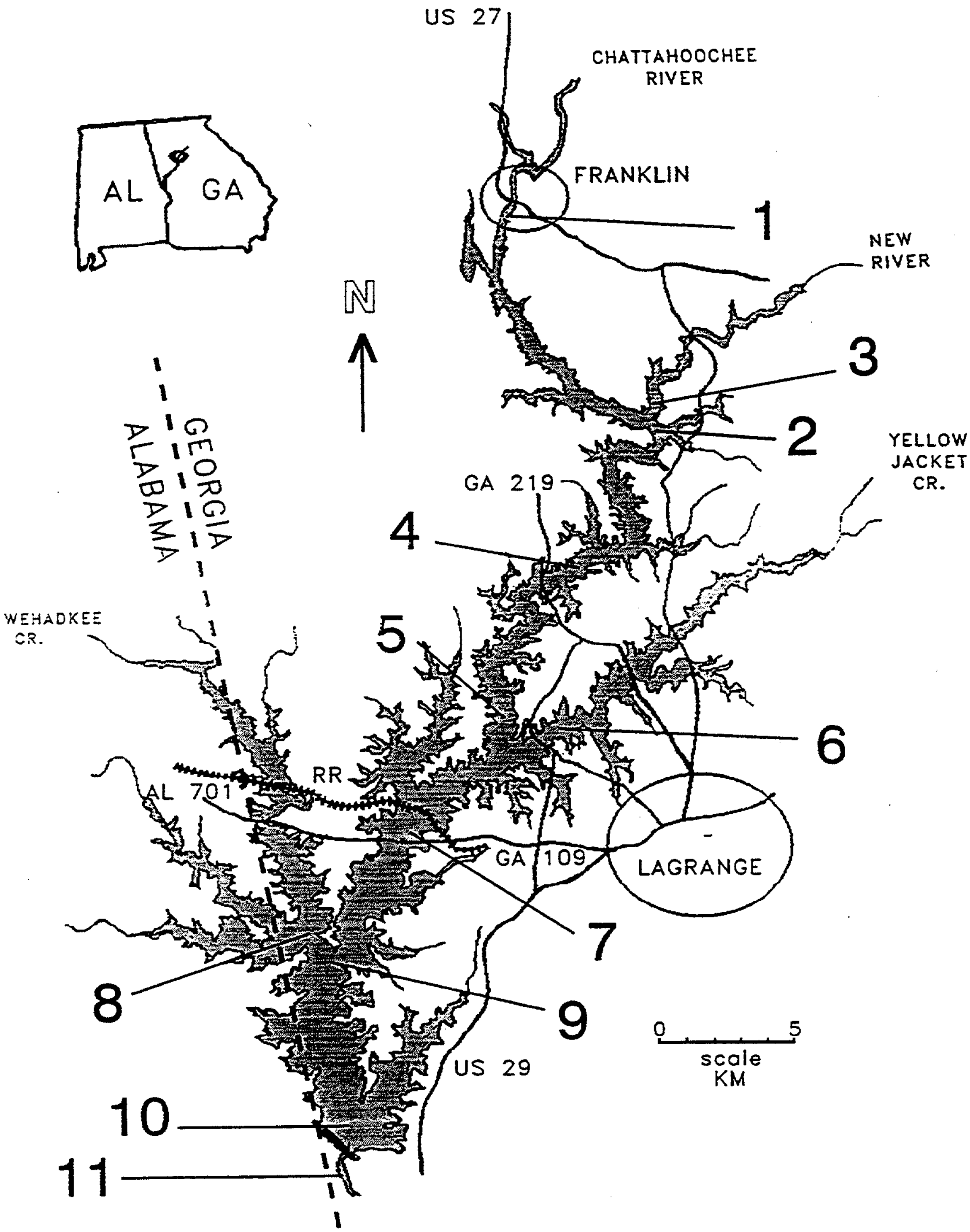

Figure 10-1. Map showing location of mainstem and embayment sampling stations on West Point Lake during the diagnostic study, June 1990 - October 1992.

Table 10-3. Analytical methods used in measuring water quality during the diagnostic study of West Point Lake, 1990-1992.

Variable	Method	Reference
In Situ		
Temperature	thermistor	APHA, 1989
Dissolved oxygen	membrane electrode	APHA, 1989
pH	glass electrode	APHA, 1989
Specific conductance	conductivity cell	APHA, 1989
Visibility	Secchi disk	Lind, 1985
Euphotic zone determination	submarine photometer	Lind, 1985
Laboratory Analyses		
Total suspended solids	vacuum filtration	APHA, 1989
Turbidity	HACH turbidimeter	APHA, 1989
Alkalinity	potentiometric titration	APHA, 1989
Total ammonia (NH_3-N)	phenate method	APHA, 1989
Nitrite (NO_2-N)	diazotizing method	APHA, 1989
Nitrate (NO_3-N)	cadmium reduction	APHA, 1989
Total phosphorus	persulfate digestion, ascorbic acid	APHA, 1989
Total organic carbon	persulfate digestion, with Dohrman DC-80	APHA, 1989
Organic nitrogen	macro Kjeldahl	APHA, 1989
Soluble reactive phosphorus	ascorbic acid	APHA, 1989
Hardness	EDTA titrimetric	Boyd, 1979

Table 10-4. Meteorological conditions and river and lake discharge measured during the 29 month study of West Point Lake, 1990-1992.

Year	Month	Temp[1] (°C)	DFN[2] (°C)	Rainfall[3] (cm)	DFN[2] (cm)	Mean Daily Solar Radiation[4] (Langleys)	Whitesburg Mean Daily Discharge[5] (CFS)	West Point Dam Mean Daily Discharge (CFS)
1990	June	26.1	+1.05	3.8	-5.2	539	2,828	3,899
	July	26.7	+0.33	9.3	-5.7	497	3,076	4,154
	Aug	27.3	+1.16	10.0	+1.6	445	3,675	4,206
	Sept	25.1	+1.21	2.1	-5.9	430	3,208	3,436
	Oct	19.2	+1.32	7.7	+0.6	338	3,604	3,769
	Nov	14.3	+1.98	5.3	-4.0	286	2,600	4,104
	Dec	10.3	+1.93	9.8	-3.5	166	2,890	3,315
1991	Jan	7.4	+0.44	15.7	+3.4	153	3,326	3,440
	Feb	9.4	+0.99	4.2	-9.4	264	3,733	4,417
	March	13.7	+1.21	13.4	-1.1	353	4,253	4,561
	April	19.6	+2.26	9.2	-3.4	365	3,645	3,791
	May	22.9	+1.43	5.3	-4.2	389	7,823	10,088
	June	24.2	-0.83	20.3	+11.3	469	4,319	5,568
	July	26.3	-0.11	16.0	+1.0	438	4,536	5,276
	Aug	26.1	-0.17	6.3	-2.1	403	4,122	4,725
	Sept	24.3	+0.50	6.2	+1.8	434	4,892	6,088
	Oct	33.8	+0.94	0.4	-6.7	368	4,610	6,608
	Nov	11.4	-0.94	14.9	+5.5	264	3,405	3,897
	Dec	10.1	+1.65	7.0	-6.4	197	2,843	4,744
1992	Jan	6.4	-0.55	15.5	+3.2	189	3,875	4,468
	Feb	10.8	+2.26	14.5	+0.9	287	4,553	5,901
	March	23.2	+0.50	9.0	-5.5	402	4,500	4,999
	April	16.3	-0.94	5.1	-7.5	498	3,878	4,333
	May	20.7	-0.83	7.7	-1.7	552	3,264	3,483
	June	24.4	-0.66	19.9	+10.9	514	2,676	2,904
	July	27.3	+0.94	11.5	-3.5	518	4,202	4,538
	Aug	25.5	-0.72	8.0	-0.4	467	3,712	3,735
	Sept	24.8	+0.28	4.3	-3.7	397	3,186	4,266
	Oct	18.1	+0.33	6.1	-0.9	358	3,713	4,565

1 - Air temperature measured at Auburn, AL.
2 - DFN = deviation from normal.
3 - West Point Dam
4 - Auburn, AL
5 - Chattahoochee River at Whitesburg, GA.

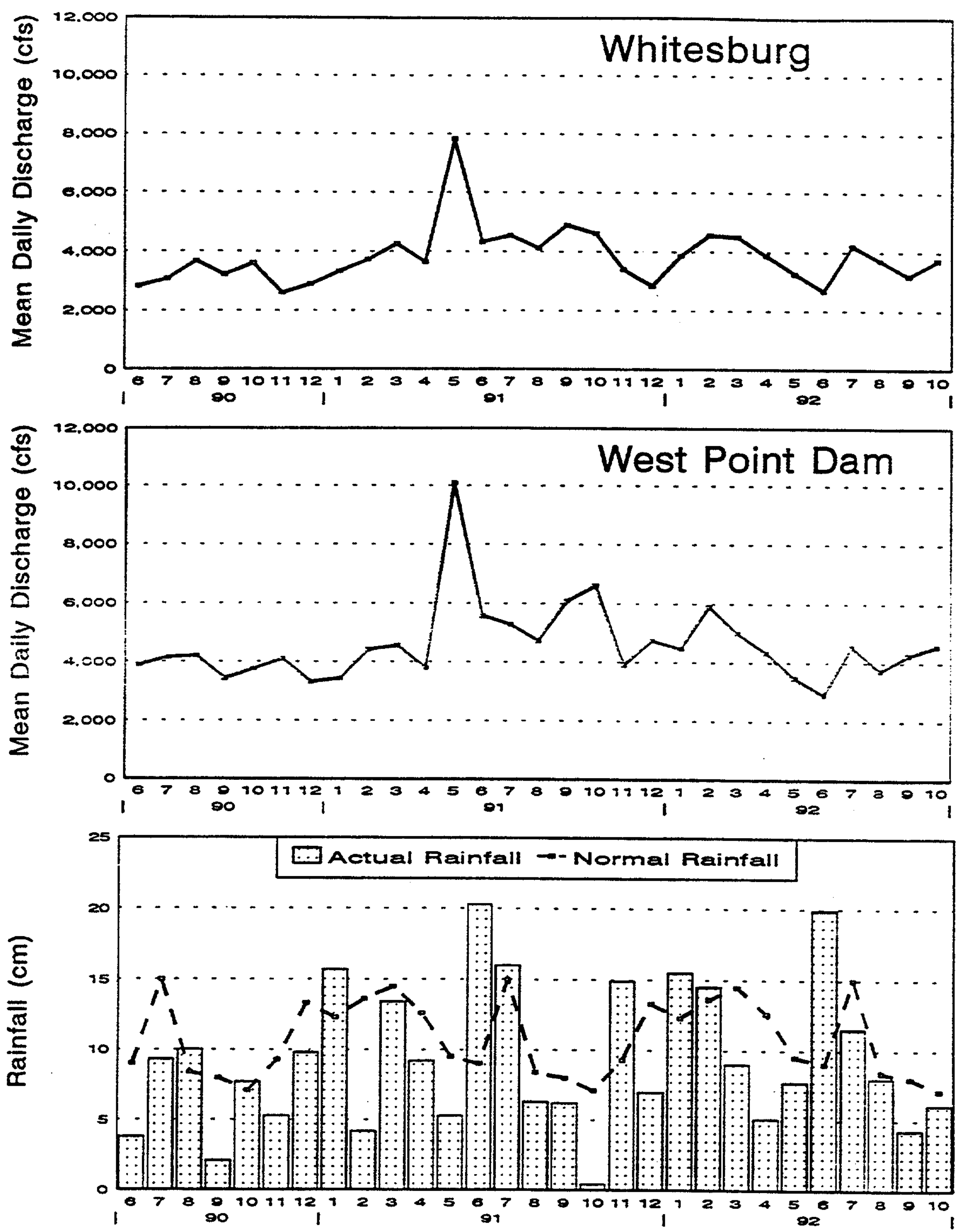

Figure 10-2. Mean daily discharge of the Chattahoochee River at Whitesburg, GA and at West Point Dam. Mean monthly rainfall and actual rainfall at West Point Dam during the diagnostic study of West Point Lake, June 1990 through October 1992.

minimize water quality variations caused by seasonal changes in meteorological conditions, water quality data were grouped and examined by season. The seasons were defined as follows: summer (June, July and August); fall (September, October and November); winter (December, January and February) and spring (March, April and May). The fall 1992 quarter consisted of only two months since the study ended in October 1992.

West Point Lake is a warm monomictic reservoir that thermally stratifies in the lacustrine zone from about late April to early September during most years (Figures 10-3, 10-4 and 10-5). Stratification was rather weak, seldom involving thermocline temperature gradients in excess of 3 °C and water column temperature gradients in the deeper areas rarely exceeding 10 °C. High flows during the summer of 1989 completely disrupted thermal stratification in upstream lentic areas of the lake (EPD 1989a). Above average rainfall in June and July 1991 and in June 1992 (Figure 10-2) increased flows into the lake (Table 10-4) that caused some mixing and displacement of the thermal layers. Thermal stratification began to develop sooner and disappeared later at downstream locations, therefore, stratified conditions persisted longer at downstream, station 10 (Figure 10-3) than at upstream station 4 (Figure 10-5). Greater water movement and possibly density currents in the upstream areas likely affected thermal stratification.

Chemical stratification always accompanied thermal stratification in West Point Lake as is evidenced by the depth-time diagrams of D.O. isopleths (Figures 10-6, 10-7 and 10-8). Dissolved oxygen concentrations in the lacustrine zone (stations 10 and 7) declined to < 1.0 mg/l by June of each year and persisted for varying time periods, frequently until fall overturn. At station 10, D.O. concentrations < 1.0 mg/l were encountered at depths as shallow as 5 to 9 meters during the summer months (Figure 10-6). Further upstream in the transition zone

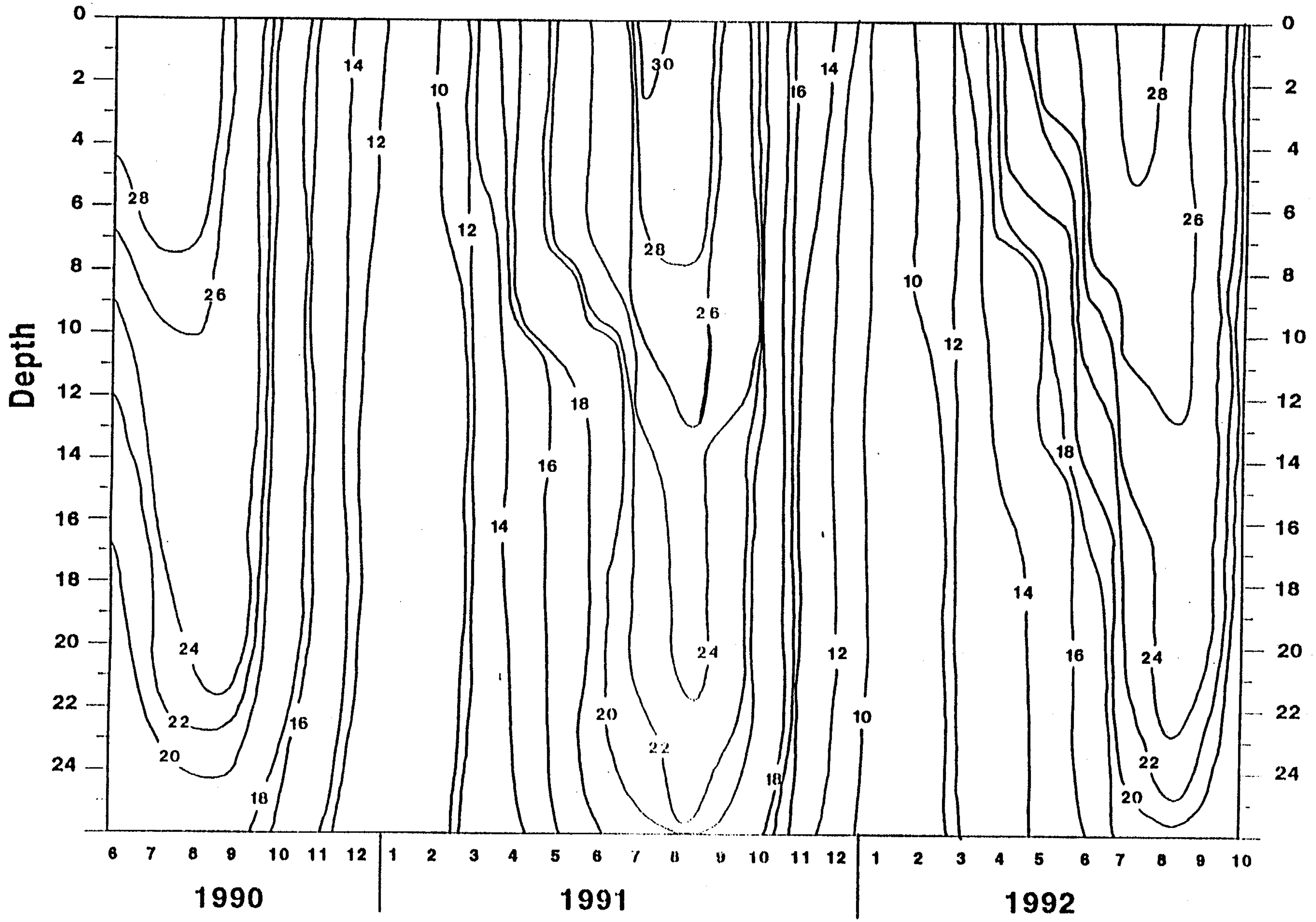

Figure 10-3. Depth-time diagram of isotherms (°C) at station 10 (dam forebay) during the diagnostic study of West Point Lake, June 1990 through October 1992.

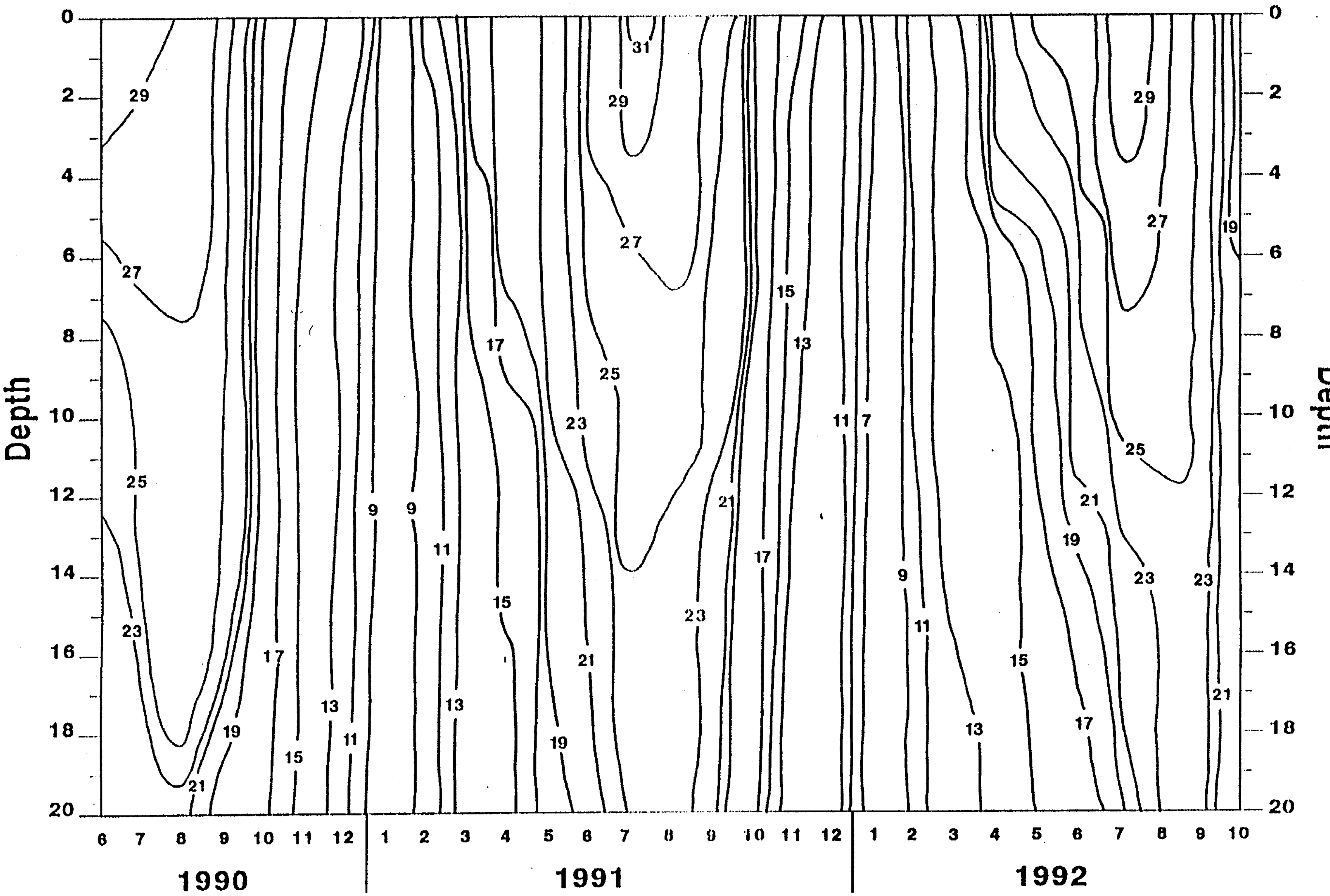

Figure 10-4. Depth-time diagram of isotherms (°C) at station 7 (mid-reservoir) during the diagnostic study of West Point Lake, June 1990 through October 1992.

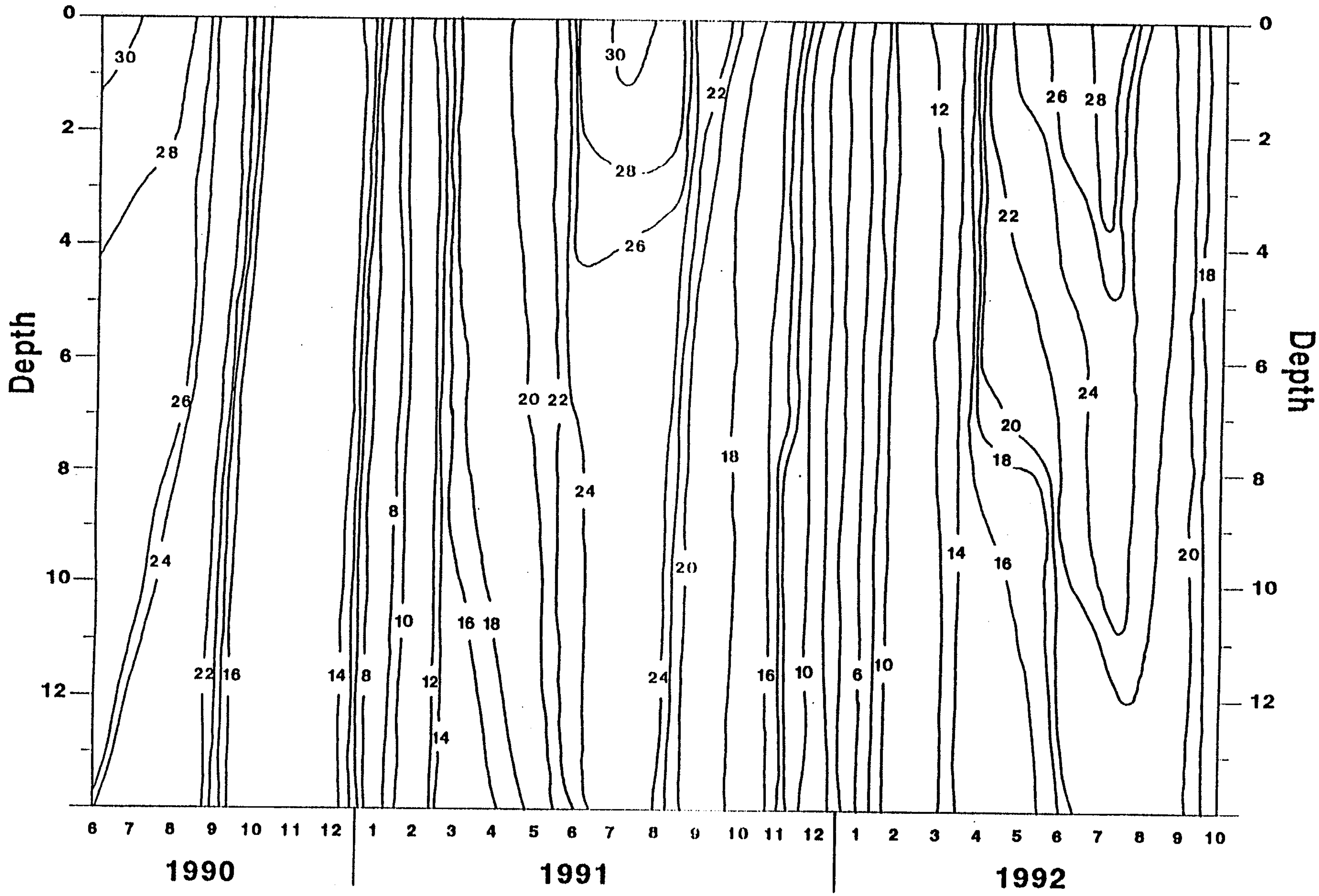

Figure 10-5. Depth-time diagram of isotherms (°C) at station 4 (transition zone) during the diagnostic study of West Point Lake, June 1990 through October 1992.

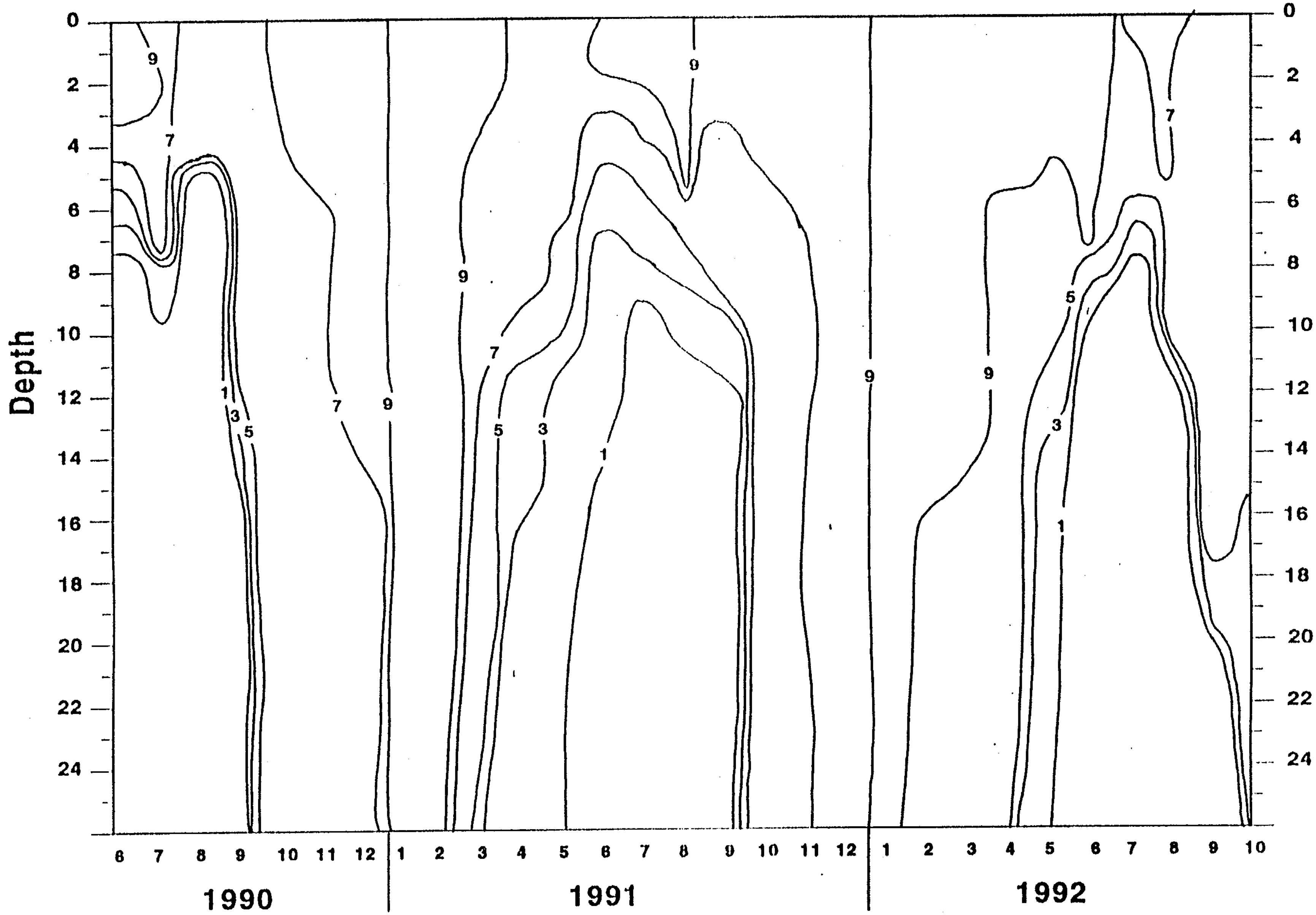

Figure 10-6. Depth-time diagram of D.O. isopleths at station 10 (dam forebay) during the diagnostic study of West Point Lake, June 1990 through October 1992.

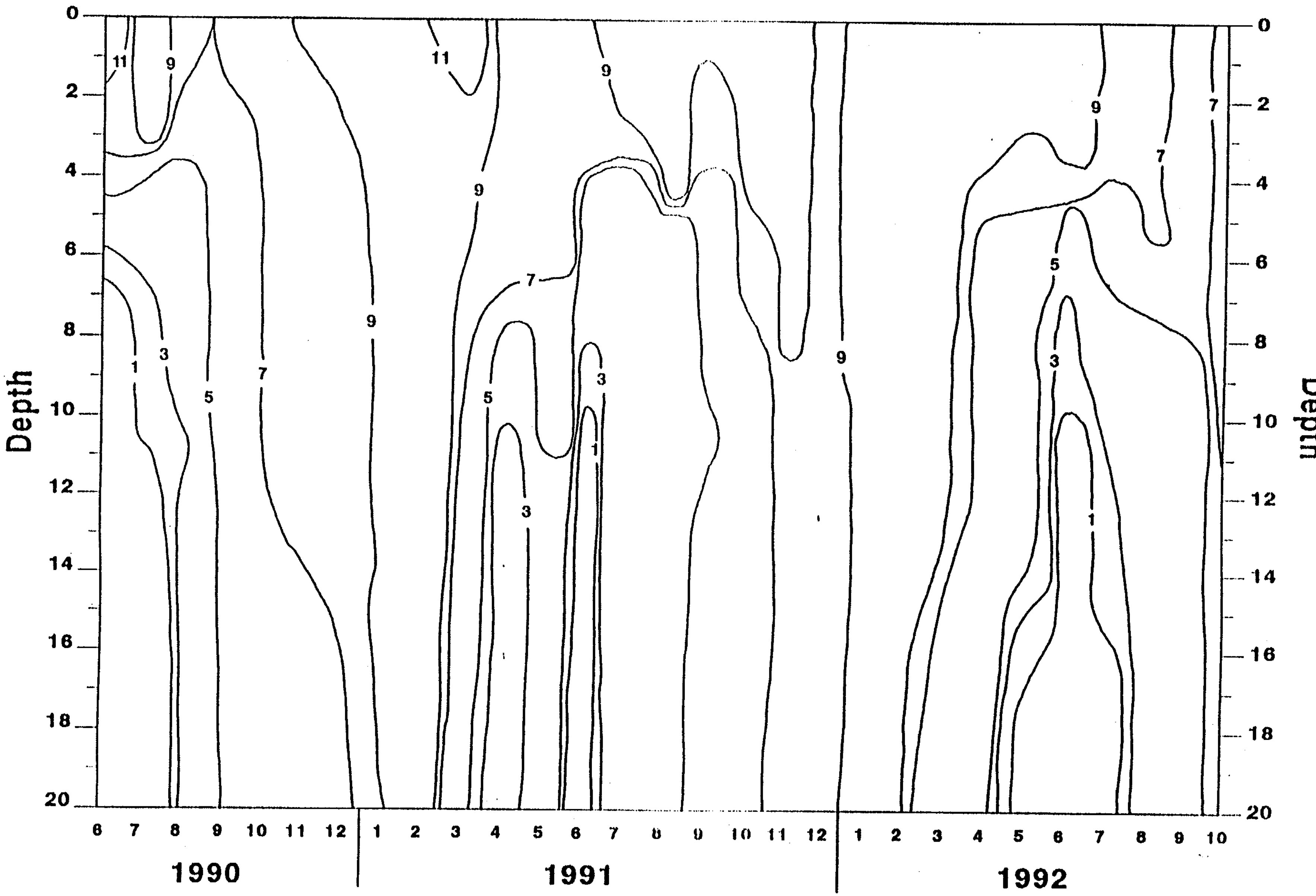

Figure 10-7. Depth-time diagram of D.O. isopleths at station 7 (mid-reservoir) during the diagnostic study of West Point Lake, June 1990 through October 1992.

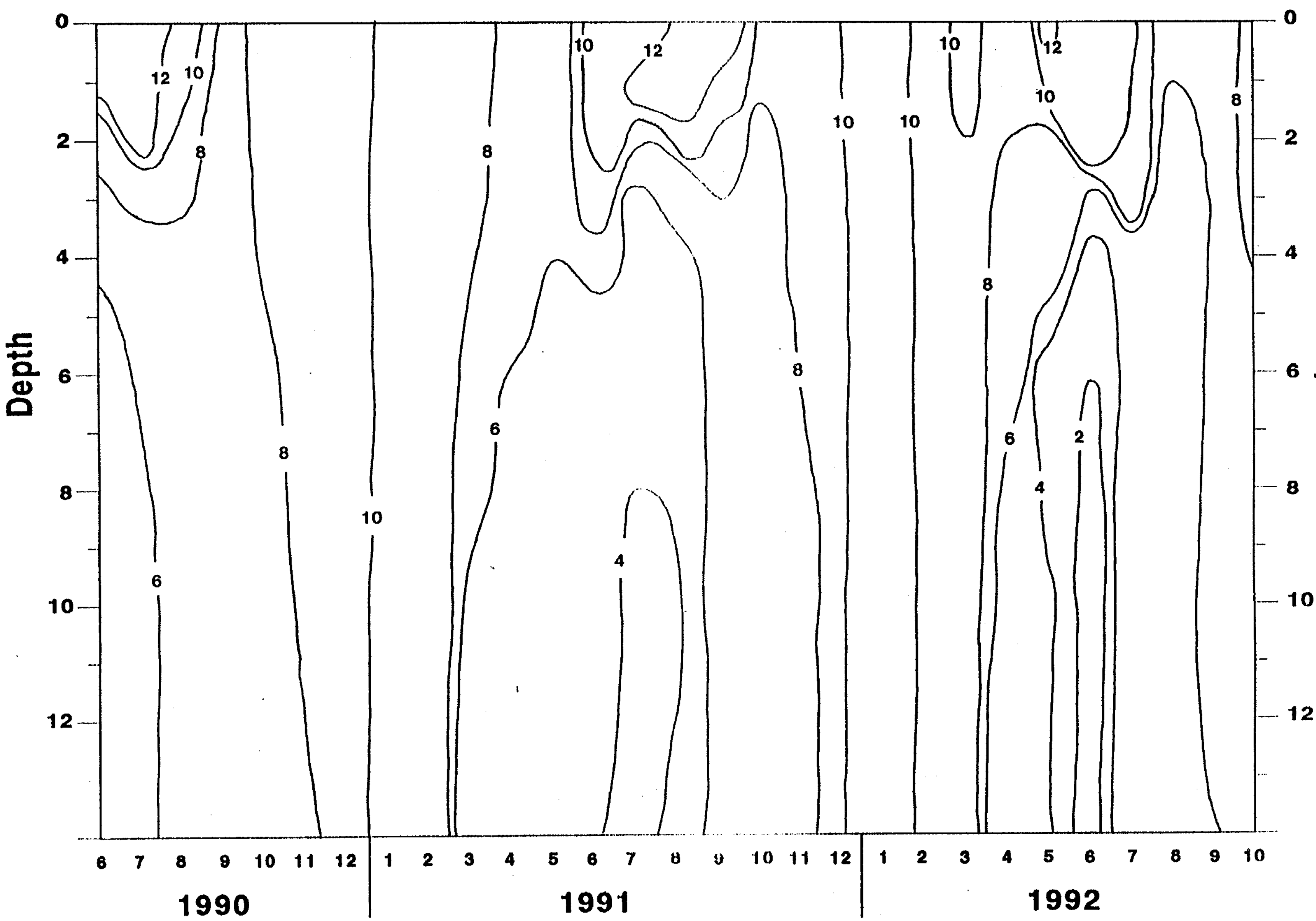

Figure 10-8. Depth-time diagram of D.O. isopleths at station 4 (transition zone) during the diagnostic study of West Point Lake, June 1990 through October 1992.

(station 4) chemical stratification was less obvious although D.O. concentrations declined with depth, but rarely reached levels < 1.0 mg/l (Figure 10-8). Specific conductance measured throughout the water column showed no consistent increase with depth during periods of thermal stratification (Appendix 10). This indicates the lack of accumulation of decomposition products in the hypolimnion during the study.

Water temperature measured at 2 m depth varied from a low of 4 °C in the winter of 1992 to a high of 30 °C in the summer of 1990 (Tables 10-5, 10-6, 10-7 and 10-8). D.O. concentrations measured at the 1 m and 2 m depths ranged between 4 and 13 mg/l and seasonally varied inversely with water temperature. Highest mean D.O. concentrations occurred during the winter and lowest during the summer.

Specific conductance, a measure of the ionic content of water, ranged from a low of 47 µmhos/cm to a high of 126 µmhos/cm at a depth of 2 m (Table 10-5, 10-6, 10-7 and 10-8). Specific conductance is a crude indicator of natural fertility since increases in ionic content are usually accompanied by increases of plant nutrients. Mainstream Alabama reservoirs were found to have specific conductance values ranging from 27 µmhos/cm to 200 µmhos/cm (Bayne et al. 1989). West Point Lake would rank in the lower half of this Alabama range indicating only moderate natural fertility. Upstream (station 1) conductance was usually higher than downstream values, which reflects the expected longitudinal gradient (upstream to downstream) in mineral and nutrient concentration (Figure 10-9). Bayne et al. (1983) noted generally higher specific conductance at upstream locations in West Point Lake during studies conducted from 1976 through 1979. Mean specific conductance for the lake as a whole increased from 66.3 µmhos/cm in 1976 to 97.8 µmhos/cm in 1985 paralleling a rise in lake fertility during that time span (Bayne et al. 1990).

Table 10-5. Mean (range) summer water temperature, dissolved oxygen, pH and specific conductance measured at a depth of 2 m at ten sampling stations in West Point Lake during 1990, 1991 and 1992.

	Temperature C°			Dissolved Oxygen mg/l			pH			Specific Conductance (μmhos/cm)		
	Year			Year			Year			Year		
Mainstem Stations	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
1	27.6 (27-28)	25.9 (25-27)	24.3 (24-25)	6.3 (6-6)	6.8 (7-7)	7.0 (7-7)	6.8 (7-7)	6.9 (7-7)	6.9 (7-7)	102.9 (95-111)	97.7 (89-113)	88.3 (75-107)
2	28.5 (28-29)	25.9 (24-28)	25.1 (24-26)	7.3 (6-9)	6.6 (6-7)	7.0 (6-8)	7.0 (7-7)	6.8 (7-7)	6.8 (7-7)	114.6 (108-126)	84.0 (70-95)	85.0 (66-113)
4	28.6 (28-29)	28.1 (27-30)	26.5 (23-29)	10.6 (10-12)	9.6 (8-11)	9.0 (6-11)	9.1 (9-9)	8.3 (8-9)	7.2 (6-9)	95.5 (84-105)	86.5 (69-96)	83.5 (56-106)
5	29.2 (29-30)	28.6 (27-30)	27.6 (25-30)	10.6 (9-13)	9.1 (9-9)	9.0 (7-10)	9.4 (9-10)	8.6 (8-9)	8.3 (8-9)	99.1 (92-112)	87.3 (79-95)	94.9 (86-112)
7	29.1 (29-30)	28.9 (28-29)	27.9 (26-30)	8.5 (6-11)	9.0 (9-10)	8.8 (8-10)	8.8 (9-9)	8.7 (9-9)	8.9 (8-9)	92.5 (90-95)	83.3 (74-92)	91.8 (87-103)
9	29.0 (29-30)	28.7 (27-30)	27.8 (25-30)	8.0 (6-11)	8.8 (8-10)	8.6 (7-10)	8.7 (8-9)	8.6 (8-9)	8.4 (8-10)	87.7 (87-89)	79.6 (69-87)	90.8 (84-101)
10	29.0 (29-29)	28.6 (27-30)	27.6 (24-30)	8.1 (5-10)	8.9 (9-9)	8.1 (7-10)	8.3 (8-9)	8.7 (8-9)	8.3 (8-10)	82.7 (78-86)	78.7 (69-88)	88.7 (82-98)
Embayment Stations												
3	27.1 (26-28)	25.7 (24-27)	25.2 (24-26)	6.8 (4-9)	5.5 (5-6)	6.2 (4-8)	6.9 (7-7)	6.9 (7-7)	6.8 (7-7)	96.0 (89-103)	79.5 (68-92)	81.7 (64-108)
6	29.3 (29-30)	29.1 (28-30)	28.0 (27-29)	8.9 (7-10)	9.3 (9-10)	8.1 (6-10)	8.8 (9-10)	8.9 (9-9)	7.8 (7-9)	84.4 (80-87)	76.1 (71-81)	83.5 (80-87)
8	29.2 (29-30)	29.1 (28-30)	27.9 (27-29)	8.5 (6-10)	9.3 (9-10)	8.3 (7-10)	8.6 (8-9)	8.8 (9-9)	8.5 (8-10)	81.4 (79-84)	75.3 (67-83)	84.4 (83-87)

Table 10-6. Mean (range) fall water temperature, dissolved oxygen, pH and specific conductance measured at a depth of 2 m at ten sampling stations in West Point Lake during 1990, 1991 and 1992.

	Temperature C°			Dissolved Oxygen mg/l			pH			Specific Conductance (µmhos/cm)		
	Year			Year			Year			Year		
Mainstem Stations	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
1	17.5 (16-19)	20.8 (21-21)	18.3 (15-21)	8.6 (8-9)	7.8 (8-8)	8.0 (7-9)	7.1 (7-7)	7.1 (7-7)	7.2 (7-7)	114.3 (102-126)	98.6 (99-99)	105.8 (103-109)
2	16.8 (15-20)	18.8 (17-23)	18.5 (16-21)	8.8 (8-9)	8.3 (8-9)	7.5 (7-8)	7.0 (7-7)	7.0 (7-7)	7.1 (7-7)	98.5 (91-103)	96.4 (71-125)	103.1 (88-119)
4	18.4 (16-24)	19.1 (16-25)	20.5 (17-25)	8.1 (7-9)	8.7 (8-10)	6.8 (6-8)	6.9 (7-7)	7.2 (7-8)	7.2 (7-8)	106.8 (96-118)	80.3 (70-96)	84.0 (67-105)
5	19.0 (16-25)	19.9 (15-27)	21.6 (18-26)	7.7 (7-9)	8.8 (8-10)	6.6 (5-8)	6.9 (7-7)	7.3 (7-9)	7.1 (7-9)	95.9 (74-115)	87.1 (72-101)	98.8 (91-109)
7	19.3 (15-25)	20.3 (15-28)	22.7 (19-27)	7.2 (6-8)	8.9 (7-10)	7.4 (5-9)	7.1 (7-7)	7.4 (7-9)	7.2 (7-9)	86.0 (84-88)	86.0 (78-92)	92.2 (86-100)
9	19.7 (16-25)	20.9 (16-28)	23.2 (20-28)	7.5 (6-10)	8.7 (7-10)	7.2 (5-10)	7.1 (7-8)	7.5 (7-9)	7.2 (7-9)	87.5 (87-88)	80.5 (79-86)	90.0 (84-94)
10	19.8 (16-26)	20.9 (15-28)	23.6 (20-29)	6.6 (5-7)	7.7 (7-9)	7.5 (6-11)	7.0 (7-7)	7.0 (7-9)	7.3 (7-9)	88.9 (88-89)	81.1 (78-84)	87.2 (83-93)
Embayment Stations												
3	16.2 (12-21)	17.4 (15-23)	18.9 (17-21)	7.9 (7-9)	7.6 (6-9)	7.4 (7-8)	7.0 (7-7)	6.9 (7-7)	7.1 (7-7)	106.9 (103-110)	97.4 (70-132)	98.4 (91-106)
6	19.5 (15-25)	20.1 (15-27)	21.3 (19-24)	6.4 (5-8)	8.2 (6-10)	6.1 (5-8)	6.9 (7-7)	7.1 (7-9)	7.0 (7-7)	83.0 (77-88)	75.5 (67-82)	80.2 (79-81)
8	19.9 (16-26)	20.8 (15-28)	22.0 (20-24)	6.2 (5-8)	8.0 (5-9)	5.9 (4-8)	7.0 (7-7)	7.2 (7-9)	6.9 (7-7)	83.5 (81-85)	75.7 (70-80)	78.9 (77-81)

Table 10-7. Mean (range) winter water temperature, dissolved oxygen, pH and specific conductance measured at a depth of 2 m at ten sampling stations in West Point Lake during 1990, 1991 and 1992.

	Temperature C°		Dissolved Oxygen mg/l		pH		Specific Conductance (µmhos/cm)	
	Year		Year		Year		Year	
Mainstem Stations	1990-91	1991-92	1990-91	1991-92	1990-91	1991-92	1990-91	1991-92
1	11.7* (8-15)	9.9 (10-10)	9.5* (8-11)	10.2 (10-10)	6.8* (7-7)	7.0 (7-7)	106.8* (89-125)	108.6 (109-109)
2	15.2 (15-15)	8.7 (6-11)	9.1 (9-9)	10.1 (9-11)	6.8 (7-7)	6.8 (7-7)	85.0 (85-85)	89.7 (61-107)
4	11.1 (8-15)	8.9 (6-11)	9.8 (9-10)	10.1 (9-11)	7.0 (7-7)	6.9 (7-7)	94.1 (77-103)	86.4 (67-96)
5	10.7 (8-14)	9.9 (6-12)	9.5 (9-10)	9.3 (9-10)	7.0 (7-7)	6.9 (7-7)	100.8 (87-120)	90.9 (67-106)
7	10.7 (8-13)	10.3 (8-12)	9.7 (9-10)	9.3 (9-10)	7.1 (7-7)	7.0 (7-7)	100.1 (94-107)	89.9 (87-93)
9	10.8 (9-13)	10.1 (8-12)	9.7 (9-10)	9.3 (8-10)	7.1 (7-7)	7.0 (7-7)	91.7 (82-97)	84.7 (81-90)
10	10.7 (9-13)	10.5 (9-12)	9.1 (7-10)	9.5 (8-10)	6.9 (7-7)	6.9 (7-7)	93.8 (91-96)	81.5 (73-91)
Embayment Stations								
3	10.6 (5-14)	6.7 (4-11)	10.2 (9-12)	10.7 (10-12)	6.9 (7-7)	6.8 (7-7)	81.2 (63-92)	64.2 (47-79)
6	10.7 (9-13)	10.1 (7-12)	9.2 (9-10)	9.3 (9-10)	7.0 (7-7)	7.0 (7-7)	75.1 (64-84)	64.9 (57-72)
8	11.0 (10-13)	10.3 (8-12)	9.8 (9-10)	9.9 (8-11)	7.0 (7-7)	7.1 (7-7)	83.5 (72-90)	68.8 (67-70)

*Values from 1 m depth.

Table 10-8. Mean (range) spring water temperature, dissolved oxygen, pH and specific conductance measured at a depth of 2 m at ten sampling stations in West Point Lake during 1990, 1991 and 1992.

	Temperature C°		Dissolved Oxygen mg/l		pH		Specific Conductance (µmhos/cm)	
	Year		Year		Year		Year	
Mainstem Stations	1991	1992	1991	1992	1991	1992	1991	1992
1	18.1 (17-19)	18.5 (12-23)	8.0 (8-8)	8.0 (7-10)	6.7 (7-7)	7.0 (7-7)	97.1 (76-122)	102.9 (99-105)
2	18.6 (18-20)	18.6 (12-23)	7.4 (6-8)	8.2 (7-10)	6.6 (6-7)	7.0 (7-7)	81.4 (51-108)	93.1 (81-101)
4	19.9 (19-21)	17.8 (12-23)	7.7 (6-9)	9.0 (7-10)	6.8 (7-8)	7.3 [illegible]	[illegible]	[illegible]
5	19.8 (19-21)	18.4 (14-24)	8.1 (5-11)	10.5 (9-13)	6.9 (7-8)	7.5 (7-10)	86.0 (61-109)	85.8 (75-94)
7	19.7 (18-22)	18.5 (14-25)	8.9 (7-11)	9.9 (9-11)	6.9 (7-8)	7.5 (7-9)	81.4 (62-89)	77.9 (68-89)
9	19.5 (17-22)	18.3 (14-25)	8.9 (7-11)	9.9 (10-11)	7.1 (7-9)	7.6 (7-9)	77.2 [illegible]	75.4 (68-85)
10	19.1 (15-24)	18.2 (14-25)	8.8 (7-10)	10.0 (9-11)	7.1 (7-8)	7.7 (7-9)	[illegible] (70-87)	70.6 (65-79)
Embayment Stations								
3	18.5 (18-20)	18.1 (11-23)	7.3 (6-9)	8.3 (7-10)	6.6 (6-7)	7.0 (7-7)	62.4 (36-75)	75.8 (68-83)
6	20.4 (18-22)	20.5 (14-25)	9.6 (8-12)	10.1 (9-11)	7.5 (7-8)	7.8 (7-9)	73.8 (50-87)	70.7 (57-80)
8	20.0 (18-23)	20.1 (14-25)	9.4 (8-11)	10.2 (9-12)	7.6 (7-9)	7.8 (7-9)	74.6 (68-79)	66.8 (61-78)

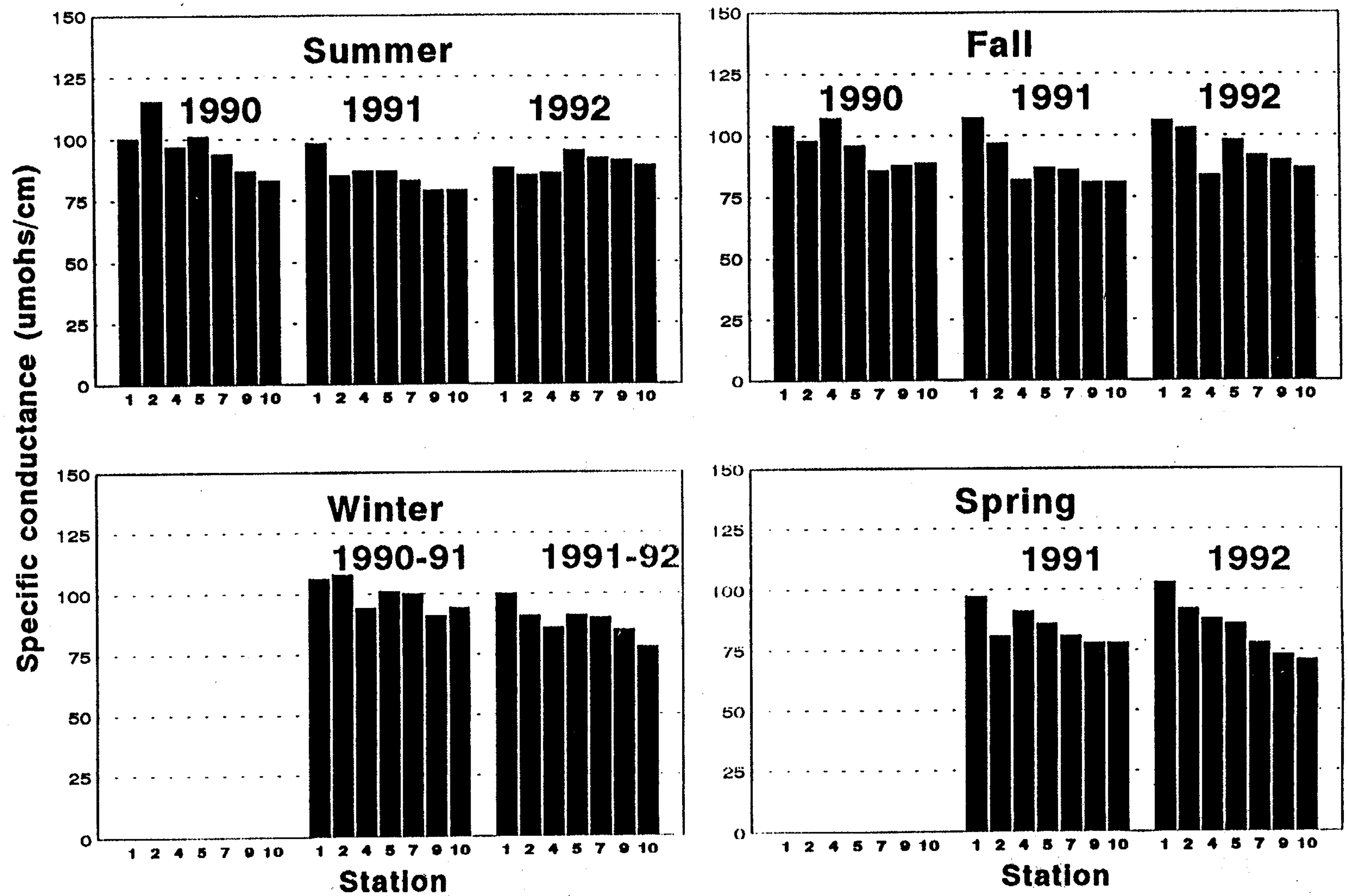

Figure 10-9: Near surface (1-3m) specific conductance measured at all mainstem sampling stations in West Point Lake during the diagnostic study, 1990-1992.

Secchi disk visibility and light penetration varied seasonally and along the longitudinal gradient within each season (Tables 10-9, 10-10, 10-11 and 10-12). Riverine stations 1 and 2 had relatively low Secchi visibility and light penetration depths caused primarily by high abiogenic turbidity. Visibility and light penetration were usually highest each season at the downstream lacustrine stations 7, 9 and 10. Light penetration in this zone is influenced more by biogenic (phytoplankton) turbidity than by abiogenic turbidity. Transition zone stations 4 and 5 were influenced by both biogenic and abiogenic turbidity depending on seasonal conditions and flows. Secchi visibility and light penetration was often lower at these stations than at the upstream locations. As the fertile waters of the Chattahoochee River reach the more lentic transition zone, abiogenic turbidity declines (particles settle) and as light penetration increases biogenic turbidity (phytoplankton) increases in response to the more favorable light conditions. Light penetration in the transition zone is controlled by the interaction of biotic and abiotic variables. Mean light penetration and Secchi visibility were always highest in Wehadkee Creek embayment and lowest in the New River embayment. Yellowjacket Creek values were intermediate between the two. The New River embayment discharges into the transition zone of the lake (between stations 1 and 2) and at times, may have been influenced by rapidly rising Chattahoochee River water levels.

A composite water sample was collected from the photic zone of the water column at each sampling station (Figure 10-1) for additional water quality analyses. EPD used the 1% incident light depth as the photic zone boundary and collected four discrete water samples at equidistance from the water surface to the 1% light level. The four samples were combined to comprise the composite

Table 10-9. Mean (range) summer Secchi disk visibility, 1% incident light depth, turbidity and total suspended solids measured at eleven sampling stations during 1990, 1991 and 1992.

	Secchi (cm)			1% Incident Light (cm)			Turbidity (NTU)			Total Suspended Solids (mg/l)		
	Year			Year			Year			Year		
Mainstem Stations	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
1	59.0 (53-68)	52.0 (39-73)	57.0 (34-79)	177.0 (154-207)	165.0 (133-206)	158.0 (81-200)	27.3 (24-31)	23.0 (9-41)	41.2 (20-89)	35.6 (33-39)	21.5 (12-30)	40.7 (19-73)
2	75.0 (66-79)	56.0 (41-70)	60.0 (38-98)	216.0 (209-230)	162.0 (115-192)	158.0 (94-236)	26.2 (14-43)	29.6 (18-49)	37.8 (16-68)	22.0 (19-25)	20.6 (13-29)	21.3 (11-30)
4	94.0 (87-100)	113.0 (100-137)	88.0 (35-116)	237.0 (214-257)	317.0 (259-397)	193.0 (94-248)	7.7 (7-9)	9.1 (4-20)	20.4 (4-80)	8.2 (7-10)	6.9 (4-13)	10.0 (4-25)
5	110.0 (102-122)	130.0 (114-147)	120.0 (94-154)	338.0 (258-384)	402.0 (344-439)	355.0 (311-383)	5.1 (5-6)	4.0 (2-6)	5.6 (3-13)	5.7 (6-6)	3.7 (3-5)	5.1 (3-9)
7	129.0 (118-138)	162.0 (135-199)	153.0 (112-210)	375.0 (305-413)	470.0 (439-505)	453.0 (397-483)	4.7 (4-5)	2.5 (1-4)	3.2 (2-4)	4.1 (4-4)	3.0 (2-4)	3.2 (2-4)
9	162.0 (160-165)	175.0 (154-205)	169.0 (107-209)	507.0 (483-551)	531.0 (488-558)	531.0 (500-562)	4.3 (4-5)	2.2 (1-3)	2.8 (2-4)	3.9 (3-5)	2.6 (2-3)	3.4 (2-6)
10	203.0 (178-215)	194.0 (177-207)	193.0 (124-243)	660.0 (634-703)	508.0 (435-576)	598.0 (479-796)	3.4 (2-5)	2.0 (1-3)	2.8 (2-4)	3.9 (4-4)	2.6 (2-3)	3.6 (2-6)
11							5.0 (3-6)	4.8 (3-6)	5.2 (4-6)	3.7 (3-4)	2.6 (1-3)	4.1 (3-6)
Embayment Stations												
3	75.0 (58-93)	79.0 (59-105)	70.0 (53-99)	144.0 (117-180)	187.0 (150-210)	164.0 (115-207)	24.9 (18-36)	21.4 (15-30)	38.0 (20-63)	22.7 (19-26)	14.3 (10-20)	19.6 (13-27)
6	129.0 (115-143)	152.0 (123-174)	147.0 (112-173)	419.0 (402-438)	473.0 (412-542)	370.0 (322-444)	4.7 (4-5)	3.7 (3-5)	4.7 (4-7)	5.2 (5-5)	3.2 (3-4)	4.1 (3-5)
8	178.0 (164-207)	197.0 (180-210)	177.0 (153-199)	545.0 (503-608)	566.0 (511-614)	570.0 (500-644)	4.5 (3-6)	2.6 (2-4)	3.2 (3-3)	3.3 (2-5)	2.6 (2-3)	3.3 (3-4)

Table 10-10. Mean (range) fall Secchi disk visibility, 1% incident light depth, turbidity and total suspended solids measured at eleven sampling stations during 1990, 1991 and 1992.

Mainstem Stations	Secchi (cm) Year 1990	Secchi (cm) Year 1991	Secchi (cm) Year 1992	1% Incident Light (cm) Year 1990	1% Incident Light (cm) Year 1991	1% Incident Light (cm) Year 1992	Turbidity (NTU) Year 1990	Turbidity (NTU) Year 1991	Turbidity (NTU) Year 1992	Total Suspended Solids (mg/l) Year 1990	Total Suspended Solids (mg/l) Year 1991	Total Suspended Solids (mg/l) Year 1992
1	92.0 (80-105)	110.0 (77-149)	75.0 (34-115)	121.0 (1-240)	--*	84.0 (84-84)	13.0 (10-16)	11.8 (5-18)	56.8 (11-96)	13.4 (10-18)	12.0 (4-34)	59.0 (11-85)
2	89.0 (58-108)	84.0 (60-116)	57.0 (49-64)	241.0 (162-286)	220.0 (170-284)	173.0 (141-204)	18.4 (14-26)	20.8 (16-26)	25.9 (18-34)	17.6 (10-23)	17.9 (12-31)	19.7 (15-24)
4	65.0 (61-73)	69.0 (52-89)	49.0 (33-76)	180.0 (111-229)	218.0 (107-336)	205.0 (172-238)	16.2 (14-20)	16.2 (11-24)	34.3 (15-52)	12.0 (9-15)	11.5 (7-15)	17.4 (9-29)
5	83.0 (51-99)	100.0 (81-137)	88.0 (72-116)	246.0 (152-320)	339.0 (278-407)	288.0 (276-299)	14.3 (9-25)	9.6 (4-15)	9.0 (6-12)	9.1 (8-11)	6.1 (3-8)	6.9 (5-8)
7	99.0 (84-109)	138.0 (100-174)	132.0 (105-151)	374.0 (295-444)	404.0 (306-458)	366.0 (322-410)	8.6 (7-11)	4.8 (2-7)	5.0 (4-7)	8.0 (7-9)	4.0 (3-5)	4.6 (3-6)
9	130.0 (129-131)	179.0 (154-215)	159.0 (117-202)	489.0 (376-591)	516.0 (465-588)	459.0 (384-534)	5.3 (4-7)	3.1 (2-4)	3.6 (2-5)	5.3 (4-7)	2.9 (2-3)	4.2 (3-5)
10	148.0 (143-159)	192.0 (174-216)	201.0 (148-266)	549.0 (430-612)	571.0 (535-589)	515.0 (397-632)	4.0 (3-5)	3.6 (1-6)	3.1 (2-4)	3.6 (3-5)	2.8 (2-4)	3.1 (3-4)
11							4.3 (4-6)	6.5 (3-11)	3.4 (3-4)	4.2 (3-7)	4.9 (3-8)	3.7 (3-4)
Embayment Stations												
3	52.0 (47-56)	76.0 (57-97)	62.0 (60-64)	146.0 (133-158)	188.0 (185-197)	191.0 (178-203)	22.1 (12-36)	21.7 (19-25)	18.5 (19-19)	19.2 (7-33)	14.6 (11-20)	14.5 (14-15)
6	97.0 (73-131)	147.0 (140-151)	129.0 (122-135)	231.0 (164-299)	314.0 (172-444)	354.0 (331-377)	9.5 (5-14)	6.6 (5-8)	5.6 (5-6)	8.2 (4-11)	5.0 (3-6)	6.0 (5-7)
8	150.0 (129-168)	178.0 (145-195)	207.0 (176-238)	467.0 (395-547)	474.0 (348-545)	405.0 (320-490)	5.5 (4-8)	3.8 (2-5)	2.9 (2-3)	4.7 (3-6)	3.4 (3-4)	3.1 (3-4)

* Insufficient water depth

Table 10-11. Mean (range) winter Secchi disk visibility, 1% incident light depth, turbidity and total suspended solids measured at eleven sampling stations during 1990, 1991 and 1992.

Mainstem Stations	Secchi (cm) Year		1% Incident Light (cm) Year		Turbidity (NTU) Year		Total Suspended Solids (mg/l) Year	
	1990-91	1991-92	1990-91	1991-92	1990-91	1991-92	1990-91	1991-92
1	84.0 (58-104)	89.0 (24-130)	170.0 (170-170)	66.0 (66-66)	18.9 (12-31)	42.6 (12-103)	17.1 (11-29)	32.9 (7-83)
2	80.0 (63-90)	91.0 (28-147)	239.0 (173-278)	273.0 (87-434)	20.5 (17-28)	37.9 (11-85)	21.3 (16-29)	26.5 (7-56)
4	67.0 (48-79)	60.0 (30-94)	253.0 (227-268)	272.0 (200-343)	18.3 (16-20)	37.8 (14-77)	12.6 (9-16)	21.5 (7-41)
5	67.0 (56-87)	67.0 (36-101)	263.0 (222-294)	277.0 (198-355)	17.9 (14-21)	30.3 (13-55)	10.0 (8-12)	15.2 (5-27)
7	86.0 (74-98)	80.0 (60-90)	310.0 (266-397)	228.0 (187-268)	14.7 (11-19)	18.0 (14-25)	8.6 (8-9)	11.1 (8-16)
9	96.0 (73-131)	99.0 (91-109)	307.0 (262-386)	248.0 (210-268)	13.0 (5-18)	13.1 (11-15)	6.2 (5-7)	7.2 (6-9)
10	127.0 (114-148)	126.0 (95-170)	366.0 (320-430)	305.0 (233-437)	8.8 (6-12)	10.9 (7-15)	5.2 (5-6)	6.3 (4-8)
11					10.8 (7-18)	9.7 (6-15)		
Embayment Stations								
3	47.0 (41-57)	94.0 (40-127)	194.0 (184-211)	120.0 (120-120)	23.7 (22-25)	27.3 (13-49)	16.5 (14-20)	12.2 (5-19)
6	76.0 (69-84)	77.0 (52-101)	226.0 (198-258)	248.0 (214-282)	13.8 (10-16)	17.6 (13-25)	8.8 (8-10)	10.9 (7-14)
8	111.0 (84-133)	133.0 (116-158)	388.0 (248-496)	290.0 (203-419)	9.6 (5-15)	8.0 (7-10)	7.2 (6-9)	6.1 (5-7)

Table 10-12. Mean (range) spring Secchi disk visibility, 1% incident light depth, turbidity and total suspended solids measured at eleven sampling stations during 1991 and 1992.

	Secchi (cm)		1% Incident Light (cm)		Turbidity (NTU)		Total Suspended Solids (mg/l)	
	Year		Year		Year		Year	
Mainstem Stations	1991	1992	1991	1992	1991	1992	1991	1992
1	64.0 (43-102)	112.0 (78-161)	119.0 (113-124)	167.0 (167-167)	48.8 (8-174)	16.6 (9-26)	64.0 (14-238)	20.7 (9-33)
2	63.0 (28-94)	92.0 (75-126)	180.0 (78-261)	291.0 (237-341)	39.2 (12-114)	17.4 (15-21)	27.5 (15-60)	13.6 (10-16)
4	62.0 (22-83)	83.0 (62-116)	195.0 (112-251)	246.0 (238-261)	34.7 (9-100)	14.1 (9-19)	20.4 (9-52)	10.0 (7-13)
5	80.0 (23-133)	102.0 (74-142)	237.0 (113-342)	348.0 (241-426)	24.4 (6-64)	10.6 (4-19)	15.4 (5-44)	7.6 (3-11)
7	120.0 (78-161)	132.0 (82-199)	354.0 (325-400)	445.0 (228-591)	7.8 (5-13)	8.7 (3-17)	6.1 (4-8)	6.6 (3-11)
9	142.0 (110-178)	136.0 (91-185)	388.0 (368-408)	487.0 (245-655)	6.4 (4-8)	7.3 (3-13)	5.0 (4-6)	5.0 (3-8)
10	175.0 (141-239)	172.0 (112-280)	425.0 (389-480)	538.0 (290-788)	5.7 (3-9)	5.8 (2-11)	3.6 (1-6)	3.9 (2-6)
11					7.7 (5-10)	6.9 (4-13)	4.0 (3-5)	3.9 (2-7)
Embayment Stations								
3	54.0 (25-73)	118.0 (87-148)	157.0 (71-175)	244.0 (226-259)	34.3 (22-86)	14.9 (13-18)	18.6 (9-33)	10.5 (10-12)
6	127.0 (96-172)	143.0 (99-201)	354.0 (276-436)	423.0 (237-580)	7.0 (5-11)	7.5 (5-13)	5.8 (5-8)	5.0 (3-8)
8	181.0 (125-274)	179.0 (98-223)	476.0 (404-558)	561.0 (275-784)	5.4 (3-6)	5.7 (3-11)	4.0 (2-6)	3.9 (2-7)

sample. In order to maintain consistency with previous AU research work on West Point Lake, AU defined the photic zone depth as four times the Secchi disk visibility (Taylor 1971). This depth usually exceeded the 1% incident light depth. A submersible electric pump and hose apparatus was raised and lowered throughout the photic zone and the water was collected in a plastic container on board boat. Aliquots from this composite sample were poured into Nalgene containers and stored, on ice, prior to transport to laboratory facilities. Samples to be held for later analysis (total phosphorus and Kjeldahl nitrogen) were preserved in the field (APHA et al. 1989). All analyses were conducted within the recommended holding times (APHA et al. 1989). Monthly (biweekly during the growing seasons) samples were collected during the study period (Table 10-1). Water quality variables analyzed and methods used appear in Table 10-3.

Composite water sample turbidity, an indirect measure of suspended particles, and total suspended solids, a gravimetric measure of suspended particles, both illustrate the effects of longitudinal changes in water quality from headwaters downstream to the dam (Tables 10-9, 10-10, 10-11 and 10-12). During each season concentrations of suspended particles were higher in the riverine zone (stations 1 and 2) than in the transition zone (stations 4 and 5) and lowest concentrations were found in the lacustrine zone (stations 7, 9 and 10). Seasonal variations in suspended particle concentrations were evident. Winter and spring concentrations were generally higher than summer and fall concentrations because of higher rainfall and runoff that occurs during the winter/spring months (Figure 10-2). Turbidity and suspended solids concentrations at station 1 were higher during summer, fall and winter of 1992 than in 1990 and 1991, however, in the spring, higher values occurred during 1991. This may have occurred as a result of unusually high Chattahoochee River discharge (at Whitesburg) during May 1991 (Figure 10-2 and Table 10-4). New River embayment (station 3) had suspended particle concentrations consistently higher than the embayments of Yellowjacket Creek (station 6) and Wehadkee Creek (station 8) although New River concentrations were similar to those of the nearest mainstem sampling location, station 2.

Total alkalinity, the concentration of bases in water (expressed as mg/l $CaCO_3$), primarily composed of bicarbonate (HCO_3^-) and carbonate ($CO_3^=$) ions, usually increases as basin soil fertility increases. Total hardness (expressed as mg/l $CaCO_3$) is a measure of the divalent, alkaline earth metal content of water. Calcium (Ca++) and magnesium (Mg++) are normally the most abundant metals in soils of the eastern United States and they are generally associated with the carbonate minerals responsible for the alkalinity of water. Therefore, total alkalinity and total hardness are usually similar and tend to vary together. In a recent study, total alkalinity of large mainstream impoundments of Alabama varied from a low of 7 mg/l to a high of 67 mg/l (Bayne et al. 1989). Total alkalinity of West Point Lake varied from a low of 9 mg/l to a high of 32 mg/l (Tables 10-13, 10-14, 10-15 and 10-16). Total hardness ranged from a low of 11 mg/l to a high of 49 mg/l (tailwater sample). As in the case of specific conductance, total alkalinity of West Point Lake waters falls in the lower half of the range expected for Alabama lakes indicating limited fertility of basin soils. Since carbonate minerals function as a natural chemical buffer, waters of low alkalinity are subject to greater fluctuations in pH than more alkaline systems. Both total alkalinity and hardness were lower during winter and spring than during summer and fall apparently because of higher flow and greater dilution that normally occurs during periods of higher rainfall and surface

Table 10-13. Mean (range) summer total hardness and total alkalinity measured at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

	Total Alkalinity (mg/l as $CaCO_3$)			Total Hardness (mg/l as $CaCO_3$)		
	Year			Year		
Mainstem Stations	1990	1991	1992	1990	1991	1992
1	19.8 (17-21)	20.6 (17-23)	18.3 (14-21)	27.6 (25-30)	25.8 (24-29)	23.4 (21-28)
2	23.1 (20-26)	22.8 (18-28)	19.2 (14-23)	27.7 (22-33)	23.6 (20-28)	22.1 (18-28)
4	22.7 (18-29)	20.2 (18-23)	17.6 (13-21)	23.2 (18-29)	21.9 (21-23)	20.6 (16-24)
5	25.1 (21-29)	21.3 (18-24)	19.6 (18-22)	22.8 (18-28)	21.2 (19-23)	21.8 (21-22)
7	22.8 (22-24)	22.8 (19-29)	19.9 (18-21)	28.0 (20-34)	21.6 (21-22)	22.2 (21-23)
9	21.8 (21-22)	20.3 (17-25)	20.8 (17-24)	21.5 (20-23)	20.2 (19-21)	21.3 (20-22)
10	21.0 (20-23)	21.0 (17-26)	19.3 (17-21)	21.5 (21-23)	20.1 (18-21)	20.9 (19-22)
11	22.9 (22-25)	21.5 (17-25)	21.8 (19-25)	21.1 (17-24)	20.2 (18-23)	31.5 (22-49)
Embayment Stations						
3	25.6 (24-29)	22.9 (20-26)	17.7 (14-23)	25.3 (22-28)	23.7 (21-27)	21.4 (17-26)
6	25.0 (24-28)	21.9 (17-25)	20.3 (18-23)	22.1 (21-23)	20.9 (18-25)	21.9 (22-22)
8	23.3 (22-25)	22.4 (18-28)	21.3 (21-21)	21.1 (19-23)	19.6 (18-22)	20.8 (20-21)

Table 10-14. Mean (range) fall total hardness and total alkalinity measured at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

	Total Alkalinity (mg/l as $CaCO_3$)			Total Hardness (mg/l as $CaCO_3$)		
	Year			Year		
Mainstem Stations	1990	1991	1992	1990	1991	1992
1	22.0 (19-25)	20.7 (16-28)	19.1 (17-24)	28.8 (27-31)	27.4 (24-34)	26.2 (25-28)
2	23.2 (22-24)	20.7 (16-26)	23.4 (20-27)	24.6 (22-26)	25.1 (19-31)	24.5 (21-28)
4	22.8 (19-26)	19.3 (13-25)	18.4 (13-25)	28.6 (26-32)	20.2 (17-23)	23.5 (21-26)
5	18.7 (18-20)	20.1 (15-24)	21.0 (18-26)	24.4 (19-31)	21.2 (18-23)	24.8 (22-27)
7	20.5 (19-24)	20.3 (16-23)	21.1 (17-26)	24.5 (21-31)	22.0 (20-24)	23.1 (21-25)
9	20.4 (19-22)	21.0 (19-23)	20.9 (19-25)	23.5 (21-25)	20.1 (19-22)	23.7 (23-24)
10	20.9 (19-23)	21.7 (19-25)	21.3 (19-24)	21.3 (21-22)	20.7 (19-22)	21.6 (21-22)
11	21.1 (20-22)	22.0 (20-24)	21.8 (20-24)	22.4 (22-23)	20.5 (20-22)	21.7 (21-22)
Embayment Stations						
3	24.5 (23-29)	24.8 (18-31)	25.4 (21-30)	27.1 (25-29)	26.1 (20-35)	25.3 (22-29)
6	24.8 (22-28)	22.6 (19-24)	23.1 (21-25)	23.6 (22-27)	20.2 (19-22)	20.6 (20-22)
8	22.4 (20-24)	22.8 (21-25)	23.4 (23-24)	21.5 (21-23)	20.3 (19-22)	20.7 (20-21)

Table 10-15. Mean (range) winter total hardness and total alkalinity measured at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

	Total Alkalinity (mg/l as $CaCO_3$)		Total Hardness (mg/l as $CaCO_3$)	
	Year		Year	
Mainstem Stations	1990-91	1991-92	1990-91	1991-92
1	22.0 (19-21)	19.3 (16-22)	26.5 (23-29)	26.8 (18-31)
2	21.5 (19-25)	19.4 (16-21)	27.1 (25-29)	25.6 (18-30)
4	19.4 (14-24)	21.0 (17-24)	24.4 (21-28)	24.1 (19-27)
5	21.0 (19-23)	21.7 (16-26)	26.4 (21-31)	24.8 (19-28)
7	22.1 (18-29)	23.4 (19-28)	22.6 (19-26)	24.4 (23-25)
9	20.9 (18-26)	20.8 (20-22)	21.4 (19-24)	23.8 (22-26)
10	20.6 (18-25)	19.7 (17-24)	23.6 (20-27)	23.3 (21-27)
11	20.9 (19-25)	20.4 (16-24)	22.5 (20-25)	21.3 (19-24)
Embayment Stations				
3	22.2 (17-32)	18.7 (11-23)	20.9 (17-26)	19.2 (13-24)
6	21.5 (19-27)	20.9 (19-25)	21.0 (17-26)	19.3 (19-20)
8	19.6 (16-25)	19.8 (18-21)	18.3 (15-23)	19.2 (19-20)

Table 10-16. Mean (range) spring total hardness and total alkalinity measured at eleven sampling stations in West Point Lake during 1991 and 1992.

	Total Alkalinity (mg/l as $CaCO_3$) Year		Total Hardness (mg/l as $CaCO_3$) Year	
Mainstem Stations	1991	1992	1991	1992
1	19.8 (11-25)	18.9 (13-22)	25.0 (20-30)	27.7 (26-29)
2	18.5 (11-24)	19.4 (18-20)	22.1 (13-27)	23.2 (21-26)
4	19.2 (12-24)	20.3 (15-25)	24.4 (21-28)	23.7 (22-27)
5	18.3 (13-22)	20.0 (16-24)	21.6 (15-26)	22.4 (21-26)
7	17.9 (15-22)	18.7 (14-22)	20.2 (16-22)	20.8 (20-22)
9	17.6 (16-21)	18.0 (16-21)	18.6 (16-20)	19.0 (18-21)
10	17.5 (15-20)	16.5 (15-20)	19.2 (18-21)	19.9 (18-23)
11	17.5 (16-19)	17.1 (15-20)	18.6 (17-20)	19.1 (18-20)
Embayment Stations				
3	17.8 (9-23)	23.6 (20-26)	16.7 (11-21)	22.3 (21-26)
6	18.0 (16-19)	19.2 (17-21)	18.7 (15-20)	21.2 (20-23)
8	19.2 (17-20)	18.3 (16-20)	18.2 (17-20)	18.1 (16-19)

runoff. In general, total alkalinity and hardness declined from headwaters toward the dam as was the case with specific conductance.

Nitrogen and phosphorus are plant nutrients that are required in relatively high concentrations to support plant growth. Nitrogen concentrations normally exceed phosphorus concentrations by an order of magnitude or more (Wetzel 1983). Of the macronutrients, phosphorus is usually in shortest supply and therefore is the element most often limiting to plant growth in freshwater ecosystems. In some cases, phosphorus concentrations, relative to nitrogen, are high and nitrogen availability becomes limiting. This usually occurs at total nitrogen to total phosphorus ratios < 16:1 (Porcella et al. 1981).

Nitrogen is available to plants as nitrates ($NO_3^=$) or as the ammonium ion NH_4^+. Bioavailable nitrogen was abundant in West Point Lake with seasonal mean concentrations in the headwaters usually exceeding 1.0 mg/l and lacustrine concentrations varying from about 0.3 - 0.5 mg/l (Tables 10-17, 10-18, 10-19, 10-20 and Figure 10-10). Nitrogen concentrations in West Point Lake were excessive. For example, Boyd (1979) reported that in ponds being used for intensive fish culture (fish being fed daily), bioavailable nitrogen reached levels of 0.75 mg/l (0.5 mg/l NH_3-N and 0.25 mg/l NO_3-N). Such concentrations were common in the mid to upper reaches of West Point Lake and extended on occasion all the way to the dam. Ammonia and nitrite concentrations in the photic zone remained well below levels known to have direct adverse affects on aquatic organisms (EPA 1986).

Phosphorus in water is routinely reported as total phosphorus (all forms of phosphorus expressed as P) and soluble reactive phosphorus which is an estimate of orthophosphate ($PO_4^=$ expressed as P), the most important and abundant form of phosphorus directly available to plants. Both forms demonstrated a strong longitudinal gradient in West Point Lake with higher concentrations

Table 10-17. Mean (range) summer concentrations of NO_2-N, NO_3-N, NH_3-N and organic nitrogen at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

Mainstem Stations	NO_2 (µg/l) 1990	NO_2 (µg/l) 1991	NO_2 (µg/l) 1992	NO_3 (µg/l) 1990	NO_3 (µg/l) 1991	NO_3 (µg/l) 1992	NH_3 (µg/l) 1990*	NH_3 (µg/l) 1991	NH_3 (µg/l) 1992	Total Organic Nitrogen (µg/l) 1990	Total Organic Nitrogen (µg/l) 1991	Total Organic Nitrogen (µg/l) 1992
1	21 (10-31)	5 (3-6)	7 (4-12)	1244 (912-1456)	1140 (952-1505)	994 (721-1370)	(<30-70)	37 (6-63)	77 (60-90)	443 (410-480)	343 (285-414)	432 (306-643)
2	24 (11-44)	7 (5-12)	8 (4-15)	1582 (1286-1932)	832 (515-1195)	845 (551-1355)	---	88 (13-164)	67 (33-91)	429 (322-644)	407 (306-507)	451 (408-514)
4	13 (8-15)	10 (8-11)	10 (6-14)	463 (141-647)	553 (409-693)	533 (385-792)	33 (<30-40)	45 (14-68)	106 (36-163)	780 (644-995)	500 (466-553)	454 (317-665)
5	12 (11-14)	11 (11-12)	13 (10-16)	337 (233-471)	512 (395-699)	546 (343-704)	(<30-30)	47 (35-62)	54 (8-85)	671 (568-843)	493 (379-582)	575 (568-585)
7	16 (13-21)	15 (12-21)	19 (16-24)	324 (266-366)	453 (410-511)	452 (406-543)	(<30-30)	45 (34-52)	42 (6-67)	677 (497-1030)	370 (332-422)	473 (448-514)
9	12 (7-17)	11 (8-16)	16 (13-19)	262 (154-360)	304 (281-327)	390 (344-419)	<30	63 (40-80)	32 (24-41)	464 (334-644)	394 (364-422)	430 (406-457)
10	8 (7-9)	6 (4-8)	7 (3-9)	244 (199-282)	157 (119-232)	221 (149-306)	<30	48 (20-87)	30 (16-54)	566 (281-1042)	406 (381-446)	378 (348-414)
11	12 (10-13)	7 (3-16)	7 (4-9)	363 (265-475)	426 (241-545)	269 (181-368)	---	140 (67-208)	156 (103-227)	624 (263-1170)	256 (201-320)	307 (286-320)
Embayment Stations												
3	9 (7-11)	7 (5-10)	6 (5-9)	348 (262-432)	498 (287-627)	509 (366-692)	---	179 (18-838)	83 (74-91)	624 (398-925)	400 (265-515)	299 (188-400)
6	4 (3-6)	7 (3-11)	11 (5-14)	175 (57-348)	262 (169-387)	350 (200-460)	---	58 (7-149)	46 (35-54)	644 (468-995)	413 (268-524)	461 (388-500)
8	8 (7-9)	8 (1-14)	13 (11-15)	112 (0-289)	268 (205-340)	288 (194-349)	---	61 (41-92)	32 (21-47)	443 (304-702)	367 (309-457)	350 (303-386)

*Data from EPD (1990)

Table 10-18. Mean (range) fall concentrations of NO_2-N, NO_3-N, NH_3-N and organic nitrogen at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

	NO_2 (µg/l)			NO_3 (µg/l)			NH_3 (µg/l)			Total Organic Nitrogen (µg/l)		
Mainstem Stations	1990	1991	1992	1990	1991	1992	1990*	1991	1992	1990	1991	1992
1	12 (6-17)	5 (2-10)	6 (5-6)	1385 (1152-1639)	1189 (818-1759)	1306 (1301-1311)	(<30-40)	313 (24-841)	149 (140-158)	277 (257-298)	296 (213-414)	468 (250-685)
2	10 (9-12)	7 (2-13)	11 (8-13)	970 (958-993)	1010 (539-1510)	1109 (921-1296)	---	330 (38-823)	100 (81-118)	240 (181-357)	314 (233-387)	281 (233-328)
4	14 (13-15)	8 (4-11)	12 (10-14)	1158 (1126-1196)	527 (110-886)	924 (683-1165)	(<30-160)	388 (41-931)	152 (86-218)	281 (181-439)	370 (245-524)	289 (271-306)
5	16 (11-24)	10 (4-15)	22 (9-34)	944 (740-1303)	796 (634-1100)	962 (959-964)	(<30-100)	326 (30-821)	199 (89-308)	308 (240-433)	334 (210-414)	315 (297-333)
7	19 (17-23)	13 (7-24)	28 (13-42)	669 (329-857)	872 (499-1515)	598 (586-609)	70 (40-100)	241 (10-679)	132 (42-221)	265 (193-345)	382 (306-437)	371 (320-422)
9	21 (16-30)	10 (7-12)	22 (18-26)	438 (215-708)	536 (295-894)	543 (430-655)	95 (30-160)	211 (4-569)	144 (63-224)	339 (304-375)	382 (373-393)	313 (271-355)
10	16 (11-23)	10 (6-16)	5 (4-5)	520 (213-705)	391 (187-626)	388 (237-539)	90 (60-120)	213 (0-592)	88 (31-145)	263 (193-304)	316 (277-364)	380 (354-405)
11	14 (10-19)	12 (6-18)	6 (5-7)	514 (197-734)	517 (321-725)	410 (236-583)	---	292 (12-706)	85 (36-134)	226 (181-298)	271 (248-291)	287 (274-300)
Embayment Stations												
3	4 (2-8)	3 (1-6)	8 (7-8)	291 (92-477)	394 (123-716)	726 (566-885)	---	348 (58-822)	96 (60-131)	275 (129-503)	317 (204-364)	282 (257-306)
6	19 (14-24)	11 (7-17)	13 (10-16)	343 (255-411)	481 (270-654)	321 (100-541)	---	290 (59-708)	172 (48-295)	359 (275-445)	382 (329-483)	277 (237-317)
8	16 (11-25)	8 (5-9)	5 (2-8)	333 (227-447)	301 (82-428)	182 (56-308)	---	261 (0-642)	146 (56-235)	238 (187-287)	366 (294-422)	254 (248-260)

*Data from EPD (1990) for months of September and October.

Table 10-19. Mean (range) winter concentrations of NO_2-N, NO_3-N, NH_3-N and organic nitrogen at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

Mainstem Stations	NO_2 (µg/l) 1990-91	NO_2 (µg/l) 1991-92	NO_3 (µg/l) 1990-91	NO_3 (µg/l) 1991-92	NH_3 (µg/l) 1990-91*	NH_3 (µg/l) 1991-92	Total Organic Nitrogen (µg/l) 1990-91	Total Organic Nitrogen (µg/l) 1991-92
1	39 (23-56)	22 (10-39)	1283 (1128-1503)	1231 (564-1601)	---	119 (61-186)	332 (211-472)	432 (335-626)
2	31 (15-42)	16 (12-24)	1125 (819-1359)	974 (520-1244)	---	161 (50-230)	257 (217-332)	382 (265-591)
4	28 (25-30)	17 (13-24)	1024 (887-1110)	854 (539-1104)	---	185 (76-307)	204 (176-239)	295 (233-376)
5	33 (29-39)	20 (14-30)	1076 (1002-1188)	945 (531-1190)	---	206 (82-293)	233 (176-291)	298 (227-347)
7	21 (20-24)	18 (12-25)	957 (901-1029)	867 (792-954)	---	176 (107-238)	268 (233-322)	252 (218-294)
9	17 (15-19)	16 (11-20)	750 (480-988)	794 (651-928)	---	115 (90-152)	266 (250-285)	308 (271-326)
10	17 (13-21)	14 (10-16)	926 (801-1003)	755 (631-998)	---	110 (87-125)	249 (187-326)	325 (250-364)
11	14 (10-17)	12 (9-14)	966 (822-1045)	772 (609-977)	---	120 (74-166)	249 (181-291)	224 (218-233)
Embayment Stations								
3	3 (2-4)	2 (2-3)	440 (295-525)	261 (209-322)	---	86 (70-113)	202 (116-326)	215 (125-329)
6	11 (8-18)	8 (3-17)	517 (293-635)	368 (218-612)	---	155 (140-182)	274 (227-344)	366 (320-405)
8	13 (10-16)	13 (9-16)	512 (59-841)	437 (333-509)	---	68 (41-115)	276 (210-328)	314 (277-367)

* Data not available.

Table 10-20. Mean (range) spring concentrations of NO_2-N, NO_3-N, NH_3-N and organic nitrogen at eleven sampling stations in West Point Lake during 1991 and 1992.

Mainstem Stations	NO_2 (µg/l) 1991	NO_2 (µg/l) 1992	NO_3 (µg/l) 1991	NO_3 (µg/l) 1992	NH_3 (µg/l) 1991*	NH_3 (µg/l) 1992	Total Organic Nitrogen (µg/l) 1991	Total Organic Nitrogen (µg/l) 1992
1	26 (10-47)	15 (5-27)	951 (849-1124)	1233 (1142-1367)	55 (40-70)	74 (40-102)	380 (373-387)	394 (271-568)
2	14 (5-19)	15 (10-23)	686 (278-866)	1015 (909-1069)	---	90 (76-106)	379 (332-565)	319 (271-355)
4	21 (9-33)	15 (13-16)	804 (621-973)	932 (882-1029)	(<30-80)	99 (66-131)	350 (317-379)	294 (208-364)
5	21 (9-34)	15 (14-17)	797 (575-949)	837 (750-919)	80 (60-100)	51 (36-59)	348 (280-472)	377 (323-437)
7	16 (6-23)	15 (10-24)	626 (446-729)	629 (449-794)	35 (30-40)	110 (59-188)	327 (253-396)	329 (286-351)
9	12 (6-17)	11 (8-15)	490 (381-577)	518 (399-706)	40 (30-50)	97 (57-117)	377 (355-414)	377 (357-394)
10	11 (7-16)	10 (8-11)	465 (328-548)	468 (429-542)	<30	46 (29-65)	293 (250-355)	335 (262-374)
11	10 (7-12)	8 (7-9)	522 (417-613)	538 (464-613)	---	90 (68-111)	248 (227-262)	256 (218-280)
Embayment Stations								
3	3 (1-10)	4 (1-5)	175 (67-561)	302 (224-368)	---	111 (44-201)	334 (233-507)	277 (214-376)
6	13 (3-19)	11 (6-15)	364 (181-450)	501 (335-684)	---	67 (28-135)	427 (347-524)	341 (306-386)
8	11 (4-15)	10 (7-13)	385 (164-478)	433 (397-467)	---	60 (24-82)	344 (207-419)	315 (243-408)

*EPD data for months of April and May 1991.

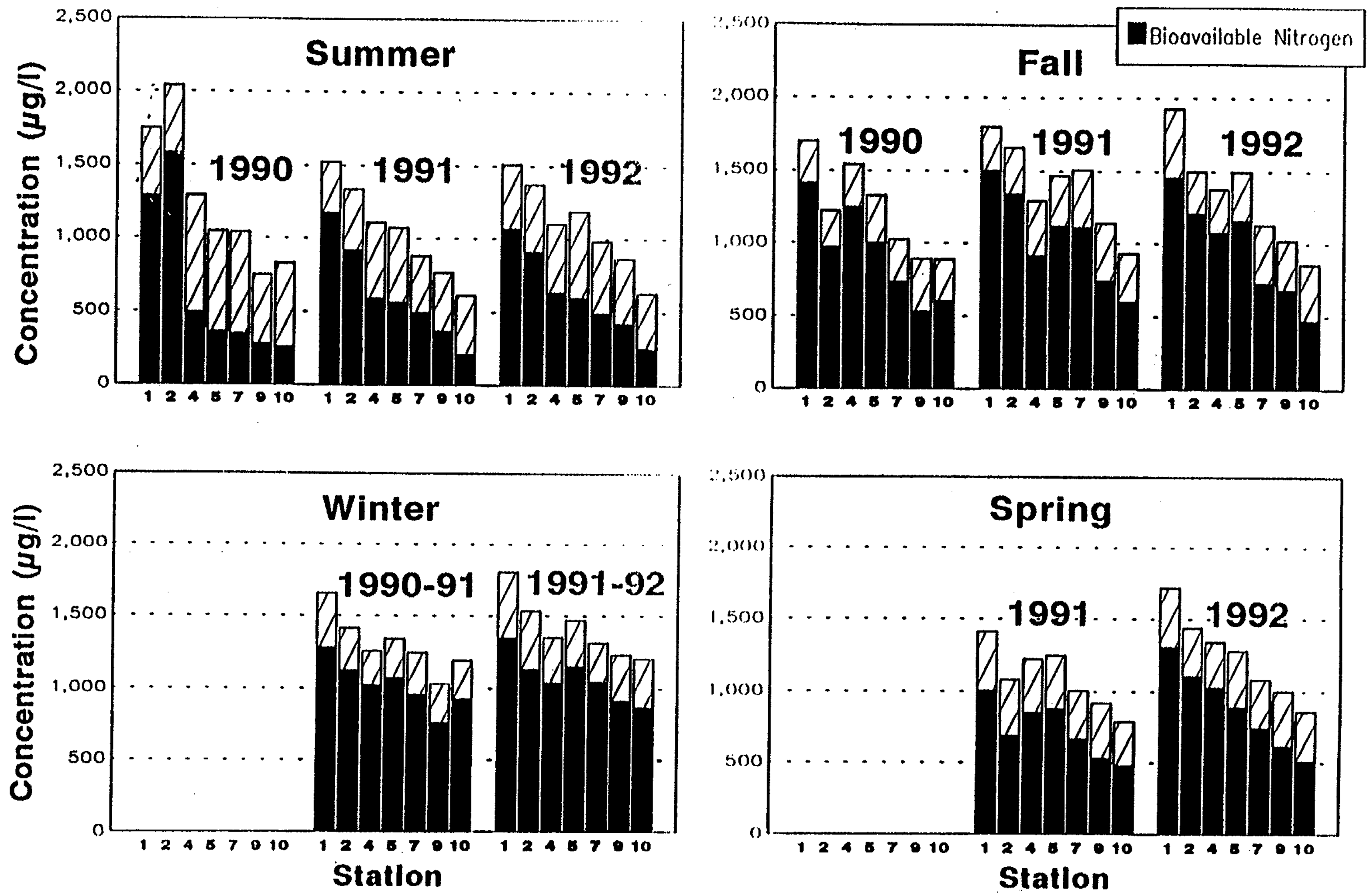

Figure 10-10. Seasonal mean total nitrogen and bioavailable nitrogen concentrations at mainstem sampling stations (headwaters at station 1 and dam at station 10) during the diagnostic study of West Point Lake, June 1990 through October 1992.

occurring at upstream locations (Tables 10-21, 10-22, 10-23 and 10-24 and Figure 10-11). Concentrations of orthophosphate (PO_4-P) at station 1 (Franklin, GA) ranged from 46 to 324 μg/l and total phosphorus (TP) concentrations at station 1 ranged from 86 to 372 μg/l. These concentrations are extremely high. TP concentrations > 100 μg/l are indicative of highly eutrophic waters (Wetzel 1983). TP concentrations > 100 μg/l were found, on occasion, as far downstream as station 5 (LaGrange water intake) during the growing season. EPA (1986) suggested a limit of 50 μg/l TP at the point where a stream enters a lake or reservoir in order to prevent excessive loading.

At station 1, the ratio of PO_4-P to TP was usually > 0.5, whereas in the tributary embayments the ratio was usually < 0.25. Chattahoochee River water entering West Point Lake had a large proportion of bioavailable P compared to the TP concentration (Figure 10-11). This is likely the result of the relatively large volume of treated municipal wastewater entering the river upstream of Franklin, GA (Raschke and Schultz 1987).

Phosphorus tends to adsorb onto surfaces of suspended inorganic particles, and therefore, increases in abiogenic turbidity are frequently accompanied by increased phosphorus concentration. That is one explanation for the elevated phosphorus concentrations at upstream locations, where greater water movement maintains particles in suspension. Further downstream, water movement subsides and particles settle to the bottom removing much of the incoming sediment and associated phosphorus. This phosphorus is deposited in bottom sediments and may remain there indefinitely. Mainstream reservoirs are known to trap large quantities of incoming phosphorus. Lawrence (1970) reported phosphorus losses of 61% and 75% in lakes Seminole and Eufaula, respectively, two lakes located on the Chattahoochee River downstream from West Point Lake. Under certain

Table 10-21. Mean (range) summer concentrations of PO_4-P and TP at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

Mainstem Stations	Orthophosphate (µg/l) 1990	Orthophosphate (µg/l) 1991	Orthophosphate (µg/l) 1992	Total Phosphorus (µg/l) 1990	Total Phosphorus (µg/l) 1991	Total Phosphorus (µg/l) 1992
1	231 (183-324)	63 (49-86)	55 (39-70)	311 (275-372)	135 (115-162)	144 (92-193)
2	255 (193-320)	33 (13-45)	32 (16-54)	302 (240-383)	124 (110-145)	122 (98-138)
4	18 (8-26)	3 (1-4)	6 (0-15)	119 (111-130)	77 (69-85)	94 (69-140)
5	4 (4-5)	4 (3-6)	2 (0-3)	75 (73-78)	55 (52-61)	60 (49-76)
7	3 (0-4)	2 (1-4)	2 (0-3)	52 (46-58)	38 (37-38)	41 (36-47)
9	1 (0-4)	3 (1-4)	1 (0-3)	32 (31-35)	29 (26-31)	28 (26-32)
10	1 (0-3)	1 (0-3)	1 (0-2)	22 (20-25)	24 (22-29)	22 (19-26)
11	2 (0-4)	3 (1-9)	3 (0-7)	30 (28-34)	28 (23-32)	35 (28-43)
Embayment Stations						
3	8 (6-9)	8 (5-13)	9 (6-14)	106 (87-126)	87 (62-96)	99 (83-120)
6	13 (0-40)	2 (0-3)	1 (0-3)	43 (38-50)	34 (32-37)	42 (37-48)
8	8 (0-23)	1 (0-3)	1 (0-3)	30 (25-36)	24 (15-31)	24 (22-25)

Table 10-22. Mean (range) fall concentrations of PO_4-P and TP at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

Mainstem Stations	Orthophosphate (µg/l) 1990	1991	1992	Total Phosphorus (µg/l) 1990	1991	1992
1	118 (92-160)	91 (53-165)	85 (56-113)	158 (127-206)	133 (86-202)	219 (105-333)
2	100 (79-129)	62 (21-121)	50 (47-52)	152 (121-179)	127 (83-166)	121 (113-128)
4	86 (69-103)	33 (6-67)	48 (45-50)	143 (126-167)	98 (69-134)	105 (102-108)
5	53 (35-86)	36 (8-85)	27 (24-30)	100 (71-136)	83 (55-129)	73 (62-83)
7	26 (0-43)	9 (2-21)	7 (3-10)	72 (43-86)	58 (44-70)	48 (47-49)
9	10 (0-22)	0.3 (0-1)	2 (2-2)	45 (27-56)	33 (28-37)	33 (33-33)
10	4 (0-7)	3 (0-4)	0.5 (0-1)	28 (15-34)	27 (21-34)	24 (23-25)
11	9 (0-16)	5 (0-10)	1 (0-2)	28 (13-43)	36 (19-53)	25 (22-27)
Embayment Stations						
3	9 (7-13)	10 (2-14)	19 (10-28)	70 (30-103)	68 (49-93)	82 (65-99)
6	7 (0-18)	5 (0-13)	1.5 (1-2)	46 (24-64)	44 (29-55)	37 (32-42)
8	3 (0-8)	0.5 (0-2)	0.5 (0-1)	27 (13-35)	25 (18-31)	19 (15-23)

Table 10-23. Mean (range) winter concentrations of PO_4-P and TP at eleven sampling stations in West Point Lake during 1990, 1991 and 1992.

Mainstem Stations	Orthophosphate (µg/l) 1990-91	Orthophosphate (µg/l) 1991-92	Total Phosphorus (µg/l) 1990-91	Total Phosphorus (µg/l) 1991-92
1	91 (78-107)	117 (71-145)	177 (128-245)	217 (191-250)
2	66 (50-82)	75 (67-88)	154 (123-183)	165 (136-200)
4	56 (49-60)	58 (55-62)	122 (111-137)	144 (128-167)
5	63 (60-68)	60 (51-72)	137 (130-148)	128 (119-136)
7	41 (26-66)	49 (30-82)	97 (78-124)	98 (88-113)
9	29 (7-65)	38 (18-65)	71 (55-91)	75 (64-82)
10	24 (14-40)	13 (10-16)	58 (45-74)	51 (47-55)
11	27 (17-38)	22 (17-27)	65 (59-69)	46 (45-47)
Embayment Stations				
3	15 (1-39)	6 (1-9)	48 (45-51)	47 (22-80)
6	9 (4-18)	17 (1-43)	62 (50-78)	67 (39-105)
8	9 (0-17)	3 (0-7)	47 (38-55)	37 (29-49)

Table 10-24. Mean (range) spring concentrations of PO_4-P and TP at eleven sampling stations in West Point Lake during 1991 and 1992.

Mainstem Stations	Orthophosphate (µg/l) 1991	Orthophosphate (µg/l) 1992	Total Phosphorus (µg/l) 1991	Total Phosphorus (µg/l) 1992
1	93 (46-160)	74 (63-88)	203 (169-238)	147 (104-190)
2	40 (10-73)	32 (10-44)	142 (106-190)	115 (108-127)
4	35 (22-51)	27 (14-39)	126 (97-144)	90 (75-112)
5	27 (25-29)	12 (3-22)	99 (79-121)	70 (51-97)
7	9 (6-14)	5 (0-16)	57 (55-61)	49 (31-77)
9	4 (0-8)	3 (0-7)	46 (43-50)	39 (26-62)
10	4 (0-11)	1 (0-3)	35 (28-45)	32 (21-47)
11	15 (7-29)	6 (2-8)	42 (35-49)	33 (25-46)
Embayment Stations				
3	9 (1-25)	1 (0-2)	82 (68-112)	47 (39-58)
6	4 (0-8)	1 (0-2)	47 (36-65)	42 (36-48)
8	2 (1-3)	3 (0-5)	39 (26-51)	31 (22-48)

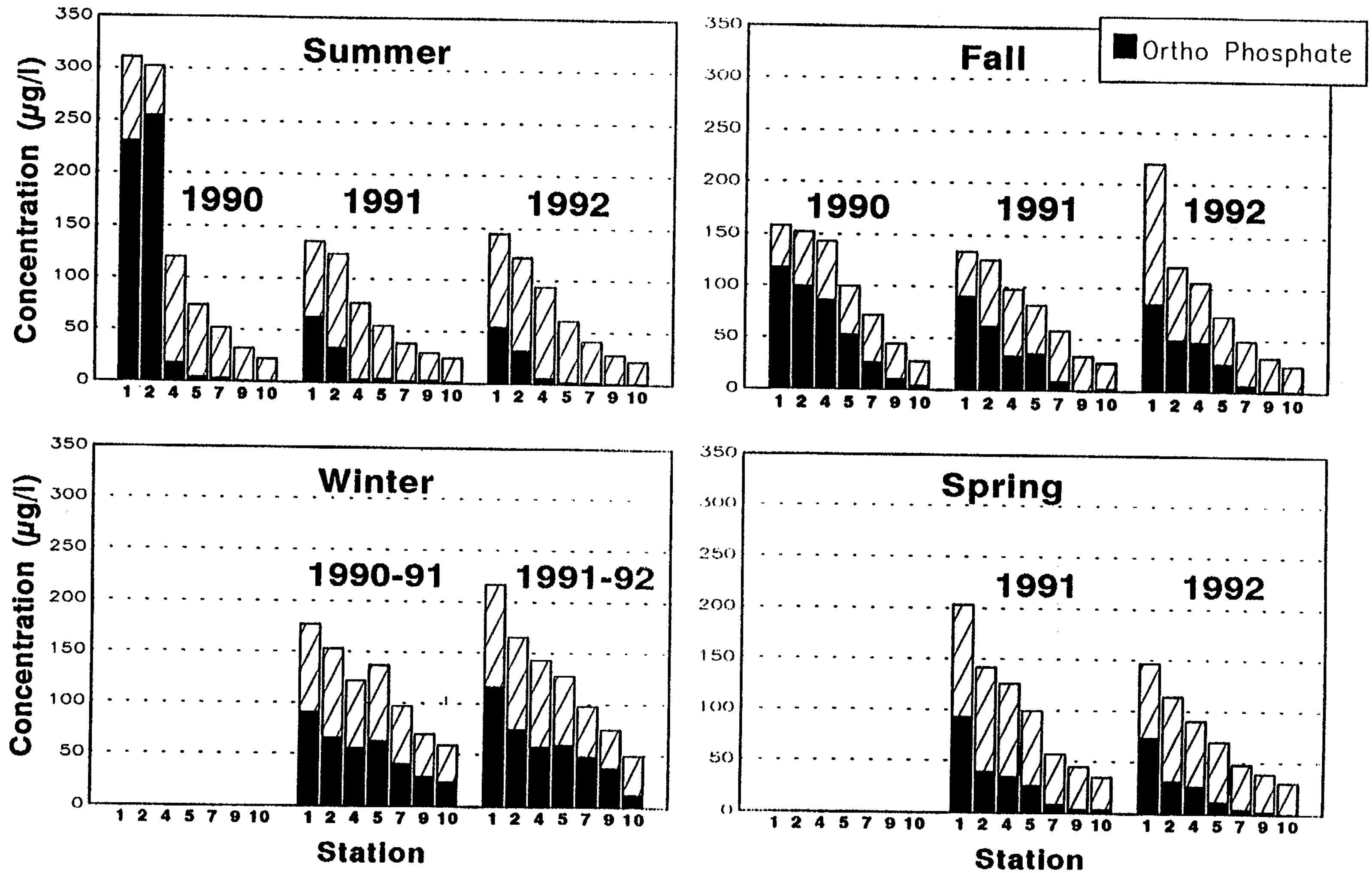

Figure 10-11. Seasonal mean total phosphorus and orthophosphate concentrations at mainstem sampling stations (headwaters at station 1 and dam at station 10) during the diagnostic study of West Point Lake, June 1990 through October 1992.

circumstances some of the accumulated phosphorus can reenter the water column and reach the photic zone, a process known as internal loading of phosphorus. Lakes with anaerobic hypolimnia are more prone to internal loading since reducing conditions mobilize phosphorus in the sediments and release soluble phosphorus to the overlying water column.

A comparison of PO_4-P and TP concentrations among years at the mainstem lake stations revealed a notable decline in both species from 1990 to 1991 (Figure 10-11). This comparison was possible only for the summer and fall quarters since sampling started in June 1990. The decline was more obvious upstream than downstream, in fact, near the dam (station 10) there was no change in mean summer phosphorus concentrations among years (Table 10-25). There were no consistent differences between 1991 and 1992 mean phosphorus concentrations during any quarter. The phosphorus decrease from 1990 to 1991 was a continuation of a decline that began in the drought year of 1988 (EPD 1990). During that year, mean growing season TP measured at Franklin, GA exceeded 0.5 mg/l (EPA-EPD 1988).

Factors other than variation in stream flow have influenced phosphorus content of West Point Lake. By the end of 1989, several Atlanta area counties had banned use of high phosphate laundry detergents and a statewide ban enacted by the Georgia General Assembly went into effect 1 January 1991 (EPD 1990). In addition, EPD has imposed a 0.75 mg/l phosphorus limit on major dischargers into the Chattahoochee River between Franklin, GA and Buford Dam. Most major dischargers were expected to comply by the end of 1991 while others will not meet the final 0.75 mg/l limit until 1993 or 1996 (EPD 1990). These actions resulted in an estimated 50% reduction in phosphorus loading by major Atlanta area point sources between 1988 and 1990 (EPA 1990). The decline in inlake phosphorus

Table 10-25. Seasonal mean total nitrogen (μg/l TN), total phosphorus (μg/l TP) and the ratio of TN to TP at select mainstem stations on West Point Lake during the summer seasons of 1990, 1991 and 1992.

Mainstem Station	1990 TN	1990 TP	1990 TN:TP	1991 TN	1991 TP	1991 TN:TP	1992 TN	1992 TP	1992 TN:TP
1	1,750	311	5.6	1,525	135	11.3	1,510	144	10.5
4	1,289	119	10.8	1,108	77	14.4	1,103	94	11.7
5	1,043	75	13.9	1,063	55	19.3	1,188	60	19.8
7	1,040	52	20.0	883	38	23.2	868	41	21.2
9	753	32	23.5	772	29	26.6	868	28	31.0
10	833	22	37.9	617	24	25.7	636	22	28.9

concentrations from 1990 levels to those encountered in 1991 and 1992 was probably caused, in part, by reduced levels of incoming phosphorus. However, reduced flows during summer and fall 1990 caused by below average rainfall (Figure 10-2) resulted in higher phosphorus concentrations than expected under more normal flow conditions (Table 10-4). In contrast, rainfall and discharge during summer and fall 1991 were above normal.

During the summer seasons, the ratio of TN to TP at least doubled from the headwaters (station 1) to the dam (station 10) each of the three years (Table 10-25). The relatively large quantity of phosphorus upstream depressed the TN:TP and as waters moved downstream TP diminished at a faster rate than TN resulting in a higher TN:TP (Table 10-25). Settling of particulate matter and its associate P is the main cause of the TP decline. Waters that receive treated municipal effluent often have relatively low (2-5) TN:TP (Raschke and Schultz 1987). During the summer of 1990 the upstream TN:TP was 5.6 and at the dam it was 37.9. Optimum TN:TP for phytoplankton growth is in the range of 11 to 16 (Porcella et al. 1974) and therefore upstream areas of West Point Lake in the summer of 1990 were clearly nitrogen limited. In the summers of 1991 and 1992, upstream (station 1) TN:TP values were 11.3 and 10.5, respectively, and downstream (station 10) values were 25.0 and 28.9, respectively. The decline in P that occurred from 1990 to 1991-92 (Tables 10-21, 10-22, 10-23 and 10-24) was accompanied by a shift in the TN:TP indicating that the lake was becoming phosphorus limited further upstream. Results of algal growth potential tests were used to further define nutrient limitation in West Point Lake (Section 10.2.2).

10.2.2 PHYTOPLANKTON

The photic zone composite water sample collected at each sampling station (Table 10-2) was the source of water used for analysis of phytoplankton related variables. Aliquots of the composite sample were separated for total organic carbon (TOC) analyses (Table 10-3), phytoplankton identification and enumeration, chlorophyll a analyses and the Algal Growth Potential Test (AGPT) (Table 10-26). Phytoplankton counts and TOC analyses were conducted monthly and the AGPT was done at intervals during the growing seasons (April - October) of 1991 and 1992 (Table 10-1). Chlorophyll a analyses were done biweekly during the growing seasons and monthly at other times (Table 10-1). Phytoplankton primary productivity was measured monthly (Table 10-1) at stations 1, 2, 4, 6, 8, 9 and 10 using the carbon-14 method (Table 10-26). Duplicate light and dark bottles were incubated for 3 h at midday at each of three depths within the euphotic zone: the lower limit of the euphotic zone, midway between the lower limit and the surface and about 0.3 m below the water surface. The lower limit of the euphotic zone was determined by multiplying the Secchi disk visibility by a factor of four (Taylor 1971). Productivity measured during the 3-h exposure was expanded to total daily productivity ($mgC/m^2 \cdot day$) using solar radiation data obtained during the exposure period and for the entire day (Boyd 1979). The productivity value for each station was then adjusted to a monthly estimate based on total solar radiation measured during that month. Finally, each station was mathematically weighted to reflect the area of the reservoir that it represented and a mean annual estimate for the entire reservoir was obtained. Continuous solar radiation was measured at the National Oceanic and Atmospheric Administration's (NOAA) National Weather Station, Auburn, Alabama (Table 10-4).

Table 10-26. Analytical methods used in measuring microbiological variables during the diagnostic study of West Point Lake, 1990-1992.

Variable	Method	Reference
Chlorophyll a	Spectrophotometric	APHA et al. 1989
Phytoplankton Enumeration	Sedimentation chamber	APHA et al. 1989
Algal Growth Potential Test	U.S.E.P.A. Methodology	Athens, GA Lab.
Phytoplankton Primary Productivity	Carbon 14 Method	APHA et al. 1989
Fecal Coliforms	Membrane Filter Procedure	APHA et al. 1989

Phytoplankton density ranged from a low of 454 organisms/ml at station 3in December of 1991 to a high of 9,120 organisms/ml at station 8 in June of 1992 (Tables 10-27, 10-28, 10-29 and 10-30). Highest densities occurred during the summer and fall and lowest densities during the winter and spring (Figure 10-12). Riverine areas (stations 1 and 2) generally supported lower phytoplankton numbers than downstream areas. During the summer and fall lacustrine areas (stations 7, 9 and 10) usually produced highest densities. During a 10-year study of West Point Lake, Bayne et al. (1990) reported mean cool season (November-April) phytoplankton densities of 843 organisms/ml and mean warm season (May-October) densities of 3,916 organisms/ml. Embayment station phytoplankton densities were usually similar to the nearest mainstem station densities (Tables 10-27, 10-28, 10-29 and 10-30). New River embayment (station 3) located upstream in the riverine zone of the lake frequently had lower phytoplankton densities than the downstream Yellowjacket Creek (station 6) and Wehadkee Creek (station 8) embayments.

Green algae (Division Chlorophyta) were dominant on most sampling occasions in the lentic areas (stations 4, 5, 7, 9 and 10) of West Point Lake (Figure 10-3). Diatoms (Division Chrysophyta) usually ranked first or second in numerical abundance in lentic areas, but were clearly dominant at upstream, riverine locations (e.g., station 1) (Figure 10-13). Diatoms become more competitive in areas where water movement is sufficient to prevent their sinking beneath the photic zone because of their relatively dense cell walls (Wetzel 1983). Diatoms and green algae alternated in seasonal abundance with diatoms relatively more abundant in winter-spring months and green algae more abundant in summer-fall months (Figure 10-13). The euglenoids (Division Euglenophyta) were the third most abundant group followed by dinoflagellates (Division Pyrrhophyta) and blue-green algae (Division Cyanobacteria) (Figure 10-13). From 1976 through 1985

Table 10-27. Seasonal mean (range) total organic carbon concentrations, chlorophyll a concentrations and phytoplankton densities at West Point Lake mainstem and embayment stations during the summers of 1990, 1991 and 1992.

Mainstem Stations	Total Organic Carbon (mg/l) 1990	1991	1992	Chlorophyll a (µg/l) 1990	1991	1992	Phytoplankton Density (organisms/ml) 1990	1991	1992
1	4.08 (3-6)	3.41 (3-4)	3.82 (3-5)	4.9 (3-7)	2.0 (2-3)	2.6 (2-3)	1071 (913-1303)	868 (678-1163)	1365 (1148-1622)
2	2.83 (3-3)	4.00 (3-6)	3.91 (3-5)	12.2 (5-23)	10.8 (8-15)	8.5 (4-14)	1270 (959-1622)	1120 (1058-1171)	1886 (1775-1991)
4	4.35 (4-5)	4.40 (4-5)	4.11 (3-5)	36.0 (34-38)	19.3 (17-23)	22.6 (6-34)	1812 (1630-1986)	1654 (1314-2000)	2248 (1909-2676)
5	4.48 (4-5)	3.83 (4-4)	4.73 (4-6)	25.7 (21-31)	17.7 (10-24)	19.3 (14-29)	2380 (2143-2726)	2072 (1625-2563)	2596 (1619-3268)
7	4.08 (4-4)	4.05 (4-5)	3.87 (4-4)	21.5 (21-22)	15.0 (10-20)	15.6 (9-24)	2591 (2092-3257)	1471 (1101-2001)	2478 (2334-2675)
9	3.84 (3-5)	3.70 (4-4)	4.21 (4-5)	13.4 (12-15)	14.7 (11-20)	14.0 (9-22)	2246 (1705-2519)	1750 (1432-2337)	3819 (1838-6613)
10	3.48 (3-4)	4.05 (4-4)	3.94 (4-4)	8.9 (6-11)	13.8 (11-16)	10.6 (3-19)	3059 (1385-5655)	2153 (1356-3225)	3781 (2654-5819)
11	4.67 (3-7)	3.88 (3-5)	3.48 (3-4)	3.4 (2-5)	4.0 (2-5)	7.3 (4-11)	1491 (1095-1719)	1733 (812-2818)	2510 (1713-2885)
Embayment Stations									
3	4.03 (4-5)	4.25 (4-5)	4.35 (4-5)	25.9 (14-39)	17.1 (9-26)	11.7 (8-15)	1721 (1029-2169)	1343 (1133-1498)	1886 (1459-2157)
6	4.36 (4-5)	4.20 (4-4)	4.14 (4-5)	19.4 (13-23)	14.7 (12-18)	14.7 (13-17)	1745 (1660-1867)	1931 (1108-2670)	2979 (2561-3311)
8	3.45 (3-4)	4.01 (4-4)	3.78 (3-4)	11.8 (11-12)	11.8 (8-15)	11.9 (9-14)	2206 (1947-2460)	2358 (1986-2753)	5267 (2242-9120)

Table 10-28. Seasonal mean (range) total organic carbon concentrations, chlorophyll *a* concentrations and phytoplankton densities at West Point Lake mainstem and embayment stations during the fall of 1990, 1991 and 1992.

Mainstem Stations	Total Organic Carbon (mg/l)			Chlorophyll *a* (µg/l)			Phytoplankton Density (organisms/ml)		
	1990	1991	1992*	1990	1991	1992*	1990	1991	1992*
1	2.72 (2-3)	3.62 (3-5)	3.75 (3-4)	2.6 (2-4)	2.3 (1-4)	1.34 (1-1)	937 (611-1448)	807 (663-892)	1212 (1204-1220)
2	2.41 (2-3)	2.64 (3-3)	3.21 (3-4)	0.5 (0-1)	4.1 (2-8)	5.8 (6-6)	1062 (675-1592)	1163 (837-1441)	1487 (1372-1601)
4	2.94 (3-3)	3.06 (3-4)	3.69 (3-4)	7.5 (0-18)	9.2 (1-26)	13.1 (5-20)	1201 (931-1573)	1528 (791-2272)	1717 (1691-1743)
5	3.53 (3-4)	2.72 (2-3)	3.54 (3-4)	11.1 (7-19)	12.3 (7-25)	21.7 (6-35)	1344 (786-1629)	1665 (860-2525)	1480 (1441-1518)
7	3.37 (3-3)	2.93 (2-3)	3.51 (3-3)	14.4 (10-21)	17.8 (12-32)	16.6 (9-23)	1234 (820-1867)	1864 (1028-2867)	2135 (1789-2480)
9	3.23 (3-3)	3.01 (3-3)	3.59 (3-4)	13.0 (10-16)	13.1 (8-18)	14.8 (7-22)	1466 (1086-2053)	1767 (1272-2586)	2573 (2152-2993)
10	3.81 (3-5)	2.99 (3-4)	3.58 (3-4)	9.0 (4-12)	9.4 (4-14)	13.9 (4-21)	1283 (1105-1425)	1855 (1011-2494)	3023 (1675-4371)
11	2.86 (3-3)	3.19 (3-3)	3.64 (3-4)	4.0 (0-9)	6.1 (4-11)	6.2 (6-6)	1288 (880-1982)	1610 (1279-1861)	2541 (1627-3454)
Embayment Stations									
3	3.76 (3-4)	2.88 (3-3)	3.76 (3-4)	6.4 (1-18)	9.6 (6-16)	7.8 (8-8)	1185 (735-2062)	1347 (1076-1557)	1891 (1774-2008)
6	3.82 (3-5)	3.86 (3-5)	3.77 (4-4)	12.5 (8-20)	14.3 (9-19)	8.9 (9-9)	1552 (1412-1803)	1683 (948-2156)	2923 (1780-4066)
8	2.94 (3-3)	3.55 (3-4)	3.50 (3-4)	6.8 (6-8)	13.3 (12-15)	6.0 (6-6)	1089 (993-1253)	2182 (1198-3315)	2845 (1663-4027)

*Data available for September and October only.

Table 10-29. Seasonal mean (range) total organic carbon concentrations, chlorophyll *a* concentrations and phytoplankton densities at West Point Lake mainstem and embayment stations during the winter of 1990, 1991 and 1992.

Mainstem Stations	Total Organic Carbon (mg/l) 1990-91	Total Organic Carbon (mg/l) 1991-92	Chlorophyll *a* (µg/l) 1990-91	Chlorophyll *a* (µg/l) 1991-92	Phytoplankton Density (organisms/ml) 1990-91	Phytoplankton Density (organisms/ml) 1991-92
1	2.92 (3-3)	3.68 (3-4)	1.3 (1-2)	2.2 (2-4)	708 (582-898)	939 (630-1127)
2	2.64 (3-3)	3.24 (3-4)	1.3 (1-2)	2.3 (1-4)	701 (666-734)	1002 (755-1324)
4	2.67 (3-3)	3.30 (3-4)	1.9 (1-2)	2.0 (1-2)	2103 (620-4571)	897 (717-1235)
5	3.29 (2-4)	3.74 (3-5)	3.9 (2-7)	2.8 (2-4)	881 (729-996)	1075 (955-1158)
7	3.32 (3-4)	2.81 (2-3)	8.8 (3-16)	5.6 (5-7)	955 (794-1221)	1199 (1032-1396)
9	2.69 (2-3)	2.79 (2-3)	7.6 (4-14)	7.1 (5-9)	1299 (1136-1599)	1362 (1234-1511)
10	3.56 (3-5)	2.97 (3-3)	4.6 (2-6)	9.6 (7-13)	1201 (1098-1289)	1492 (1095-1312)
11	2.89 (3-3)	3.82 (3-6)	2.2 (2-2)	4.6 (4-5)	899 (746-986)	1151 (948-1312)
Embayment Stations						
3	2.44 (2-3)	3.08 (3-4)	1.6 (2-2)	1.0 (1-1)	742 (623-964)	569 (454-691)
6	2.82 (3-3)	3.02 (3-4)	9.4 (7-11)	10.8 (8-14)	1519 (817-2028)	2631 (1574-4313)
8	2.88 (3-3)	2.87 (3-3)	10.7 (7-16)	16.2 (13-22)	1565 (1451-1786)	1645 (1565-1715)

Table 10-30. Seasonal mean (range) total organic carbon concentrations, chlorophyll *a* concentrations and phytoplankton densities at West Point Lake mainstem and embayment stations during the spring of 1991 and 1992.

Mainstem Stations	Total Organic Carbon (mg/l) 1991	Total Organic Carbon (mg/l) 1992	Chlorophyll *a* (µg/l) 1991	Chlorophyll *a* (µg/l) 1992	Phytoplankton Density (organisms/ml) 1991	Phytoplankton Density (organisms/ml) 1992
1	4.74 (4-5)	11.33 (3-27)	2.8 (2-4)	1.9 (1-3)	1167 (1041-1266)	1305 (1169-1543)
2	4.65 (4-6)	2.63 (2-3)	4.5 (2-7)	4.0 (2-6)	1392 (978-1604)	1305 (808-1606)
4	4.20 (4-5)	2.78 (2-3)	11.3 (2-16)	11.2 (3-34)	1331 (750-1711)	1876 (1578-2344)
5	4.49 (4-5)	3.01 (3-4)	12.9 (3-23)	12.6 (7-30)	1621 (671-2418)	1629 (1212-1840)
7	3.85 (4-4)	2.86 (3-3)	12.8 (8-17)	10.2 (4-18)	1493 (1146-1957)	1559 (1398-1700)
9	4.61 (4-6)	3.20 (3-4)	13.1 (8-16)	11.6 (6-16)	1450 (1383-1547)	1466 (1216-1855)
10	4.68 (4-6)	3.29 (3-3)	9.1 (6-15)	11.0 (5-21)	973 (888-1129)	1399 (1059-1659)
11	3.73 (4-4)	2.93 (3-3)	4.2 (3-5)	5.3 (3-8)	946 (674-1121)	1378 (999-1674)
Embayment Stations						
3	4.83 (4-6)	2.63 (2-3)	5.5 (4-6)	6.3 (2-9)	1350 (1119-1637)	1956 (1065-3483)
6	4.06 (4-4)	2.90 (3-3)	17.3 (11-24)	8.8 (4-12)	1762 (1177-2496)	1470 (1344-1605)
8	3.64 (3-4)	3.06 (3-4)	10.3 (4-15)	8.0 (3-16)	1441 (1105-1694)	1332 (1044-1596)

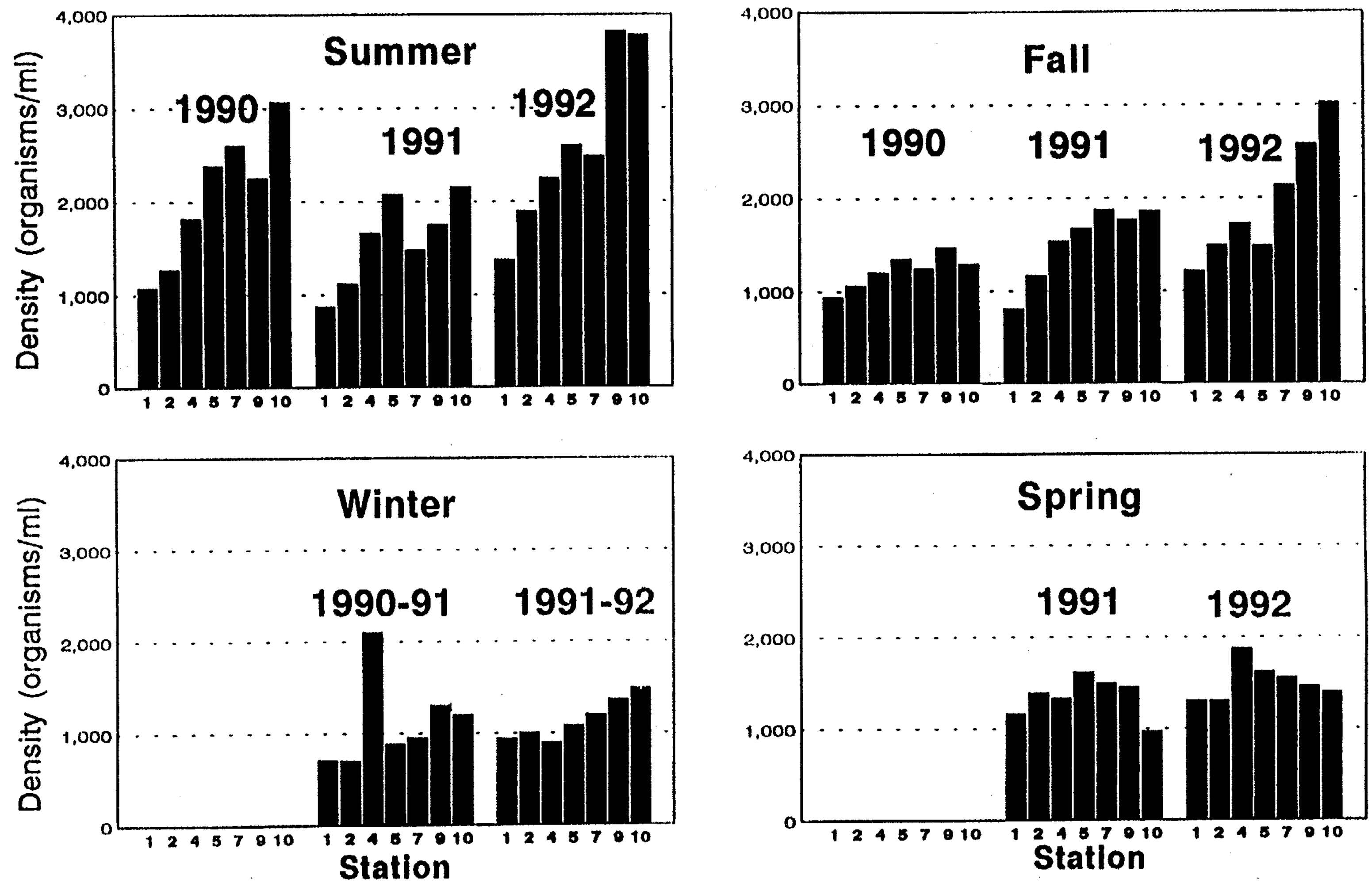

Figure 10-12. Seasonal mean phytoplankton densities at mainstem sampling stations (headwaters at station 1 and dam at station 10) during the diagnostic study of West Point Lake, June 1990 through October 1992.

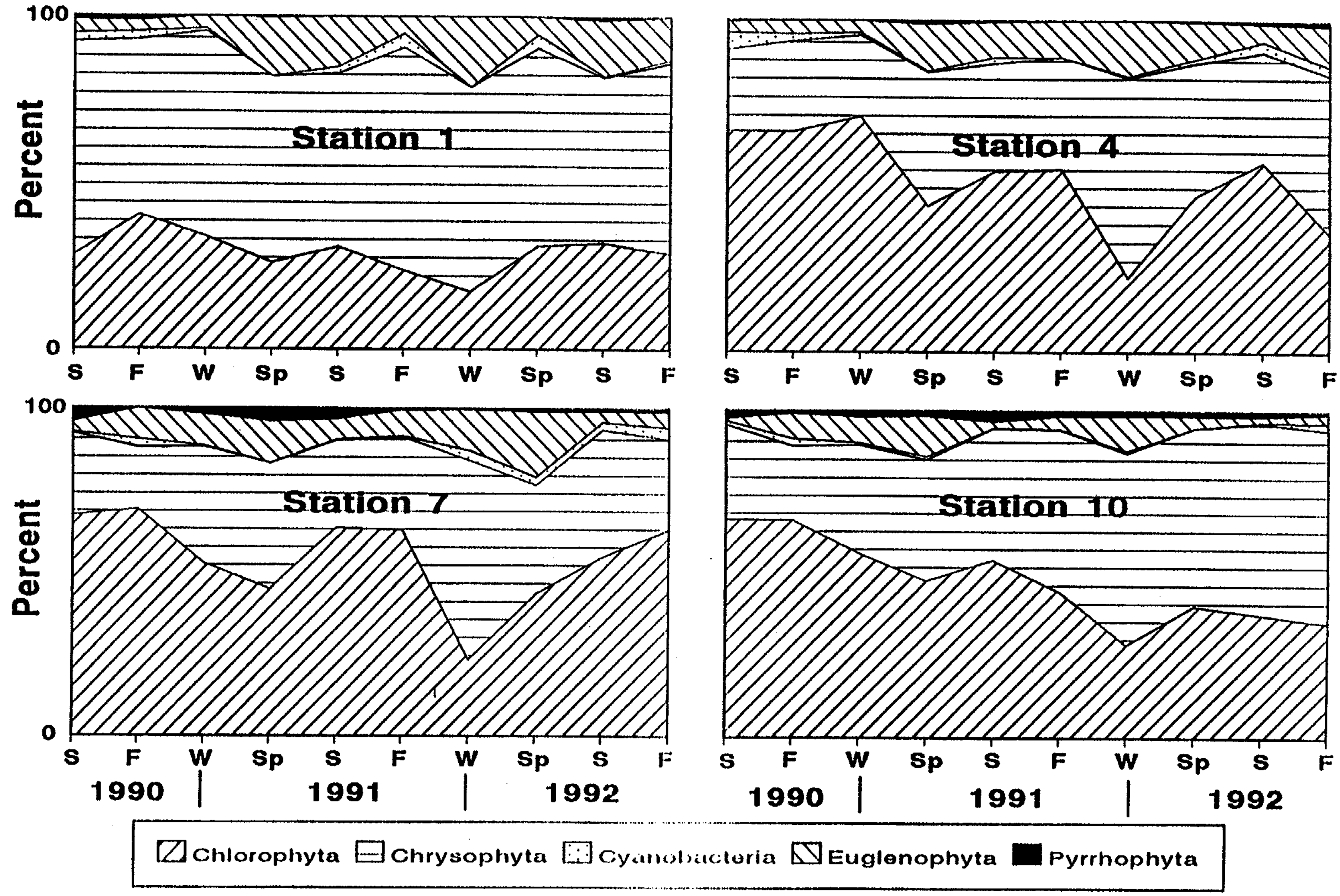

Figure 10-13. Percent composition of phytoplankton communities by algal Division during the diagnostic study of West Point Lake, June 1990 through October 1992.

diatoms and green algae were usually most abundant followed by blue-green algae (Bayne et al. 1990). During those years of increasing lake trophic status, blue-green algae were dominant on 7% of the sampling occasions (station-date) and green algae increased in abundance. In contrast, from June 1990 through October 1992 blue-green algae were dominant on only one occasion (December 1991 at station 6) and diatoms appeared to be increasing in relative abundance (Figure 10-13). This shift in community structure might be a response to changes in water quality, most notably the increase in TN:TP ratio in the lentic areas of the lake.

Sixty-six algal taxa were identified during the study (Table 10-31). Virtually all of the organisms have been previously reported from Georgia reservoirs (Morris et al. 1977). Chlorophyta (green algae) taxa were most numerous followed by Cyanobacteria (blue-green algae) and Chrysophyta (primarily diatoms).

Pennate diatoms were common and abundant throughout the reservoir and, in aggregate, were numerically dominant on most sampling occasions (Table 10-32). The most commonly encountered pennate diatoms that could be identified without special preparation were Tabellaria spp., Synedra spp., and Asterionella formosa. The centric diatoms, Melosira distans and M. granulata were abundant and frequently ranked among the top three dominant organisms. Dominant green algae included Chlamydomonas spp., Ankistrodesmus convolutus, Scenedesmus quadricauda, Oocystis sp. and Scenedesmus sp. In the division Euglenophyta (euglenoids) Trachelomonas spp. and Euglena spp. were occasionally among the dominant taxa (Table 10-32). Bluegreen algae were rarely among the dominant organisms encountered. Dominant blue-greens were Oscillatoria spp. and Chroococcus spp.

Table 10-31. Taxa list of plankton algae identified in West Point Lake from June 1990 through October 1992.

CHLOROPHYTA	
Actinastrum sp.	Oocystis sp.
Ankistrodesmus convolutus	Pachycladon umbrinus
Ankistrodesmus falcatus	Pachycladon sp.
Ankistrodesmus nannoselene	Pandorina sp.
Arthrodesmus sp.	Pediastrum sp.
Chlamydomonas sp.	Scenedesmus abundans
Chodatella sp.	Scenedesmus acuminatus
Closterium sp.	Scenedesmus armatus
Coelastrum sp.	Scenedesmus denticulatus
Cosmarium sp.	Scenedesmus quadricauda
Crucigenia apiculata	Scenedesmus sp.
Crucigenia sp.	Schroederia sp.
Desmidium sp.	Selenastrum sp.
Dictyosphaerium sp.	Sphaerocystis sp.
Elakatothrix sp.	Staurastum sp.
Euastrum sp.	Tetraedron caudatum
Eudorina sp.	Tetraedron gracile
Franceia sp.	Tetraedron minimum
Gloeocystis sp.	Tetraedron trigonum
Golenkinia sp.	Tetraedron sp.
Kirchneriella sp.	Tetrastrum sp.
Micrasterias sp.	Treubaria sp.
	Green Filament
CHRYSOPHYTA	
Asterionella sp.	Melosira granulata
Dinobryon sp.	Centric diatoms
Melosira distans	Pennate diatoms
CYANOBACTERIA	
Anabaena sp.	Merismopedia sp.
Chroococcus sp.	Microcystis scp.
Coelosphaerium sp.	Oscillatoria sp.
Gloeocapsa sp.	Raphidiopsis sp.
Gomphosphaeria sp.	Spirulina sp.
Lyngbya sp.	
	B-G Filament
EUGLENOPHYTA	
Euglena sp.	Trachelomonas sp.
Phacus sp.	
PYRRHOPHYTA	
Ceratium sp.	Peridinium sp.

Table 10-32. Dominant algal taxa encountered at representative mainstem sampling stations on West Point Lake from June 1990 through October 1992.

Season	Station 1	Station 4	Station 7	Station 10
Summer 1990	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Melosira distans* 3. *Trachelomonas* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Scenedesmus* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Ankistrodesmus convolutus*	1. Pennate diatoms 2. *Chlamydomonas* sp. 3. *Ankistrodesmus convolutus*
Fall 1990	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Melosira distans*	1. Pennate diatom 1. *Chlamydomonas* sp. 2. *Oocystis* sp. 3. *Scenedesmus* sp.	1. *Chlamydomonas* sp. 2. Pennate diatom 3. *Trachelomonas* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Scenedesmus quadricauda*
Winter 1990-91	1. Pennate diatom 2. *Melosira granulata* 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Melosira granulata*	1. *Chlamydomonas* sp. 2. Pennate diatom 3. *Trachelomonas* sp.	1. *Chlamydomonas* sp. 2. Pennate diatom 3. *Melosira distans*
Spring 1991	1. Pennate diatom 2. *Trachelomonas* sp. 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Trachelomonas* sp.	1. Pennate diatom 1. *Chlamydomonas* sp. 2. *Trachelomonas* sp. 3. *Melosira distans*	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Melosira distans*
Summer 1991	1. Pennate diatom 2. *Trachelomonas* sp. 3. *Euglena* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Ankistrodesmus convolutus*	1. *Ankistrodesmus convolutus* 2. Pennate diatom 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Ankistrodesmus convolutus* 3. *Chlamydomonas* sp.
Fall 1991	1. Pennate diatom 2. *Melosira granulata* 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Melosira distans*	1. *Ankistrodesmus convolutus* 2. Pennate diatom 3. *Melosira distans*	1. Pennate diatom 2. *Ankistrodesmus convolutus* 3. *Chlamydomonas* sp.
Winter 1991-92	1. Pennate diatom 2. *Trachelomonas* sp. 3. *Melosira distans*	1. Pennate diatom 2. *Trachelomonas* sp. 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Melosira distans* 3. *Trachelomonas* sp.	1. *Melosira distans* 2. Pennate diatom 3. *Melosira granulata*
Spring 1992	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Oocystis* sp.	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Trachelomonas* sp.	1. Pennate diatom 2. *Trachelomonas* sp. 3. *Ankistrodesmus convolutus*	1. *Melosira distans* 2. *Melosira granulata* 3. *Chlamydomonas* sp. 3. Pennate diatom
Summer 1992	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Ankistrodesmus convolutus*	1. Pennate diatom 2. *Ankistrodesmus convolutus* 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Ankistrodesmus convolutus* 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Ankistrodesmus convolutus* 3. *Chlamydomonas* sp.
Fall 1992 (2 mo.)	1. Pennate diatom 2. *Chlamydomonas* sp. 3. *Melosira distans* 3. *Trachelomonas* sp.	1. Pennate diatom 2. *Trachelomonas* sp. 3. *Chlamydomonas* sp.	1. *Ankistrodesmus convolutus* 2. Pennate diatom 3. *Chlamydomonas* sp.	1. Pennate diatom 2. *Ankistrodesmus convolutus* 3. *Chlamydomonas* sp.

Some changes in dominant organisms have occurred since the 1976-1985 study (Bayne et al. 1990). Cyclotella spp. and Melosira varians were among the dominant centric diatoms in the earlier study, but were not dominant in this study. Among green algae, Oocystis spp. emerged as a dominant on occasion but was not dominant in the earlier study. The blue-green, Oscillatoria spp., was a dominant in both studies, but Chroococcus spp. replaced Spirulina laxa as dominant blue-green organisms in this study.

Among the dominant phytoplankton genera, all occur with great frequency in reservoirs of the southeastern United States (Taylor et al. 1979). Palmer (1969) listed Ankistrodesmus, Chlamydomonas, Euglena, Melosira and Scenedesmus as genera of algae tolerant of organic pollution. In addition, each of the dominant genera listed in Table 10-32 were found to occur most frequently at mean total phosphorus concentrations ranging from 100 to 200 μg/l and mean NO_2^- + $NO_3^=$ concentrations of from 350 to 700 μg/l (Lambou et al. 1981). The phytoplankton community composition of West Point Lake is indicative of a typical, nutrient enriched southeastern reservoir.

Phaeophytin-corrected, chlorophyll a concentration is an indicator of phytoplankton biomass and is a variable often used to determine the trophic status of lakes in the absence of macrophytes (Carlson 1977, EPA 1990). It is a variable that integrates the physical, chemical and biological environmental components into one expression of biotic response and is, therefore, superior to simple physical (water transparency) or chemical (nutrients) variables used to characterize trophic status (Hern et al. 1981). Corrected chlorophyll a concentrations from about 6.4 to 56.0 μg/l are indicative of eutrophic waters (Carlson 1977). Waters having concentrations >56.0 μg/l are considered hypereutrophic. Raschke (1987) reported a maximum chlorophyll a concentration of 147 μg/l in West Point Lake during summer of 1986.

Chlorophyll a concentrations in West Point Lake ranged from a high of 39 μg/l in the New River embayment in June of 1990 to a low of 0.0 μg/l at station 2 in October and station 11 in November of 1990 (Tables 10-27, 10-28, 10-29 and 10-30). Mean summer concentrations were generally highest and mean winter concentrations were lowest (Figure 10-14). Spring and fall concentrations were similar.

Except for the winter of 1991-92, seasonal mean chlorophyll a concentrations were always highest at some mid-reservoir location (Figure 10-14). During the summer, chlorophyll a concentrations were highest at station 4 each year (Table 10-27). Station 4 is in the transition zone of the reservoir between the upstream riverine area (station 1 and 2) and the downstream lacustrine zone (stations 7, 9 and 10). During those summers, declining abiogenic turbidity (Table 10-9) coupled with abundant plant nutrients (Tables 10-17 and 10-21) and annual peaks in solar radiation (Table 10-4) resulted in optimum conditions for phytoplankton growth. During the fall, winter and spring the most favorable growing conditions for phytoplankton shifted further downstream usually in the vicinity of stations 5 and 7. In the winter of 1991-92, chlorophyll a concentrations increased from the headwaters all the way to the dam (Figure 10-14).

During the summer, mean chlorophyll a concentrations at upstream locations (station 1, 2, 3, 4, 5, 6 and 7) were higher in 1990 than in 1991 and 1992 (Table 10-27 and Figure 10-14). At downstream locations (stations 8, 9, 10 and 11) 1991 and 1992 concentrations were higher than 1990 concentrations. During the summer of 1990 rainfall averaged 9.4 cm below normal and mean daily discharge at Whitesburg was 3,187 cfs (Table 10-4). The summers of 1991 and 1992 were similar

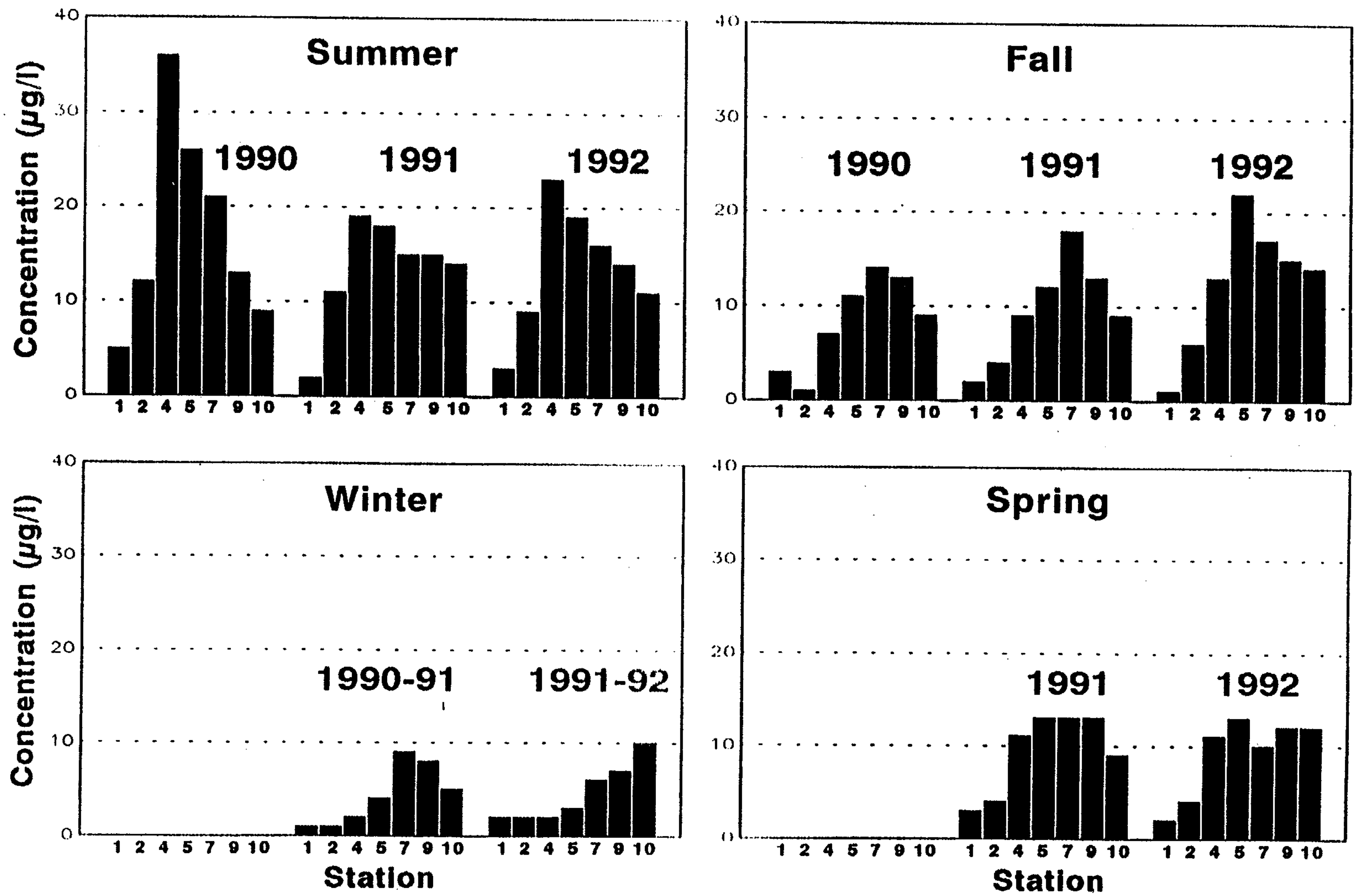

Figure 10-14. Seasonal mean chlorophyll a concentrations at mainstem sampling stations (headwaters at station 1 and dam at station 10) during the diagnostic study of West Point Lake, June 1990 through October 1992.

in that June rainfall was well above normal (+11.3 cm in 1991 and +10.9 cm in 1992) each year resulting in a seasonal mean rainfall surplus of 10.2 cm in 1991 and 7.0 cm in 1992. Mean daily discharge at Whitesburg averaged 4,326 cfs in 1991 and 3,530 cfs in 1992. Reduced flows in 1990 may have resulted in lower abiogenic turbidity in the upstream portions of the lake and algal biomass (chlorophyll a) responded with an increase. In 1991 and 1992 increased flows caused higher abiogenic turbidities in the upstream areas and moved nutrients more quickly downstream where they were utilized by lacustrine phytoplankton communities. Light related data (Table 10-9) only partially support this hypothesis, however. Mean summer chlorophyll a concentrations in 1991 and 1992 were similar. Some of the decline in chlorophyll a from 1990 levels to 1991 and 1992 levels was probably attributable to higher nutrient concentrations entering the lake in 1990 (Tables 10-17 and 10-21).

Seasonal mean chlorophyll a concentrations for fall were similar among years (Table 10-28 and Figure 10-14). Data for fall of 1992 included only two months, September and October, because the study was completed in October 1992. Falls of both 1990 and 1991 were drier than normal (-9.3 and -3.0 cm, respectively) and this was reflected in the mean daily discharge into the lake (3,137 and 4,302 cfs, respectively) as measured at Whitesburg (Table 10-4 and Figure 10-2).

Seasonal mean chlorophyll a concentrations were also similar among years for both the winter and spring seasons (Tables 10-29 and 10-30 and Figure 10-14). Below average rainfall occurred at West Point Dam in the winter (-8.8 and -2.3 cm for 1990-91 and 1991-92, respectively) and spring (-8.8 and -14.8 cm for 1991 and 1992, respectively) although heavy rainfall in the upper Chattahoochee River basin during May 1991 resulted in extremely high discharge during that month at both Whitesburg and West Point Dam (Table 10-4 and Figure 10-2). The effects of this rather unusual hydrological event was not readily detectable in either the monthly (Appendix 10) or seasonal chlorophyll a data (Table 10-30). Springtime phytoplankton assemblages are apparently resilient and well adjusted to conditions apt to develop during this period of high rainfall and watershed runoff.

Phytoplankton primary productivity is the rate of formation of organic matter over a specified time period (Wetzel 1983). The C-14 method of measuring productivity approximates net productivity, which is the gross accumulation of new organic matter minus any losses (e.g. respiration) that occur during the specified time interval. Phytoplankton biomass is an important variable influencing primary productivity although the efficiency with which a unit of phytoplankton biomass produces a unit of organic matter (photosynthetic efficiency) is quite variable (Fogg 1965). Efficiency can be affected by such physicochemical variables as light, temperature, degree of turbulence and nutrients. Species composition, size structure of the plankton algae and predation are examples of biotic influences on efficiency. Bayne et al. (1990) reported photosynthetic efficiencies (mgC fixed per mg chlorophyll a · hour) of West Point Lake phytoplankton communities ranging from 0.2 to 4.9. Phytoplankton primary productivity integrates a number of environmental variables in addition to algal biomass into an expression of system productivity. Productivity rates have also been used to trophically categorize lakes. Lakes with productivities ranging from 250-1000 $mgC/m^2 \cdot day$ are considered mesotrophic and values >1000 $mgC/m^2 \cdot day$ are eutrophic (Wetzel 1983).

Primary productivity, expressed on an areal basis, was highest in the summer (Table 10-33) and lowest during winter (Table 10-35). Spring and fall productivities (Tables 10-36 and 10-34) were similar. During the winter and the

Table 10-33. Seasonal mean (range) phytoplankton primary productivity (expressed on volume and areal bases) of West Point Lake at representative mainstem and embayment stations during the summers of 1990, 1991 and 1992.

Mainstem Stations	Primary Productivity ($mgC/m^3 \cdot hr$) 1990	1991	1992	Primary Productivity ($mgC/m^2 \cdot day$) 1990	1991	1992
1	23.9 (11-38)	4.7 (3-6)	6.8 (2-13)	513 (170-968)	53 (39-65)	153 (17-333)
2	86.4 (40-155)	34.6 (30-42)	45.4 (8-93)	1630 (587-3221)	419 (285-650)	1157 (78-2653)
4	140.1 (121-168)	81.5 (62-93)	87.3 (38-150)	2968 (2383-3646)	1952 (777-2836)	2086 (155-3856)
9	53.3 (41-66)	28.7 (22-36)	53.3 (28-80)	2137 (1453-2820)	1201 (1056-1383)	3349 (1667-5542)
10	31.6 (30-35)	24.7 (18-30)	39.9 (16-77)	1262 (950-1699)	1091 (981-1202)	2124 (1218-3709)
Embayment Stations						
6	58.7 (23-104)	42.5 (36-51)	35.3 (33-38)	2204 (600-4510)	1345 (1058-1645)	2043 (1521-2517)
8	45.2 (25-63)	20.0 (15-23)	26.0 (13-41)	1664 (1300-1898)	997 (761-1144)	1962 (929-3051)

Table 10-34. Seasonal mean (range) phytoplankton primary productivity (expressed on volume and areal bases) of West Point Lake at representative mainstem and embayment stations during the falls of 1990, 1991 and 1992.

Mainstem Stations	Primary Productivity ($mgC/m^3 \cdot hr$) 1990	1991	1992*	Primary Productivity ($mgC/m^2 \cdot day$) 1990	1991	1992*
1	2.6 (2-3)	2.4 (1-4)	1.5 (1-2)	93 (30-209)	37 (23-61)	31 (21-41)
2	5.0 (1-12)	9.3 (3-22)	9.2 (9-10)	91 (48-159)	175 (41-411)	169 (126-212)
4	27.9 (9-60)	16.3 (8-31)	27.1 (23-32)	454 (197-903)	353 (91-804)	592 (563-620)
9	38.3 (24-56)	17.9 (15-21)	20.0 (18-22)	1399 (604-1984)	932 (629-1259)	970 (712-1229)
10	15.3 (10-23)	18.8 (15-25)	22.6 (13-33)	708 (356-994)	806 (558-1273)	904 (688-1120)
Embayment Stations						
6	27.7 (12-49)	20.6 (19-22)	19.1 (18-21)	638 (315-1239)	737 (560-885)	912 (906-918)
3	19.1 (8-29)	14.9 (10-19)	11.7 (10-14)	675 (422-1060)	683 (410-1015)	619 (614-625)

*Data available for September and October only.

Table 10-35. Seasonal mean (range) phytoplankton primary productivity (expressed on volume and areal bases) of West Point Lake at representative mainstem and embayment stations during the winters of 1990, 1991 and 1992.

Mainstem Stations	Primary Productivity ($mgC/m^3 \cdot hr$) 1990-91	Primary Productivity ($mgC/m^3 \cdot hr$) 1991-92	Primary Productivity ($mgC/m^2 \cdot day$) 1990-91	Primary Productivity ($mgC/m^2 \cdot day$) 1991-92
1	1.9 (1-3)	1.4 (1-2)	38 (16-57)	14 (8-21)
2	1.2 (1-2)	1.4 (1-2)	37 (19-70)	25 (22-29)
4	4.5 (1-9)	2.8 (2-3)	106 (24-250)	39 (35-42)
9	14.4 (5-31)	9.3 (5-14)	394 (88-928)	291 (111-586)
10	13.5 (7-22)	16.9 (7-30)	512 (147-819)	475 (263-810)
Embayment Stations				
6	18.1 (9-29)	14.8 (11-20)	402 (155-694)	339 (234-444)
3	13.0 (12-14)	11.1 (3-14)	402 (334-498)	439 (275-765)

Table 10-36. Seasonal mean (range) phytoplankton primary productivity (expressed on volume and areal bases) of West Point Lake at representative mainstem and embayment stations during the springs of 1991 and 1992.

Mainstem Stations	Primary Productivity ($mgC/m^3 \cdot hr$) 1991	Primary Productivity ($mgC/m^3 \cdot hr$) 1992	Primary Productivity ($mgC/m^2 \cdot day$) 1991	Primary Productivity ($mgC/m^2 \cdot day$) 1992
1	5.2 (1-10)	4.6 (3-6)	109 (16-270)	93 (14-139)
2	7.8 (4-10)	40.3 (27-54)	142 (54-249)	1002 (576-1429)
4	30.2 (2-47)	40.1 (17-57)	530 (18-877)	977 (256-1738)
9	29.1 (14-40)	28.4 (26-32)	944 (782-1143)	1547 (532-2444)
10	16.6 (9-24)	16.9 (12-25)	1048 (328-2012)	883 (747-1050)
Embayment Stations				
6	30.2 (13-47)	34.2 (13-47)	840 (531-1117)	1250 (835-1987)
8	10.7 (7-17)	22.2 (9-35)	576 (256-860)	1371 (630-2709)

spring of 1991 there was a progressive increase in productivity from headwaters to the dam forebay (Figure 10-15). In the summer, fall and spring of 1992, highest productivity occurred at some midlake location, usually station 9 (Table 10-33, 10-34 and 10-35).

Under relatively low flow conditions that existed during the summer of 1990, (Figure 10-2) primary productivity was higher at the upstream stations 1, 2, 4 and 6 than 1991 and 1992 rates at those same locations (Figure 10-15). However, at downstream stations 8, 9 and 10 highest productivities occurred in 1992. Productivity in the Yellowjacket Creek embayment was consistently higher than in Wehadkee Creek.

During the fall (Table 10-34), differences in primary productivity among years were not clear. Highest productivity varied among years from one station to the next (Figure 10-15). In the winter (Table 10-35), production rates measured in 1990-91 were somewhat higher than 1991-92 rates at all but one sampling location. However, spring production rates were considerably higher at most locations in 1992 than in 1991 (Table 10-36). Embayment differences were not as obvious during the fall, winter and spring seasons as they were during the summer.

From 1976 through 1979, Bayne et al. (1983) using methods similar to those used in this study, measured mean annual primary productivity of West Point Lake. They reported values ranging from a low of 550 $mgC/m^2 \cdot day$ in 1976 to a high of 763 $mgC/m^2 \cdot day$ in 1979. During the past 12 years (1980-81 through 1991-92) mean annual primary productivity has varied between 504 $mgC/m^2 \cdot day$ in 1980-81 and 1,767 $mgC/m^2 \cdot day$ in 1985-86 (Figure 10-16). Some of the data presented in Figure 10-16 appeared in a publication describing the cultural eutrophication of West

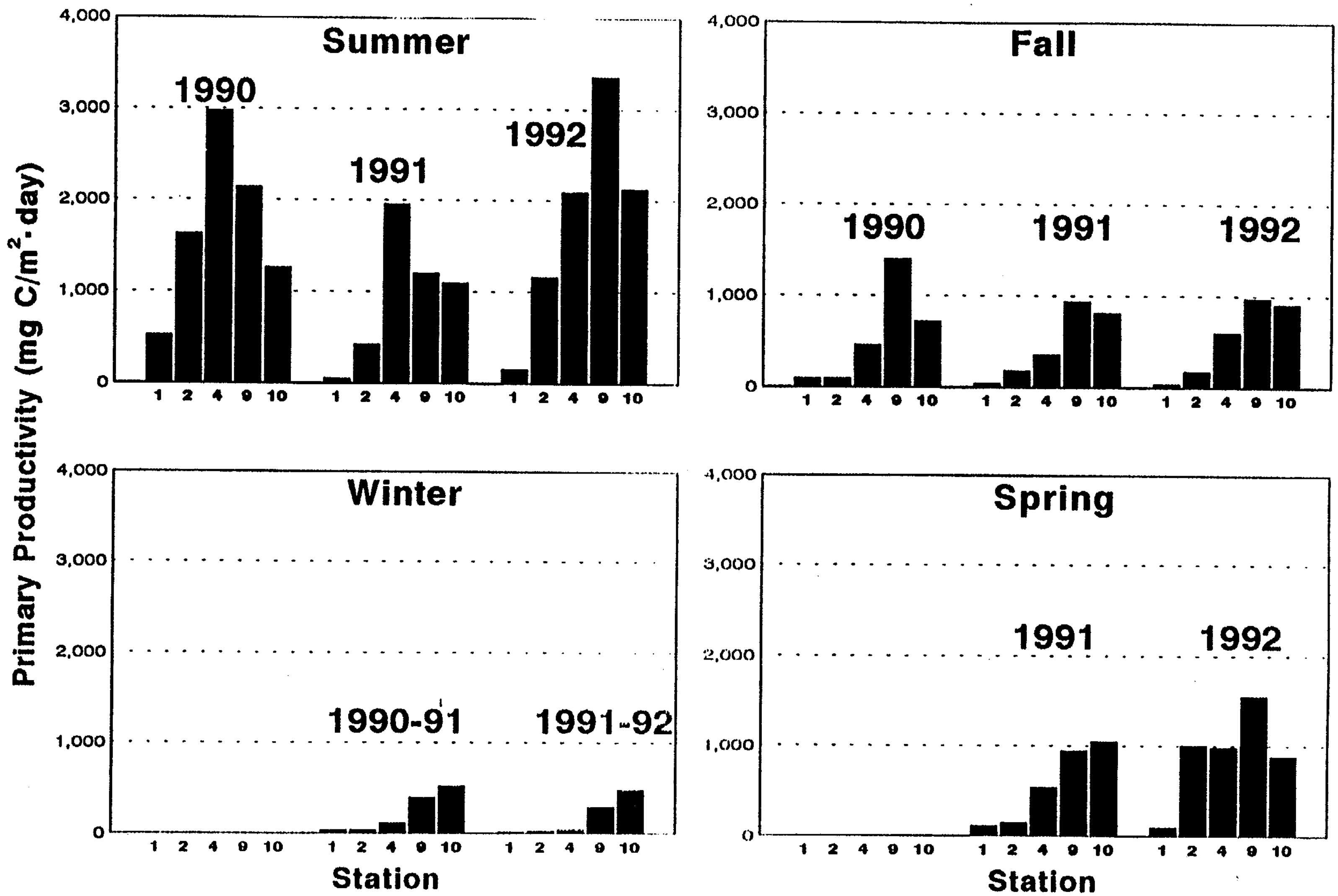

Figure 10-15. Seasonal mean phytoplankton primary productivity at mainstem reservoir stations (headwaters at station 1 and dam at station 10) during the diagnostic study of West Point Lake, June 1990 through October 1992.

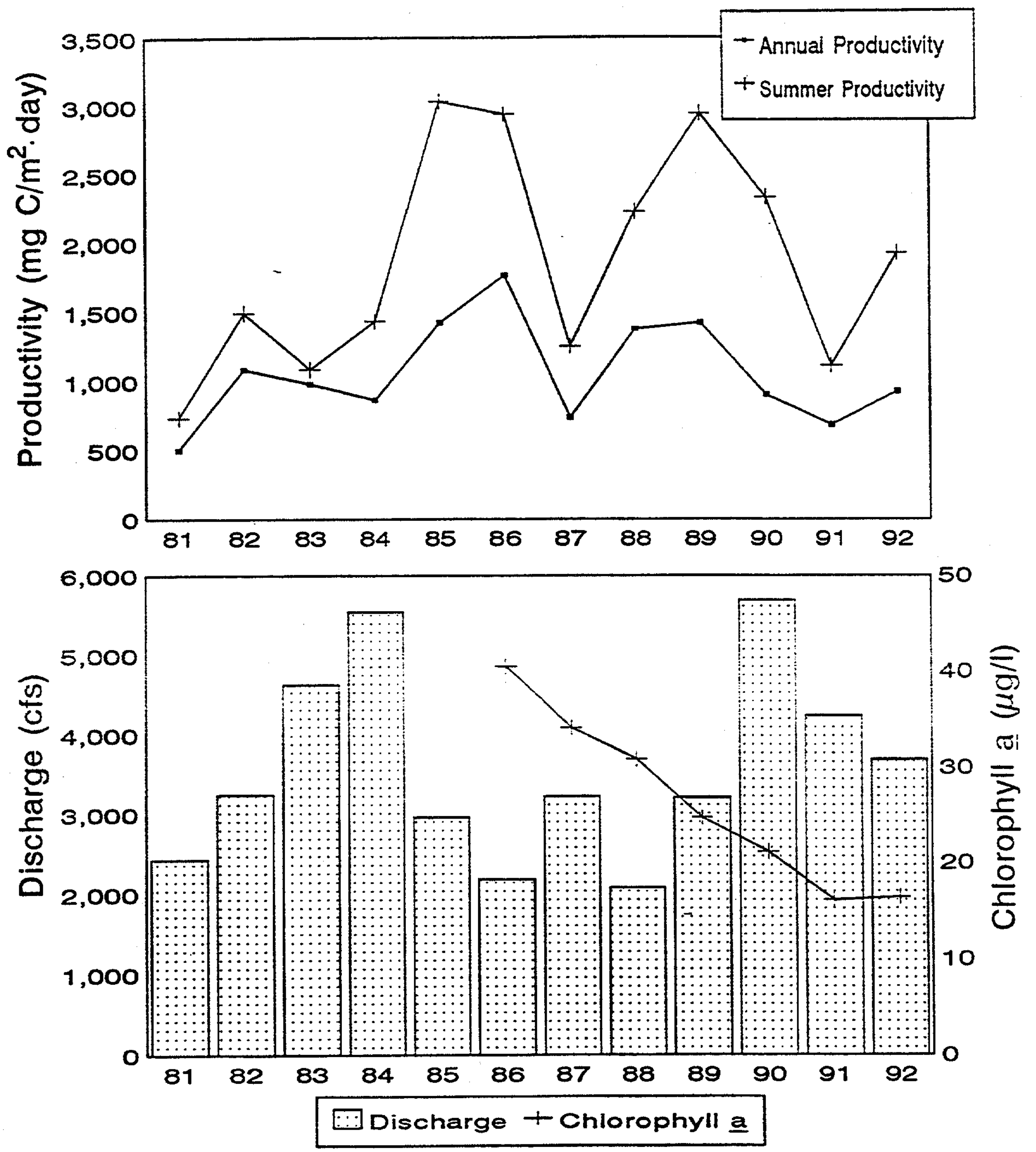

Figure 10-16. Mean annual and summer-season primary productivity for West Point Lake from June 1980 through October 1992 (upper graph). Mean annual Chattahoochee River discharge (at Whitesburg, GA) and mean growing season (April-October) chlorophyll a (phaeophytin corrected) concentrations measured in lentic areas (between stations 4 and 10) of West Point Lake sampling years.

Point Lake during a 10 year period from 1976 through 1985 (Bayne et al. 1990). A surge in primary productivity of the lake was documented for the period 1981 through 1985. This move from mesotrophic to highly eutrophic status was attributed to a rise in volume of wastewater entering the Chattahoochee River from urban centers, primarily the Atlanta metropolitan area. Since that time, annual productivity for the lake has oscillated between a record high of 1,767 mgC/m^2·day in 1986 and lows of near 700 mgC/m^2·day in 1987 and 1991 (Figure 10-16). The variation in primary productivity was not well correlated with water discharge (hydraulic retention time) or phytoplankton chlorophyll a concentrations (estimated algal biomass). Highest productivity occurred during a drought year with abundant chlorophyll a (1986), however, the following year was also a drought year with abundant chlorophyll a and productivity declined to a cyclical low. Second highest productivity occurred during a year (1989) of relatively high discharge and moderate chlorophyll a concentrations (Figure 10-16). Those oscillations in productivity may be related to complex interactions among phytoplankton, zooplankton and fish (primarily shad) that are controlled by cyclical variations in fish density (Bayne 1991).

Since 1981, summer season production rates have remained well above the eutrophic threshold level and, at times (1985, 1986 and 1989), have reached extremely high levels (Figure 10-16). It is apparent that summer productivity has a controlling influence on annual productivity of the lake. The overall trend in phytoplankton primary productivity of West Point Lake since the mid-1980's has been downward.

The Algal Growth Potential Test (AGPT) determines the total quantity of algal biomass supportable by the test waters and provides a reliable estimate of the bioavailable and limiting nutrients (Raschke and Schultz 1987). Algal growth potential was much higher at the upstream riverine station (station 1) than at downstream locations (Table 10-37 and Appendix 10). Station 1 concentrations were about an order of magnitude higher than dam forebay (station 10) concentrations each year. This was obviously an effect of the high nutrient concentrations existing at the upstream locations (Figures 10-10 and 10-11).

West Point Lake waters were capable of supporting higher algal biomass (mg dry weight/l) during the 1990 growing season than during the growing seasons of 1991 and 1992 (Table 10-37 and Appendix 10). There were no consistent differences between 1991 and 1992. During 1990, mean algal biomass (dry weight) estimates at all mainstem, inlake stations exceeded 5 mg/l, a threshold concentration thought to afford protection from nuisance algal blooms and fish-kills in southeastern lakes, excluding Florida (Raschke and Schultz 1987). Concentrations exceeding 10 mg/l are indicative of eutrophic conditions likely to result in nuisance algal blooms. All but one station (station 10) had concentrations exceeding 10 mg/l in 1990 (Table 10-37). In 1991 and 1992, mean growing season concentrations at the two downstream stations (9 and 10) were ≤5 mg/l. The decline in algal biomass supportable by West Point Lake waters from the 1990 level to the 1991-92 level is encouraging although the upstream half of the lake from Georgia Highway 109 (station 7) to Franklin (station 1) was still capable of supporting excessive algal concentrations (> 10 mg/l).

In most freshwater lakes, phosphorus is the essential plant nutrient that limits growth and productivity of plankton algae (Wetzel 1983). Nitrogen usually becomes the limiting nutrient when bioavailable phosphorus increases relative to nitrogen, as in the case of waters receiving quantities of treated municipal waste (Raschke and Schultz 1987). The AGPT is helpful in identifying these common growth limiting nutrients. In West Point Lake, the upstream locations (stations 1 and 4) were usually nitrogen limited or nitrogen and phosphorus co-limited (Table 10-38). Lacustrine stations 7, 9 and 10 were usually phosphorus

Table 10-37. Mean maximum dry weight (mg/l) of <u>Selenastrum capricornutum</u> cultured in West Point Lake waters. Values represent growing season (April - October) means for 1990, 1991 and 1992.[1]

Mainstem Stations	Mean Maximum Dry Weight (mg/l) Year 1990[2]	1991	1992
1	63	33	39
4	37	24	28
5	30	18	21
7	20	13	9
9	11	4	5
10	7	1	2

[1]Results of Algal Growth Potential Tests conducted by the Ecological Support Branch, U.S.E.P.A. Region IV and Field Operations, of the Alabama Department of Environmental Management.

[2]From EPD 1990.

Table 10-38. Temporal and spacial variation in nutrient limitation based on results of Algal Growth Potential Tests conducted during the growing seasons of 1990, 1991 and 1992.

	Limiting Nutrient					
	Mainstem Station					
Date	1	4	5	7	9	10
1990[1]						
June	N[2]	N	N	N+P	P	P
July	N	N	N	N+P	P	P
Aug	N+P[3]	N+P	N+P	P	N+P	---
Sept	N+P	N+P	N+P	P	P	P
Oct	N+P	---	N+P	N+P	P	P
1991						
Apr	N	P	P	P	P	P
June	N+P	---	P	P	N+P	P
Aug	N	N+P	P	P	P	P
Oct	N+P	N+P	P	P	P	P
1992						
Apr	N+P	P	P	P	P	P
June	N+P	N+P	P	P	P	P
July	N+P	P	P	P	P	P
Aug	N+P	N	N+P	P	P	P
Oct	N	N	N	P	P	P

[1]From EPD (1990).
[2]N = Nitrogen
[3]P = Phosphorus

limited or co-limited. The upstream nitrogen limitation was caused by the relative abundance of phosphorus upstream (Figure 10-11) that shifted the TN:TP below 15 (Table 10-25). Nitrogen limitation does not mean that nitrogen was in short supply only that phosphorus was relatively more abundant than nitrogen. The decline in phosphorus from 1990 levels to 1991-1992 levels has resulted in more of West Point Lake being phosphorus limited (Table 10-38). This is desirable since phosphorus can be more readily manipulated than nitrogen to affect changes in the trophic condition of lakes.

Total organic carbon (TOC) concentrations are composed of dissolved and particulate fractions and the ratio of dissolved to particulate ranges from 6:1 to 10:1 in most unpolluted lakes (Wetzel 1983). Most of the particulate fraction is composed of dead organic matter with living plankton contributing a small amount to the total (Wetzel 1983). The overwhelming influence of dissolved organic carbon, most of which is contributed from the watershed, tends to stabilize TOC concentrations and prevents wide fluctuations in concentration both spatially and temporally (Tables 10-27, 10-28, 10-29 and 10-30). With one exception (station 1 in the spring of 1992), individual sample TOC concentrations ranged from 2 to 7 mg/l and seasonal means from 2.4 to 4.8 mg/l. Bayne et al. (1990) reported similar TOC concentrations for West Point Lake for the period 1976 to 1985. The unusually high value measured at station 1 in May of 1992 likely was caused by a relatively large, carbon-rich particle included in the sample. Highest TOC concentrations occurred during the summer (Table 10-27) and lowest concentrations during the winter (Table 10-29). Embayment TOC concentrations were similar to mainstem concentrations and varied seasonally in a similar manner.

10.2.3 BACTERIA

The coliform group of bacteria are found in the gut and feces of warm-blooded animals. This group of bacteria is used as an indicator of suitability of water for various uses (APHA et al. 1989). Coliform density is widely accepted as a criterion of the degree of pollution and sanitary quality of surface waters.

From November 1990 through October 1991, AU collected water samples, monthly, from all eleven sampling stations (Table 10-2) on West Point Lake for fecal coliform bacteria analysis. From April through October 1991, AU and EPD combined efforts to sample all stations a second time each month (Table 10-1). AU collected samples at stations 2, 3, 6, 8 and 11 and EPD collected samples at stations 1, 4, 5, 7, 9 and 10 usually within a time span of 1 or 2 days. From April through October 1992, EPD sampled stations 1, 4, 5, 7, 9 and 10, monthly. Samples were taken just under the water surface using a sterilized container. The container was then placed on ice and transported to the laboratory for analysis. Fecal coliform densities were measured by AU using the membrane filter procedure and EPD used the multiple tube procedure (APHA et al. 1989).

Fecal coliform densities were higher at the upstream sampling stations and declined downstream toward the dam (Table 10-39). At station 1 near Franklin, GA, concentrations exceeded 200 fecal coliform colonies per 100 ml on 13 of the 26 sampling dates. The highest counts (4,900 colonies/100 ml) were recorded at this station. At station 2, just downstream of the mouth of New River, fecal coliform counts exceeded 200 colonies/100 ml on four of 18 sampling dates. Fecal coliform concentrations in excess of 200 colonies/100 ml were encountered further downstream on only two of the 29 sampling dates, 7 and 8 May 1991 and 7 October 1992 (Table 10-39). The May 1991 samples were taken during a high flow period (Table 10-4 and Figure 10-2) that moved water downstream rapidly and resulted in

Table 10-39. Fecal coliform bacterial densities (fecal coliform colonies per 100 ml) measured during monthly and biweekly sampling of West Point Lake, 1990-1992.

	Fecal Coliform Colonies per 100 ml												
	1990		1991										
Date	11/27	12/18	1/24	2/20	3/27	4/10	4/23	5/7-8	5/23	6/4-5	6/18	7/9-10	7/23
Station													
1	95	20	60	160	40	170	75	4,900	500	790	80	640	1,110
2	65	40	55	50	*	--	*	1,125	245	50	*	55	420
3	60	140	55	85	*	--	20	920	70	*	*	*	50
4	25	75	125	*	*	20	*	490	110	*	*	*	*
5	*	35	150	20	*	*	*	895	75	*	*	*	*
6	*	*	25	*	*	--	*	*	*	*	*	*	20
7	*	*	25	*	*	*	*	*	*	*	*	*	*
8	*	*	*	*	*	--	*	*	*	*	*	*	*
9	*	*	*	*	*	*	*	*	*	*	20	*	*
10	*	*	*	*	*	*	*	*	*	*	*	*	110
11	*	*	*	*	*	--	*	*	155	20	40	*	190

* = < 20 colonies/100 ml.
-- = No sample was taken.

Table 10-39. (Cont.)

	Fecal Coliform Colonies per 100 ml												
	1991						1992						
Date	8/7	8/21	9/10-12	9/24	10/6-8	10/22	4/9	5/14	6/9	7/8	8/12	9/9	10/7
Station													
1	230	45	330	100	110	50	230	170	3,300	700	1,700	2,300	1,300
2	35	*	85	150	675	*	--	--	--	--	--	--	--
3	*	*	*	*	125	*	--	--	--	--	--	--	--
4	*	*	*	*	65	*	170	*	*	*	*	170	1,100
5	*	*	*	*	20	*	*	*	*	35	*	*	20
6	*	*	*	*	35	*	--	--	--	--	--	--	--
7	*	*	*	*	*	*	*	*	*	*	20	*	*
8	*	*	*	*	*	*	--	--	--	--	--	--	--
9	*	*	*	*	*	*	*	*	*	170	*	*	*
10	*	*	*	*	*	*	*	*	*	*	*	*	*
11	40	*	*	*	25	*	--	--	--	--	--	--	--

* = < 20 colonies/100 ml.
-- = No sample was taken.

fecal coliform counts of 895 colonies/100 ml near the LaGrange, GA water intake (station 5). However, on most occasions station 5 and all downstream stations to the dam (7, 9 and 10) had fecal coliform levels of < 20 colonies/100 ml. New River embayment (station 3) was the only tributary stream to exceed 200 colonies/100 ml and that occurred during the high flows of 7 and 8 May 1991 (Table 10-39). The fecal coliform criterion for fisheries and recreational waters is a geometric mean of 200 colonies/100 ml based on a series of samples, usually five, taken during a 30 day period (EPA 1986). Data reported in Table 10-39 represent single bacteriological samples and therefore should not be interpreted in terms of this criterion.

In 1992, AU bacteriological sampling was conducted following periods of rainfall in the Atlanta metropolitan area that would be expected to cause combined sewer overflows resulting from storm-water runoff. The sampling was conducted during the months of June, July, August and September when user recreational and water contact activities were normally at a peak. Calculated flow time for the Chattahoochee River between Atlanta and Franklin, GA is about 4 days (personal communication, David Kamps, Georgia EPD). Beginning 2 to 4 days after an Atlanta rain event, West Point Lake was sampled at 1.6 km (1 mile) intervals from station 1 (Franklin, GA) to station 4 (Highway 219 bridge) and at 3.2 km (2 mile) intervals from station 4 to station 10 (dam forebay). Appendix 10 gives the approximate location of each of the 22 sample sites. Rainfall amounts measured at three Atlanta metropolitan area weather stations prior to each sampling effort appear in Table 10-40.

Rainfall in the Atlanta area during June through September 1992 was above normal. The DeKalb/Peachtree weather station reported a deviation from

Table 10-40. Rainfall amounts (inches) at three Atlanta, GA area weather stations prior to commencing bacterial sampling of West Point Lake in 1992.

		Weather Station		
Date		Hartsfield Airport	DeKalb/Peachtree	Atlanta/Bolton
June	4	2.34	1.60	0.99
	7	0.00	0.00	0.00
	8	0.00	0.00	0.00
	9	0.67	1.80	0.24
	10	0.01	0.10	0.35
	11	Sampling began	Sampling began	Sampling began
July	16	0.01	0.10	1.26
	17	1.15	M	0.01
	18	0.01	0.40	0.82
	19	0.08	0.10	0.16
	20	Sampling began	Sampling began	Sampling began
August	13	0.72	0.50	1.25
	14	0.82	M	0.72
	15	0.00	0.00	0.00
	16	0.36	0.60	0.20
	17	Sampling began	Sampling began	Sampling began
August	27	0.13	0.10	0.05
	28	1.10	0.90	1.01
	29	0.00	0.00	0.00
	30	0.00	0.00	0.00
	31	Sampling began	Sampling began	Sampling began

M = Missing data.

normal (DFN) of +6.92 inches for the period and the Atlanta/Bolton station reported a DFN of +8.25 inches.

Following summer rain storms in the Atlanta area, fecal coliform concentrations in West Point Lake usually increased in the upstream one-third of the lake (Table 10-41). The June 1992 samples had the highest concentrations encountered, with levels exceeding 200 colonies/100 ml for 10 miles (16 km) downstream from Franklin, GA. In August 1992 a single sample collected 9 miles (14.4 km) downstream from Franklin exceeded 200 colonies/100 ml. From a point 11 miles (17.6 km) downstream from Franklin to the dam, 32 miles (51.2 km) downstream, fecal coliform densities did not exceed 200 colonies/100 ml and were usually < 20 colonies/100 ml (Table 10-41).

Abundant and scattered rainfall during the summer of 1992 made it difficult to time the sampling based on discrete rainfall events in the Atlanta area. For example, the June sample timing appeared to be good, but in July the sampling was begun one day too soon to fully characterize a four day event (Table 10-41). The highest fecal coliform densities reported for the summer of 1992 (3,300 colonies/100 ml) occurred 9 June 1992 following a 1 to 2 inch rainfall (Table 10-40) in the Atlanta area 5 days earlier (Table 10-39). This sample was collected by EPD during their monthly sampling. The remnants of that unusual event appeared at several downstream locations on 11 June 1992 (Table 10-41).

The use classification of West Point Lake between Franklin and the mouth of New River (about 8 miles downstream) was designated as fishing. The Georgia water quality criterion for fecal coliform bacteria in fishing waters is a geometric mean of 200 colonies/100 ml (at least four samples during a 30 day period) (EPD 1990). This criterion was exceeded in a 7 mile portion of West

Table 10-41. Mean fecal coliform bacterial densities (fecal coliform colonies per 100 ml) measured in West Point Lake following rainfall events in the Atlanta, Georgia area, June through September, 1992.

	Mean Fecal Coliform Colonies per 100 ml															
	Month/Day															
Month/day	6/11	6/12	6/13	6/14	7/20	7/21	7/22	7/23	8/17	8/18	8/18	8/20	8/31	9/1	9/2	9/3
Miles[1]																
0	950	980	660	470	30	340	60	640	40	230	270	220	150	170	280	210
1	1300	1520	840	100	*	230	30	350	110	220	110	190	320	200	190	110
2	320	450	560	360	30	270	110	190	230	350	350	260	160	90	100	120
3	*	310	100	200	20	70	30	300	70	80	170	200	110	70	70	80
4	540	440	400	290	50	130	100	420	340	300	340	80	190	20	100	130
5	310	320	310	140	*	100	30	400	110	30	70	110	60	170	110	90
6	450	210	220	170	40	160	40	140	310	270	60	90	170	90	140	70
7	290	600	160	110	20	120	30	20	80	70	60	80	90	40	50	*
8	370	300	120	*	*	100	40	110	90	320	90	*	100	*	20	*
9	330	70	*	*	*	120	*	150	20	270	70	20	100	*	*	*
10	320	260	20	50	*	90	30	*	70	90	*	*	70	*	*	*
11	140	120	40	30	*	70	*	30	*	*	40	*	20	*	*	*
12	20	*	80	100	*	*	*	30	40	70	*	*	*	*	*	*
13	*	20	*	*	*	*	*	*	*	0	*	*	*	*	*	*
14	40	*	*	*	*	*	*	*	20	40	*	*	*	*	*	*
16	80	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
18	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
22	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
24	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
26	20	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
28	50	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
30	80	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
32	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

[1]Distance downstream from Franklin, Georgia.
* = < 20 colonies per 100 ml.

Point Lake extending from Franklin downstream to a point about 1 mile upstream from the mouth of New River during the June 1992 sampling period (Table 10-41). In addition, from 17-20 August 1992, fecal coliform densities exceeded the criterion at miles 2 and 4 downstream from Franklin. Elevated fecal coliform densities in the upper reaches of West Point Lake have been previously reported (Radtke et al 1984, EPD 1989 and EPD 1990). The criterion for fishing waters was exceeded at Franklin during the period 10 July through 7 August 1990 (EPD 1990).

Periods of high rainfall and runoff in the Atlanta metropolitan area resulted in elevated densities of fecal coliform bacteria in the upstream reaches of West Point Lake several days following the runoff event. At times, bacterial concentrations exceeded the use designated criterion for lake areas tested. The combined sewer overflow problem in the Atlanta area following rainfall events results in some untreated domestic sewage as well as urban runoff entering the Chattahoochee River. This is believed to be the primary source of fecal coliform bacteria in West Point Lake.

From May into September of 1991 and 1992 the Corps of Engineers collected water samples for fecal coliform analysis from four swimming beaches on West Point Lake; Earl Cook Beach, Rocky Point Beach, State Line Beach and Yellowjacket Beach. In some cases, samples were collected frequently enough that geometric means could be calculated for at least four samples taken within a 30 day period. The bacterial analyses were conducted by the City of LaGrange, GA, Water Department.

Fecal coliform densities on most sampling dates were < 20 colonies/100 ml (Appendix 10). Highest individual sample densities were encountered at the most upstream location, Yellowjacket Beach, during 1991. Densities of 568, 388 and 240 colonies/100 ml were reported for individual samples collected at that site in August, September and July, respectively. However, 4-day geometric means that included those higher values did not exceed 50 colonies/100 ml. The standard for water contact recreation is 200 colonies/100 ml.

10.2.4 TOXIC CONTAMINANTS.

Water, sediment and fish samples were collected during the Fall 1990, Spring 1991 and Fall 1991 (Figure 10-17). Fish samples collected during the Fall of 1990 for toxics were lost in a freezer outage. Water samples collected during the three sampling periods were found to be free of volatile organic compounds (VOA's), base/neutral/acid semi-volatiles (BNA's), metals and pesticides. Occasional water samples collected during the spring of 1991 were found to contain detectable levels of mercury (range <0.4 to 1.46 ppb). Mercury values were: (1) less than the 2 ppb drinking water standard; (2) higher in the Spring than in the Fall; (3) did not appear to accumulate in the sediment or fish tissues (Figures 10-18 and 10-19).

Sediment samples collected during the Fall 1990, Spring 1991 and Fall 1991 were generally found to be free of VOA's and BNA's. The exception being sediments from U.S. Highway 27 Bridge and New River which contained detectable levels of polynuclear aromatic compounds (PNA) indicative of possible industrial activity. The most common PNA's found were pyrene, fluoranthene and benzopyrene.

Sediment heavy metal levels were:

	West Point Lake mean	Lake Lanier mean
As	0.93 ppm	1.6 ppm
Se	0.6 ppm	0.5 ppm
Hg	0.06 ppm	<0.01 ppm
Cd	2.1 ppm	N.A.
Cr	17.6 ppm	12.2 ppm
Ni	7.5 ppm	6.2 ppm
Cu	13.0 ppm	13.3 ppm
Pb	32.5 ppm	38.2 ppm
Zn	37.9 ppm	32.3 ppm

Lake Lanier metal levels are presented for comparative purposes. There was no indication of mercury build-up in the sediment. Pesticide residue levels in sediment were generally low or nondetectable.

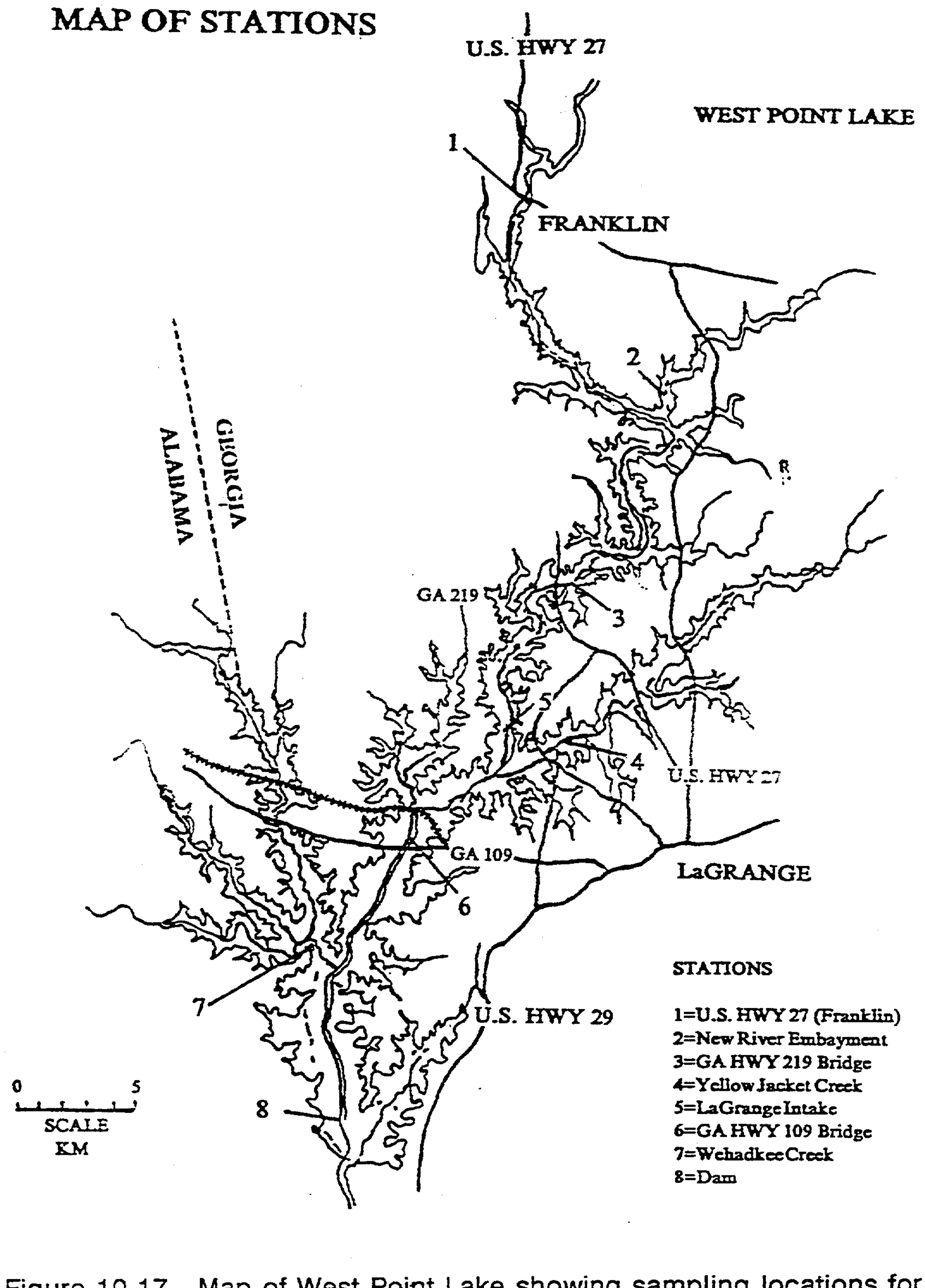

Figure 10-17. Map of West Point Lake showing sampling locations for water, sediment and fish collected and analyzed for toxic contaminants by the University of Georgia.

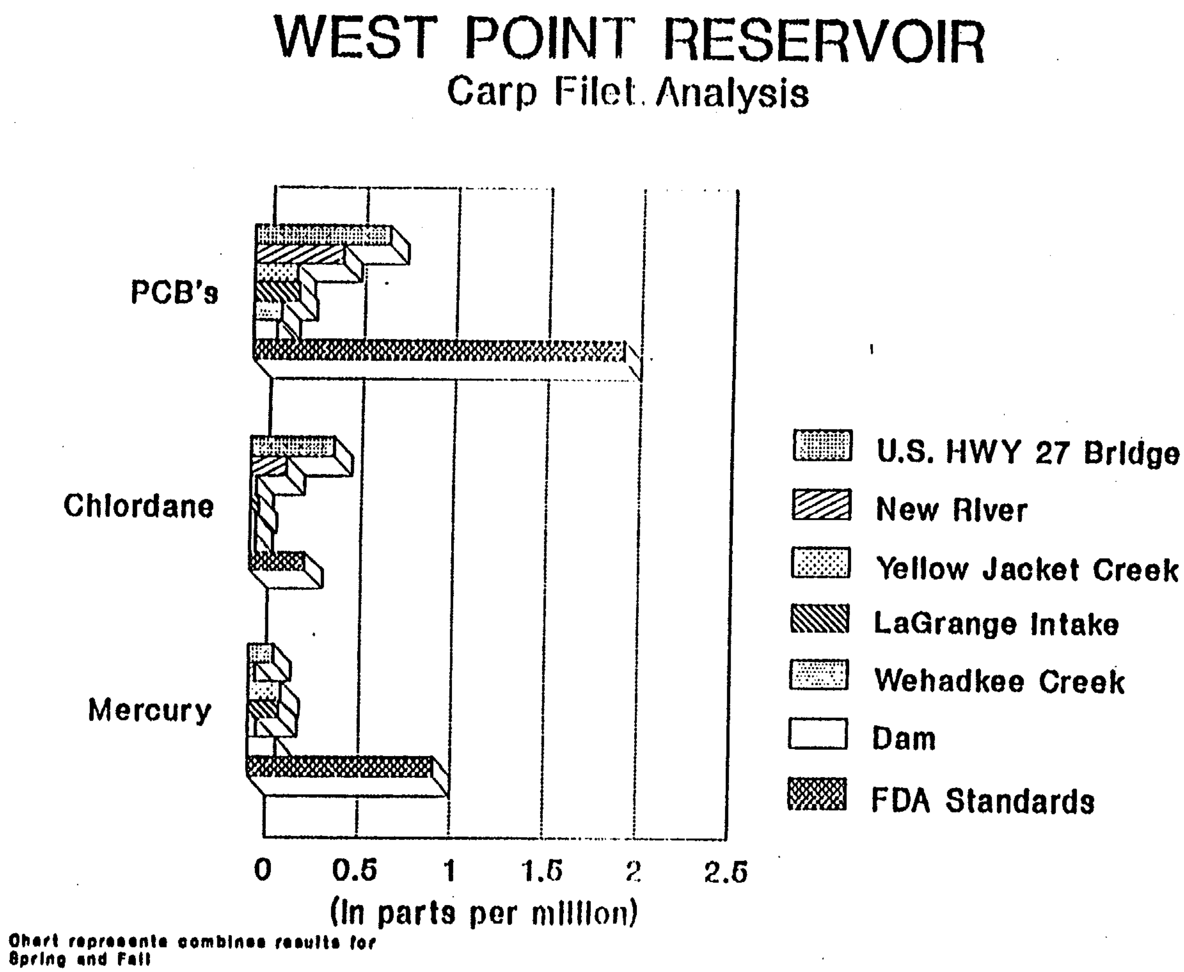

Figure 10-18. Concentrations of PCB's, chlordane and mercury in carp fillets collected from various locations in West Point Lake during 1991.

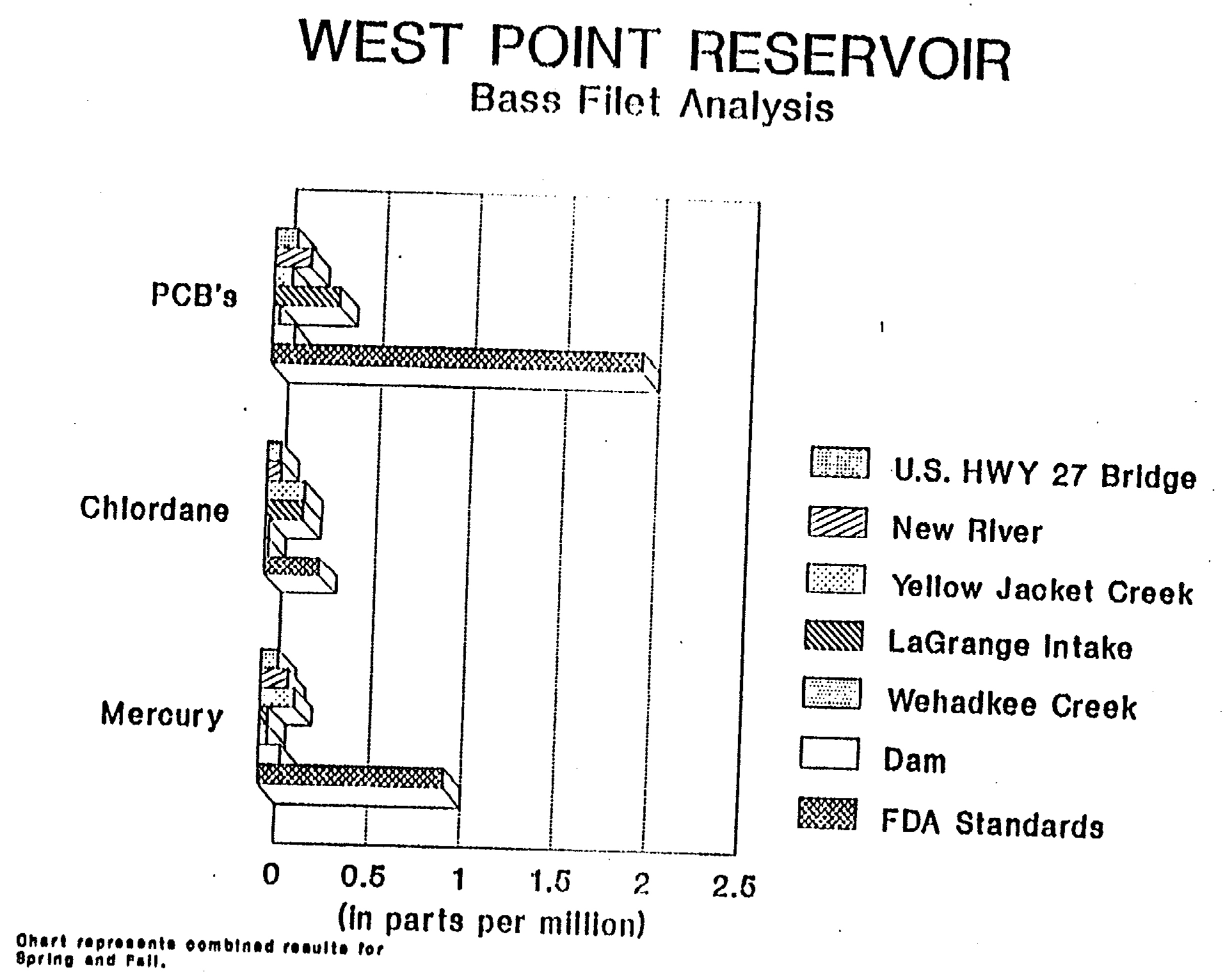

Figure 10-19. Concentrations of PCB's, chlordane and mercury in bass fillets collected from various locations in West Point Lake during 1991.

Residues of PCB, chlordane, pentachloroanizole and DDT metabolites were detected in fish fillets and whole fish. Notable observations include: (1) PCB's (primarily Arachlor 1260) was detected at concentrations ranging from <0.03 to 1.57 ppm (Figures 10-18 and 10-19). All PCB levels were below the 2.0 ppm FDA action level. (2) Chlordane was detected in carp fillets and whole fish at levels ranging from <0.03 to 0.89 ppm while all bass chlordane residue levels were below the 0.3 ppm action level (Figures 10-18 and 10-19). (3) Whole fish PCB and chlordane residue levels were generally higher than fillet residues. (4) PCB and chlordane residues in fish tissues decrease in progression from head water to the dam. (5) PCB and chlordane levels were generally higher in fall than in spring. (6) PCB and chlordane residues were higher in carp than in bass. (7) Hg concentrations tended to be higher in spring than in fall. (8) No indication of accumulation of Hg in the edible fish tissue.

These studies were conducted by the University of Georgia's Extension Pesticide Residue Laboratory under the direction of Dr. Parshall B. Bush. His final report, in its entirety, is appended to this document.

To supplement existing data (DNR News Release 1991) on toxic contamination of West Point Lake fishes, AU collected and had analyzed a sportfish species that had not been previously examined. Black crappie (*Pomoxis nigromaculatus*) were collected near station 4 and near station 7 during October 1992 (Table 10-42) using gillnets and electrofishing gear. In addition, hybrid striped bass (*Morone saxatilis* x *Morone chrysops*) were collected near station 10 (Table 10-42) during October 1992 using gillnets. All fish were placed on ice in the field and sample preparation followed the EPD *1992 Field Procedures For Preparing Fish Samples For Toxic Analyses*. At each location three replicates, consisting of the filets of five fish, were prepared and the frozen samples were shipped to Triangle

Table 10-42. Lengths, weights, collection dates and locations of fish species collected for toxic contamination analyses during the diagnostic study of West Point Lake, 1990-1992.

Date	Species	Location	Length (mm)	Weight (g)
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	203	117
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	204	119
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	204	125
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	205	116
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	207	130
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	215	154
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	215	159
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	222	174
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	225	170
8 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	267	296
9 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	216	152
9 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	233	195
15 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	225	181
15 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	247	244
15 October 1992	Pomoxis nigromaculatus	Hwy 219 Bridge	271	336
15 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	281	381
15 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	285	373
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	234	232
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	238	221
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	242	206
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	248	258
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	253	267
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	253	288
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	259	281
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	265	265
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	267	314
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	270	299
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	270	312
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	271	343
16 October 1992	Pomoxis nigromaculatus	Hwy 109 Bridge	275	336
27 October 1992	Morone saxatilis x Morone chrysops	Dam	435	1241
27 October 1992	Morone saxatilis x Morone chrysops	Dam	467	1440
27 October 1992	Morone saxatilis x Morone chrysops	Dam	472	1470
27 October 1992	Morone saxatilis x Morone chrysops	Dam	490	1655
27 October 1992	Morone saxatilis x Morone chrysops	Dam	490	1789
27 October 1992	Morone saxatilis x Morone chrysops	Dam	526	2001
27 October 1992	Morone saxatilis x Morone chrysops	Dam	575	2768
30 October 1992	Morone saxatilis x Morone chrysops	Dam	485	1512
30 October 1992	Morone saxatilis x Morone chrysops	Dam	491	1556
30 October 1992	Morone saxatilis x Morone chrysops	Dam	514	1999
30 October 1992	Morone saxatilis x Morone chrysops	Dam	515	1847
30 October 1992	Morone saxatilis x Morone chrysops	Dam	516	1866
30 October 1992	Morone saxatilis x Morone chrysops	Dam	525	2086
30 October 1992	Morone saxatilis x Morone chrysops	Dam	526	1945
30 October 1992	Morone saxatilis x Morone chrysops	Dam	531	2361

Laboratories of RTP, Inc., Durham, North Carolina for analyses. Metals and organic chemicals tested and detection limits for each appear in Appendix 10. Methods and procedures used by Triangle Laboratories also appear in Appendix 10.

None of the toxic chemical compounds occurred in concentrations that exceeded U.S. Food and Drug Administration (FDA) standards for edible portions of fish (Appendix 10). Concentrations of some of the organic chemical compounds that had been previously reported in West Point Lake fish (Radtke 1984, DNR News Release 1991) varied greatly among the two taxa, with hybrid bass having levels an order of magnitude higher than black crappie (Table 10-43). This was presumably a trophic level effect since the bass are principally piscivores and crappie primarily insectivores although larger crappie do consume some small fish (Pflieger 1975). The two taxa, although quite different in size (Table 10-42) were likely similar in age, 2-4 years (personal communication, Mike Maciena, AU Fisheries). Chlordane concentrations in hybrid bass were approaching 0.3 mg/kg, the FDA standard for that compound. Action levels for the other chemicals, 5.0 mg/kg for DDT (no level has been set for DDD or DDE), 0.3 mg/kg for dieldrin, and 2.0 mg/kg for PCB (Aroclor 1260), far exceeded concentrations found in West Point Lake black crappie and hybrid bass.

Most of the heavy metals tested were not detectable in the fish flesh (Table 10-44). Only cadmium, chromium, nickel, selenium, thallium and zinc were found above detection limits in at least one replicate and only zinc was consistently found in every sample. The FDA standard for mercury in edible fish tissue is 1.0 mg/kg, however, no mercury was detected in West Point Lake black crappie and hybrid bass.

Table 10-43. Concentrations of select toxic chemical compounds found in edible portions of two fish taxa collected at three locations in West Point Lake during October 1992.

Species	Location	Rep	Chlordane (technical) (µg/kg)	4,4'-DDD (µg/kg)	4,4'-DDE (µg/kg)	Dieldrin (µg/kg)	Aroclor 1248 (µg/kg)	Aroclor 1254 (µg/kg)	Aroclor 1260 (µg/kg)
Pomoxis nigromaculatus	Hwy 219 Bridge (Station 4)	A	65	3	7	6	95	76	58
Pomoxis nigromaculatus	Hwy 219 Bridge (Station 4)	B	61	1	5	4	68	50	36
Pomoxis nigromaculatus	Hwy 219 Bridge (Station 4)	C	52	1	4	4	62	47	31
Pomoxis nigromaculatus	Hwy 109 Bridge (Station 7)	A	46	2	7	4	54	61	39
Pomoxis nigromaculatus	Hwy 109 Bridge (Station 7)	B	47	3	11	5	66	63	44
Pomoxis nigromaculatus	Hwy 109 Bridge (Station 7)	C	53	2	8	4	74	56	34
Morone chrysops x Morone saxatilis	Dam (Station 10)	A	204	20	84	25	375	352	289
Morone chrysops x Morone saxatilis	Dam (Station 10)	B	230	22	91	28	410	376	309
Morone chrysops x Morone saxatilis	Dam (Station 10)	C	272	25	97	27	390	416	347

Table 10-44. Concentrations of heavy metals found in edible portions of two fish taxa collected at three locations in West Point Lake during October 1992.

Species	Location	Rep	Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
Pomoxis nigromaculatus	Hwy 219 Bridge (Station 4)	A	nd	nd	nd	.949	nd	nd	nd	nd	nd	nd	nd	nd	9.22
Pomoxis nigromaculatus	Hwy 219 Bridge (Station 4)	B	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	.755	nd	7.12
Pomoxis nigromaculatus	Hwy 219 Bridge (Station 4)	C	nd	nd	nd	.869	nd	nd	nd	nd	nd	nd	nd	nd	5.00
Pomoxis nigromaculatus	Hwy 109 Bridge (Station 7)	A	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.10	.377	7.24
Pomoxis nigromaculatus	Hwy 109 Bridge (Station 7)	B	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	.402	nd	6.37
Pomoxis nigromaculatus	Hwy 109 Bridge (Station 7)	C	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	.374	nd	7.56
Morone chrysops x *Morone saxatilis*	Dam (Station 10)	A	nd	nd	nd	nd	21.6	nd	nd	8.35	nd	nd	.684	nd	6.82
Morone chrysops x *Morone saxatilis*	Dam (Station 10)	B	nd	nd	nd	nd	1.26	nd	nd	nd	nd	nd	.581	nd	5.92
Morone chrysops x *Morone saxatilis*	Dam (Station 10)	C	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	.437	nd	5.59

nd = not detectable.
Detection limits were: 1 mg/kg for Ag, Be, Cr, Cu, Ni, Sb, Tl, and Zn; 0.03 mg/kg for Pb; 0.02 mg/kg for Ar and Se; 0.01 mg/kg for Cd and Hg.

10.2.5 SEDIMENT OXYGEN DEMAND

Sediment oxygen demand (SOD) is an expression of the rate at which lake sediments consume dissolved oxygen from the overlying water column (Hatcher 1986). Two processes, respiration of living organisms and decomposition of organic matter in the sediment, account for most of the oxygen consumption. SOD is an important component of water quality models that attempt to account for variations in dissolved oxygen of water bodies. During the week of 19-22 October 1992, personnel from the U.S.E.P.A., Region IV, and ADEM conducted field measurements of SOD using SOD chambers placed on the lake bottom (Murphy and Hicks 1986). Mean water temperature ranged between 17.0° and 19.8°C and initial chamber dissolved oxygen concentrations ranged from 4.3 to 8.7 mg/l. The studies were conducted at seven locations near water quality sampling stations 2, 4, 5, 6, 7, 8 and 10. The results are summarized in Table 10-45 and the report containing all data gathered appears in Appendix Table 5.

Soft muds in lacustrine areas of the lake (stations 6, 8 and 10) had the highest SOD rates (Table 10-45). The Yellowjacket Creek (station 6) and Wehadkee Creek (station 8) embayments had very similar SOD rate. Firm mud bottoms in the lacustrine zone (stations 5 and 7) as well as soft mud bottoms in the riverine (station 2) and transition (station 4) zones seemed to have had a lower demand for dissolved oxygen. Murphy and Hicks (1986) reported mean SOD rates detected with the EPA in-situ method ranging between 0.89 g $O_2/m^2 \cdot day$ and 3.91 g $O_2/m^2 \cdot day$ in several TVA reservoirs. The range of SOD values for West Point Lake, 0.75-1.49 g $O_2/m^2 \cdot day$, was similar to values reported for Jackson Lake, an impoundment of the Upper Ocmulgee River in Georgia (0.8-1.5 g $O_2/m^2 \cdot day$) (EPD, In Review). Weiss Lake on the Coosa River in Alabama had a range of SOD values (0.52-1.02 g $O_2/m^2 \cdot day$) somewhat lower than the West Point Lake range (Bayne et al. In Review).

Table 10-45. Sediment oxygen demand rates, water column respiration and bottom sediment characteristics for West Point Lake, 19-22 October 1992.

Mainstem Sampling Stations	Mean SOD		Water Column Respiration	Bottom Sediment
	$g\ O_2/m^2 \cdot hr$	$g\ O_2/m^2 \cdot day$	$\mu g/l \cdot min$	
2[1] (5)[2]	0.0376 (0.033-0.048)	0.90 (0.79-1.15)	1.06	Soft mud, some organic debris
4 (6)	0.0518 (0.049-0.055)	1.24 (1.18-1.33)	0.06	Soft mud
5 (7)	0.0313 (0.027-0.037)	0.75 (0.90-0.63)	0.36	Firm mud
7 (10)	0.0496 (0.033-0.081)	1.19 (0.78-1.95)	0.31	Soft mud, firm mud sandy-silt
10 (13)	0.0615 (0.050-0.074)	1.48 (1.21-1.78)	0.25	Soft mud
Embayment Stations				
6 (8)	0.0620 (0.055-0.067)	1.49 (1.33-1.62)	0.77	Soft mud
8 (11)	0.0610 (0.034-0.072)	1.46 (1.28-1.74)	0.25	Soft mud

[1]Nearest water quality sampling station.
[2]EPA-ADEM station designation.

10.2.6 TRIHALOMETHANE

Eutrophication leads to increased organic matter content in surface waters. This can cause problems in potable water supply lakes because chlorination of the water during the treatment process forms organohalides called trihalomethanes (THM's) that threaten human health (Cooke et al. 1986). Four organic compounds comprise THMs: trichloromethane (chloroform), bromodichloromethane, dibromochloromethane and tribromomethane (bromoform). These compounds are known or suspected of being carcinogenic and/or mutagenic agents and the U.S. Environmental Protection Agency has established a maximum contaminant level of 100 μg/l in finished drinking water (Vogt and Regli 1981). Increasing THM levels in drinking water supplies across the country have raised concern about sources and control of organic THM precursor molecules entering treatment plants (EPA 1990). Although watershed sources, like marshes, are known to be important sources of organic precursors, within lake production of organic matter by algae and higher plants also contributes. Palmstrom et al. (1988) demonstrated that 30% of the precursors entering a treatment plant withdrawing water from an Ohio, water supply reservoir was generated within the lake, primarily by algae.

The source of water for the City of LaGrange, Georgia is West Point Lake. The water is withdrawn through an intake located mid-reservoir near sampling station 5. The LaGrange Water System monitors THM concentrations in the treated drinking water. Once each quarter, water samples were collected at the same four locations within the distribution system and these samples are submitted to a commercial laboratory for analysis. The results are reported directly to the Georgia EPD.

Using these data for THM, an effort was made to determine if changes in organic matter content of West Point Lake water at station 5 were related to changes in THM concentrations in finished drinking water. The estimated retention time for water in the municipal supply system was < 3 days (personal communication, Keith Hester, LaGrange Water System). Three estimates of lake water, organic matter content (chlorophyll a, total organic nitrogen and total organic carbon) measured on a date nearest the quarterly THM analysis, were matched with the nine quarterly THM values (Table 10-46). The analyses (THM and organic matter) seldom occurred on the same day, but were always measured within 15 days. Simple product moment correlation analyses were used to explore relationships between THM and organic matter content of lake water.

THM concentrations were significantly correlated with TOC ($r = 0.73$; $P < 0.05$), but not with chlorophyll a or TON. TOC was not significantly ($P > 0.05$) related to TON or chlorophyll a, although TON and chlorophyll a were highly correlated ($r=0.88$; $P < 0.002$). Based on these limited data, it appears that THM precursors in West Point Lake water near the LaGrange water intake are being supplied primarily from allochthonous sources of organic matter. Morrow and Minear (1987) reported a linear relationship between TOC and THM formation. Palmstrom et al. (1988) suggested rainfall induced watershed runoff as an important source of THM precursors, particularly noticeable during periods of the year when biological activity within the lake was naturally low. Variations in algal biomass (chlorophyll a) in West Point Lake apparently were not associated with changes in THM concentrations in finished drinking water although additional data are needed to verify this finding.

Table 10-46. Mean quarterly trihalomethane (THM) concentrations in LaGrange, Georgia treated drinking water and concentrations of chlorophyll a, total organic nitrogen and total organic carbon in West Point Lake water near the LaGrange water intake (station 5), all measured within a 15 day period.

Date	THM (µg/l)	Chlorophyll a (µg/l)	Total Organic Nitrogen (µg/l)	Total Organic Carbon (µg/l)
25 July 1990	43	30.7	603	4,628
29 Oct 1990	48	6.9	252	3,315
4 Feb 1991	44	2.7	233	3,242
8 May 1991	56	2.8	280	5,296
6 Aug 1991	35	18.4	518	3,989
1 Nov 1991	13	7.8	210	2,336
31 Mar 1992	29	9.6	323	2,656
15 May 1992	24	29.5	437	2,931
9 Oct 1992	46	10.8	333	3,230

10.2.7 MACROPHYTE SURVEY

A macrophyte survey of West Point Lake was conducted late in the growing season of 1992. The survey was conducted from shallow draft boats and was limited to the main body of the lake and larger tributary embayments. Initial reconnaissance revealed the only significant concentrations of macrophytes were in the upstream reach of the lake from about the mouth of Potato Creek upstream to the Glover's Creek Waterfowl Area (Figure 10-20). However, scattered stands of emergent macrophytes were present from Franklin, GA downstream to Grayson's Landing (10 miles downstream from Franklin). On 4 September 1992 aquatic plants were collected and identified. Coverage of the dominant species was estimated by plotting their distribution on aerial photographs and measuring the area with planimetry.

A list of macrophytes identified during the survey appears in Table 10-47. Except for _Lemna_ sp. (a floating plant), all of the plants were classified as marginal emergents, usually confined to relatively shallow water. Some of the dominant species, however, form hollow stems when growing in deeper water and can produce floating mats of vegetation (_Alternanthera philoxeroides_, _Polygonum pensylvanicum_ and _P. lapathifolium_). Filamentous algae were the only submersed aquatics encountered and were present in small, scattered stands.

Two species of smartweed (_P. pensylvanicum_ and _P. lapathifolium_) growing together in mixed stands with other smartweed species (Table 10-47) were the dominant plants based on areal coverage (Table 10-48). The mat forming habit of these two smartweed species produced floating stands along the shore up to 15 m wide. Small islands (0.09 to 3.19 ha) were completely covered with the plant. Smartweed is considered an excellent food plant for waterfowl (Fassett 1966) and considering that it was concentrated in the reservoir adjacent to the Georgia

WEST POINT LAKE

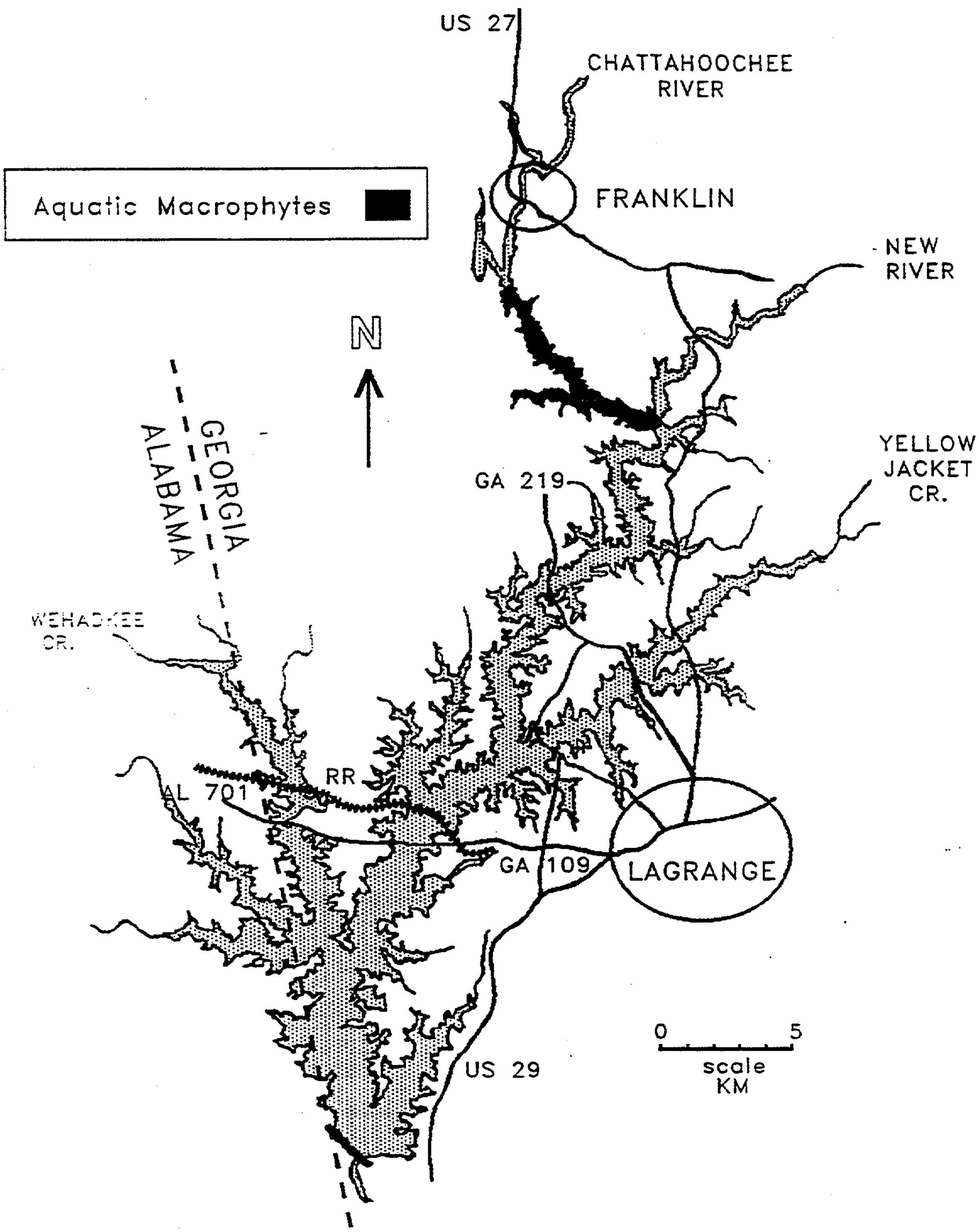

Figure 10-20. Location (darkened area) of significant aquatic macrophytes identified during the macrophyte survey of West Point Lake.

Table 10-47. Vascular aquatic plants identified in survey conducted in September 1992 on West Point Lake.

Species	Common Name
Salix nigra	black willow
Betula nigra	river birch
Carya aquatica	water hickory
Acer rubrum	red maple
Cephalanthus occidentalis	buttonbush
Hibiscus militaris	halberd-leaved marsh mallow
Polygonum pensylvanicum	pinkweed (smartweed)
P. lapathifolium	smartweed
P. sagittatum	tear thumb (smartweed)
P. densiflorum	smartweed
P. punctatum	smartweed
Alternanthera philoxeroides	alligator-weed
Juncus effusus	soft rush
Hydrochloa caroliniensis	southern watergrass
Ludwigia peploides	water primrose
Sacciolepis striata	grass
Arundanaria gigantea	cane
Typha latifolia	cattail
Mikania scandens	hemp vine
Scirpus cyperinus	wood grass
Echinocloa crusgalli	barnyard grass
Impatiens capensis	jewel-weed
Lobelia cardinalis	cardinal flower
Lemna sp.	duckweed

Table 10-48. Estimated coverage of dominant aquatic macrophytes present on West Point Lake in September, 1992.

Species	Common Name	Coverage (ha)
Polygonum pensylvanicum	pinkweed (smartweed)	7.4
Polygonum lapathifolium	smartweed	7.4
Alternanthera philoxeroides	alligator weed	3.8
Juncus effusus	soft rush	< 1.0

Wildlife Management Area, the plant likely provides major benefits to waterfowl populations.

In terms of surface area coverage, alligator-weed (A. philoxeroides) followed the co-dominant smartweed species (Table 10-48). Alligator-weed, an aggressive exotic weed species, also forms floating mats that have the potential to cover large surface areas. In West Point Lake, shoreline stands of the plant up to about 30 m wide were observed, although most stands were 1 to 3 m wide and growing along the lakeward edge of the more abundant smartweed mats. This suggests that the smartweeds established early and limited alligator-weed colonization of shallow water habitat in this case. Alligator-weed is not a beneficial plant but does not appear to be causing significant problems in the lake at this time.

Soft rush, Juncus effusus, was the fourth most dominant macrophyte (Table 10-48) usually found growing in shallow areas and frequently associated with alligator-weed. Soft rush roots in the bottom soil and grows up and out of the water. It does not form floating mats and consequently has a more disjunct distribution. Soft rush is of limited value to wildlife, but does help stabilize shoreline areas and reduce erosion.

The dominant macrophytes are all species that do not require inundation and therefore are not greatly affected by the annual water level fluctuation of West Point Lake. At full pool in this portion of the reservoir, waters flood overbank areas adjacent to the old river channel creating shallow water habitat conducive to marginal emergent vegetation. The annual 3 m drawdown and relatively high turbidity of lake waters in this upstream area probably have prevented establishment of submersed aquatic macrophytes. Further downstream, the drawdown exposes 2,900 ha of the littoral zone each year and eliminates all but the hardiest species of marginal aquatic plants (grasses, rushes and sedges).

The Corps of Engineers has had a tree planting program around the shoreline and shallow water areas of West Point Lake for several years (Eddie Sosebee, Corps of Engineers). The purpose of the planting was to enhance fish habitat and to mark or delineate shoal areas. More recently, the Georgia Game and Fish Division working with various bass fishing clubs in the area conducted tree planting around the lake to improve fish habitat. Tree planting has been limited to cypress (Taxodium) and "bankers willow" (Salix).

10.2.8 FISH HEALTH ASSESSMENT

Common carp and largemouth bass were collected from six sites in Spring and Fall 1991 for determination of a fish health assessment index. In general, the fish appeared fairly healthy. No fish were grossly deformed, had ulcerated or open lesions, fin rot or appeared emaciated. Lipomas (benign tumors) were found in the spleen of some bass. These benign tumors have never been correlated with environmental pollution and did not appear to cause much damage to the fish. Any lesions observed on the fish were attributable to parasites which do not constitute a human health hazard.

The following summarize the fish health assessment index findings: (1) no significant differences were found among the sites in the overall health assessment index in Spring for bass or carp. (2) Bass collected from the Dam site had a significantly higher index (or were in worse shape) than those from other sites. The major contribution to the observed index for bass was parasite load. (3) Carp health assessment indices were consistently lower in Spring compared to Fall. This difference is primarily due to abnormal gills and kidneys in Fall. (4) None of the gross lesions observed appeared to be life-threatening or to be severely compromising to the fish. (5) The only strong correlation between contaminant level and a measure response was the positive correlation between PCB levels and liver/somatic index. (6) The method used for determining fish health is somewhat crude and may not be sensitive enough for the relatively low level pollution observed at West Point Lake. (7) Further research is necessary to identify the parasites observed and determine their life cycles and factors that influence their prevalence. Once identified, an attempt could be made to determine if immunosuppression caused by chronic levels of environmental contaminants may increase their prevalence in fish.

The fish health studies were conducted by Dr. Vickie Blazer who was with the School of Forest Resources, University of Georgia. Dr. Blazer is now a Fisheries Biologist with the National Fish Health Lab, U.S. Fish and Wildlife Service, Kearneysville, West Virginia. Her final report in its entirety is appended to this document.

11.0 BIOLOGICAL RESOURCES

Fish Populations.

Preimpoundment studies of fish populations in the West Point basin produced fifty-three species of fish. Some species known to be common to the area were not collected initially. Table 11-1 lists fish present in West Point Lake and the surrounding watershed. Since impoundment some new species have appeared while others have totally disappeared. Table 11-2 documents the change in species composition (Timmons et al. 1977). These changes in species composition were expected as the flowing water habitats became more lentic. Gizzard shad quickly became the dominant forage species. Largemouth bass, bluegill, black crappie and channel catfish were identified as the important game species (Timmons et al. 1977).

The Georgia Department of Natural Resources (DNR) has maintained a standardized fish sampling program since the 1980's. Recent results (1988-1992) of the gillnetting segment of this sampling is presented in Tables 11-3 through 11-7. Dominant species by number and weight are summarized in Table 11-8. Relative condition of principal species from both gillnetting and electrofishing is presented in Tables 11-9 through 11-13. Hybrid bass (striped bass x white bass) have increased in importance in the fishery since stocking in 1978. Public pressure resulted in the stocking of striped bass in 1989 in West Point Lake. However, the impact from this stocking is not yet known.

Table 11-1. Checklist of fishes of West Point Lake and immediate watershed.

Scientific Family and Name	Common Name
Petromyzonidae	
1. Ichthyomyzon gagei	Southern brook lamprey
Lepisosteidae	
2. Lepisosteus osseus	Longnose gar
Amiidae	
3. Amia calva	Bowfin
Clupeidae	
4. Dorosoma cepedianum	Gizzard shad
5. D. petenense	Threadfin shad
Esocidae	
6. Esox americanus	Redfin pickerel
7. Esox niger	Chain pickerel
Cyprinidae	
8. Cyprinus carpio	Carp
9. Carassius auratus	Goldfish
10. Campostoma anomalum	Stoneroller
11. Notropis buccatus	Silverjaw minnow
12. Notropis winchelli	Clear chub
13. Nocomis leptocephalus	Bluehead chub
14. Notomigonus crysoleucas	Golden shiner
15. Lythrurus atrapiculus	Blacktip shiner
16. Cyprinella callitaenia	Bluestripe shiner
17. Notropis hypsilepis	Highscale shiner
18. N. longirostris	Longnose shiner
19. Cyprinella lutrensis	Red shiner
20. Notropis texanus	Weed shiner
21. Cyprinella venusta	Blacktail shiner
22. Luxilus zonistius	Bandfin shiner
23. Semotilus atromaculatus	Creek chub
24. Pimephales promelas	Fathead minnow
Castostomidae	
25. Carpiodes cyprinus	Quillback sucker
26. Erimyzon oblongus	Creek chubsucker
27. E. sucetta	Lake chubsucker
28. Hypentelium etowanum	Alabama hogsucker
29. Minytrema melanops	Spotted sucker
30. Moxostoma sp. cf. M. poecilurum	undescribed redhorse
31. M. lachneri	Greater jumprock

Table 11-1. (Cont.)

Family and Scientific Name	Common Name
Ictaluridae	
32. *Ameiurus catus*	White catfish
33. *Ameiurus brunneus*	Snail bullhead
34. *Ameiurus natalis*	Yellow bullhead
35. *Ameiurus nebulosus*	Brown bullhead
36. *Ictalurus punctatus*	Channel catfish
37. *Ameiurus melas*	Black bullhead
38. *Noturus leptacanthus*	Speckled madtom
Cyprinodontidae	
39. *Fundulus stellifer*	Southern studfish
Poeciliidae	
40. *Gambusia affinis*	Mosquitofish
Atherinidae	
41. *Labidesthes sicculus*	Brook silverside
Cottidae	
42. *Cottus carolinae*	Banded sculpin
Centrarchidae	
43. *Lepomis marginatus*	Dollar sunfish
44. *Centrarchus macropterus*	Flier
45. *Lepomis gulosus*	Warmouth sunfish
46. *L. auritus*	Redbreast sunfish
47. *L. cyanellus*	Green sunfish
48. *L. macrochirus*	Bluegill sunfish
49. *L. microlophus*	Redear sunfish
50. *L. punctatus*	Spotted sunfish
51. *Micropterus coosae*	Redeye bass
52. *M.* sp. cf. *M. coosae*	Shoal bass
53. *M. punctulatus*	Spotted bass
54. *M. salmoides*	Largemouth bass
55. *Pomoxis nigromaculatus*	Black crappie
Percidae	
56. *Perca flavescens*	Yellow perch
57. *Percina nigrofasciata*	Blackbanded darter
58. *Etheostoma fusiforme*	Swamp darter
59. *Stizostedion vitreum*	Walleye
Percicthyidae	
60. *Morone saxatilis* X *Morone chrysops*	Striped X white bass hybrid

Table 11-2. Fishes collected in West Point Lake area, January 1972-May 1977.

Common Name	Scientific Name
Both Before and Two Years After Impoundment	
Longnose gar	Lepisosteus osseus
Bowfin	Amia calva
Gizzard shad	Dorosoma cepedianum
Threadfin shad	D. petenense
Chain pickerel	Esox niger
Clear chub	Notropis winchelli
Golden shiner	Notemigonus crysoleucas
Blacktip shiner	Lythrurus atrapiculus
Bluestripe shiner	Cyprinella callitaenia
Longnose shiner	Notropis longirostris
Red shiner	Cyprinella lutrensis
Weed shiner	Notropis texanus
Blacktail shiner	Cyprinella venusta
Quillback	Carpiodes cyprinus
Creek chubsucker	Erimyson oblongus
Spotted sucker	Minytrema melanops
Greater jumprock	Moxostoma lachneri
Undescribed sucker	M. sp. cf. M. poecilurum
Snail bullhead	Ameiurus brunneus
Black bullhead	A. melas
Yellow bullhead	A. natalis
Brown bullhead	A. nebulosus
Channel catfish	Ictalurus punctatus
Mosquitofish	Gambusia affinis
Brook silverside	Labidesthes sicculus
Flier	Centrarchus macropterus
Redbreast sunfish	Lepomis auritus
Green sunfish	L. cyanellus
Warmouth	L. gulosus
Bluegill	L. macrochirus
Redear sunfish	L. microlophus
Spotted sunfish	L. punctatus
Spotted bass	Micropterus punctulatus
Largemouth bass	M. salmoides
Undescribed bass	M. sp. cf. M. coosae
Black crappie	Pomoxis nigromaculatus
Yellow perch	Perca flavescens
Before Impoundment Only	
Bluehead chub	Nocomis leptocephalus
Highscale shiner	Notropis hypsilepis
Bandfin shiner	Luxilus zonistius
Fathead minnow	Pimephales promelas
Creek chub	Semotilus atromaculatus
Lake chubsucker	Erimyzon sucetta
Alabama hogsucker	Hypentelium etowanum

Table 11-2. (Cont.)

Common Name	Scientific Name
Before Impoundment Only (cont).	
Speckled madtom	Noturus leptacanthus
Southern studfish	Fundulus stellifer
Redeye bass	Micropterus coosae
Banded sculpin	Cottus carolinae
Before and After Impoundment but Disappearing After One Year	
Southern brook lamprey	Ichthyomyzon gagei
Redfin pickerel	Esox americanus
Stoneroller	Campostoma anamalum
Silverjaw minnow	Ericymba buccata
Blackbanded darter	Percina nigrofasciata
After Impoundment Only	
Goldfish	Carassius auratus
Carp	Cyprinus carpio
White catfish	Ameiurus catus
Dollar sunfish	Lepomis marginatus
Swamp darter	Etheostoma fusiforme
Walleye	Stizostedion vitreum

Timmons, T. J., W. L. Shelton, and W. D. Davies. 1978. Initial fish population changes following impoundment of West Point Reservoir, Alabama-Georgia. Proc. Southeast. Assoc. Fish Wildl. Agencies 31(1977):312-317.

Table 11-3. Catch per unit effort and the relative abundance of species collected during gillnetting at 10 stations, on West Point Lake, Georgia from November 21 through November 22, 1988.

Species	(n)	Catch Per Net-Night Number	Catch Per Net-Night Percent of Total Number	Weight (Kg)	Percent of Total Weight
Bowfin	1	0.1	0.2	0.1	0.3
Gizzard Shad	176	17.6	29.6	1.2	4.2
Carp	8	0.8	1.3	1.9	6.7
Golden Shiner	1	0.1	0.2	t*	t
Spotted Sucker	4	0.4	0.7	1.1	3.9
White Catfish	11	1.1	1.9	1.1	3.9
Brown Bullhead	1	0.1	0.2	t	t
Flat Bullhead	1	0.1	0.2	t	t
Channel Catfish	132	13.2	22.2	5.5	19.4
White Bass	33	3.3	5.5	3.5	12.4
SB x WB Hybrid	107	10.7	18.0	9.2	32.5
Redbreast sunfish	1	0.1	0.2	t	t
Warmouth	8	0.8	1.3	0.1	0.4
Bluegill Sunfish	20	2.0	3.4	0.1	0.4
Spotted Bass	14	1.4	2.4	1.0	3.5
Largemouth Bass	20	2.0	3.4	1.5	5.3
Black Crappie	55	5.5	9.3	2.0	7.1
Yellow Perch	1	0.1	0.2	t	t
All species	594	59.4	100.2	28.3	100.0

*t = <0.1 kg.
Georgia DNR, Game and Fish, Standardized fish sampling program 1988.

Table 11-4. Catch per unit effort and the relative abundance of species collected during gillnetting at 10 stations, on West Point Lake, Georgia from November 5 through November 6, (3 stations) and from November 28 through November 29, 1989 (7 stations).

		Catch Per Net-Night			
Species	(n)	Number	Percent of Total Number	Weight (Kg)	Percent of Total Weight
Gizzard Shad	57	5.7	17.2	0.5	2.6
Threadfin Shad	1	0.1	0.3	t*	0.1
Carp	17	1.7	5.1	2.2	9.9
Golden Shiner	1	0.1	0.3	t	t
White Catfish	28	2.8	8.4	0.7	3.4
Channel Catfish	53	5.3	16.0	1.5	7.0
White Bass	11	1.1	3.3	0.9	4.1
SB x WB Hybrid	74	7.4	22.3	11.6	54.1
Warmouth	4	0.4	1.2	t	0.1
Bluegill	2	0.2	0.6	t	t
Redear	1	0.1	0.3	t	t
Spotted Bass	17	1.7	5.1	0.9	4.1
Largemouth Bass	17	1.7	5.1	1.7	7.9
Black Crappie	49	4.9	14.8	1.4	6.6
All species	332	33.2	100.0	21.4	99.9

*t = <0.1 kg.

Georgia DNR, Game and Fish, Standardized fish sampling program 1989.

Table 11-5. Catch per unit effort and the relative abundance of species collected during gillnetting at 10 stations, on West Point Lake, Georgia from November 19 through November 20, 1990.

		Catch Per Net-Night			
Species	(n)	Number	Percent of Total Number	Weight (Kg)	Percent of Total Weight
Gizzard Shad	90	9.0	15.9	0.7	3.1
Carp	32	3.2	5.7	4.2	18.6
Golden Shiner	2	0.2	0.4	t*	T**
Lake Chubsucker	2	0.2	0.4	t	0.2
Spotted Sucker	1	0.1	0.2	t	0.4
Snail Bullhead	1	0.1	0.2	t	T
White Catfish	29	2.9	5.1	0.7	3.1
Brown Bullhead	2	0.2	0.4	t	0.3
Channel Catfish	142	14.2	25.1	5.1	22.6
White Bass	129	12.9	22.8	3.5	15.5
Striped Bass	1	0.1	0.2	t	0.1
SB x WB Hybrid	52	5.2	9.2	5.8	25.7
Redbreast	5	0.5	0.9	t	T
Warmouth	7	0.7	1.2	t	0.3
Bluegill	8	0.8	1.4	t	0.1
Redear	1	0.1	0.2	t	T
Spotted Bass	11	1.1	1.9	0.3	1.3
Largemouth Bass	19	1.9	3.4	0.8	3.5
Black Crappie	31	3.1	5.5	1.1	4.9
All species	565	56.5	100.1	22.2	99.7

*t = <0.1 kg.
**T = < 0.1%
Georgia DNR, Game and Fish, Standardized fish sampling program 1990.

Table 11-6. Catch per unit effort and the relative abundance of species collected during gillnetting at 10 stations, on West Point Lake, Georgia from November 30 through December 1, 1991.

		Catch Per Net-Night			
Species	(n)	Number	Percent of Total Number	Weight (Kg)	Percent of Total Weight
Longnose Gar	1	0.1	0.1	T*	0.1
Bowfin	2	0.2	0.3	0.2	0.8
Gizzard Shad	143	14.3	19.9	1.0	4.5
Carp	13	1.3	1.8	2.1	9.6
Golden Shiner	1	0.1	0.1	T	t**
White Catfish	35	3.5	4.9	1.0	4.6
Brown Bullhead	3	0.3	0.4	0.1	0.3
Channel Catfish	284	28.4	39.6	7.5	34.7
White Bass	37	3.7	5.2	1.8	8.1
Hybrid Striped Bass	40	4.0	5.6	3.6	16.7
Redbreast Sunfish	1	0.1	0.1	T	t
Warmouth	2	0.2	0.3	T	t
Bluegill	11	1.1	1.5	T	0.1
Redear Bass	1	0.1	0.1	T	t
Spotted Bass	25	2.5	3.5	0.8	3.5
Largemouth Bass	30	3.0	4.2	1.8	8.6
Black Crappie	87	8.7	12.1	1.8	8.2
Yellow Perch	1	0.1	0.1	T	t
All species	717	71.7	100.0	21.7	99.8

*T = Trace (<0.1 kg)
**t = Trace (< 0.1%)
Georgia DNR, Game and Fish, Standardized fish sampling program 1991.

Table 11-7. Catch per unit effort and the relative abundance of species collected during gillnetting at 10 stations, on West Point Lake, Georgia from November 9 through November 10, 1992.

		Catch Per Net-Night			
Species	(n)	Number	Percent of Total Number	Weight (Kg)	Percent of Total Weight
Longnose Gar	1	0.1	0.2	0.1	0.7
Gizzard Shad	106	10.6	22.7	0.8	4.6
Threadfin Shad	6	0.6	1.3	T*	t**
Carp	14	1.4	3.0	1.8	9.8
Golden Shiner	1	0.1	0.2	T	t
Spotted Sucker	13	1.3	2.8	1.2	6.7
Snail Bullhead	1	0.1	0.2	T	t
White Catfish	11	1.1	2.4	0.2	1.0
Brown Bullhead	2	0.2	0.4	T	t
Channel Catfish	84	8.4	18.0	3.0	16.7
White Bass	85	8.5	18.2	3.9	21.6
Striped Bass	3	0.3	0.6	0.1	0.4
Hybrid Striped Bass	36	3.6	7.7	4.3	23.5
Redbreast Sunfish	1	0.1	0.2	T	t
Bluegill	6	0.6	1.3	T	t
Spotted Bass	12	1.2	2.6	0.5	2.8
Largemouth Bass	12	1.2	2.6	0.7	4.0
Black Crappie	68	6.8	14.6	1.3	7.4
Yellow Perch	4	0.4	0.9	T	t
All species	466	46.6	100.0	18.2	99.3

*T = Trace (<0.1 kg)
**t = Trace (< 0.1%)
Georgia DNR, Game and Fish, Standardized fish sampling program 1992.

Table 11-8. Dominant fish species by number and weight captured during gillnetting from 10 stations on West Point Lake 1988-1992.

Number	Year	Weight
	1988	
1. Gizzard Shad		Striped Bass x White Bass
2. Channel Catfish		Channel Catfish
3. Striped Bass x White Bass		White Bass
4. Black Crappie		Black Crappie
5. White Bass		Carp
	1989	
1. Striped Bass x White Bass		Striped Bass x White Bass
2. Gizzard Shad		Carp
3. Channel Catfish		Largemouth Bass
4. Black Crappie		Channel Catfish
5. White Catfish		Black Crappie
	1990	
1. Channel Catfish		Striped Bass x White Bass
2. White Bass		Channel Catfish
3. Gizzard Shad		Carp
4. Striped Bass x White Bass		White Bass
5. Carp		Black Crappie
	1991	
1. Channel Catfish		Channel Catfish
2. Gizzard Shad		Striped Bass x White Bass
3. Black Crappie		Carp
4. Striped Bass x White Bass		White Bass, Largemouth Bass, Black Crappie
5. White Bass		
	1992	
1. Gizzard Shad		Striped Bass x White Bass
2. White Bass		White Bass
3. Channel Catfish		Channel Catfish
4. Black Crappie		Carp
5. Carp		Black Crappie

Georgia DNR, Game and Fish, Standardized fish sampling program, 1988-1992.

Table 11-9. Relative condition (Kn) of principal species collected on West Point Lake, Georgia during 1988.

		Relative Condition (Kn) 20mm Size Groups																		
Species	(n)	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	>380
Fall Electrofishing																				
Threadfin Shad	293	1.67	1.32	0.92	1.03	0.91														
Redbreast Sunfish	10.4				1.02	0.93	0.84	0.84	0.76	0.81										
Bluegill Sunfish	176	1.40	1.71	1.17	1.10	1.01	1.00	0.98	0.79											
Spotted Bass	17				0.75	0.90	1.07	0.92	1.07	0.98	0.98									
Largemouth Bass	158		1.41	0.98	1.11	0.98	0.98	0.94	0.97	0.94	0.93	0.97	0.99	0.98	1.01	1.03	1.00	1.03	1.04	1.03
Fall Gillnetting																				
Gizzard Shad	176					1.15	0.82	0.77	0.86	0.79	0.86	0.87	0.98	0.97	0.97	0.94		0.91		
Channel Catfish	132						0.60		0.96	0.74	0.76	0.73	0.74	0.71	0.71	0.71	0.80	0.76	0.73	0.88
White Bass	33															1.10	1.11	1.11	1.12	1.19
SB x WB Hybrid	107									1.11		1.24	1.26	1.20	1.28	1.30	1.20	1.16	1.13	1.14
Black Crappie	55					0.89	0.72	0.72	0.87		1.05	1.26	1.29	1.25	1.32	1.37	1.37			

Georgia DNR, Game and Fish, Standardized fish sampling program 1988.

Table 11-10. Relative condition (Kn) of principal species collected on West Point Lake, Georgia during 1989.

		Relative Condition (Kn) 20mm Size Groups															
Species	(n)	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	>380
Fall Electrofishing																	
Gizzard Shad	190		0.80	0.75	0.82	0.94	0.98	0.94	0.98	1.05	0.98	1.01	1.14	1.12			
Redbreast Sunfish	143	1.13	1.03	1.00	0.91	0.84											
Bluegill	147	1.12	1.06	1.01	1.00	1.05											
Redear	27			0.91	1.02	1.03	1.03	1.12		0.93							
Spotted Bass	14	0.90	1.01	1.12		0.95		1.34		1.35	1.32			1.15			
Largemouth Bass	155	1.04	0.99	0.97	0.96	1.02	0.93	1.03	1.04	0.99	0.98	1.00	1.03	1.06	1.08	1.11	1.11
Fall Gillnetting																	
Gizzard Shad	57			0.81	0.78	0.83	0.81	0.80		0.95	0.93	0.94	0.94				
Channel Catfish	53																
White Bass	11			0.95									1.03			1.16	1.00
SB x WB Hybrid	74			1.29						1.27	1.21	1.37	1.18	1.26		1.10	1.08
Black Crappie	49				0.88	0.88	1.01	1.18	1.18	1.23	1.34	1.41	1.34				

Georgia DNR, Game and Fish, Standardized fish sampling program, 1989.

Table 11-11. Relative condition (Kn) of principal species collected on West Point Lake, Georgia during 1990.

		Relative Condition (Kn) 20mm Size Groups															
Species	(n)	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	>380
Fall Electrofishing																	
Gizzard Shad	113	1.76	0.99	0.76	0.81	0.83	0.87	0.94	1.02	1.00	1.03	1.10	1.05	1.11	1.12		
Redbreast	117	0.98	0.90	0.84	0.77	0.79	0.74	0.87									
Bluegill	141	0.96	0.90	0.92	0.91	0.89											
Redear	32					0.99	0.96	0.92	1.05								
Spotted Bass	61	0.93	1.09	0.94	1.05	1.02	1.16	1.04	1.08	1.07		1.18	1.21				1.14
Largemouth Bass	231	0.82	0.83	0.91	0.90	0.91	0.94	0.92	0.92	0.96	0.94	0.95	0.91	0.97	0.97	1.00	1.02
Fall Gillnetting																	
Gizzard Shad	90			0.85	0.90	0.84	0.84	0.89		1.04	0.96	1.09	0.75				
Channel Catfish	142				0.79	0.78	0.76	0.77	0.74	0.75	0.74	0.75	0.79	0.74	0.76	0.76	0.91
White Bass	129					0.99	1.10	1.04	1.10	1.10	1.10	1.16		1.10	1.04		0.91
Striped Bass	1											1.07					
SB x WB Hybrid	52					1.27				1.10			1.21		1.13		1.05
Black Crappie	31					1.01	0.99	1.11	1.08	1.33	1.25	1.25	1.36	1.39	1.34		1.14

Georgia DNR, Game and Fish, Standardized fish sampling program, 1990.

Table 11-12. Relative condition (Kn) of principal species collected on West Point Lake, Georgia during 1991.

Species	(n)	Relative Condition (Kn) 20mm Size Groups 60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	>380
Fall Electrofishing																			
Gizzard Shad	147		1.75	1.08	0.93	0.97	0.93	0.97	0.92	1.00	0.92	1.04	1.05	1.03	1.05	1.04			
Threadfin Shad	118	--	--	--	--	--	--												
Redbreast	104			1.07	0.99	0.91	0.89	0.87	0.86										
Bluegill	131	1.76	1.49	1.31	1.06	0.98	0.96	1.05											
Redear	60					0.96	1.05	1.01	0.95	1.01	1.11	1.05							
Spotted Bass	49		1.41	1.52	1.00	1.13	1.12	1.04	0.95	0.99	1.04	0.92		0.98		1.01			
Largemouth Bass	191	0.61	1.26	1.28	0.97	0.89	1.01	0.88	0.99	1.27	1.02	0.91	0.90	0.90	0.93	0.97	0.92	1.02	
Fall Gillnetting																			
Gizzard Shad	14					0.94	0.93	0.89	0.86	0.91	1.05	1.06	0.91	1.03	1.14			0.95	
White Catfish	4							0.74	0.89	0.84	0.91	1.00	0.88	1.01	1.06	1.01		1.21	
Channel Catfish	28						1.02	1.25	0.93	0.92	0.98	0.96	0.93	0.98	0.87	0.91	0.88	1.04	
White Bass	4										1.22	1.20	0.90	1.01	1.05	1.07	1.06		
SB x WB Bass	4					1.22		1.31	1.36		1.31	1.18	.15	1.20	1.14	1.13		0.97	
Black Crappie	9				0.72	0.93	0.95	0.96	1.22	1.15	1.18	1.25	1.18	1.29	0.99	1.33			

Georgia DNR, Game and Fish, Standardized fish sampling program, 1991.

Table 11-13. Relative condition (Kn) of principal species collected on West Point Lake, Georgia during 1992.

		Relative Condition (Kn) 20mm Size Groups																	
Species	(n)	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	>380
Fall Electrofishing																			
Gizzard Shad	107							0.88	0.77	0.94	0.89	0.91	0.92	0.93	0.96	0.83			
Threadfin Shad	8	1.18	1.17																
Redbreast	58			0.80	1.06	0.97	0.93	0.89	0.81	0.81									
Bluegill	113		1.39	0.99	1.05	0.91	1.05	1.01	1.04	1.17									
Redear	28			0.65			0.97	0.92	1.05	0.98									
Spotted Bass	39		1.04	0.98	0.95	0.97		1.06	1.01		1.08			1.03	1.15	1.05	1.23	0.97	
Largemouth Bass	121		0.86	1.15		1.0		1.03	0.95		0.98	0.93	0.86	1.00	0.94	0.96	0.93	0.94	1.05
Fall Gillnetting																			
Gizzard Shad	11						0.87	0.79	0.86	0.81	0.82	0.75	0.94	0.88	0.87	1.20	0.64		0.60
White Catfish	1							0.80			0.74	0.80	0.68	0.79	0.77	0.90			
Channel Catfish	8								0.88		0.78	0.82	0.92	0.76	0.78	0.78	0.79	0.91	0.95
White Bass	9								1.00	1.03	0.84	1.07	1.10	0.89	1.05	1.03	1.07	1.07	0.92
Striped Bass	1													1.02	0.99				
SB x WB Hybrid	4															1.13			1.03
Black Crappie	7					0.87	0.82	0.90	0.90	1.17	1.16	1.17	1.26	1.28	1.32	1.35	1.22		

Georgia DNR, Game and Fish, Standardized fish sampling program, 1992.

Wildlife.

A wildlife management area for primarily recreational purposes was created when West Point Lake was formed as partial mitigation for lost habitat caused by creation of the lake. The management area is approximately 3,642 ha in size and provides habitat for deer, quail, dove and various waterfowl. The Chattahoochee River corridor (including West Point Lake) is an important migratory route for many birds. These birds often stop within the management area during their travel north or south. Habitat enhancements (nesting boxes, food plots and ponds) have been added to accommodate those species stopping over as well as year-round residents. A list of common and transient birds is presented in Table 11-14. The management area holds several hunts available to the public during the different hunting seasons.

The bald eagle, Haliaeetus leucocephalus, an endangered species, was seen on several occasions during sampling on West Point Lake. During the summer and fall of 1992, several bald eagles were observed in the area from Buoy 126 (about 3 miles downstream of Franklin, GA bridge) to Yellowjacket Creek. Five eagles were sited in one day during one sampling trip through this area. Single birds were also sited in this area on different sampling dates. On the lower end of the reservoir near Rocky Point an eagle was sited during winter sampling. Eagles are nesting in Georgia and it is not known whether those sited were birds living around the lake or migratory individuals. Both immature and adult birds were present.

Table 11-14. Bird species of the West Point Lake watershed.

Common Name	Scientific Name
Common loon	Gavia immer
Pied-billed grebe	Podilymbus podiceps
Double-crested cormorant	Phalacrocorax auritus
American anhinga	Anhinga anhinga
Great blue heron	Ardea herodias
Green heron	Butorides striatus
Great egret	Casmerodius albus
Black-crowned night heron*	Nycticorax nycticorax
Yellow-crowned night heron*	Nyctanassa violacea
Least bittern	Ixobrychus exilis
American bittern*	Botaurus lentiginosus
Canada goose	Branta canadensis
Mallard	Anas platyrhynchos
American black duck	Anas rubripes
Gadwall	Anas strepera
Common pintail	Anas acuta
Green-winged teal	Anas crecca
Blue-winged teal	Anas discors
American wigeon	Anas americana
Wood duck	Aix sponsa
Ring-necked duck	Aythya collaris
Lesser scaup	Aythya affinis
Bufflehead	Bucephala albeola
Ruddy duck	Oxyura jamaicensis
Hooded merganser	Lophodytes cucullatus
Turkey vulture	Cathartes aura
Black vulture	Coragyps atratus
Mississippi kite	Ictinia mississippiensis
Sharp-shinned hawk	Accipiter striatus
Cooper's hawk	Accipiter cooperii
Red-tailed hawk	Buteo jamaicensis
Red-shouldered hawk	Buteo lineatus
Broad-winged hawk	Buteo platypterus
Bald eagle	Haliaeetus leucocephalus
Northern harrier	Circus cyaneus
Osprey*	Pandion haliaetus
Merlin	Falco columbarius
American kestrel	Falco sparverius
Common bobwhite	Colinus virginianus
Wild turkey	Meleagris gallopavo
King rail	Rallus elegans
Common gallinule	Gallinula chloropus
American coot	Fulica americana
Wilson's plover*	Charadrius wilsonia
Killdeer	Charadrius vociferus
Piping plover*	Charadrius melodus
Greater yellowlegs	Tringa melanoleuca
American woodcock	Philohela minor

Table 11-14. (Cont.)

Common Name	Scientific Name
Common snipe	Capella gallinago
Least sandpiper	Calidris minutilla
Herring gull	Larus argentatus
Laughing gull	Larus atricilla
Little tern*	Sterna albifrons
Mourning dove	Zenaida macroura
Yellow-billed cuckoo	Coccyzus americanus
Barn owl	Tyto alba
Common screech owl	Otus asio
Great horned owl	Bubo virginianus
Barred owl	Strix varia
Long-eared owl	Asio otus
Short-eared owl	Asio flammeus
Chuck-will's widow	Caprimulgus carolinensis
Common nighthawk	Chordeiles minor
Chimmney swift	Chaetura vauxi
Ruby-throated hummingbird	Archilochus colubris
Belted kingfisher	Megaceryle alcyon
Common flicker	Caloptes auratus
Pileated woodpecker	Dryocopus pileatus
Red-billed woodpecker	Melanerpes carolinus
Red headed woodpecker	Melanerpes erythrocephalus
Yellow bellied sapsucker	Sphyrapicus varius
Hairy woodpecker	Picoides villosus
Downey woodpecker	Picoides pubescens
Eastern kingbird	Tyrannus tyrannus
Great crested flycatcher	Myiarchus crinitus
Eastern phoebe	Sayornis phoebe
Acadian flycatcher	Empidonax virescens
Eastern pewee	Contopus virens
Rough-winged shallow	Stelgidopteryx ruficollis
Barn swallow	Hirundo rustica
Purple martin	Progne subis
Blue jay	Cyanocitta cristata
American crow	Corvus brachyrhynchos
Fish crow	Corvus ossifragus
Carolina chickadee	Parus carolinensis
Tufted titmouse	Parus bicolor
White breasted nuthatch	Sitta carolinensis
Red breasted nuthatch	Sitta canadensis
Brown creeper	Certhia familiaris
House wren	Troglodytes aedon
Winter wren*	Troglodytes troglodytes
Bewick's wren*	Thryomanes bewickii
Carolina wren	Thryothorus ludovicianus
Marsh wren	Cistothorus palustris
Sedge wren	Cistothorus platensis
Northern mockingbird	Mimus polyglottos

Table 11-14. (Cont.)

Common Name	Scientific Name
Gray catbird	Dumetella carolinensis
Brown thrasher	Toxostoma rufum
American robin	Turdus migratorius
Wood thrush	Hylocichla mustelina
Hermit thrush	Catharus guttatus
Eastern bluebird	Sialia sialis
Blue-gray gnatcatcher	Polioptila caerulea
Golden-crowned kinglet	Regulus satrapa
Ruby-crowned kinglet	Regulus calendula
Water pipet	Anthus spinoletta
Cedar waxwing	Bombycilla cedrorum
Loggerhead shrike	Lanius ludovicianus
European starling	Sturnus vulgaris
White-eyed vireo	Vireo griseus
Yellow-throated vireo	Vireo flavifrons
Solitary vireo	Vireo solitarius
Red-eyed vireo	Vireo olivaceus
Prothonotary warbler	Protonotaria citrea
Swainson's warbler	Limnothlypis swainsonii
Worm-eating warbler	Helmitheros vermivorus
Orange crowned warbler	Vermivora celata
Northern parula warbler	Parula americana
Yellow warbler	Dendroica petechia
Yellow-rumped warbler	Dendroica coronata
Yellow-throated warbler	Dendroica dominica
Pine warbler	Dendroica pinus
Prairie warbler	Dendroica discolor
Palm warbler	Dendroica palmarum
Louisiana waterthrush	Seiurus motacilla
Kentucky warbler	Oporornis formosus
Common yellowthroat	Geothlypis trichas
Yellow breasted chat	Icteria virens
Hooded warbler	Wilsonia citrina
American redstart	Setophaga ruticilla
House sparrow	Passer domesticus
Eastern meadowlark	Sturnella magna
Orchard oriole	Icterus spurius
Redwing blackbird	Agelaius phoeniceus
Rusty blackbird	Euphagus carolinus
Brewers blackbird	Euphagus cyanocephalus
Common grackle	Quiscalus quiscula
Brownheaded cowbird	Molothrus ater
Summer tanager	Piranga rubra
Northern cardinal	Cardinalis cardinalis
Blue grosbeak	Guiraca caerulea
Indigo bunting	Passerina cyanea
Dickcissel	Spiza americana
Purple finch	Carpodacus purpureus

Table 11-14. (Cont.)

Common Name	Scientific Name
Pine siskin	_Carduelis pinus_
American goldfinch	_Carduelis tristis_
Rufous-sided towhee	_Pipilo erythrophthalmus_
Savannah sparrow*	_Passerculus sandwichensis_
Grasshopper sparrow	_Ammodramus savannarum_
Henslow's sparrow	_Ammodramus henslowii_
LeConte's sparrow	_Ammospiza leconteii_
Vesper sparrow	_Pooecetes gramineus_
Bachman's sparrow*	_Aimophila aestivalis_
Northern junco	_Junco hyemalis_
Chipping sparrow	_Spizella passerina_
Field sparrow	_Spizella pusilla_
White-crowned sparrow	_Zonotrichia leucophrys_
White throated sparrow	_Zonotrichia albicollis_
Fox sparrow	_Passerella iliaca_
Swamp sparrow	_Melospiza georgiana_
Song sparrow	_Melospiza melodia_

Petersen, R. T., 1980. A field guide to the birds of Easter and Central North America. Fourth edition. Houghton Mifflin Co., Boston, MA. 384 pp.

* Indicates special birds of Georgia

Other Species.

Amphibians, reptiles and mammals also expected to occur in this watershed are listed in Table 11-15.

A list of species of special concern, (plants and animals), are presented in Table 11-16. These animals are tracked by the Georgia Natural Heritage program due to their limited numbers and/or threatened habitat.

Table 11-15. Amphibians and reptiles of the middle Chattahoochee watershed (above Columbus and below Atlanta) Georgia.

AMPHIBIANS	
Northern cricket frog	Acris crepitans
Southern cricket frog	Acris gryllus
Spotted salamander	Ambystoma maculatum
Marbled salamander	Ambystoma opacum
American toad	Bufo americanua
Woodhouse's toad	Bufo woohousii
Dusky salamander	Desmognathus fuscus
Seal salamander	Desmognathus monticola
Two-lined salamander	Eurycea cirrigera
Three-lined salamander	Eurycea guttolineata
Eastern narrowmouth toad	Gastrophryne carolinensis
Four-toed salamander	Hemidactylium scutatum
Cope's gray treefrog	Hyla chrysoscelis
Spring peeper	Hyla crucifer
Squirrel treefrog	Hyla squirella
Alabama waterdog	Necturus alabamensis
Eastern newt	Notophthalmus viridescens
Slimy salamander	Plethodon glutinosus
Southern redback salamander	Plethodon serratus
Webster's salamander	Plethodon websteri
Mud salamander	Psuedotriton montanus
Red salamander	Pseudotriton ruber
Bullfrog	Rana catesbeinana
Green frog	Rana clamitans
Pickerel frog	Rana palustris
Southern leopard frog	Rana sphenocephala
Eastern spadefoot	Scaphiopus holbrookii
REPTILES	
Copperhead	Agkistrodon contortrix
Cottonmouth	Agkistrodon piscivorus
American alligator	Alligator mississippiensis
Green anole	Anolis carolinensis
Spiny softshell	Apalone spinifera
Worm snake	Carphophis amoenus
Scarlet snake	Cemophora coccinea
Snapping turtle	Chelydra serpentina
Painted turtle	Chrysemys picata
Six-lined racerunner	Cnemidophorus sexlineatus
Racer	Coluber constrictor
Timber rattlesnake	Crotalus horridus
Ringneck snake	Diadophis punctatus
Corn snake	Elaphe guttata
Rat snake	Elaphe obsoleta
Five-lined skink	Eumeces fasciatus
Southeastern five-lined skink	Eumeces inexpectatus
Broadhead skink	Eumeces laticeps

Table 11-15. (Cont.)

REPTILES (cont.)	
Mud snake	Farancia abacura
Eastern hognose snake	Heterodon platirhinos
Eastern mud turtle	Kinosternon subrubrum
Prairie kingsnake	Lampropeltis calligaster
Common kingsnake	Lampropeltis getula
Milk snake	Lampropeltis triangulum
Alligator snapping turtle	Macroclemys temminckii
Coachwhip	Masticophis flagellum
Plainbelly water snake	Nerodia erythrogaster
Northern water snake	Nerodia sipedon
Brown water snake	Nerodia taxispilota
Rough green snake	Opheidrys aestivus
Slender grass lizard	Ophisaurus attenuatus
Eastern glass lizard	Ophisaurus ventralis
River cooter	Pseudemys concinna
Queen snake	Regina septemvittata
Eastern fence lizard	Sceloporus undulatus
Ground skink	Scincella lateralis
Pigmy rattlesnake	Sistrurus miliarius
Loggerhead musk turtle	Sternotherus minor
Stinkpot	Sternotherus odoratus
Brown snake	Storeria dekayi
Redbelly snake	Storeria occipitomaculata
Southeastern crowned snake	Tantilla coronata
Eastern box turtle	Terrapene carolina
Eastern ribbon snake	Thamnophis sauritus
Common garter snake	Thamnophis sirtalis
Slider	Trachemys scripta
Rough earth snake	Virginia striatula
Smooth earth snake	Virginia valeriae

Table 11-16. Special species tracked by Georgia Natural Heritage Program known to occur in the middle Chattahoochee watershed (south of Atlanta and north of Columbus) in Georgia.

Common Name	Scientific Name
BIRDS	
Bachman's sparrow	Aimophila aestivalis
FISH	
Bluestripe shiner	Cyprinella callitaenia
Southern brook lamprey	Ichthyomyzon gagei
Highscale shiner	Notropis hypsilepis
PLANTS	
Pool sprite, snorkelwort	Amphianthus pusillus
Georgia rockcress	Arabis georgiana
Harper dodder	Cuscuta harperi
Large yellow ladyslipper	Cypripeium calceolus car pubescens
Crested wood fern	Dryopteris cristata
Longleaf sunflower	Helianthus longifolius
Shoals spiderlily	Hymenocallis coronaria
Black-spored quillwort	Isoetes melanospora
Southern twayblade	Listera australis
American ginseng	Panax quinquefolius
Monkey-face	Platanthera integrilabia
Mountain-mint	Pycnanthemum curvipes
Plumleaf azalea	Rhododendron prunifolium
Bay starvine	Schisandra glabra
Nevius stonecrop	Sedum nevii
Dwarf granite stonecrop	Sedum pusillum
Silky camellia	Stewartia malacodendron
Piedmont barren strawberry	Waldsteinia lobata
Northern prickly ash	Zanthoxylum americanum

Georgia Department of Natural Resources
Wildlife Resources Division
Georgia Natural Heritage Program
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PART II. FEASIBILITY STUDY

LAKE RESTORATION ALTERNATIVES

PROBLEM: Cultural Eutrophication.

PRIMARY CAUSES:

Atlanta metropolitan area point source dischargers

Urban storm runoff

Combined sewer overflow in Atlanta area

This study, as well as others, has documented the cultural eutrophication of West Point Lake that has occurred as a result of excessive nutrient enrichment of lake waters. From November 1990 through October 1991, permitted dischargers in the Atlanta metropolitan area contributed about 88% (241 MGD) of the total point source wastewater volume entering West Point Lake. Municipal wastewater treatment plants (WPCP) were responsible for 98% of that total. About 70% of the total phosphorus entering the lake via the Chattahoochee River resulted from point sources, although under low-flow conditions some of the point and nonpoint source phosphorus may temporarily settle to the river bottom or be taken up by filamentous algae. Atlanta area dischargers contributed about 98% (498,453 kg/yr) of the total phosphorus load (511,868 kg/yr) entering West Point Lake from all point sources (Table 12-1).

Table 12-1. Total phosphorus loading (kg/yr) of West Point Lake.

	Point Source			Nonpoint Source		
	Atlanta Municipals	Other Municipals	All Industrials	Chatta-hoochee River	All Others	TOTAL
Total Phosphorus	498,453	12,248	1,167	219,153	19,402	750,423

Nonpoint source loading of total phosphorus into West Point Lake was estimated to be 238,555 kg/yr (Table 12-1). Of that amount, 92% entered the lake via the Chattahoochee River. A large but unquantified portion of this loading resulted from urban storm runoff and combined sewer overflows occurring in the Atlanta metropolitan area. Nonpoint source phosphorus loading of the lake from that portion of the basin between the West Point Dam and Franklin, Georgia was 19,402 kg/yr. Clearly, the Atlanta area point source dischargers were responsible for most (66%) of the phosphorus loading of West Point Lake. In addition, treated municipal wastewater is known to have a relatively high proportion of the TP present in a bioavailable form. Total phosphorus loading of the lake was an estimated 7.2 g $P/m^2 \cdot$ year. The annual mean TP concentration in the Chattahoochee River where it entered West Point Lake (Franklin, Georgia) was over three times the concentration (0.050 mg/l) recommended by EPA to prevent excessive lake eutrophication (EPA 1986).

As recently as 1987, Algal Growth Potential Tests revealed that West Point Lake was nitrogen limited at all mainstem locations during the growing season except in the dam forebay (EPA-EPD 1987). Since manipulation of nitrogen is generally considered impractical in combatting eutrophication (EPA 1990a), efforts are underway to reduce phosphorus loading of the lake to levels that will slow algal growth to more acceptable rates (EPD 1990a). Actions (phosphate detergent ban and 0.75 mg/l effluent limitations) taken to date have resulted in a decline in phosphorus loading (Figure 8-4) and a decline in mean TP concentration at most mainstem stations (Table 10-25). More of the lake was phosphorus limited during the 1991 and 1992 growing seasons than during the 1990 growing season (Table 10-38). Further phosphorus reduction will be necessary to bring the entire lake into phosphorus limitation.

An increase in plankton algae biomass has been the prominent biological manifestation of nutrient enrichment of West Point Lake. Raschke (1987) reported corrected chlorophyll a concentrations of 147 μg/l during the 1986 growing season. Growing season mean (April-October) chlorophyll a concentration at a mid-reservoir location (LaGrange water intake) in 1987 was 43.4 μg/l (EPA and EPD 1987) and in 1988 it was 44.9 μg/l (EPA and EPD 1988). Such high levels of algal growth and accumulation do not enhance any of the designated uses of West Point Lake. In fact, in 1988 the discharge of hypolimnial waters through the dam during hydroelectric generation caused fish kills in the tailwaters and taste and odor problems in the potable water supplies taken from the tailwaters. These were both indirect effects of the proliferation of the plankton algae in lake waters. Such eutrophic lakes usually have Secchi disk visibilities of less than 1.0 m (Carlson 1977).

West Point Lake is use-classified as recreation and fishing in Georgia and swimming and fish and wildlife in Alabama. Recreational users, particularly skiers and swimmers, prefer clearer waters for aesthetic and safety reasons. A Secchi disk visibility of 1.2 m (4 feet) or greater is recommended for swimming waters to allow sufficient visibility for rescue of a submerged drowning victim (National Academy of Sciences 1973). During the growing season, an increase in water clarity would require a decrease in plankton algae abundance. These algae are the primary producers of food for other aquatic organisms living in the lake and some anglers believe the more food available to the fish the better the fishing. Fishery scientists have expressed concern that improvements in lake water quality (i.e., reduced phosphorus, reduced algae and increased water clarity) will result in an unacceptable decline in the quality of the sport and commercial fisheries (Yurk and Ney 1989). While it is clear that oligotrophic lakes will not support as large a fish biomass as eutrophic lakes, recent studies conducted at Auburn University suggest that increases in algal biomass beyond certain limits does not enhance sport fishing (Bayne et al. 1994). Their study of four mainstream reservoirs spanning the trophic range of Alabama lakes revealed that increases in phytoplankton chlorophyll a concentrations in excess of 10 to 15 µg/l did not improve sportfish (primarily black bass and crappie) growth and abundance or the quality of the fishery. It appears, therefore, that improvement of water quality from near hypereutrophic condition to a moderately eutrophic state would not adversely affect the sport fishery in West Point Lake.

West Point Lake serves as a potable water supply for the city of LaGrange, Georgia. The water supply intake structure is located about 2.2 km upstream of the mouth of Yellowjacket Creek in the more highly productive transition zone of the lake. Other municipalities utilize West Point Lake tailwaters as potable water sources. Aside from taste and odor problems associated with algal by-products or decomposition products, excessive algal growth in water supplies can increase the potential for the formation of the carcinogenic trihalomethanes. Although our study failed to reveal a relationship between phytoplankton biomass and THM's in LaGrange water, Palmstrom et al. (1988) reported as much as 30% of the THM precursors in an Ohio lake was generated within the lake primarily by plankton algae. An upper limit on algal biomass near the LaGrange water intake (station 5) might prevent THM production in the water supply in the future.

Two approaches have been used in trying to determine the extent to which total phosphorus must be reduced in the effluent of Atlanta-area municipal waste treatment facilities to improve the water quality of West Point Lake. In February 1989, the Georgia Environmental Protection Division released a document entitled "Phosphorus Loading Reduction To West Point Reservoir" in which it was reported that an effluent limitation of 0.75 mg/l total phosphorus would result in a mean summertime chlorophyll a concentration of 27 µg/l at the LaGrange water intake and 25 μg/l lakewide (EPD 1989b). In August 1990 a report was released by EPA (1990) based, in large part, on results of a water quality model applied by the Corps of Engineers, Waterways Experiment Station (Gaugush 1989), under contract with EPA. The West Point Lake model (BATHTUB) predicted that in order to reduce mean summertime chlorophyll a concentrations at the LaGrange water intake to 27 μg/l, an effluent total phosphorus concentration of no more than 0.2 mg/l must be maintained. It was further predicted that this phosphorus level would result in mean growing season chlorophyll a concentrations of 15-20 μg/l lakewide under both average and 10-year low-flow conditions and that maximum instantaneous chlorophyll a concentrations would not exceed 40 μg/l under average flows or 50 μg/L under 10-year low-flow conditions. Estimates by both agencies were based on a maximum effluent flow of 358 MGD, the committed expansion flow through the year 2010. This flow is 94.5 MGD higher than the permitted flow that existed in 1989. DNR has informed local Atlanta governments that no effluent flows to the Chattahoochee River beyond the committed 358 MGD will be allowed (EPD 1989c).

RECOMMENDATIONS

The following steps are recommended to assure that cultural eutrophication of West Point Lake is halted and that lake waters will be safe and suitable for fishing, swimming and as a public water supply.

1) Chlorophyll a (corrected for phaeopigments)

Under 10-year low-flow conditions (2,100 cfs at Whitesburg, Georgia) mean (based on samples collected at about 15 day intervals) photic zone chlorophyll a concentrations measured near the LaGrange water intake structure during the growing season (April through October) should not exceed 27 μg/l. Mean photic zone chlorophyll a concentration should not exceed 50 μg/l at any time, anywhere in West Point Lake. Lakewide, the growing season average should range between 15 to 20 μg/l. Lakewide photic zone chlorophyll a means will be based on samples collected at about 15 day intervals at no less than four mainstem (along Chattahoochee River channel) locations distributed about equidistance between West Point Dam and the mouth of New River.

If future water withdrawal within the Chattahoochee River Basin upstream of West Point Lake exceeds current (1993) levels and results in Chattahoochee River flows of less than 2,100 cfs (at Whitesburg, Georgia), the chlorophyll a standards for the 10-year, low-flow condition (as stated above) will apply until such time as river flows exceed 2,100 cfs.

Under average flow conditions (3,925 cfs at Whitesburg) mean photic zone chlorophyll a concentrations measured near the LaGrange water intake structure during the summer (June through August) should not exceed 27 μg/l. Mean photic zone chlorophyll a concentration should not exceed 40 μg/l at any time, anywhere in West Point Lake. Lake-wide, the growing season average should range between 15 and 20 μg/l. Lake-wide photic zone chlorophyll a means will be based on samples collected at about 15 day intervals at not less than four mainstem (along Chattahoochee River channel) locations distributed about equidistance between West Point Dam and the mouth of New River.

Note. These chlorophyll a limitations are based, in large part, on information provided by both EPD (1989b) and EPA (1990b). The critical level of 27 μg/l chlorophyll a at the midreservoir location near the LaGrange water supply intake was supported by both agencies. Limiting mean growing season chlorophyll a concentrations to 27 μg/l in the lake transition zone is predicted to result in mean lake-wide chlorophyll a levels of 15-20 μg/l during the growing season

(EPA 1990b). The following water quality improvements should result:

- greater water clarity;
- reduced oxygen demand caused by overproliferation and decomposition of organic matter (plankton algae);
- higher minimum and lower maximum pH;
- reduced probability that trihalomethane precursors will result from excessive phytoplankton blooms and
- reduced probability of taste and odor problems developing in potable water supplies taken from the lake.

Chlorophyll a concentrations of 15-20 µg/l during the growing season should be more than adequate to support a productive lake fishery.

2) Total Phosphorus

Total phosphorus loading of the Chattahoochee River and its tributaries upstream of West Point Lake by point source dischargers must be reduced to levels that will ensure maintenance of the chlorophyll a concentrations as stated above.

Note. About two-thirds of the phosphorus entering West Point Lake in 1991 came from Atlanta-area WPCP. This source of phosphorus is known to have a relatively high proportion of bioavailable phosphorus (Raschke and Schultz 1987). About one-half of the TP in Chattahoochee River water at Franklin, Georgia was in a form that was readily usuable by algae and other aquatic plants (Figure 10-11). Control of these point sources of phosphorus will have a greater impact on lake water quality than a comparable amount of effort aimed at nonpoint source phosphorus control. However, as lake phosphorus concentrations decline as a result of point source TP control efforts, nonpoint sources of phosphorus will become increasingly important. Urban storm runoff and combined sewer overflow problems in the Atlanta-area are obvious significant sources of phosphorus to

West Point Lake. Actions taken to date (phosphate detergent ban and initiation of a 0.75 mg/l effluent limitation) have resulted in a decline in phosphorus loading and in total phosphorus concentrations of lake waters. However, during the 1992 growing season, there was still enough excess phosphorus present as far downstream as the LaGrange water intake (station 5) to cause nitrogen limitation or co-limitations during the latter portion of the growing season (August and October) (Table 10-38). Further phosphorus reduction is needed just to bring the most productive area of the lake (stations 4 and 5) into phosphorus limitation. Reductions in effluent total phosphorus to maintain the recommended chlorophyll a concentrations must be sufficient to offset increased discharge of treated wastewater (a total of 358 MGD by 2010) and anticipated reduced tributary flows into West Point Lake caused by increased consumptive water use upstream. Any reasonable course of action to address this problem will likely involve a cooperative effort among the three government agencies (EPD, ADEM and EPA) charged with the responsibility for maintaining quality of this important resource.

3) Total Nitrogen

Since the lake will be phosphorus limited in terms of algal growth, nitrogen concentrations can vary as long as concentrations of toxic species (e.g. NH_3 and NO_2^-) remain at safe levels (EPA 1986).

4) pH

Lake water pH should not decline below pH 6.5 nor rise above pH 9.5.

Note. Total alkalinity of West Point Lake waters is generally low (13-29 mg/l as $CaCO_3$) and therefore the chemical buffering capacity of the lake is reduced. Normal variation in CO_2 of lake waters caused by algal photosynthesis and respiration can cause wide diel fluctuations in pH of poorly buffered systems

(Wetzel 1983). pH values within the range of 6.5 to 9.0 are generally considered adequate for protection of fish and other aquatic life (Boyd 1979, Alabaster and Lloyd 1980 and EPA 1986). During the growing season of 1992, with relatively low chlorophyll a concentrations (<25.8 µg/l), afternoon pH values in the photic zone of the lake frequently exceeded 9.0 but were usually below 9.5. It may be unreasonable to expect a poorly buffered, eutrophic lake to always maintain pH values between 6.5 and 9.0. Boyd (1976 and 1990) reported good fish production in ponds with low alkalinity even though afternoon pH values typically rose above 9.0.

5) Dissolved Oxygen

Under isothermal conditions (change in water column temperature of 1.0 °C or less) the dissolved oxygen concentration of the photic zone (that portion of the upper water column receiving at least 1.0 % of the surface incident light) should maintain a dissolved oxygen concentration of 5.0 mg/l or higher at all times. When a thermocline (change in water column temperature of greater than 1.0 °C) exists, dissolved oxygen concentration in the upper 5.0 m of the water column should remain at 5.0 mg/l or higher at all times.

Note. Eutrophication usually promotes plant growth (plankton algae in West Point Lake) in lakes resulting in increased rates of organic matter decomposition. Organisms responsible for the decomposition utilize dissolved oxygen in the water and therefore eutrophication can cause an oxygen shortage among competing aerobic organisms. Warmwater species of fish and invertebrates usually thrive as long as minimum oxygen concentrations remain ≥ 5.0 mg/l (Alabaster and Lloyd 1980, EPA 1986 and Boyd 1990). Eutrophic lakes of the southeastern U.S. that thermally stratify usually have hypolimnial (deep water) oxygen deficiencies and West Point Lake is no exception. However, the upper, lighted portion of the water column (photic zone), where algal photosynthesis and surface diffusion supply oxygen to the water, should maintain dissolved oxygen concentrations ≥ 5.0 mg/l at all times. This will assure a voluminous, well oxygenated life zone for support of most warmwater organisms. One notable exception, however, is the striped bass, Morone saxatilis, that was routinely stocked into many southeastern reservoirs including West Point Lake as an additional piscivorous sportfish. These anadromous fish that ascended streams to spawn in times past, prior to wide-spread river impoundment, require a cool water (20 - 24 °C) refuge in addition to adequate dissolved oxygen (Coutant and Carroll 1980). There is no guarantee that our recommendations will ensure adequate areas of cool, well oxygenated water to support any future stocking of striped bass into West Point Lake.

These recommendations should be included as part of the West Point Lake Water Quality Standards to be established by the Georgia Board of Natural Resources as called for in Act Number 1274 approved by the Georgia General Assembly in April 1990. The cost associated with implementing these recommendations will depend largely on the level of phosphorus reduction in wastewater effluent necessary to meet the recommended lake water quality standards. EPA (1990b) estimated the cost of meeting the 0.75 mg/l limit at $75,000 per year per MGD and the 0.2 mg/l limit at $100,000 per year per MGD of wastewater. Calculated at the future 358 MGD wastewater design flow, total cost of the 0.75 mg/l limit would be $26.9 million and total cost of the 0.2 mg/l limit would be $35.8 million.

PROBLEM: Bacterial Contamination.

PRIMARY CAUSES:

Urban storm runoff

Combined sewer overflow in Atlanta area

Studies designed to detect fecal coliform contamination of West Point Lake during 1991 and 1992 revealed incidences of elevated bacterial counts (> 200 colonies/100 ml) confined to the upstream one-half of the lake. On most occasions, waters tested between the LaGrange water intake (station 5) and the dam (station 10) had fecal coliform levels of < 20 colonies/100 ml. However, upstream areas of the lake, primarily a 13-km reach between Franklin, Georgia and the mouth of New River, frequently exceeded the use designated criterion (a geometric mean of 200 colonies/100 ml based on at least four samples collected within a 30 day period). Intensive sampling of the lake following periods of high rainfall and runoff in the Atlanta metropolitan area resulted in elevated bacterial counts in the upstream reaches of the lake several days following the rain event. Rainfall in the Atlanta area increases fecal coliform densities in the Chattahoochee River in at least two ways. Untreated stormwater runoff from city streets, parking lots and homes is a major source of bacteria often containing fecal coliform densities as high as 10^5 colonies/100 ml (Novotny and Chesters 1981). The other source of bacteria following rainfall events in the Atlanta area results from combined sewer overflow (CSO). A 26 square mile area of the City of Atlanta is served by a system of combined sewers (EPD 1989c). Rainfall in this area of the city results in untreated domestic sewage as well as urban runoff entering the Chattahoochee River from six Atlanta area CSO's.

CSO's contribute more bacteria (10^6 colonies/100 ml) and a higher proportion of bacteria derived from humans as opposed to other warm blooded animals (Novotny and Chesters 1981).

RECOMMENDATIONS

The following water quality standard must be strictly enforced:

Fecal Coliform Bacteria.

The geometric mean fecal coliform density based on four samples collected during a 30 day period should not exceed 200 colonies/100 ml in lake water. At least 24 hours should elapse between samples.

Note. Urban storm runoff and CSO's are contributing buoyant solids, settable solids, nutrients, bacteria and toxics to the Chattahoochee River and West Point Lake. It appears that these sources are the primary cause of elevated fecal coliform densities in the upstream portions of West Point Lake. Improvements in the quality of storm runoff water and CSO's are essential if the fecal coliform standard is to be met. Actions are underway that could result in substantial reductions of solids and bacteria in Atlanta area stormwater and CSO's.

Sediment control has been strengthened through more active enforcement of the Erosion and Sedimentation Act (the Act) of 1975 as amended through 1989. The Act provided for counties and municipalities to become certified issuing authorities for permits involving land disturbing (mainly construction) activities. An amendment to the Act gave EPD the authority to review actions and progress of certified counties and municipalities. In addition, EPD assumed responsibility for issuing and enforcing permits for those cities and counties which were not certified and had failed to adopt a local ordinance. All cities and counties in the Atlanta metropolitan area now have ordinances that attempt to assure "sound conservation and engineering practices to prevent and minimize erosion and resultant sedimentations".

Metropolitan Atlanta also has a storm water management program. EPD is in the process of issuing NPDES Area-Wide Permits to the municipalities in the metro Atlanta area. The permit requires that the permittee not create a condition of nuisance, cause interference with the legitimate water use of the State of Georgia as set forth in Section 391-3-6-.03 of the Rules and Regulations for Water Quality Control or cause the following conditions:

- Foam or floating, suspended or deposited macroscopic particulate matter;
- Bottom deposits or aquatic growths;
- Alteration of temperature, turbidity or apparent color beyond present background levels;
- Visible, floating, suspended, or deposited oil, grease or any products of petroleum origin; and
- Toxic or deleterious substances to be present in concentrations or quantities which will cause harmful effects on aquatic biota, wildlife, or waterfowl or which render any of these unfit for human consumption either at levels created in the receiving waters or as a result of biological concentration.

The permit requires that the permittee institute best management practices to control the quality of the storm water discharged to the waters of the State (personal communication, Jim Sommerville, EPD).

Neither nutrients nor bacteria are specifically mentioned among permit requirements but perhaps they would be considered "deleterious substances" introduced to receiving waters that interfere with legitimate water use. If that is the case, vigorous enforcement of this stormwater program could be very effective in controlling sedimentation, bacterial and toxic contamination and nutrient enrichment (cultural eutrophication) of West Point Lake. If nutrients and bacteria are not considered "deleterious substances" in this context, then they should be added to the permit requirements. EPD must provide the leadership, guidance and impetus to fully implement this program.

The initial efforts to address the CSO problem in the City of Atlanta are underway. EPD has issued NPDES permits to the six CSO's that discharge to waters tributary to the Chattahoochee River. The permits require that the CSO must not cause violations of the Georgia Water Quality Control Standards. In addition, the CSO's must be controlled to prevent the following conditions for waters downstream of the CSO:

- materials which would settle to form sludge deposits that become putrescent, unsightly or interfere with legitimate water uses;
- oil, scum and floating debris in amounts sufficient to be unsightly or to interfere with legitimate water uses;
- materials which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses;
- toxic, corrosive, acidic and caustic substances in amounts, concentrations or combinations which are harmful to humans, animals or aquatic life.

Concurrently with the NPDES Permits, the EPD issued Administrative Orders for those CSO's that were deemed to be unable to meet the requirements of the permit (a total of six orders were issued). The Orders required that the CSO's meet their permits requirements by January 1, 1994.

To meet the requirements of the permit, the City is building the following facilities at the CSO's:

- effluent flow measurement;
- coarse screening;
- fine screening;
- disinfection.

The construction of the above facilities is scheduled to be completed by December 31, 1993 at four of the six CSO's. One of the remaining CSO's will be eliminated by separating the sewers, while the construction of the control facilities at the other CSO has been delayed due to a change in the location of the control facilities.

To address the City's failure to initiate construction at two of the CSO's by the date specified in the Order, the EPD entered into a Consent Order with the City of Atlanta. The Order requires the City pay a stipulated penalty of $1,000 per day per CSO for each month or portion of month beyond the date specified in the Order that the City fails to initiate construction of the CSO's. In addition, the City will pay an escalating stipulated penalty ($1,000-$4,000 per day per CSO) for each month or portion of month beyond January 1, 1994 that the City fails to complete construction of the CSO control facilities (personal communication, Jim Sommerville, EPD).

Completion of construction on all six of these CSO's could require an additional year or more although some are scheduled to begin operation early in 1994. The separation of stormwater and domestic waste sewers is the surest way to reduce nutrient and bacterial contamination of receiving waters. CSO's typically have higher bacterial densities and nutrient concentrations than stormwater (Novotny and Chesters 1981). The fact that some stormwater flows to wastewater treatment plants during light precipitation events does not offset the negative effects of untreated domestic sewage discharged into surface waters following moderate to heavy rainfall. Sewer separation would assure thorough treatment of all domestic wastewater that would remove most of the solids, nutrients and pathogens while stormwater would be dealt with under the new stormwater management program. Problems related to stormwater runoff could be more easily identified without the complication of having domestic wastewater mixed with stormwater. The potential benefits and problems associated with sewer separation are discussed in the context of other CSO control alternatives in a recent manual published by EPA (EPA 1993).

The planned screening and disinfection of CSO's at five of the six CSO sites in Atlanta will remove larger solids (> 1.0 cm) and will reduce bacterial densities in the receiving waters. There will be virtually no reduction in suspended solids (turbidity), toxic substances or nutrients. There will be no incentive to improve stormwater management since it will be virtually impossible to demonstrate need because of the mixing of stormwater and domestic wastewater.

Disinfection will be accomplished by diffusing a 10% solution of sodium hypochlorite (NaClO) into the outflow of the CSO to achieve a concentration of 10 mg/l. Residual chlorine in receiving waters will be monitored to assure that concentrations do not rise above the designated standard of 11.0 μg/l. It is expected that this level of chlorination will be sufficient to reduce bacterial densities in receiving waters to levels that meet water quality standards (personal communication, Jim Sommerville, EPD). If so, incidences of episodic bacterial contamination in the upstream portions of West Point Lake might be reduced or eliminated. If chlorination controls bacteria in the CSO's but fecal coliform densities remain high in upstream West Point Lake, other sources of bacterial contamination, most notably Atlanta stormwater runoff, must be verified and controlled. If chlorination does not control bacteria in CSO's, sewer separation or further treatment of CSO waters will be necessary to meet the fecal coliform standard recommended for West Point Lake.

PROBLEM: Toxic Contaminants

PRIMARY CAUSES:

Atlanta metropolitan area municipal waste treatment dischargers

Urban storm runoff

The monitoring of West Point Lake water, sediment and fish during the Fall of 1990 and Spring of 1991 for toxics revealed the following:

(1) No volatile organic, acid/base/neutral extractable semivolatiles or pesticides were detected in any water samples. Occasional detectable quantities of mercury were the only heavy metal residues found in water samples. Mercury was detected in seven of twenty water samples (0.18 ppb to 1.46 ppb) which exceeds the Georgia water quality standard of 0.12 ppb.

(2) Sediments contained detectable quantities of As, Se, Hg, Cd, Cr, Ni, Cu, Pb, Zn, phthalates, pyrene, PNA's, fluoranthene and benzopyrene. Nitrogen was detected at levels ranging from 134 - 569 ppm. Phosphorus levels ranged from 20 - 868 ppm with a mean value of 309 ppm which falls within the mean total phosphorus level (300 - 400) found in most Georgia Piedmont lakes. There are no Federal or State standards for sediment concentrations.

(3) Filet samples of carp and largemouth bass contained detectable quantities of As, Se, Hg, Cr, Cu, Pb, Ni, Zn, PCB, chlordane, PCA and DDT. Concentrations of these substances were compared to FDA action levels and EPA guidance levels for fish filets to assess human consumption risks. Only PCB and

chlordane residue levels were found to approach or exceed EPA or FDA action levels. PCB's (primarily 1260) were detected in fish filets and concentrations were below the FDA action level but in excess of the EPA 10^{-4} risk level. Chlordane was detected in fish filets in excess of the FDA action level and EPA 10^{-4}, 10^{-5}, and 10^{-6} risk levels. Residue levels of chlordane and PCB decreased as sampling proceeded from Franklin toward the dam.

Hybrid striped bass and black crappie filet samples contained detectable levels of chlordane, DDT, dieldrin and PCB but all concentrations were below FDA action levels. Chlordane concentrations in hybrid bass were approaching 0.3 mg/kg, the FDA standard for that compound.

Prior to the 1980's, chlordane was used as a household termite treatment and was readily available to homeowners. Since the federal EPA banned the use of chlordane and the industrial chemical PCB, future discharges of these materials should decrease. Monitoring of municipal waste treatment plant discharges has revealed trace quantities from residual home and industrial usage. In addition, effective erosion control will help to mitigate pesticides containing surface runoff from home owners, homes treated with termiticides, and PCBs from industrial sites.

It is anticipated that PCB and chlordance levels should decrease in the future. Levels of pyrene, fluoranthene and benzopyrene in the sediments result from industrial activity. With increasing upstream activity, these residues might be expected to increase. The source of mercury in the water column is unknown.

PHASE 2 MONITORING PROGRAM

Specific actions have been initiated in Georgia to reduce nutrient (primarily phosphorus) loading resulting from point sources of pollution. The debate between EPD and EPA over the effluent phosphorus limit necessary to assure maintenance or recommended chlorophyll a standards is continuing. Until this issue has been settled and for, at least, 2 years following completion of all actions to reduce nutrient loading of West Point Lake, monitoring of the lake during the growing season (April through October) should be continued. Sampling should be conducted twice monthly at seven mainstream locations (Franklin, confluence of New River, 219 bridge, LaGrange water intake, 109 bridge, off Rocky Point and dam forebay) and three embayments (New River, Yellowjacket Creek and Wehadkee Creek) (Table 10-2). At each location, water column profile measurements of temperature, dissolved oxygen, pH and conductivity should be made and *in situ* measurements of visibility and light penetration done using methods described in Table 10-3. A photic zone composite sample should be collected at each location and the following variables measured: total suspended solids, turbidity, alkalinity, hardness, total ammonia, nitrite, nitrate, organic nitrogen, total phosphorus, soluble reactive phosphorus and total organic carbon using methods listed in Table 10-3. The composite samples should be further analyzed for chlorophyll a (phaeophytin corrected) and phytoplankton identification and enumeration (Table 10-26). At least four times (every other month), composite water samples from the mainstem sampling locations should be submitted for Algal Growth Potential Test (Table 10-26).

Actions are underway to improve the quality of stormwater runoff and CSO's in the Atlanta area. Since construction on CSO facilities will be completed in stages during the next year or so, monitoring of fecal coliform bacteria in the upstream 13-km reach (Franklin to the mouth of New River) of West Point Lake should be conducted each growing season (April through October) until it is determined if control of nonpoint sources of bacterial pollution in the Atlanta area has been successful. Sampling should be conducted on a delayed basis following at least three significant (> 2.54 cm) rainfall events in the Atlanta metro area, preferably early growing season, mid-growing season and late growing season. Starting 2 days following an Atlanta rainfall event, fecal coliform samples should be collected and analyzed daily for 6 consecutive days at no less than seven sampling locations spaced equidistance between Franklin and the mouth of New River. The results can be compared to the 1992 data gathered in this study (Section 10.2.3) prior to completion of CSO facilities. If West Point Lake headwaters are not meeting the recommended fecal coliform water quality standard, the public must be notified in a manner similar to the advisories issued for toxic contaminants. Such studies should be repeated annually until it has been demonstrated that West Point Lake headwaters have met recommended fecal coliform criteria for 2 consecutive years.

A limited toxics monitoring program should be conducted yearly to insure that: a) chlordane and PCB residue levels are actually decreasing; b) levels of industrial chemicals (polynuclear aromatic compounds) are not increasing and c) new industrial chemicals are not being discharged into the lake. Monitoring should consist of annual sediment and fish sample collection from the eight sampling stations on West Point Lake used by Bush and Blazer (1992) in the appended report. Sampling and analysis should consist of the following: a) filets of carp, largemouth bass and hybrid striped bass analyzed for heavy metals, pesticides and industrial chemicals; sediment analyzed for heavy metals, pesticides and industrial chemicals and c) water sampled for the heavy metal mercury.

Given the rapid expansion of the Atlanta metropolitan area and the increasing demands being placed on the Chattahoochee River that affect both its water quality and quantity, plans should be made to monitor West Point Lake indefinitely. This long term monitoring effort should be designed to assure compliance with the lake water quality standards to be established for West Point Lake in the near future. This program should include, at least, monthly sampling during the growing season (April through October) at five mainstem locations (Franklin, Highway 219, LaGrange water intake, Highway 109 and the dam forebay) and three embayment locations (New River, Wehadkee and Yellowjacket). All variables related to West Point Lake water quality standards should be routinely monitored.

ENVIRONMENTAL EVALUATION

The following questions and answers pertain to restoration activities currently underway to address water quality problems identified in the Phase I Diagnostic/Feasibility Study of West Point Lake.

1. Will the proposed projects displace any people? No
2. Will the proposed projects deface existing residences or residential areas? No
3. Will the proposed projects be likely to lead to a change in established land use patterns such as increased development pressure near the lake? No
4. Will the proposed projects adversely affect a significant amount of prime agricultural land or agricultural operations on such land? No
5. Will the proposed projects results in a significant adverse effect on parkland, other public land or lands of recognized scenic value? Yes
6. Will the proposed projects result in a significant adverse effect on lands or structures of historic, architectural, archaeological or cultural value? No
7. Will the proposed projects lead to a significant long-range increase in energy demands? No
8. Will the proposed projects result in significant and long range adverse changes in ambient air quality or noise levels? No
9. Do the proposed projects involve use of in-lake chemical treatment? No
10. Will the proposed projects involve construction of structures in a floodplain? Yes

11. Will dredging be employed as part of the restoration procedures, and if so, where will the dredge material be deposited? No

12. Will the proposed projects have a significant adverse effect on fish and wildlife, or on wetlands or any other wildlife habitat, especially those of endangered species? No

13. Are there additional feasible alternatives to the proposed restoration projects, and why were they not chosen? Restoration activities on West Point Lake were begun prior to completion of this Phase I study. Should the current restoration projects fail to produce desired results, other feasible alternatives have been identified in this study.

14. Are there additional adverse environmental impacts from the proposed restoration projects that were not addressed in the previous questions? No

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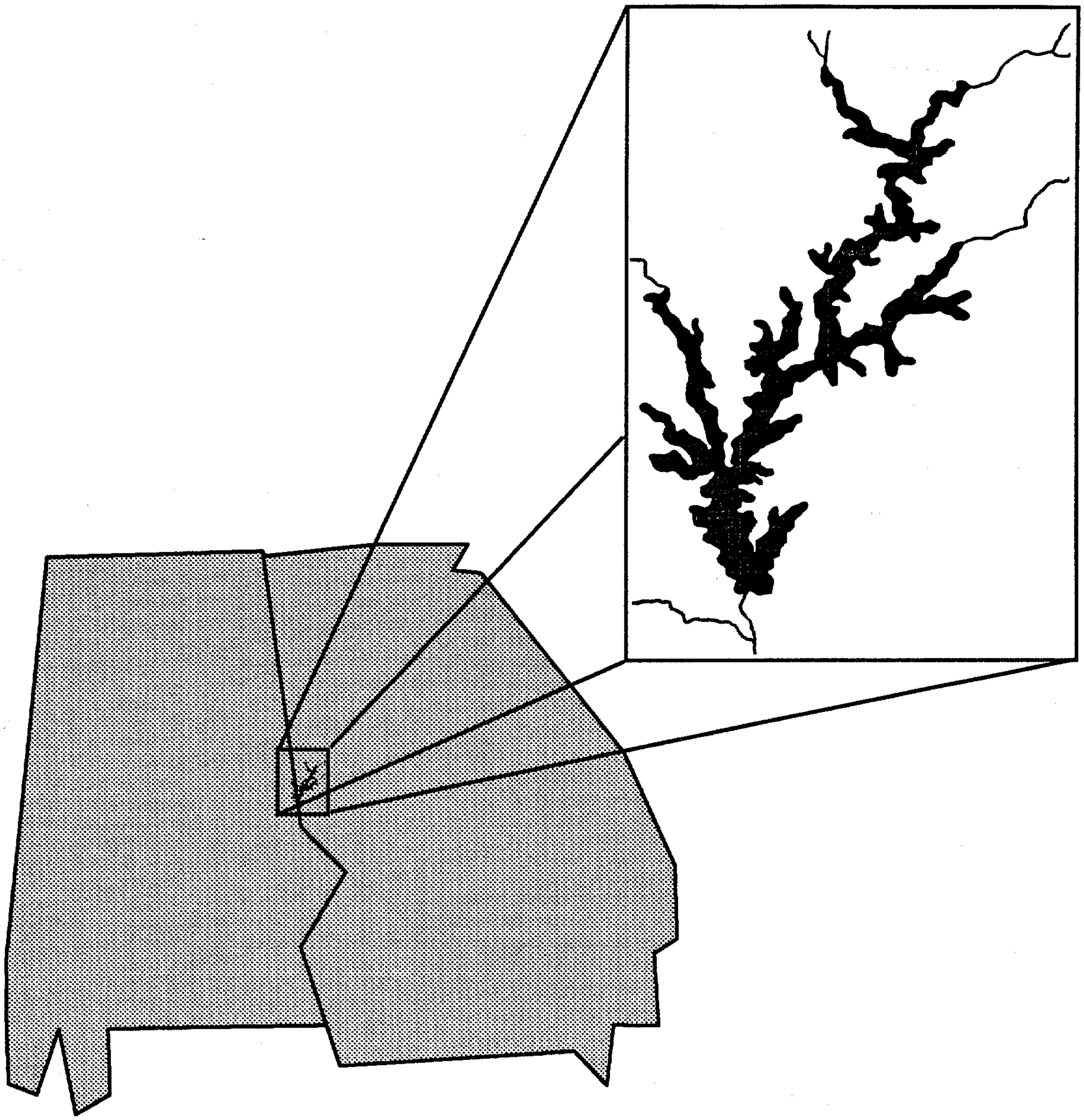
West Point Lake
Phase I Diagnostic /Feasibility Study
Appendix



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Appendix

30 September 1994

List Of Appendix Items

Appendix 1

Water quality criteria for the water use classification for Georgia and Alabama portions of West Point Lake.

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Water Division - Water Quality Program

Chapter 335-6-10
Water Quality Criteria

Table of Contents

335-6-10-.01 Purpose.

(1) Title 22, Section 22-22-1 et seq., Code of Alabama 1975, includes as its purpose "... to conserve the waters of the State and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; to provide for the prevention, abatement and control of new or existing water pollution; and to cooperate with other agencies of the State, agencies of other states and the federal government in carrying out these objectives."

(2) Water quality criteria, covering all legitimate water uses, provide the tools and means for determining the manner in which waters of the State may be best utilized, provide a guide for determining waste treatment requirements, and provide the basis for standards of quality for State waters and portions thereof. Water quality criteria are not intended to freeze present uses of water, nor to exclude other uses not now possible. They are not a device to insure the lowest common denominator of water quality, but to encourage prudent use of the State's water resources and to enhance their quality and productivity commensurate with the stated purpose of Title 22, Section 22-22-1 et seq., Code of Alabama 1975.

(3) Water quality criteria herein set forth have been developed by the Commission for those uses of surface waters known and expected to exist over the State. They are based on present scientific knowledge, experience and judgment. Characteristics or parameters included in the criteria are those of fundamental significance to a determination of water quality and are those which are and can be routinely monitored and compared to data that are generally available. It is the intent that these criteria will be applied only after reasonable opportunity for mixture of wastes with

receiving waters has been afforded. The reasonableness of the opportunity for mixture of wastes and receiving waters shall be judged on the basis of the physical characteristics of the receiving waters and approval by the Department of the method in which the discharge is physically made.

Author: James E. McIndoe
Statutory Authority: Code of Alabama 1975, §§22-22-9, 22-22A-5, 22-22A-6, 22-22A-8.
History: Originally Adopted: May 5, 1967; Amended: June 19, 1967; Amended: July 17, 1972; Amended: February 26, 1973; Amended: May 30, 1977; Amended: December 19, 1977; Amended: February 4, 1981; Amended: Adopted January 24, 1990, Filed January 26, 1990, Effective: March 2, 1990; Amended: Adopted February 20, 1991, Filed February 27, 1991, Effective: April 3, 1991.

335-6-10-.02 Definitions.

(1) "Commission" means the Environmental Management Commission, established by the Environmental Management Act, Code of Alabama 1975, §§22-22A-1 to 22-22A-16.

(2) "Department" means the Alabama Department of Environmental Management, established by the Alabama Environmental Management Act, Code of Alabama 1975, §§22-22A-1 to 22-22A-16.

(3) "existing uses" means those legitimate beneficial uses of a water body attained in fact on or after November 28, 1975, whether or not they are included as classified uses in ADEM Administrative Code Rule 335-6-11-.02.

(4) "industrial waste" means liquid or other wastes resulting from any process of industry, manufacture, trade or business or from the development of natural resources.

(5) "NPDES" means National Pollutant Discharge Elimination System.

(6) "other wastes" means all other substances, whether liquid, gaseous or solid, from all other sources including, but not limited to, any vessels, or other conveyances traveling or using the waters of this State, except industrial wastes or sewage, which may cause pollution of any waters of the State.

(7) "pollutant" includes but is not limited to dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water. Pollutant does not mean (a) sewage from vessels; or (b) water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil or gas production and disposed of in a well, if the well used either to facilitate production or for disposal purposes is approved by authority of the State, and if the Department determines that such injection or disposal will not result in

the degradation of ground or surface water resources.

(8) "pollution" means the discharge of a pollutant or combination of pollutants.

(9) "sewage" means water-carried human wastes from residences, buildings, industrial establishments or other places including, but not limited to, any vessels, or other conveyances traveling or using the waters of this State, together with such ground, surface, storm or other waters as may be present.

(10) "State waters" or "waters of the State" means all waters of any river, stream, watercourse, pond, lake, coastal, or surface water, wholly or partially within the State, natural or articificial. This does not include waters which are entirely confined and retained completely upon the property of a single individual, partnership or corporation unless such waters are used in interstate commerce.

Author: James E. McIndoe
Statutory Authority: Code of Alabama 1975, §§22-22-9, 22-22A-5, 22-22A-6, 22-22A-8.
History: Originally Adopted: May 5, 1967; Amended: June 19, 1967; Amended: July 17, 1972; Amended: February 26, 1973; Amended: May 30, 1977; Amended: December 19, 1977; Amended: February 4, 1981; Amended: Adopted January 24, 1990, Filed January 26, 1990, Effective: March 2, 1990; Amended: Adopted February 20, 1991, Filed February 27, 1991, Effective: April 3, 1991.

335-6-10-.03 Water Use Classifications.

(1) Public Water Supply

(2) Swimming and Other Whole Body Water-Contact Sports

(3) Shellfish Harvesting

(4) Fish and Wildlife

(5) Agricultural and Industrial Water Supply

(6) Industrial Operations

(7) Navigation

(8) Outstanding Alabama Water

Author: James E. McIndoe
Statutory Authority: Code of Alabama 1975, §§22-22-9, 22-22A-5, 22-22A-6, 22-22A-8.
History: Originally Adopted: May 5, 1967; Amended: June 19, 1967; Amended: July 17, 1972; Amended: February 26, 1973; Amended: May 30, 1977; Amended: December 19, 1977; Amended: February 4, 1981; Amended: Adopted November 24, 1992, Filed November 25, 1992, Effective: December 30, 1992.

335-6-10-.08 Waste Treatment Requirements. The following treatment requirements apply to all industrial waste discharges, sewage treatment plants, and combined waste treatment plants:

(a) As a minimum, secondary treatment or "equivalent to secondary treatment" as provided for in rules and regulations promulgated by the U.S. Environmental Protection Agency at 40 CFR Part 133 (1990), shall be applied to all waste discharges. The term "secondary treatment" is applied to biologically degradable waste and is interpreted to mean a facility which at design flow is capable of removing substantially all floating and settleable solids and to achieve a minimum removal of 85 percent of both the 5-day biochemical oxygen demand and suspended solids which, in the case of municipal wastes, is generally considered to produce an effluent quality containing a BOD_5 concentration of 30 mg/l and a suspended solids concentration of 30 mg/l. Disinfection, where necessary, will also be required. Waste treatment requirements also include those established under the provisions of Sections 301, 304, 306, and 307 of the Federal Water Pollution Control Act (FWPCA). In addition, the Department may require secondary treatment of biologically degradable industrial wastewaters when the application of guidelines published under federal law do not produce a similar reduction in the parameters of concern. In the application of this requirement, consideration will be given to efficiencies achieved through in-process improvements.

(b) In all cases an analysis of water use and flow characteristics for the receiving stream shall be provided to determine the degree of treatment required. Where indicated by the analysis, a higher degree of treatment may be required.

(c) The minimum 7-day low flow that occurs once in 10 years shall be the basis for design criteria.

Author: James E. McIndoe
Statutory Authority: Code of Alabama 1975, §§22-22-9, 22-22A-5, 22-22A-6, 22-22A-8.
History: Originally Adopted: May 5, 1967; Amended: June 19, 1967; Amended: July 17, 1972; Amended: February 26, 1973; Amended: May 30, 1977; Amended: December 19, 1977; Amended: February 4, 1981; Amended: Adopted January 24, 1990, Filed January 26, 1990, Effective: March 2, 1990; Amended: Adopted February 20, 1991, Filed February 27, 1991, Effective: April 3, 1991.

335-6-10-.09 Specific Water Quality Criteria.

(1) PUBLIC WATER SUPPLY

(a) Best usage of waters:

Source of water supply for drinking or food-processing purposes.*

***NOTE:** In determining the safety or suitability of waters for use as sources of water supply for drinking or food-processing purposes after approved treatment, the Commission will be guided by the physical and chemical standards specified by the Department.

(b) Conditions related to best usage:

The waters, if subjected to treatment approved by the Department equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to remove naturally present impurities, and which meet the requirements of the Department, will be considered safe for drinking or food-processing purposes.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health..

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

(e) Specific criteria:

1. Sewage, industrial wastes, or other wastes:

None which are not effectively treated or controlled in accordance with Rule 335-6-10-.08.

2. pH:

Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.0, nor greater than 8.5.

3. Temperature:

(i) The maximum temperature in streams, lakes, and reservoirs, other than those in river basins listed in subparagraph (ii) hereof, shall not exceed 90°F.

(ii) The maximum temperature in streams, lakes, and reservoirs in the Tennessee and Cahaba River Basins, and for that portion of the Tallapoosa River Basin from the tailrace of Thurlow Dam at Tallassee downstream to the junction of the Coosa and Tallapoosa Rivers which has been designated by the Alabama Department of Conservation and Natural Resources as supporting smallmouth bass, sauger, or walleye, shall not exceed 86°F.

(iii) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 5°F in streams, lakes, and reservoirs in non-coastal and non-estuarine areas.

(iv) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 4°F in coastal or estuarine waters during the period October through May, nor shall the rise exceed 1.5°F during the period June through September.

(v) In lakes and reservoirs there shall be no withdrawal from, nor discharge of heated waters to, the hypolimnion unless it can be shown that such discharge or withdrawal will be beneficial to water quality.

(vi) In all waters the normal daily and seasonal temperature variations that were present before the addition of artificial heat shall be maintained, and there shall be no thermal block to the migration of aquatic organisms.

(vii) Thermal permit limitations in NPDES permits may be less stringent than those required by subparagraphs (i) - (iv) hereof when a showing by the discharger has been made pursuant to Section 316 of the Federal Water Pollution Control Act (FWPCA), 33 U.S.C.§1251 et seq. or pursuant to a study of an equal or more stringent nature required by the State of Alabama authorized by Title 22, Section 22-22-9(c), Code of Alabama, 1975, that such limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, in and on the body of water to which the discharge is made. Any such demonstration shall take into account the interaction of the thermal discharge component with other pollutants discharged.

4. Dissolved oxygen:

(i) For a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels. In no event shall the dissolved oxygen level be less than 4 mg/l due to discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including addition of new hydroelectric generation units to existing impoundments, shall be designed so that the discharge will contain at least 5 mg/l dissolved oxygen where practicable and technologically possible. The Environmental Protection Agency, in cooperation with the State of Alabama and parties responsible for impoundments, shall develop a program to improve the design of existing facilities.

(ii) In coastal waters, surface dissolved oxygen concentrations shall not be less than 5 mg/l, except where natural phenomena cause the value to be depressed.

(iii) In estuaries and tidal tributaries, dissolved oxygen concentrations shall not be less than 5 mg/l, except in dystrophic waters or where natural conditions cause the value to be depressed.

(iv) In the application of dissolved oxygen criteria referred to above, dissolved oxygen shall be measured at a depth of 5 feet in waters 10 feet or greater in depth; and for those waters less than 10 feet in depth, dissolved oxygen criteria will be applied at mid-depth.

5. Toxic substances; color producing; heated liquids; or other deleterious substances attributable to sewage, industrial wastes, or other wastes:

Only such amounts, whether alone or in combination with other substances, and only such temperatures as will not render the waters unsafe or unsuitable as a source of water supply for drinking or food-processing purposes, or exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish, wildlife and aquatic life, or adversely affect the aesthetic value of waters for any use under this classification.

6. Taste and odor producing substances attributable to sewage, industrial wastes, or other wastes:

Only such amounts, whether alone or in combination with other substances or wastes, as will not cause taste and odor difficulties in water supplies which cannot be corrected by treatment as specified under subparagraph (b), or impair the palatability of fish.

7. Bacteria:

(i) Bacteria of the fecal coliform group shall not exceed a geometric mean of 2,000/100 ml; nor exceed a maximum of 4,000/100 ml in any sample. The geometric mean shall be calculated from no less than five samples collected at a given station over a 30-day period at intervals not less than 24 hours. The membrane filter counting procedure will be preferred, but the multiple tube technique (five-tube) is acceptable.

(ii) For incidental water contact and recreation during June through September, the bacterial quality of water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100/100 ml in coastal waters and 200/100 ml in other waters. When the geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes, are not acceptable for swimming or other whole body water-contact sports.

8. Radioactivity:

No radionuclide or mixture of radionuclides shall be present at concentrations greater than those specified by the requirements of the State Department of Public Health.

9. Turbidity:

There shall be no turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of waters or interfere with any beneficial uses which they serve. Furthermore, in no case shall turbidity exceed 50 Nephelometric units above background. Background will be interpreted as the natural condition of the receiving waters, without the influence of man-made or man-induced causes. Turbidity levels caused by natural runoff will be included in establishing background levels.

(2) SWIMMING AND OTHER WHOLE BODY WATER-CONTACT SPORTS

(a) Best usage of waters:

Swimming and other whole body water-contact sports.*

(b) Conditions related to best usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports. The quality of waters will also be suitable for the propagation of fish, wildlife and aquatic life. The quality of salt waters and estuarine waters to which this classification is assigned will be suitable for the propagation and harvesting of shrimp and crabs.

(c) Specific criteria:

1. Sewage, industrial wastes, or other wastes:

None which are not effectively treated or controlled in accordance with Rule 335-6-10-.08.

2. pH:

Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.0, nor greater than 8.5. For estuarine waters and salt waters to which this classification is assigned, wastes as described herein shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.5, nor greater than 8.5.

***NOTE:** In assigning this classification to waters intended for swimming and water-contact sports, the Commission will take into consideration the relative proximity of discharges of wastes and will recognize the potential hazards involved in locating swimming areas close to waste discharges. The Commission will not assign this classification to waters, the bacterial quality of which is dependent upon adequate disinfection of waste and where the interruption of such treatment would render the water unsafe for bathing.

3. Temperature:

(i) The maximum temperature in streams, lakes, and reservoirs, other than those in river basins listed in subparagraph (ii) hereof, shall not exceed 90°F.

(ii) The maximum temperature in streams, lakes, and reservoirs in the Tennessee and Cahaba River Basins, and for that portion of the Tallapoosa River Basin from the tailrace of Thurlow Dam at Tallassee downstream to the junction of the Coosa and Tallapoosa Rivers which has been designated by the Alabama Department of Conservation and Natural Resources as supporting smallmouth bass, sauger, or walleye, shall not exceed 86°F.

(iii) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 5°F in streams, lakes, and reservoirs in non-coastal and non-estuarine areas.

(iv) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 4°F in coastal or estuarine waters during the period October through May, nor shall the rise exceed 1.5°F during the period June through September.

(v) In lakes and reservoirs there shall be no withdrawal from, nor discharge of heated waters to, the hypolimnion unless it can be shown that such discharge or withdrawal will be beneficial to water quality.

(vi) In all waters the normal daily and seasonal temperature variations that were present before the addition of artificial heat shall be maintained, and there shall be no thermal block to the migration of aquatic organisms.

(vii) Thermal permit limitations in NPDES permits may be less stringent than those required by subparagraphs (i) - (iv) hereof when a showing by the discharger has been made pursuant to Section 316 of the Federal Water Pollution Control Act (FWPCA), 33 U.S.C. §1251 et seq. or pursuant to a study of an equal or more stringent nature required by the State of Alabama authorized by Title 22, Section 22-22-9(c), Code of Alabama, 1975, that such limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, in and on the body of water to which the discharge is made. Any such demonstration shall take into account the interaction of the thermal discharge component with other pollutants discharged.

4. Dissolved oxygen:

(i) For a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels. In no event shall the dissolved oxygen level be less than 4 mg/l due to discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including addition of new hydroelectric generation units to existing impoundments, shall be designed so that the discharge will contain at least 5 mg/l dissolved oxygen where practicable and technologically possible. The Environmental Protection Agency, in cooperation with the State of Alabama and parties responsible for impoundments, shall develop a program to improve the design of existing facilities.

(ii) In coastal waters, surface dissolved oxygen concentrations shall not be less than 5 mg/l, except where natural phenomena cause the value to be depressed.

(iii) In estuaries and tidal tributaries, dissolved oxygen concentrations shall not be less than 5 mg/l, except in dystrophic waters or where natural conditions cause the value to be depressed.

(iv) In the application of dissolved oxygen criteria referred to above, dissolved oxygen shall be measured at a depth of 5 feet in waters 10 feet or greater in depth; and for those waters less than 10 feet in depth, dissolved oxygen criteria will be applied at mid-depth.

5. Toxic substances; color producing substances; odor producing substances; or other deleterious substances attributable to sewage, industrial wastes, or other wastes:

Only such amounts, whether alone or in combination with other substances or wastes, as will not render the water unsafe or unsuitable for swimming and water-contact sports; exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish, wildlife, and aquatic life or, where applicable, shrimp and crabs; impair the palatability of fish, or where applicable, shrimp and crabs; impair the waters for any other usage established for this classification or unreasonably affect the aesthetic value of waters for any use under this classification.

6. Bacteria:

(i) Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes*, are not acceptable for swimming or other whole body water-contact sports.

***NOTE:** In assigning this classification to waters intended for swimming and water-contact sports, the Commission will take into consideration the relative proximity of discharges of wastes and will recognize the potential hazards involved in locating swimming areas close to waste discharges. The Commission will not assign this classification to waters, the bacterial quality of which is dependent upon adequate disinfection of waste and where the interruption of such treatment would render the water unsafe for bathing.

(ii) In all other areas, the bacterial quality of water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100/100 ml in coastal waters and 200/100 ml in other waters. When the geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters.

(iii) The policy of nondegradation of high quality waters shall be stringently applied to bacterial quality of recreational waters.

7. Radioactivity:

The concentrations of radioactive materials present shall not exceed the requirement of the State Department of Public Health.

8. Turbidity:

There shall be no turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of waters or interfere with any beneficial uses which they serve. Furthermore, in no case shall turbidity exceed 50 Nephelometric units above background. Background will be interpreted as the natural condition of the receiving waters, without the influence of man-made or man-induced causes. Turbidity levels caused by natural runoff will be included in establishing background levels.

(3) SHELLFISH HARVESTING

(a) Best usages of waters:

Propagation and harvesting of shellfish for sale or use as a food product.

(b) Conditions related to best usage:

Waters will meet the sanitary and bacteriological standards included in the latest edition of the National Shellfish Sanitation Program Manual of Operations, Sanitation of Shellfish Growing Areas (1965), published by the Food and Drug Administration, U.S. Department of Health and Human Services and the requirements of the State Department of Public Health. The waters will also be of a quality suitable for the propagation of fish and other aquatic life, including shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

6. Color, taste, and odor-producing substances and other deleterious substances attributable to sewage, industrial wastes, or other wastes:

Only such amounts, whether alone or in combination with other substances, as will not exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish and shellfish, including shrimp and crabs; adversely affect marketability or palatability of fish and shellfish, including shrimp and crabs; <u>or</u> unreasonably affect the aesthetic value of waters for any use under this classification.

7. Bacteria:

(i) Not to exceed the limits specified in the latest edition of the <u>National Shellfish Sanitation Program Manual of Operations, Sanitation of Shellfish Growing Areas</u> (1965), published by the Food and Drug Administration, U. S. Department of Health and Human Services.

(ii) For incidental water contact and recreation during June through September, the bacterial quality of water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100/100 ml in coastal waters and 200/100 ml in other waters. When the geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes, are not acceptable for swimming or other whole body water-contact sports.

8. Radioactivity:

The concentrations of radioactive materials present shall not exceed the requirements of the State Department of Public Health.

9. Turbidity:

There shall be no turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of waters or interfere with any beneficial uses which they serve. Furthermore, in no case shall turbidity exceed 50 Nephelometric units above background. Background will be interpreted as the natural condition of the receiving waters without the influence of man-made or man-induced causes. Turbidity levels caused by natural runoff will be included in establishing background levels.

(4) FISH AND WILDLIFE

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food-processing purposes.

(b) Conditions related to best usage:

The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

(e) Specific criteria:

1. Sewage, industrial wastes, or other wastes:

None which are not effectively treated in accordance with Rule 335-6-10-.08.

2. pH:

Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.0, nor greater than 8.5. For salt waters and estuarine waters to which this classification is assigned, wastes as herein described shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.5, nor greater than 8.5.

3. Temperature:

(i) The maximum temperature in streams, lakes, and reservoirs, other than those in river basins listed in subparagraph (ii) hereof, shall not exceed 90°F.

(ii) The maximum temperature in streams, lakes, and reservoirs in the Tennessee and Cahaba River Basins, and for that portion of the Tallapoosa River Basin from the tailrace of Thurlow Dam at Tallassee downstream to the junction of the Coosa and Tallapoosa Rivers which has been designated by the Alabama Department of Conservation and Natural Resources as supporting smallmouth bass, sauger, or walleye, shall not exceed 86°F.

(iii) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 5°F in streams, lakes, and reservoirs in non-coastal and non-estuarine areas.

(iv) The maximum in-stream temperature rise above ambient water temperature due to the addition of artificial heat by a discharger shall not exceed 4°F in coastal or estuarine waters during the period October through May, nor shall the rise exceed 1.5°F during the period June through September.

(v) In lakes and reservoirs there shall be no withdrawal from, nor discharge of heated waters to, the hypolimnion unless it can be shown that such discharge or withdrawal will be beneficial to water quality.

(vi) In all waters the normal daily and seasonal temperature variations that were present before the addition of artificial heat shall be maintained, and there shall be no thermal block to the migration of aquatic organisms.

(vii) Thermal permit limitations in NPDES permits may be less stringent than those required by subparagraphs (i) - (iv) hereof when a showing by the discharger has been made pursuant to Section 316 of the Federal Water Pollution Control Act (FWPCA), 33 U.S.C. §1251 et seq. or pursuant to a study of an equal or more stringent nature required by the State of Alabama authorized by Title 22, Section 22-22-9(c), Code of Alabama, 1975, that such limitations will assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife, in and on the body of water to which the discharge is made. Any such demonstration shall take into account the interaction of the thermal discharge component with other pollutants discharged.

4. Dissolved oxygen:

(i) For a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels. In no event shall the dissolved oxygen level be less than 4 mg/l due to discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including addition of new hydroelectric generation units to existing impoundments, shall be designed so that the discharge will contain at least 5 mg/l dissolved oxygen where practicable and technologically possible. The Environmental Protection Agency, in cooperation with the State of Alabama and parties responsible for impoundments, shall develop a program to improve the design of existing facilities.

(ii) In coastal waters, surface dissolved oxygen concentrations shall not be less than 5 mg/l, except where natural phenomena cause the value to be depressed.

(iii) In estuaries and tidal tributaries, dissolved oxygen concentrations shall not be less than 5 mg/l, except in dystrophic waters or where natural conditions cause the value to be depressed.

(iv) In the application of dissolved oxygen criteria referred to above, dissolved oxygen shall be measured at a depth of 5 feet in waters 10 feet or greater in depth; and for those waters less than 10 feet in depth, dissolved oxygen criteria will be applied at mid-depth.

5. Toxic substances attributable to sewage, industrial wastes, or other wastes:

Only such amounts, whether alone or in combination with other substances, as will not exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish and aquatic life, including shrimp and crabs in estuarine or salt waters or the propagation thereof.

6. Taste, odor, and color-producing substances attributable to sewage, industrial wastes, or other wastes:

Only such amounts, whether alone or in combination with other substances, as will not exhibit acute toxicity or chronic toxicity, as demonstrated by effluent toxicity testing or by application of numeric criteria given in Rule 335-6-10-.07, to fish and aquatic life, including shrimp and crabs in estuarine and salt waters or adversely affect the propagation thereof; impair the palatability or marketability of fish and wildlife or shrimp and crabs in estuarine and salt waters; or unreasonably affect the aesthetic value of waters for any use under this classification.

7. Bacteria:

(i) Bacteria of the fecal coliform group shall not exceed a geometric mean of 1,000/100 ml on a monthly average value; nor exceed a maximum of 2,000/100 ml in any sample.

(ii) For incidental water contact and recreation during June through September, the bacterial quality of water is acceptable when a sanitary survey by the controlling health authorities reveals no source of dangerous pollution and when the geometric mean fecal coliform organism density does not exceed 100/100 ml in coastal waters and 200/100 ml in other waters. When the geometric mean fecal coliform organism density exceeds these levels, the bacterial water quality shall be considered acceptable only if a second detailed sanitary survey and evaluation discloses no significant public health risk in the use of the waters. Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes, are not acceptable for swimming or other whole body water-contact sports.

8. Radioactivity:

The concentrations of radioactive materials present shall not exceed the requirements of the State Department of Public Health.

9. Turbidity:

There shall be no turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of waters or interfere with any beneficial uses which they serve. Furthermore, in no case shall turbidity exceed 50 Nephelometric units above background. Background will be interpreted as the natural condition of the receiving waters without the influence of man-made or man-induced causes. Turbidity levels caused by natural runoff will be included in establishing background levels.

(5) AGRICULTURAL AND INDUSTRIAL WATER SUPPLY

(a) Best usage of waters:

Agricultural irrigation, livestock watering, industrial cooling and process water supplies, and any other usage, except fishing, bathing, recreational activities, including water-contact sports, or as a source of water supply for drinking or food-processing purposes.

(b) Conditions related to best usage:

(i) The waters, except for natural impurities which may be present therein, will be suitable for agricultural irrigation, livestock watering, industrial cooling waters, and fish survival. The waters will be usable after special treatment, as may be needed under each particular circumstance, for industrial process water supplies. The waters will also be suitable for other uses for which waters of lower quality will be satisfactory.

(ii) This category includes watercourses in which natural flow is intermittent and non-existent during droughts and which may, of necessity, receive treated wastes from existing municipalities and industries, both now and in the future. In such instances, recognition must be given to the lack of opportunity for mixture of the treated wastes with the receiving stream for purposes of compliance. It is also understood in considering waters for this classification that urban runoff or natural conditions may impact any waters so classified.

(c) Specific criteria:

1. Sewage, industrial wastes, or other wastes:

None which are not effectively treated or controlled in accordance with Rule 335-6-10-.08.

2. pH:

Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.0, nor greater than 8.5. For salt waters and estuarine waters to which this classification is assigned, wastes as herein described shall not cause the pH to deviate more than one unit from the normal or natural pH, nor be less than 6.5, nor greater than 8.5.

3. Temperature:

(i) The maximum temperature rise above natural temperatures before the addition of artificial heat shall not exceed 5°F in streams, lakes, and reservoirs, nor shall the maximum water temperature exceed 90°F.

SECTION THREE: WATER QUALITY OBJECTIVES

3.1 Water Quality Standards

Georgia is authorized, through the Rules and Regulations for Water Quality Control promulgated under the Georgia Water Quality Control Act of 1964, as amended, to establish water quality standards and water use classifications for the waters of the State. Further, the State is authorized to designate appropriate waters as trout waters.

There are nine water use classifications recognized. These are: drinking water supplies; recreation; fishing, propagation of fish, shellfish, game and other aquatic life; wild river; scenic river; urban stream; agricultural; industrial; and navigation. For each of these classifications, there are specific criteria which apply. In nearly every case, the criteria relate to the parameters of dissolved oxygen, pH, fecal coliform, and temperature. Specific parameter limitations for each use classification are identified in Table 3-1.

There are also a number of general criteria which apply to all the waters of the State, regardless of the water use classification. In summary, these relate to the prohibition of: materials which cause sludge deposits; materials which cause scums; materials which produce turbidity, odor, color, or other objectionable conditions; substances which would be harmful to aquatic life; radioactive substances in amounts which exceed federal or state regulations; and stream-bed alterations which may result in the violation of stream water quality standards. The standards also address the approach to be followed to maintain existing high quality waters. The specific details can be found in Chapter 391-3-6.03, Water Use Classifications and Water Quality Standards.

In addition to the four specific parameters mentioned above, the State does regulate all pollutants, on a case-by-case basis, that would have a detrimental impact on the beneficial uses of the waters. Many of the pollutants, although significant, can appear in such low concentrations that they are immeasurable in the stream water. Therefore, the State has found it better to control these pollutants through the establishment of adequate effluent limitations on the source rather than through the use of in-stream water quality standards. This is done using guidelines produced by the U. S. Environmental Protection Agency and other sources.

TABLE 3-1

SUMMARY OF GEORGIA WATER QUALITY STANDARDS BY USE CLASSIFICATIONS

Use Classification	Bacteria (fecal coliform): 30-day Geometric Mean (no./100 ml)	Bacteria (fecal coliform): Maximum (no./100 ml)	Dissolved Oxygen (other than trout streams): Daily Average (mg/1)	Dissolved Oxygen (other than trout streams): Minimum (mg/1)	pH	Temperature (other than estuaries or trout streams): Maximum Rise (°F)	Temperature (other than estuaries or trout streams): Maximum (°F)	Remarks
Drinking water no treatment	50	*	---	---	---	---	---	A, E
Drinking Water requiring treatment	1,000	4,000	5.0	4.0	6.0-8.5	5	90	B, E
Recreation	200**	---	5.0	4.0	6.0-8.5	5	90	C, E, F
Fishing (excluding shellfishing)	1,000	4,000	5.0	4.0	6.0-8.5	5	90	C, E, F
Agricultural	5,000	---	---	3.0	6.0-8.5	5	90	D, F
Industrial	---	---	---	3.0	6.0-8.5	5	90	D, F
Navigation	5,000	---	---	3.0	6.0-8.5	5	90	D, F
Urban Stream	2,000	5,000	---	3.0	6.0-8.5	---	---	---
Wild River	No alteration of natural water quality							G
Scenic River	"	"	"	"				G

A - No waste discharge.
B - No substance in a concentration which after treatment exceeds State or Federal drinking water standards.
C - No concentrations of toxic wastes harmful to man, fish, game, or other beneficial aquatic life.
D - No concentrations of toxic water preventing fish survival.
E - Trout streams: D.O. - 6 mg/1 daily average and greater than 5 mg/1 at all times; water temperature cannot be elevated or depressed; designated as such by the State Game and Fish Division.
F - Estuarine waters: Maximum temperature rise limited to 1.5°F.
G - Designated as such by an authorized State or Federal legislative branch.

* Not greater than 200/100 ml in greater than 5% of samples taken in a 90 day period.
** 100/100 ml for Coastal Waters.

Appendix 9

Documentation of aerial photography for West Point Lake watershed during diagnostic study, November 1990-October 1991.

Documentation of aerial photography for West Point Lake watershed during diagnostic study, November 1990-October 1991.

Project: West Point Lake

Photography program 8 NAPP - Natural Aerial Photography Program

Date of photography: 21 February 1988, 24 February 1988, 29 February 1988 and 21 March 1988.

Photo acquisition (contractor): United States Geological Survey

Medium: Color infrared (Kodak Aerochrome 2443 film)

Camera type: Conventional cartographic aerial camera

Flight altitude (above mean ground level): 20,000 feet

Focal length: 6 inches

Resolution: 1 meter

Photo scale: 1:40,000

Role frame series: 723, 824, 725, 726, 728 and 740.

Node location summary for aerial photography analysis of West Point Lake watershed during the diagnostic study, November 1990-October 1991.

Node location summary for aerial photography analysis of West Point Lake watershed during the diagnostic study, November 1990-October 1991.

Node	Area (Hectare)	Location
		Alabama
01	1,027	Chattahoochee River from Maple Creek to Wehadkee Creek.
0202	1,587	Wehadkee Creek from Veasey Creek to Guss Creek.
020202	1,327	Veasey Creek from Stroud Creek to full pool.
02020201	1,130	Stroud Creek from Veasey Creek to full pool.
02020202	4,245	Stroud Creek from full pool to headwaters.
020203	656	Veasey Creek from full pool to Alabama Highway 263 bridge.
020204	2,751	Veasey Creek from Alabama Highway 263 bridge to headwaters.
0203	267	Wehadkee Creek from Gus Creek to bridge off Alabama Highway 16.
020301	5,347	Gus Creek from Wehadkee Creek to headwaters.
0204	143	Wehadkee Creek from bridge off of Alabama Highway 16 to Little Wehadkee Creek.
020401	1,687	Little Wehadkee Creek from Wehadkee Creek to headwaters.
0205	10,685	Wehadkee Creek from Little Wehadkee Creek to headwaters.
090201	641	Cedar Creek from Hillabatchee Creek to headwaters.
0903	1,150	Hillabatchee Creek from Town Creek to headwaters.
090301	1,572	Town Creek from Hillabatchee Creek to headwaters.
	Georgia	
00	30	Chattahoochee River from West Point Dam to Maple Creek.
01	1,847	Chattahoochee River from Maple Creek to Wehadkee Creek.
0101	2,714	Maple Creek from Chattahoochee River to headwaters.
02	1,502	Chattahoochee River from Wehadkee Creek to Wilson Creek.
0201	121	Wehadkee Creek from Chattahoochee River to Veasey Creek.
0202	4,165	Wehadkee Creek from Veasey Creek to Guss Creek.
020201	15	Veasey Creek from Wehadkee Creek to Stroud Creek.
020202	31	Veasey Creek from Stroud Creek to headwaters.
02020201	77	Stroud Creek from Veasey Creek to full pool.
0203	479	Wehadkee Creek from Guss Creek to bridge off Alabama Highway 16.
020401	2,749	Little Wehadkee Creel from Wehadkee Creek to headwaters.
03	1,193	Chattahoochee River from Wilson Creek to Whitewater Creek.
0301	1,799	Wilson Creek from Chattahoochee River to headwaters.
04	861	Chattahoochee River from Whitewater Creek to Yellowjacket Creek.

Cont.

Node	Area (Hectare)	Location
	Georgia	
0401	534	Whitewater Creek from Chattahoochee River to unnamed creek.
0402	2,213	Whitewater Creek from unnamed creek to full pool.
040201	934	Unnamed creek from Whitewater Creek to Hagedons Lake.
040202	894	Unnamed creek from Hagedons Lake to headwaters.
0403	1,922	Whitewater Creek from full pool to Heard/Troup county line.
0404	3,581	Whitewater Creek from Heard/Troup county line to headwaters.
05	9,404	Chattahoochee River from Yellowjacket Creek to Potato Creek.
0501	2,109	Yellowjacket Creek from Chattahoochee River to Jackson Creek.
0502	350	Yellowjacket Creek from Jackson Creek to Dixie Creek.
050201	1,604	Jackson Creek from Yellowjacket Creek to headwaters.
0503	228	Yellowjacket Creek from Dixie Creek to Beech Creek.
050301	134	Dixie Creek from Yellowjacket Creek to full pool.
050302	185	Dixie Creek from full pool to Georgia Highway 219 bridge.
050303	690	Dixie Creek from Georgia Route 219 bridge to headwaters.
0504	3,243	Yellowjacket Creek from Beech Creek to bridge at Hammett Road.
050401	515	Beech Creek from Yellowjacket Creek to Shoal Creek.
050402	567	Beech Creek from Shoal Creek to full pool.
05040201	867	Shoal Creek from Beech Creek to bridge at Hammett Road.
05040202	3,893	Shoal Creek from bridge at Hammett Road to headwaters.
050403	652	Beech Creek from full pool to bridge at Hammett Road.
050404	4,593	Beech Creek from bridge at Hammett Road to Bear Creek.
050405	5,072	Beech Creek from Bear Creek to headwaters.
05040501	4,327	Bear Creek from Beech Creek to headwaters.
0505	676	Yellowjacket Creek from bridge at Hammett Road to Flat Creek.
050501	9,341	Flat Creek from Yellowjacket Creek to headwaters.
0506	13,998	Yellowjacket Creek from Flat Creek to headwaters.
06	56	Chattahoochee River from Potato Creek to New River.
0601	1,949	Potato Creek from Chattahoochee River to full pool.
0602	2,665	Potato Creek from full pool to headwaters.
07	711	Chattahoochee River from New River to Brush Creek.
0701	3,343	New River from Chattahoochee River to Clear Creek.

Cont.

Node	Area (Hectare)	Location
	Georgia	
0702	462	New River from Clear Creek to Georgia Highway 100 bridge.
070201	2,564	Clear Creek from New River to headwaters.
0703	938	New River from Georgia Highway 100 bridge to Caney Creek.
0704	328	New River from Caney Creek to Mountain Creek.
070401	5,897	Caney Creek from New River to headwaters.
0705	9,691	New River from Mountain Creek to headwaters.
070501	16,686	Mountain Creek from New River to headwaters.
08	3,319	Chattahoochee River from Brush Creek to Hillabatchee Creek.
0801	719	Brush Creek from Chattahoochee River to full pool.
0802	5,032	Brush Creek from full pool to headwaters.
09	733	Chattahoochee River from Hillabatchee Creek to U.S. Highway 27 bridge.
0901	4,564	Hillabatchee Creek from Chattahoochee River to Cedar Creek.
0902	397	Hillabatchee Creek from Cedar Creek to Town Creek.
090201	3,115	Cedar Creek from Hillabatchee Creek to headwaters.
0903	6,177	Hillabatchee Creek from Town Creek to headwaters.
090301	3,006	Town Creek from Hillabatchee Creek to headwaters.
	196,677	

Landuse/landcover acreage by class and node for aerial photography analysis of West Point Lake watershed during the diagnostic study, November 1990-October 1991.

Landuse/landcover acreage by class and node for aerial photography analysis of West Point Lake watershed during the diagnostic study, November 1990-October 1991.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
AL	01	2	63	1027
AL	01	21	58	
AL	01	4	588	
AL	01	5	318	
AL	0202	1	4	1587
AL	0202	2	210	
AL	0202	21	22	
AL	0202	4	1197	
AL	0202	45	64	
AL	0202	5	92	
AL	020202	2	91	1327
AL	020202	21	3	
AL	020202	210	1	
AL	020202	4	919	
AL	020202	45	5	
AL	020202	5	308	
AL	02020201	1	35	1130
AL	02020201	2	56	
AL	02020201	210	2	
AL	02020201	4	745	
AL	02020201	45	44	
AL	02020201	5	247	
AL	02020202	2	825	4245
AL	02020202	21	209	
AL	02020202	4	3174	
AL	02020202	45	2	
AL	02020202	5	34	
AL	020203	2	130	656
AL	020203	4	504	
AL	020203	5	22	
AL	020204	1	4	2751
AL	020204	2	389	
AL	020204	21	197	
AL	020204	4	2158	
AL	020204	5	3	
AL	0203	2	28	267
AL	0203	21	11	
AL	0203	4	215	
AL	0203	45	7	
AL	0203	5	6	
AL	020301	2	1007	5347
AL	020301	21	235	
AL	020301	210	14	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
AL	020301	4	3740	
AL	020301	45	7	
AL	020301	5	67	
AL	020301	1	277	
AL	0204	2	5	143
AL	0204	21	47	
AL	0204	4	90	
AL	0204	5	1	
AL	020401	2	115	1687
AL	020401	210	1	
AL	020401	4	1548	
AL	020401	45	16	
AL	020401	5	7	
AL	0205	1	55	10685
AL	0205	2	2406	
AL	0205	21	391	
AL	0205	210	9	
AL	0205	4	7542	
AL	0205	45	228	
AL	0205	5	34	
AL	0205	750	3	
AL	0205	751	13	
AL	0205	762	4	
AL	090201	2	75	641
AL	090201	4	555	
AL	090201	45	7	
AL	090201	5	1	
AL	090201	762	2	
AL	0903	2	149	1150
AL	0903	21	18	
AL	0903	4	820	
AL	0903	5	1	
AL	0903	45	162	
AL	090301	2	191	1572
AL	090301	21	24	
AL	090301	4	1314	
AL	090301	5	3	
AL	090301	45	38	
AL	090301	210	2	
GA	00	2	2	30
GA	00	4	9	
GA	00	5	19	
GA	01	2	30	1847
GA	01	210	6	
GA	01	4	414	
GA	01	5	1398	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	0101	1	49	2714
GA	0101	2	323	
GA	0101	21	114	
GA	0101	4	1498	
GA	0101	5	731	
GA	02	1	52	1502
GA	02	2	110	
GA	02	21	14	
GA	02	4	786	
GA	02	5	540	
GA	0201	4	28	121
GA	0201	5	92	
GA	0202	1	112	4165
GA	0202	2	147	
GA	0202	21	67	
GA	0202	4	2965	
GA	0202	5	873	
GA	020201	4	3	15
GA	020201	5	12	
GA	020202	2	1	31
GA	020202	4	10	
GA	020202	5	21	
GA	02020201	1	1	77
GA	02020201	2	6	
GA	02020201	4	21	
GA	02020201	5	49	
GA	0203	2	7	479
GA	0203	4	472	
GA	020401	2	554	2749
GA	020401	4	2083	
GA	020401	5	17	
GA	020401	45	95	
GA	03	1	16	1193
GA	03	2	36	
GA	03	21	13	
GA	03	4	630	
GA	03	5	498	
GA	0301	1	395	1799
GA	0301	2	269	
GA	0301	21	64	
GA	0301	210	14	
GA	0301	4	900	
GA	0301	5	157	
GA	04	1	115	861
GA	04	2	13	
GA	04	4	376	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	04	5	357	
GA	0401	2	1	534
GA	0401	4	375	
GA	0401	45	30	
GA	0401	5	129	
GA	0402	1	7	2213
GA	0402	2	84	
GA	0402	45	73	
GA	0402	4	1797	
GA	0402	5	234	
GA	0402	761	19	
GA	040201	2	11	934
GA	040201	4	715	
GA	040201	45	89	
GA	040201	5	120	
GA	040202	2	8	894
GA	040202	4	819	
GA	040202	45	53	
GA	040202	5	14	
GA	0403	1	6	1922
GA	0403	2	36	
GA	0403	4	1811	
GA	0403	45	66	
GA	0403	5	2	
GA	0404	1	3	3581
GA	0404	2	177	
GA	0404	4	3085	
GA	0404	45	309	
GA	0404	5	8	
GA	05	1	115	9404
GA	05	2	481	
GA	05	21	294	
GA	05	4	6591	
GA	05	45	280	
GA	05	5	1634	
GA	05	762	9	
GA	0501	1	328	2109
GA	0501	2	80	
GA	0501	21	43	
GA	0501	4	1230	
GA	0501	5	428	
GA	0502	1	6	350
GA	0502	2	2	
GA	0502	4	236	
GA	0502	5	105	
GA	050201	1	109	1604

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	050201	1235	2	
GA	050201	2	61	
GA	050201	4	1304	
GA	050201	5	128	
GA	0503	1	42	228
GA	0503	2	8	
GA	0503	21	3	
GA	0503	4	100	
GA	0503	5	75	
GA	050301	1	4	134
GA	050301	4	110	
GA	050301	5	20	
GA	050302	1	36	185
GA	050302	2	34	
GA	050302	4	110	
GA	050302	5	5	
GA	050303	1	423	690
GA	050303	2	16	
GA	050303	21	30	
GA	050303	4	220	
GA	050303	45	1	
GA	0504	1	120	3243
GA	0504	2	296	
GA	0504	21	100	
GA	0504	4	2271	
GA	0504	45	111	
GA	0504	5	345	
GA	050401	1	47	515
GA	050401	2	32	
GA	050401	4	274	
GA	050401	5	162	
GA	050402	1	24	567
GA	050402	2	15	
GA	050402	21	8	
GA	050402	4	446	
GA	050402	5	74	
GA	05040201	1	145	867
GA	05040201	2	36	
GA	05040201	4	651	
GA	05040201	45	16	
GA	05040201	5	19	
GA	05040202	1	565	3893
GA	05040202	2	449	
GA	05040202	21	90	
GA	05040202	4	2693	
GA	05040202	45	55	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	05040202	5	22	
GA	05040202	750	19	
GA	050403	2	41	652
GA	050403	21	73	
GA	050403	4	538	
GA	050404	1	75	4593
GA	050404	2	177	
GA	050404	21	309	
GA	050404	210	4	
GA	050404	4	3640	
GA	050404	45	372	
GA	050404	5	16	
GA	050405	1	12	5072
GA	050405	2	112	
GA	050405	21	276	
GA	050405	210	12	
GA	050405	4	4523	
GA	050405	45	121	
GA	050405	5	16	
GA	05040501	1	3	4327
GA	05040501	2	838	
GA	05040501	21	102	
GA	05040501	210	2	
GA	05040501	4	3202	
GA	05040501	45	115	
GA	05040501	5	65	
GA	0505	2	45	676
GA	0505	4	570	
GA	0505	45	59	
GA	0505	5	2	
GA	050501	1	161	9341
GA	050501	2	1273	
GA	050501	21	568	
GA	050501	210	46	
GA	050501	4	6759	
GA	050501	45	491	
GA	050501	5	43	
GA	0506	1	680	13998
GA	0506	2	2124	
GA	0506	21	709	
GA	0506	210	8	
GA	0506	4	9626	
GA	0506	45	571	
GA	0506	5	280	
GA	06	4	19	56
GA	06	5	37	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	0601	2	196	1949
GA	0601	21	35	
GA	0601	4	1257	
GA	0601	45	391	
GA	0601	5	70	
GA	0602	2	308	2665
GA	0602	21	95	
GA	0602	4	1968	
GA	0602	45	288	
GA	0602	5	6	
GA	07	2	2	711
GA	07	4	542	
GA	07	5	167	
GA	0701	2	146	3343
GA	0701	4	2848	
GA	0701	45	194	
GA	0701	5	155	
GA	0702	2	51	462
GA	0702	21	8	
GA	0702	4	276	
GA	0702	45	126	
GA	0702	5	1	
GA	070201	1	13	2564
GA	070201	2	29	
GA	070201	21	36	
GA	070201	4	1965	
GA	070201	45	410	
GA	070201	5	111	
GA	0703	2	52	938
GA	0703	4	781	
GA	0703	45	105	
GA	0704	2	11	328
GA	0704	21	15	
GA	0704	210	4	
GA	0704	4	288	
GA	0704	45	8	
GA	0704	5	2	
GA	070401	1	9	5897
GA	070401	2	509	
GA	070401	21	55	
GA	070401	210	8	
GA	070401	4	4549	
GA	070401	45	723	
GA	070401	5	44	
GA	0705	1	223	9691
GA	0705	2	708	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	0705	21	735	
GA	0705	4	7708	
GA	0705	45	274	
GA	0705	5	43	
GA	070501	1	1349	16686
GA	070501	2	2299	
GA	070501	21	858	
GA	070501	210	40	
GA	070501	4	10449	
GA	070501	45	1366	
GA	070501	5	297	
GA	070501	762	28	
GA	08	2	291	3319
GA	08	21	132	
GA	08	4	2561	
GA	08	45	150	
GA	08	5	185	
GA	0801	1	1	719
GA	0801	2	16	
GA	0801	4	615	
GA	0801	45	9	
GA	0801	5	78	
GA	0802	2	401	5032
GA	0802	21	113	
GA	0802	4	4067	
GA	0802	45	418	
GA	0802	5	15	
GA	0802	751	20	
GA	09	1	79	733
GA	09	2	77	
GA	09	4	533	
GA	09	5	43	
GA	0901	1	39	4564
GA	0901	2	630	
GA	0901	21	146	
GA	0901	4	3362	
GA	0901	45	127	
GA	0901	5	66	
GA	0901	751	194	
GA	0902	2	2	397
GA	0902	4	388	
GA	0902	45	5	
GA	0902	5	2	
GA	090201	2	299	3115
GA	090201	21	27	
GA	090201	4	2762	

Cont.

State	Node	Landuse/ Landcover Class	Area (Hectares)	Total (Hectares)
GA	090201	45	22	
GA	090201	5	5	
GA	0903	2	769	6177
GA	0903	21	57	
GA	0903	4	5276	
GA	0903	45	68	
GA	0903	5	6	
GA	090301	2	325	3006
GA	090301	21	119	
GA	090301	210	4	
GA	090301	4	2552	
GA	090301	5	6	
TOTAL			196678	196678

Appendix 10

U.S. Food and Drug Administration action level guidelines for chemical contamination in fish tissue.

U.S. Food and Drug Administration action level guidelines for chemical contamination in fish tissue.

Metal	Value
Mercury	1.0 ppm[1]

Pesticides	Value
Aldrin	0.3 ppm[1]
Chlordane	0.3 ppm[1]
DDT	5.0 ppm[1]
Dieldrin	0.3 ppm[1]
Endrin	0.3 ppm[1]
Heptachlor	0.3 ppm[1]
Kepone (chlorodecone)	0.3 ppm[1]
Mirex	0.10 ppm[1]
PBC's	2.0 ppm[2]
Toxaphene	5.0 ppm[1]

[1]Action level.
[2]Tolerance level.

Limiting nutrients and mean maximum standing crop (mg/l) of *Selenastrum capricornutum* cultures in West Point Lake waters during 1990, 1991 and 1992.

Limiting nutrients and mean maximum standing crop (mg/l) of <u>Selenastrum capricornutum</u> cultures in West Point Lake waters during 1990, 1991 and 1992.

Station Date	Mean Maximum Standing Crop (mg/l) 1	LN[1]	4	LN	5	LN	7	LN	9	LN	10	LN
24 April '91	40.32	(N)	29.38	(P)	26.82	(P)	15.45	(P)	6.38	(P)	1.64	(P)
19 June '91	33.90	(N+P)	--		15.50	(P)	8.98	(P)	7.66	(N+P)	0.33	(P)
22 Aug '91	45.62	(N)	20.59	(N+P)	17.09	(P)	11.68	(P)	1.03	(P)	0.43	(P)
23 Oct '91	11.72	(N+P)	21.83	(N+P)	13.11	(P)	16.63	(P)	0.30	(P)	0.22	(P)
22 April '92	39.22	(N+P)	24.58	(P)	11.14	(P)	3.02	(P)	5.15	(P)	0.42	(P)
22 June '92	54.60	(N+P)	34.38	(N+P)	20.35	(P)	8.60	(P)	3.68	(P)	0.11	(P)
20 July '92	25.28	(N+P)	18.86	(P)	12.33	(P)	0.77	(P)	0.43	(P)	0.17	(P)
25 Aug '92 (ADEM)	30.85	(N+P)	20.02	(N)	21.67	(N+P)	13.07	(P)	6.38	(P)	1.06	(P)
19 Oct '92	44.69	(N)	42.25	(N)	40.31	(N)	20.88	(P)	10.92	(P)	6.38	(P)

[1]LN = Limiting nutrient; N = Nitrogen; P = Phosphorus.

Definitive sampling station locations for the West Point Lake studies conducted from June 1990 through October 1992.

Definitive sampling station locations for the West Point Lake studies conducted from June 1990 through October 1992.

Station Number	Station Description	County State	Maximum Depth (m)	Latitude	Longitude
1	Hwy 27 Franklin, GA	Heard, GA	3.1	33°16'39"	85°08'52"
2	Main channel downstream mouth of New River	Heard, GA	8.0	33°11'26"	85°02'34"
3	New River embayment	Heard, GA	5.3	33°11'46"	85°02'40"
4	Hwy 219 main channel	Troup, GA	12.0	33°07'46"	85°05'53"
5	LaGrange water intake main channel	Troup, GA	15.0	33°04'43"	85°06'45"
6	Yellowjacket Creek embayment	Troup, GA	13.5	33°04'10"	85°06'03"
7	Main channel Hwy 109	Troup, GA	18.0	33°01'44"	85°09'53"
8	Wehadkee Creek embayment	Troup, GA	17.0	32°59'54"	85°12'01"
9	Rocky Point main channel	Troup, GA	20.1	32°59'15"	85°11'33"
10	Forebay of dam	Troup, GA	24.0	32°55'11"	85°11'04"
11	Tailwaters	Troup, GA	0.5	32°55'03"	85°11'23"
12	Dixie Creek	Troup, GA	0.5	33°04'22"	85°02'38"
13	Yellowjacket Creek	Troup, GA	1.7	33°08'21"	84°58'33"
14	New River	Heard, GA	4.0	33°14'07"	84°59'16"
15	Wehadkee Creek	Randolph, AL	4.0	33°07'20"	85°14'57"
16	Veasey Creek	Chambers, AL	1.5	33°00'28"	85°16'39"
17	Blue John Creek	Troup, GA	0.5	32°59'57"	85°03'04"

Approximate location of sampling sites for fecal coliform bacteria in West Point Lake, June-September, 1992.

Approximate location of sampling sites for fecal coliform bacteria in West Point Lake, June-September, 1992.

Miles[1]	Water Quality Lake Station	Description
0	1	Downstream (DS) Franklin Bridge
1		Between (B/T) powerlines
2		Creek mouth - upstream (US) Buoy 128
3		Buoy (B) 126
4		B/T B125 and B124
5		Snake Creek - B122
6		B119
7		B/T B117 and B116
8	2	B114
9		B110
10		200 yds DS B105
11		B102
12		B99
13		B93
14	4	US 219 Bridge
16		B76
18		B67
20		B55
22		B47
24	7	US 109 Bridge
26		200 yds DS B32
28		B/T B20 and B18
30		B10
32	10	Dam forebay

[1]Distance downstream from Franklin, Georgia.222

Letter from U.S. Army Corps of Engineers regarding sedimentation data for West Point Lake

DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 2288
MOBILE, ALABAMA 36628-0001
October 21, 1993

REPLY TO
ATTENTION OF:

Hydrology and Hydraulics Branch
Engineering Division

Dr. David R. Bayne
Fisheries Department
Auburn, Alabama 36849

Dear Dr. Bayne:

Reference is made to your recent telephone conversation with Geary McDonald regarding sedimentation data for West Point Lake. The initial survey was performed in 1978 with a resurvey in 1983. From the results of the two surveys, the depletion was 0.04% during the five-year interval. This depletion is considered minimal.

A resurvey is scheduled for late summer 1994 and is contingent on available funding.

If you need further assistance, feel free to call Geary at 205-694-3697.

Sincerely,

BENTON W. ODOM, JR.,
Chief, Hydrology & Hydraulics Branch

Letters and documents related to report completion and recommended Lake Water Quality standards for West Point Lake.

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April 6, 1993

Mr. Mork Winn, Program Director
Water Quality Management Program
Georgia Environmental Protection Division
Georgia Department of Natural Resources
205 Butler Street, Twin Towers East
Atlanta, Georgia 30334

Dear Mr. Winn:

Enclosed you will find a first draft copy of the West Point Lake diagnostic study conducted from June 1990 through October 1992. Although there are sections of the diagnostic phase of the report that we have not completed, the enclosed copy contains all findings of studies carried out to define problems that may exist on West Point Lake. We are still working to improve this draft and would welcome your comments and criticism, however, the purpose of submitting this draft of the diagnostic study at this time is to initiate a dialogue with Georgia (DNR) and Alabama (ADEM) concerning the feasibility phase of the study. After both states have had an opportunity to review the enclosed diagnostic study results, I will plan a meeting, perhaps in LaGrange, Georgia, to discuss viable approaches to solving existing problems. Hopefully we can come to mutual agreement on the issues.

Remember that the University of Georgia is completing final reports of their work on fish health and toxics and those results should be available to us prior to the proposed meeting. The final draft of our report will contain all data in an appendix but should you need additional information at this time please let me know.

Look forward to hearing from you when you have completed your review.

Sincerely,

David Bayne
Professor

DB/aja

Dr. Walter Murphy
Dr. Vickie Blazer
Dr. Parshall Bush

Auburn University

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April 6, 1993

Mr. Bob Cooner, Chief
Special Studies Section
Field Operations Division
Alabama Department of Environmental Management
1751 Congressman W. L. Dickinson Drive
Montgomery, Alabama 36130

Dear Mr. Cooner:

Enclosed you will find a first draft copy of the West Point Lake diagnostic study conducted from June 1990 through October 1992. Although there are sections of the diagnostic phase of the report that we have not completed, the enclosed copy contains all findings of studies carried out to define problems that may exist on West Point Lake. We are still working to improve this draft and would welcome your comments and criticism, however, the purpose of submitting this draft of the diagnostic study at this time is to initiate a dialogue with Georgia (DNR) and Alabama (ADEM) concerning the feasibility phase of the study. After both states have had an opportunity to review the enclosed diagnostic study results, I will plan a meeting, perhaps in LaGrange, Georgia, to discuss viable approaches to solving existing problems. Hopefully we can come to mutual agreement on the issues.

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Sincerely,

David Bayne
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2 August 1993

Mr. Alan Hallum, Branch Chief
Environmental Protection Division
Georgia Department of Natural Resources
205 Butler Street, Twin Tower East
Atlanta, Georgia 30334

Dear Mr. Hallum:

On Tuesday, 20 July 1993, a meeting was held at LaGrange College in LaGrange, Georgia, to discuss the feasibility phase of the West Point Lake Clean Lakes Study and to recommend water quality standards as called for in the 1990 amendment to the "Georgia Water Quality Control Act" dealing with lake water quality standards. Attending the meeting were Dr. Parshall Bush, University of Georgia, Dr. David Kamps, Georgia Environmental Protection Division, Mr. Robert Cooner and Mr. James McIndoe, Alabama Department of Environmental Management, and me. I have enclosed a meeting agenda for your information.

As you know, I submitted a draft of the diagnostic phase of the study to EPD and ADEM on 6 April 1993, asking for comments and a meeting on the feasibility phase of the study. The July 20th meeting was most helpful with the participants agreeing on many of the crucial issues. I will now proceed to finish the feasibility report and forward it to you in the near future.

In order to meet the deadlines spelled out in the Lake Standards Law, I am submitting the recommended water quality standards for West Point Lake (see enclosed). More discussion and justification of these criteria will appear in the feasibility report, but I will be glad to answer any questions or hear your comments on these recommendations. Please advise me if I can assist you in any way.

Sincerely,

David R. Bayne
Professor

cc. Mork Winn
Bob Cooner
David Kamps
Parshall Bush
James McIndoe

Bayne

MEETING AGENDA

WEST POINT LAKE FEASIBILITY STUDY
20 JULY 1993

1 - Review status of water quality issues related to West Point Lake.

2 - Discuss problems revealed by diagnostic phase of Clean Lakes Study.

3 - Discuss Georgia lake water quality standards law as it relates to West Point Lake.

   Establish numerical standards to be recommended.

4 - Recommendations related to toxic substances.

5 - Recommendations to reduce sedimentation.

STATUS OF WATER QUALITY ISSUES

1. 0.75 mg/L phosphorus limitation.

2. Use classification changes. (Action Plan page 3 + 11)
   Law fish, swim, water supply

3. Stormwater control.(AP 3)

4. Combined sewer overflow.(AP 2

5. Toxics.(AP 10)
   Chlordane only advisory?
   Is dioxin a concern?

6. Others.

PROBLEMS IDENTIFIED

I. Eutrophication

Point source nutrient loading
Combined sewer overflow
Urban stormwater runoff
Water quantity

Lake water quality standards

II. Bacterial Contamination

Combined sewer overflow
Urban stormwater runoff

III. Toxics

Urban stormwater runoff

IV. Sedimentation

Stormwater control

Lake Water Quality Standards

1 - pH 6.5 - 9.5

2 - Fecal coliform < 200 colonies/100 ml

3 - Corrected chlorophyll a (mean photic zone concentration) (summertime) ?

Lakewide mean during growing season 15 - 20 µg/l
Maximum 50 µg/l
LaGrange water intake mean growing season 27 µg/l

4 - Total nitrogen } Cap discharge at 358 mgd

5 - Total phosphorus

6 - Dissolved oxygen

When a thermocline (change in temperature of 1.0°C or more per meter depth) exist, the epilimnion (water column above thermocline) that is within the photic zone (that portion of the upper water column receiving at least 1.0% of the surface incident light) should maintain a dissolved oxygen concentration of 5.0 mg/L or higher at all times.

In the absence of a thermocline (no epilimnion) the dissolved oxygen concentration of the photic zone should be 5.0 mg/L or higher at all times.

RECOMMENDED WEST POINT LAKE WATER QUALITY STANDARDS

The following standards are recommended to assure that West Point Lake waters will be safe and suitable for fishing, swimming, and as a public water supply.

pH. Lake water pH should not decline below pH 6.5 nor rise above pH 9.5.

Fecal Coliform Bacteria.

The geometric mean fecal coliform density based on four samples collected during a 30 day period should not exceed 200 colonies/100 ml in lake water. At least 24 hours should elapse between samples.

Chlorophyll *a* (corrected for pheopigments)

Under 10-year, low flow conditions (2,100 cfs at Whitesburg, Georgia) mean (based on samples collected at about 15 day intervals) photic zone chlorophyll *a* concentrations measured near the LaGrange water intake structure during the growing season (April through October) should not exceed 27 µg/L. Mean photic zone chlorophyll *a* concentration should not exceed 50 µg/L at any time, anywhere in West Point Lake. Lake-wide, the growing season average should range between 15 to 20 µg/L. Lake-wide photic zone chlorophyll *a* means will be based on samples collected at about 15 day intervals at no less than four mainstem (along Chattahoochee River channel) locations distributed about equidistance between West Point Dam and the mouth of New River.

If future water withdrawal within the Chattahoochee River Basin, upstream of West Point Lake, exceeds current (1993) levels and results in Chattahoochee River flows of less than 2,100 cfs (at Whitesburg, Georgia) the chlorophyll *a* standards for the 10-year, low flow condition (as stated above) will apply until such time as river flows exceed 2,100 cfs.

Under average flow conditions (3,925 cfs at Whitesburg) mean photic zone chlorophyll *a* concentrations measured near the LaGrange water intake structure during the summer (June through August) should not exceed 27 µg/L. Mean photic zone chlorophyll *a* concentration should not exceed 40 µg/L at any time, anywhere in West Point Lake. Lake-wide the growing season average should range between 15 and 20 µg/L. Lake-wide photic zone chlorophyll *a* means will be based on samples collected at about 15 day intervals at no less than four mainstem (along Chattahoochee River channel) locations distributed about equidistance between West Point Dam and the mouth of New River.

Total Phosphorus.

Total phosphorus loading of the Chattahoochee River and its tributaries upstream of West Point Lake by point source dischargers will be reduced to levels that will ensure maintenance of the chlorophyll a standards as stated above.

Total Nitrogen.

Since the lake will be phosphorus limited in terms of algal growth, nitrogen concentrations can vary as long as concentrations of toxic species (e.g. NH_3 and NO_2^-) remain at safe levels.

Dissolved Oxygen.

When a thermocline (change in temperature of 1.0 C or more per meter depth) exists, the epilimnion (water column above thermocline) that is within the photic zone (that portion of the upper water column receiving at least 1.0 % of the surface incident light) should maintain a dissolved oxygen concentration of 5.0 mg/L or higher at all times.

In the absence of a thermocline (no epilimnion) the dissolved oxygen concentration of the photic zone should be 5.0 mg/L or higher at all times.

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August 20, 1993

Mr. Mork Winn, Program Director
Water Quality Management Program
Georgia Environmental Protection Division
Georgia Department of Natural Resources
205 Butler Street, Twin Towers East
Atlanta, GA 30334

Dear Mr. Winn:

Just a reminder to send comments on the diagnostic portion of the West Point Lake Phase I Study at your earliest convenience. I would like to complete that report prior to taking on new tasks in the fall. I am working on the feasibility portion of the report and will forward you a draft as soon as it is completed.

I appreciate all of your help and cooperation on this project through the years.

Sincerely,

David Bayne
Professor

DB/mdm

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December 14, 1993

Mr. Robert Cooner
Alabama Dept. Environmental Mgt.
1751 Federal Drive
Montgomery, AL 36130

Dear Mr. Cooner:

Enclosed, you will find a draft copy of the feasibility study report (West Point Lake Phase I, Diagnostic/Feasibility Study) for West Point Lake. Please review this document and provide me with your comments and criticisms as soon as possible so that I can complete the final draft in a timely manner. We have incorporated recommended improvements and suggested changes into the diagnostic study report and it is ready to be submitted.

Please advise me if you have questions or if I can assist you in any way.

Sincerely,

David Bayne
Professor

DRB/apb

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December 14, 1993

Mr. Mork Winn, Program Director
Water Quality Management Program
Georgia Environmental Protection Division
Georgia Department of Natural Resources
205 Butler Street, Twin Towers East
Atlanta, GA 30334

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Please advise me if you have questions or if I can assist you in any way.

Sincerely yours,

David Bayne
Professor

DB/apb

cc: Alan Hallum
David Kamps
Parshall Bush
Walter Murphy

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January 11, 1994

Mr. Dan Ahern
Chief Watershed Protection Section
U.S.E.P.A., Region IV
345 Courtland St.
Atlanta, GA 30365

Dear Mr. Ahern:

Mr. Mork Winn, Georgia EPD, has requested that I forward to you a copy of the revised West Point Lake Diagnostic Report that has been reviewed by both EPD and ADEM. Comments and suggestions made by these agencies have been addressed in the enclosed draft. Please advise me if I can assist you in any way as you review these documents.

Sincerely,

David R. Bayne
Professor

DRB/apb

cc: Mork Winn
Robert Cooner

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET. N.E.
ATLANTA. GEORGIA 30365

JUN 03 1994

Mr. W.M. Winn, III
Program Manager
Water Quality Management Program
GA Dept. of Natural Resources
205 Butler Street S.E.
Floyd Towers East
Atlanta, GA 30334

Dear Mr. Winn:

This correspondence concerns the Draft West Point Lake Phase 1 Feasibility Report transmitted by your letter of December 23, 1993, as well as the Revised Diagnostic Report transmitted by Dr. David R. Bayne, Auburn University, on January 11, 1994.

We have reviewed both of the above-referenced reports and commend the many participants in the study on a well balanced and highly professional effort. A few limited comments on the technical aspects of these reports are noted below.

The diagnostic section of the report provides an excellent description of the eutrophic conditions in the lake, and documents the ongoing strategy of phosphorus reduction in the watershed as a control mechanism to correct these problems. However, the feasibility section should include more detailed information on the Georgia Environmental Protection Division's short-term and long-term goals for the reduction of total phosphorus entering the lake. There also should be a explanation of the status of existing attempts to meet these goals. Projected future total phosphorus loadings and the resultant water quality conditions should be included.

The feasibility section contains an excellent description of the use of chlorophyll a as indicator of eutrophic conditions in West Point Lake. EPA has found that chlorophyll a is probably the best single parameter for the establishment of water quality goals for large lakes. However, we have noted over the past twenty years that water quality resources are protected best if water quality goals are formally established through the adoption of numerical water quality standards. Therefore, EPA Region IV recommends that the Phase 1 Diagnostic/Feasibility Report for West Point Lake and other studies already completed be utilized to establish numerical water quality standards for West Point Lake. EPA Region IV has reviewed Georgia Senate Bill 714, which became a state law in 1990, and feels that it provides an excellent format for the establishment of lake water quality standards.

Georgia Senate Bill 714 also requires the establishment of Total Maximum Daily Loads. Although Senate Bill 714 does not specifically reference Section 303(d) of the Clean Water Act, it does follow the legal principles established in the Act. Therefore, EPA Region IV recommends Total Maximum Daily Loads be established for West Point Lake and its tributaries. The methodology for the establishment of the Total Maximum Daily Loads should comply with the procedural requirements of Section 303(d) of the Federal Clean Water Act.

If I may be of additional assistance, please do not hesitate to contact me.

Sincerely yours,

R F McGhee

Robert F. McGhee
Acting Director
Water Management Division

cc: Mr. Robert Cooner
Alabama Department of Environmental Management

Dr. David R. Bayne
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July 22, 1994

Mr. W. M. Winn, III
Program Manager
Water Quality Management Program
GA Dept. of Natural Resources
205 Butler Street S.E.
Floyd Towers East
Atlanta, GA 30334

Dear Mr. Winn:

At your request I am enclosing a copy of the letter addressed to you from Mr. Robert F. McGhee of EPA Region IV concerning the West Point Lake Phase I study report. As I move to complete the final report and address review comments, I will need your assistance in answering questions raised in paragraph three of this letter. I would not feel comfortable addressing EPD goals for phosphorus reduction in West Point Lake. If you care to comment on questions raised in the letter about the establishment of numerical water quality standards and total maximum daily loads for the lake, that could be included in the final Feasibility Report also. Any response to these questions will be appended in its entirety to the final report to help prevent misinterpretation.

I plan to begin revising the draft Feasibility Report next week and will need your response as soon as possible to complete the task. Look forward to hearing from you.

Sincerely,

David R. Bayne
Professor

DRB/aja

cc: Mr. Robert Cooner

Toxic substances in water, sediment and fish and fish health assessment (1990-1992)

PROJECT: WEST POINT LAKE: PHASE 1 - DIAGNOSTIC/FEASIBILITY STUDY

Toxic Substances in Water, Sediments and Fish

and

Fish Health Assessment

(1990 - 1992)

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Date of Submission: December, 1992

TABLE OF CONTENTS

SUMMARY

The University of Georgia in cooperation with the States of Georgia and Alabama and the U.S. Environmental Protection Agency collected water, sediment, and fish tissue samples for toxic substance analysis as a part of the Clean Lakes Phase I Diagnostic/Feasibility Study of West Point Lake. A sampling catalogue and map of locations are included in Appendix 1.

Water samples collected during the three sampling periods contained no measurable volatile organic compounds (VOA's), base/neutral/acid semi-volatiles (BNA's), metals or pesticides (Appendix 2). Occasional water samples collected during the spring of 1991 contained detectable levels of mercury (Table 3) at concentrations in excess of Georgia water quality standards.

Sediment samples collected during the fall of 1990 , spring 1991 and fall 1991 were generally found to contain no measurable VOA's, BNA's or pesticides with the exceptions presented in Appendix 3. Detectable nitric acid extractable metal residues are presented (Table 5) and the positive BNA semi-volatile residues are summarized (Table 6). Sediment samples were found to contain phthalates (plasticisers) and polynuclear aromatic compounds (PNA's). The most common PNA's were pyrene, fluoranthene and benzopyrene. Nitrogen and phosphorus levels were determined and are reported (Tables 7-8).

Fish pesticide and heavy metal residue levels for whole fish and filets are summarized in Appendix 4 (Tables 9-14). Residues of PCB, chlordane, pentachloroanisole and DDT metabolites were detected. PCB's (primarily Arachlor 1260) concentrations ranged from non-detectable to 1.57 ppm. All PCB levels were below the Food and Drug Administration (FDA) 2.0 ppm action level. Numerous chlordane residues were detected at levels above the FDA action level of 0.3 ppm. Other detectable residues were below action levels. U.S. Environmental Protection Agency (EPA) fish tissue guidance values for the protection of human health are also reviewed in this report.

Common carp and largemouth bass were collected from six sites in Spring and Fall 1991 for determination of a site-specific fish health assessment index (HAI). The results are

presented in Appendix 5. The assessment included a visual evaluation of various organs as well as collection of blood for hematocrit, leucocrit and serum protein. In addition, condition factor (Ktl) was calculated.

In general, the fish appeared fairly healthy. No fish were grossly deformed, had ulcerated or open lesions, had fin rot or were emaciated.

Condition factor and hematocrit values tended to be higher in Fall than Spring when differences between seasons were noted. Bass leucocrits varied greatly with no apparent pattern. Carp leucocrits were higher in Spring at all stations except the river site (U.S. Hwy 27). No discernible patterns were found in serum protein. The data indicate that blood parameters are too variable to use as indicators of health in wild populations. A large number of factors (water temperature, feeding status, etc.) can influence the results. No significant differences were found among the sites in the overall HAI in the Spring for either carp or bass. Significant differences were found between sites for Fall samples. Bass caught at the Dam had a significantly higher index (or were in worse shape) than those from the other sites. Carp caught at the river site (U.S. Hwy 27) had the highest index, those caught at Yellowjacket Creek had the lowest and the other four sites were intermediate.

The majority of conditions contributing to the observed index values for largemouth bass were parasite load and pathological indicators for the kidney and spleen. A histopathological evaluation indicated that nodules found in the spleen were lipomas. These are benign tumors, have never been correlated with environmental pollution and did not appear to cause significant damage to the tissue. Both helminth and myxosporidian parasites were found in the kidney tissue.

In the carp, HAI's were consistently lower in the Spring compared to Fall. This difference was primarily due to changes in gill and kidney tissue in the Fall. Histologically, mucus proliferation and an increase in inflammatory cells was observed in the gills and increased ceroid deposition was noted in the kidneys.

Correlation analyses were conducted for bass health parameters and contaminants found in both tissues and sediments in Fall 1991. The only parameters which were highly correlated were tissue PCB levels and liver/somatic index.

The results indicate that the HAI is probably not sensitive enough to detect effects from exposure to low concentrations of environmental contaminants. Many of the lesions observed grossly were due to parasites (which do no constitute a human health hazard).

LIST OF TABLES

Page

LIST OF FIGURES

INTRODUCTION

The U.S. Environmental Protection Agency, Georgia Environmental Protection Division, and Alabama Department of Environmental Management with the assistance of LaGrange College, Auburn University and the University of Georgia are engaged in a cooperative water quality assessment study of West Point Lake supported by the Federal Clean Lakes Program with local matching funds provided by the Calloway Foundation. The purpose of the study is to assess and diagnose water quality problems and review potential feasible courses of actions to reduce documented problems. A contract was entered into between the Georgia Department of Natural Resources Environmental Protection Division and the University of Georgia (Riverbend Research Laboratory) to conduct a two-year study of toxic substances and fish health as part of the West Point Lake Clean Lakes Study. This report is the final result of that two-year study.

The objective of this portion of the West Point Lake study was 1) to conduct the sampling and analysis of water, sediments and fish (whole fish and filets) for toxic substances at eight stations located on the lake and, 2) to conduct fish health assessments. The sampling stations were pre-selected by the Georgia Department of Natural Resources and are listed in Appendix 1 (Table 1).

In Fall 1990, four stations were selected by the researchers of this study to conduct preliminary sampling and analyses. This preliminary study was conducted to develop and refine sampling and laboratory procedures. Water, sediments and fish samples were subsequently collected from all eight stations in Spring and Fall 1991. Water and sediment samples collected in all sampling periods were analyzed for metals, pesticides, organophosphates, herbicides, volatiles and semi-volatiles. Any additional compounds detected were included in this report.

A total of 16 largemouth bass (Micropterus salmoides) and 16 common carp (Cyprinus carpio) composites of six fish each were collected and analyzed for toxic contaminants. Twelve to fifteen additional largemouth bass and common carp from six of the sampling stations were anesthetized, weighed, measured and bled. Fish were collected in Fall and Spring to allow for seasonal comparisons. Individual hematocrit, leucocrit and plasma protein values were determined. A Fish Health Condition Assessment was conducted for each fish. Eighteen external and internal organs, including blood, were evaluated as indicators of stress in fish. The liver was removed from each fish to allow calculation of a liver-somatic index. Other tissues were removed from fish, classified according to pathological condition and evaluated for histopathologically. Correlation analyses were conducted for health parameters and contaminants found in both tissues and sediments in the Fall 1991 sample. Modification of the fish health assessment technique is discussed.

The data from this study is included in this report. The results have been evaluated for overall fish health and human health concerns for West Point Lake.

METHODS AND MATERIALS

Sample Receipt and Storage:

Water and sediment samples were stored on ice and delivered to the laboratory within 1-2 days of collection. Water and sediment samples were logged into the Agricultural Services Laboratory master log. Water and sediment samples were stored in a refrigerator until extraction could be initiated.

Analysis of Water Samples:

(1) VOA: EPA Method 624; GC-MS; 60 meter megabore Volcol capillary column

(2) BNA: EPA Method 625; GC-MS; 60 meter megabore SPB-5 capillary column

(3) PESTICIDE SCREEN: Water samples (800 ml) were extracted 3 times with ethyl acetate. Extracts were combined, dehydrated with sodium sulfate, and concentrated on a rotary evaporator. The extract was made to a final volume of 2 ml for GLC-EC and GLC-FPD analysis.

(4) METAL ANALYSIS:

	Digestion Method		EPA Method
Element	Water[1]	Sediment	Method
As	None	Wet ash ($HNO_3/HClO_4$)	Atomic absorption (Hydride)
Se	Acid	Wet ash ($HNO_3/HClO_4$)	Atomic absorption (Hydride)
Hg		Wet ash ($HNO_3/HClO_4$)	Cold Vapor
Cd	None	Wet ash ($HNO_3/HClO_4$)	200.7
Cr	None	Wet ash ($HNO_3/HClO_4$)	200.7
Pb	None	Wet ash ($HNO_3/HClO_4$)	200.7
Ni	None	Wet ash ($HNO_3/HClO_4$)	200.7
Zn	None	Wet ash ($HNO_3/1HClO_4$)	200.7
Cu	None	Wet ash ($HNO_3/HClO_4$)	200.7
Sb	None	Wet ash ($HNO_3/HClO_4$)	200.7
Be	None	Wet ash ($HNO_3/HClO_4$)	200.7
Fe	None	Wet ash ($HNO_3/HClO_4$)	200.7
Mn	None	Wet ash ($HNO_3/HClO_4$)	200.7
Ag	None	Wet ash ($HNO_3/HClO_4$)	200.7
Ti	None	Wet ash ($HNO_3/HClO_4$)	200.7

[1]Water Samples: Elemental analysis (Method 200.7 referenced above) was conducted directly on water samples without digestion. Arsenic and mercury levels were also determined on water samples without digestion via atomic absorption hydride and cold vapor techniques, respectively. For determination of selenium, an aliquot of water was made 3N with HCL and digested for one hour. The selenium level was determined by atomic absorption hydride method.

Analysis of Sediment Samples:

(1) VOA: EPA-RCRA Method 8010

(2) BNA: Soxhlet extraction by EPA method 3540; analysis by GC-MS using EPA 625 parameters.

(3) PESTICIDE SCREEN: Sediment samples were analyzed for chlorinated and organophosphate content as follows: Approximately 30 gm of sediment was Soxhlet extracted overnight (16 hrs) with ethyl acetate. The extract was concentrated using a rotary evaporator and made to a volume of 10 ml with ethyl acetate:toluene (75:25). Further cleanup was achieved by gel Permeation Chromatography (GPC). After GPC cleanup, the extract was concentrated and made to a final volume of 5 ml with ethyl acetate (This generated an equivalent final volume of 10 ml.). The extract was screened for chlorinated hydrocarbon content and organophosphate content as described below.

A. Organophosphate Screen: The initial ethyl acetate extract was screened for possible organophosphate content. The organophosphate analysis was conducted with a Tracor Model 222 gas chromatograph equipped with a flame photometric detector (FPD) operated in the P & S mode simultaneously. The chromatograph contained a U-shaped column (2 M X 4mm, I.D.) packed with 3% OV-1 on Chromosorb WHP. The hydrogen and air flow were optimized for maximum response and the detector temperature was 220° C. The carrier gas was nitrogen at a flow rate of 40 ml/min.

Residue levels were determined by comparison of peak height in the sample chromatogram to those of analytical standards obtained from the U.S. Environmental Protection Agency, Research Triangle Park, NC. The analytical standards included: malathion, methylparathion, ethylparathion, ethion, and carbophenothion.

B. Chlorinated Hydrocarbon Content: The extract was analyzed for toxaphene (chlorinated hydrocarbon) content using a Tracor Model 222 gas chromatograph equipped with a Ni^{63} electron capture detector and a 2 M X 4 mm I.D. glass column packed with 3% OV-

1 on Chromosorb WHP. The detector, inlet, and column temperatures were 350, 250, and 200°C, respectively. The carrier and purge gases were 5% methane/95% argon, with a flow rate of 45 ml/min and 10 ml/min, respectively.

Residue levels were determined by comparison of peak height in the sample chromatogram to those of analytical standards obtained from the U.S. Environmental Protection Agency, Research Triangle Park, NC.

(4). METAL ANALYSIS: Wet ashing of sediments (modified AOAC method 975.03.B.b.(1988)): A 1 gm sample was transferred to a 150 ml Pyrex beaker. HNO_3 (10ml) was added, and the sample was allowed to soak thoroughly. Five ml of 60% $HClO_4$ was added and the sample was heated on a hot plate (slowly at first) until frothing ceased. The sample was heated until HNO_3 was almost evaporated. Ten milliliters of HNO_3 was added and the sample was heated to white fumes. The sample was allowed to cool, 10 ml HCL (1+1) was added, and the sample was made to volume in a 100 ml volumetric flask. Elemental analysis was conducted using an ICP spectrophotometer. The As and Se levels were determined by Atomic Absorption Sodium Borohydride reduction. Hg samples (ca 1 gm) were digested in nitric sulfuric acid (10:5) for approximately 1 hr on a hot plate. The sample was analyzed by atomic absorption cold vapor technique.

(5). NITROGEN ANALYSIS: Total kjeldahl nitrogen was determined by AOAC Method 976.05, Official Methods of Analysis of the Association of Official Analytical Chemist, 15th Edition, 1990. Nitrogen was determined from frozen samples in November, 1992.

Analysis of Fish Samples:

The organic pesticide and heavy metal screens were conducted on ground filet composites and whole fish composites from each station. One filet from each of six fish in a composite sample was ground together, using a Hobart meat grinder (2 passes). A 200 gm subsample was taken for pesticide and heavy metal analysis and the remaining ground filet sample was added back to the remaining whole fish. The whole fish sample was ground (2 passes) through a Hobart meat grinder and a 200 gm portion of the ground whole fish sample was retained for analysis. Fish were scaled prior to fileting.

Approximately 30 grams of fish sample was homogenized in a Waring blender for 2 minutes with sodium sulfate. The extract was vacuum filtered using a Buchner funnel and the filter cake was re-extracted with an additional 100 ml of extraction solvent and filtered. The combined extracts were concentrated using a rotary evaporator and made to volume of 10 ml with ethyl acetate:toluene (75:25). Additional cleanup was achieved by Gel Permeation Chromatography (GPC). After GPC cleanup, the extract was concentrated and made to a final volume of 5 ml with ethyl acetate (This generated an equivalent final volume of 10 ml). The extract was screened for chlorinated hydrocarbon content and organophosphate content as described under sediment analysis.

Metal Analysis: Wet ashing of filet and whole fish samples (modified AOAC method 975.03.B.b.(1988)): A 1 gm sample was transferred to a 150 ml Pyrex beaker. HNO_3 (10ml) was added, and the sample was allowed to soak thoroughly. Five ml of 60% $HClO_4$ was added and the sample was heated on a hot plate (slowly at first) until frothing ceased. The sample was heated until HNO_3 was almost evaporated. Ten milliliters of HNO_3 was added and the sample was heated to white fumes. The sample was allowed to cool, 10 ml HCL (1+1) was added, and the sample was made to volume in a 100 ml volumetric flask. Elemental analysis was conducted using an ICP spectrophotometer. The As and Se levels were determined by Atomic Absorption Sodium Borohydride reduction. Hg samples (ca 1 gm) were digested in nitric sulfuric acid (10:5) for approximately 1 hr on a hot plate. The whole sample was analyzed by atomic absorption cold vapor technique.

Fish Health Assessment:

Twelve to fifteen largemouth bass and common carp were collected from six sites along West Point Lake. The sites were positioned at various intervals along the lake. The site at the U.S. Hwy-27 bridge (Station 1) was selected to evaluate fishes from the Chattahoochee River immediately before the main impoundment area. New River, Yellowjacket Creek, and

Wehadkee Creek flow into West Point Lake and fish were collected at embayment areas. The final site, West Point Dam forebay, was chosen to evaluate the water quality prior to discharge and possible clearance of contaminants by water impoundment.

Fishes were collected by electroshocking boat and were transported in a live well to minimize handling stress. At the shore fishes were anesthetized with MS-222, weighed, and measured. Blood samples were obtained via puncture of the caudal vein. Microhematocrit tubes were filled immediately and stored in a cooler on ice. The remaining blood samples were also kept cool for later processing. When a sufficient number of hematocrit tubes were collected, they were centrifuged at 12,000 rpms for 5 minutes.

Immediately after withdrawal of blood, fishes were euthanized by an overdose of MS-222 and necropsied using the Goede and Barton (1990) fish health/condition profile. Fish tissues were classified according to color, texture, or level of pathological condition. A complete listing of the necropsy classifications as done in the field is given in Table 1. During the necropsy, samples of liver, spleen, head kidney, hind kidney, and gill were preserved in 10% buffered formalin for later histopathological assessment. The first six fish of each species from each site were reserved for contaminant analysis, wrapped in aluminum foil, and stored on ice for later processing.

After necropsies were completed, the hematocrits and leucrocrits were read and recorded. Approximately six to eight hours after collection blood samples were centrifuged to obtain serum samples. Serum was removed, placed into individual vials and stored on ice for later determination of serum protein.

Serum protein concentration was determined using the biuret method (Gornall et al., 1949). Total protein reagent and protein standards were obtained from Sigma Diagnostics. One ml of reagent and 0.02 ml plasma were mixed and delivered as 0.1 ml aliquots into 4 wells of a 96-well flat-bottomed microplate. A 0.1 ml aliquot of a mixture of 1 ml reagent and 0.02 distilled water was used as a blank. The mixtures were incubated for 10 minutes then read on a BT2000 Microkinetics reader using a 540 nm filter. A standard curve was developed from the given standards and serum protein concentrations calculated from the curve.

Results from the necropsy and blood analysis were entered into a computer program designed to calculate an index of fish health. The original program presents data as percentage of fishes with pathological conditions (Goede and Barton, 1990). The program has been modified for warmwater fishes and a health assessment index (HAI) is generated for each fish (Adams and Greely, Jr., 1991). A value of zero is given to normal variables. Pathological conditions are given a 30 or values ranging from 10 to 30 depending on the severity of the condition (Table 2). The values are summed for each fish thus rendering the HAI. A completely normal fish would have a HAI of zero. Increasing HAI's indicate a more severe or stressed condition.

Statistical comparisons of length, weight, condition factor, hematocrit, leucocrit, serum protein, and HAI were made between sample sites and sample dates using SAS (1985) multivariate ANOVA (proc glm). Correlations between HAI and length were determined using the Pearson correlation coefficients (proc corr, SAS 1985).

HAI for common carp was calculated in the presence and absence of hematological parameters. During the course of the study, both hematocrit and serum protein values averaged below values considered normal for the model. Although addition of hematological parameters did increase the HAI, this was not found to be significant. The increase in HAI also did not alter the patterns between sample sites or dates.

RESULTS AND DISCUSSION

Water Samples:

Water samples collected from all eight stations during the three sampling periods contained no measureable concentrations of volatile organic compounds (VOAs), base/neutral/acid semi-volatiles (BNAs), metals and pesticides (Table 2). The GC-MS total ion chromatographic tracing contained no unidentified components. Appendix 2 provides a list of analities tested and detection limits.

Mercury was detected in a number of samples and results are detailed in Table 3. Fall 1990 samples from the New River and Yellowjacket Creek stations contained mercury levels above the detection limit. Spring 1991 water samples from five of the eight stations contained mercury at levels above the detection limit of the analytical procedures used in this study. Concentrations of mercury from this sampling period ranged from less than 0.4 ppb to 1.46 ppb. The New River and 219 Bridge samples contained the highest levels of mercury at 1.46 ppb. Water samples collected in Fall 1991 did not contain mercury levels above the detection limit. The mercury concentrations documented in this study were in excess of the Georgia water quality standard for aquatic life of 0.012 ppb.

Sediment Samples:

Sediment samples collected in all three periods contained no measurable concentrations of VOAs, BNAs, and pesticides. The exceptions being sediments from U.S. Highway 27 bridge and New River which contained detectable levels of polynuclear aromatic compounds (PNA's) indicative of possible industrial activity. The most common PNA's found were pyrene, fluroanthene, and benzopyrene. Nitrogen concentrations were determined for Fall 1990 and Fall 1991. Concentrations ranged from 134-569 ppm and are detailed in Table 7. Phosphorus levels were determined for all three sampling periods. The mean phosphorus level was 309 ppm and concentrations ranged from 20-868 ppm. Most Georgia Piedmont lakes are mesotrophic with a mean total phosphorus level of 300-400 ppm. Sediments from the fertilized fish pond at Rock Eagle 4-H Camp, Eatonton, Georgia contain a mean total phosphorus level of 737 ppm (data of Dr. R. Rashke, EPA, Athens, Georgia). Appendix 3 provides a list of analities and detection limits. Those parameters detected are detailed in Tables 4-8. There are no Federal or State standards for sediments.

Fish Samples:

Pesticide and heavy metal residue levels for whole fish and filets are summarized in Appendix 4, Tables 9-14. Federal guidelines for toxic substances in fish tissue apply to filets only. There are no guidelines for whole fish. Whole fish were analyzed to provide information on the overall body burden of the fish. This information was utilized in assessing fish health. Mercury was detected in whole fish and filets from several sampling stations (Tables 11-12). However, all values were below the EPA guidelines. Residues of PCB, chlordane, pentachloroanisole, and DDT metabolites were detected (Tables 11-12). PCB's (primarily Arachlor 1260) were detected, but all PCB levels were below the Food and Drug Administration (FDA) 2.0 ppm action level. Table 13 provides mean concentrations for detected contaminants.

Table 14 summarizes the results of human health concerns in relation to fish consumption. Levels of metal concentrations and lipophilic organochlorine compounds in filet tissue showed some variation between seasons and species. Metal concentrations in filet tissue tended to be higher in Spring, with the exception of zinc. Concentrations of lipophilic organochlorine compounds tended to be higher in Fall. Chromium, zinc and organics (PCB's, chlordane and DDT metabolites) tended to higher in carp filets than bass. Although mean values did not exceed the FDA action levels for bass or carp, some individual samples of carp filets did exceed the action level for chlordane. Compared to U.S. EPA guidance levels, values for arsenic, PCB and chlordane exceeded guidance values for $1x10^{-6}$ risk in bass and carp filets. DDT exceeded the 10^{-6} criteria only in carp filets. PCB levels in both bass and carp filets exceeded the criteria at the 10^{-4} risk level. Therefore, PCB's represent the greatest concern for long term exposure.

Fish Health Assessment:

The results of fish health assessment are listed in Appendix 5. Common carp and largemouth bass were collected from 4 sites in Fall 1990 and 6 sites in Fall and Spring 1991. Histopathology was not conducted on fish from Fall 1990. This collection was treated as a practice run for the fish health assessments. Hence, discussion of the data collected focuses on Fall and Spring of 1991. The fish health data collected during Fall 1990 is available in Appendix 5. A necropsy classification code is outlined in Table 15 and Table 16 and provides the designations and substituted values for fish health conditions. Tables 17 and 18 provide a summary of all the data collected during the fish health assessment. Data sheets provided in Appendix 5 also give a compilation of the data, percentages of male and female collected, and percentages of fish showing individual abnormalities. Although an attempt was made to limit variation in fish lengths, differences were found among sites in all but the largemouth bass Spring 1991 sample. Weights were likewise different in most samples. A correlation test (proc corr, SAS,1985) did not find significant correlations between lengths and any other measurements. Therefore the differences in mean lengths should not bias any results.

The majority of fish collected appeared grossly to be in relatively good health. No emaciated or deformed fish were found. Nor were any fish observed with large ulcerated lesions, extensive fin rot, or fin or tail erosion. External lesions noted such as reddening of the fins, small pinpoint hemorrhages on the ventral body surface and some nodules on the fins were considered minor, certainly not life threatening, and often due to external parasites.

There were significant differences observed between some sites for individual measurements such as condition factor, hematocrit, leucocrit and serum protein. Condition factor (Ktl) is often used to compare stressed vs. non-stressed fishes (Barnes et al., 1984). It is basically a measure of the plumpness of a fish expressed as weight/length^3 (Carlander, 1977). The condition factor calculated by the fish health/condition profile was similar between Fall and Spring 1991 for some sites in both bass and carp. When variation was observed between seasons, the Spring Ktl values were lower than the Fall, perhaps reflecting reproductive condition or the fact that they have just come out of the winter/low temperature period. There is no agreement in the literature as to whether there are seasonal cycles in condition factor or plumpness of largemouth bass (Carlander, 1977). At least one study has suggested seasonal changes in condition factors are related to weights of the stomach contents, at least in small fish (Kramer and Smith, 1960). Another study found the mean condition factors to be higher during the spawning season for age III and IV bass (Zweiacker, 1972).

In order to achieve some comparison of the condition of West Point Lake bass to other systems mean relative weights were calculated from the various sites during the two seasons. Relative weight compares the actual weight of a bass with a standard weight for that particular size. It has been reported that a mean relative weight of 95-100 indicates a balanced population in satisfactory condition. Relative weights well below 100 indicate problems exist in food and feeding relationships (Wege and Anderson, 1978). Bass collected during the Spring had mean relative weights of 98 to 110 at the first five sites. Only fish collected at the Dam had a mean relative weight of 92. During the Fall, mean relative weights ranged from 96 to 110. Hence, by this means of evaluation the fish appeared relatively healthy.

Hematocrit values represent the packed cell volume of red blood cells in a given blood sample. Stress has been shown to affect hematocrits which may be increased or decreased depending on the type of stress involved (Novotny and Beeman, 1990). Season also affects hematocrit values in a number of fish species. In this study bass hematocrits varied as a result of season with Spring measurements being lower than Fall at all but one site (Fig. 1). Common carp hematocrits were much more similar between season, with the exception of one site Spring measurements were still lower (although not significantly) than Fall (Fig. 2).

Leucocrit is a measure of the white blood cell volume. The response of white blood cells to stress also varies greatly with the type of stress (Blaxhall, 1972). White blood cell number may increase with infection (Wedemeyer et al., 1990). The leucocrits of bass in this study varied greatly but with no apparent pattern (Fig. 3). Carp leucocrits showed a consistent difference between season (except at Station 1, U.S. Hwy 27) with Spring samples having higher values (Fig. 4).

Serum protein values are influenced by stress, temperature, sex, and nutritional status (Goede and Barton, 1990). Lockhart and Metner (1984) showed that low protein levels are associated with lowered energy stores. In this study, for both carp and bass, the serum protein values tended to be more consistent from site to site in the Fall (Fig. 6 and 7). During the Spring sample, fish of both species collected at the New River Embayment site had the lowest serum protein levels and increased as one progressed toward the Dam. Carp had consistently lower serum protein values than bass, in many cases below the "normal" range. However, other reports in the literature (Van Vuren and Hattingh, 1978) indicate this may be normal for carp.

In wild fish it is difficult, if not impossible to determine of what value variations in blood parameters such as hematocrit, leucocrit and serum protein are in determining "fish health". Sex, age, water temperature, oxygen level, presence or absence of infectious disease, nutritional status, and time after last meal, are only a few of the factors which may affect one or more of these parameters. Even in most cultured fish, fish pathologists do not use these clinical methods to evaluate fish health because there is not enough background data for most species to determine 1) what are acceptable ranges and 2) what does it mean if a value is above or below that range.

The overall fish condition assessment (HAI) incorporates blood parameters as well the gross observations of a number of organs. The program used was the modification developed for warmwater fish populations. This modification gives conditions numerical values (Table 16). Because of variability in the blood parameters measured - hematocrit, leucocrit and plasma protein, particularly in the common carp the data were analyzed with and without blood parameters (Tables 17 and 18).

The spring sample showed no significant difference in HAI for either largemouth bass or common carp (Tables 19 and 20). This was true regardless of blood parameter status.

Significant differences in mean HAI were found between sites for the Fall samples of both largemouth bass and common carp when data was analyzed without the blood parameters. The Fall 1991 bass sample indicated that the dam site was significantly higher than all other sites, except LaGrange intake which was intermediate (when hematological parameters were included in the analysis). These differences are primarily due to increased serum protein levels at the Dam site and LaGrange Intake. The significantly higher HAI values for bass from the Dam site without the hematological parameters is primarily due to a higher parasite load and the pathological indication in the kidney. Histologically, evidence of helminths and the myxosporidian parasite were determined to be the causes of these lesions. The bass HAI values did not change significantly from one season to another (Fig. 8, presented as HAI with hematological values included).

The Fall 1991 common carp sample analyzed without hematological values, showed a lower mean index value for the Yellowjacket creek site and a higher HAI value at Station 1, with the other sites being intermediate. The Yellowjacket site carp all had normal spleens and a majority had normal kidneys. Carp from Station 1 had a majority of abnormal kidneys, and a number of abnormal spleens and livers. It is evident (Figure 9) that a somewhat similar pattern occurred in the carp health index during both Fall and Spring. It is also evident that carp caught in the Fall were in poorer health at all sites when compared to Spring. This difference is primarily due to an increase in abnormal gills and kidneys in the Fall. A preliminary histological evaluation indicates that the pale gills observed during the Fall had mucus proliferation and an increase in eosinophils (an inflammatory cell). Kidneys given the OT (other) designation can best be described as appearing "velvety". Histologically this appears to be due to an increase in inflammatory cells in the interstitial tissue of the kidney and an increase in ceroid deposition.

Correlation analyses were run for health parameters and contaminants found in both tissues and sediments during the Fall 1991 sample (Tables 21 and 22). As can be seen in these tables, a number of contaminants did show moderate correlation with individual contaminants. The only two which showed a high correlation were tissue PCB levels and the liver somatic index.

The fish health assessment technique was first developed for the monitoring of fishes in culture facilities (Novotny and Beeman, 1990). Other studies involving the use of this fish health assessment have concentrated on trout and salmon populations in the western and northwestern United States (Goede and Barton, 1990). Although this technique has been modified for largemouth bass and other warmwater fishes, this study indicates that further refinement may be necessary for other fish species such as common carp. For example, the blood parameters as previously discussed. In addition, it is obvious that liver color and consistency differ greatly among fish species. Again, although many "pathological" conditions were noted in the liver of both carp and bass it is questionable whether these are really problems. A "coffee and cream" or fatty liver may be perfectly normal for some species during some times of the year. A mottled liver may represent differential storage of glycogen or fat by different portions of the liver in some species.

A similar fish health/condition assessment done by Adams and Greeley, Jr (1991) showed much neater results. In that study 3 sites (2 contaminated and 1 reference) were examined in Lake Hartwell. Thirty largemouth bass from each site were examined. A clear correlation between PCB levels in fish flesh and HAI values was found. However, the three sample sites from the Adams and Greeley study were chosen according to previous indications of contamination and there were no seasonal comparisons. The West Point Lake study chose six sites representing locations throughout the lake. The HAI's generated in the Hartwell study were well below those reported in this study. However, due to the subjective nature of this health assessment method, it is difficult to compare values from one study group to another. In working with two other groups involved in this type of assessment since completing the West Point project it is obvious that different researchers have varying perceptions of conditions such as "mottled" or "coffee and cream" livers, as well as for pale gills etc. In this study, the HAI's were higher because the investigators were more stringent on what was normal, not because the fish were in worse shape.

The majority of pathological conditions contributing to HAI values for largemouth bass came from gills, liver, and parasite load. The main conditions contributing to HAI values for common carp were gills, kidney, and liver. Largemouth bass had a much higher, grossly visible, parasite load than common carp.

Some potential fish tumors were found during the necropsy and are listed as OT in the HAI program, which gives a numerical rating of 30. Grossly four possible tumor types were found. These included liver and testicular masses, white nodules in the spleen and mesentery and a papilloma-like growth. Fall 1990, Spring 1991, and Fall 1991 incidences of suspected tumors seen grossly were 15%, 14%, and 19% for largemouth bass and 0%, 2%, and 9% for carp, respectively (Tables 23 and 24). Certain epithelial tumors (liver, pancreas, skin) have been correlated with environmental contaminants (Harshbarger and Clark, 1990). These include the papillomas and hepatocarcinomas described from a number of polluted sites. Again a preliminary histopathological evaluation indicated that known of the suspected tumors were papillomas. The papilloma-like growth was actually granulation tissue, probably from a old hook wound. At least one of the liver "tumors" appeared to be trauma induced and none of the others were advanced hepatocarcinomas. There were some actual gonadal tumors found. Epizootics of gonadal tumors have been observed in other areas but their occurrence seems unrelated to environmental pollution (Harshbarger and Clark, 1990). By far the most prevalent tumor type found in the West Point Lake fish was the lipoma - found in the spleen and mesentery of the largemouth bass. Again, this type of neoplasm has never been correlated to environmental pollution. It is speculated that both the gonadal tumors of carp and the lipomas of the bass may have a genetic basis.

A preliminary histopathological assessment indicated that many of the lesions noted grossly were due to infectious agents. For instance, pathological conditions of the kidney in bass were due primarily to the presence of digenetic trematodes, microsporidia and myxosporidia parasites. The observations on parasites and tumors raise a number of questions. First is the level of parasitism we observed affecting the overall health and survival of the fish? Second, the lipomas observed a problem to the fish? Particularly if they are benign growth which do not invade or destroy other tissues.

CONCLUSIONS

1. Water, sediment, and fish samples were collected in Fall 1990 and Spring and Fall of 1991 for toxic substream analyses. Additional fish were collected for fish health assessment.

2. Three sets of water samples collected from eight locations in West Point Lake were analyzed for 115 toxic substances including volatile organic compounds, base/neutral/acid semi-volatiles, metals and pesticides. Mercury was the only substance detected in water samples.

3. Mercury was detected in seven of twenty water samples with a range of 0.18 ppb to 1.46 ppb. This concentration of mercury in water samples is in excess of the Georgia water quality standard of 0.12 ppb.

4. Three sets of sediment samples collected from eight locations in West Point Lake were analyzed for 115 toxic substances. Substances documented at levels greater than detection limits in sediments included As, Se, Hg, Cd, Cr, Ni, Cu, Pb, Zn, phthalates, pyrene, fluoranthene, and benzophyrene. Nitrogen was detected at levels ranging from 134-569 ppm. Phosphorus levels ranged from 20-868 ppm with a mean value of 309 ppm which falls within the mean total phosphorus level (300-400 ppm) found in most Georgia Piedmont lakes. There are no Federal or State standards for sediment concentrations.

5. Fish were collected from six locations in West Point Lake for testing. Largemouth bass and common carp were the target species. A total of 18 composites of six fish of each species were collected and tested for 34 toxic substances. As, Se, Hg, Cr, Cu, Pb, Ni, Zn, PCB, chlordane, PCA, and DDT were detected. Concentrations of these substances were compared to FDA action levels and EPA guidance levels for fish filets to assess human consumption risks. PCB's (primarily 1260) were detected in fish filets below the FDA action level but in excess of the EPA 10^{-4} risk level. Chlordane was detected in fish filets in excess of the FDA action level and EPA 10^{-4}, 10^{-5}, and 10^{-6} risk levels. Other substances detected were below Federal guideline levels where guidelines are available.

6. Additional largemouth bass and carp were collected for fish health assessment. In general, fish appeared healthy. It is the researchers opinion that the method employed to determine fish health may not be sensitive enough for the relatively low level pollution observed

at West Point Lake. None of the gross lesions observed appeared to be life-threatening or to be severely compromising the fish. No ulcerations, open sores, deformities, fin rot, or emaciated fish were observed. The only strong correlation between contaminant level and a measured response was the positive correlation between PCB levels and liver/somatic index. This should be further examined histologically to try to determine the reason. More research is necessary to a) identify the parasites observed; b) determine their life cycles and what factors such as organic load, presence or absence of various intermediate hosts etc may play in the prevalence we observed; c) determine if immunosuppression caused by chronic levels of environmental contaminants may increase that prevalence and d) use the quantification of histopathological findings (as recently described by Reimschussel et al., 1992) to try to correlate tissue contaminant levels to certain findings. In addition, use image analysis to quantify parasite density, macrophage aggregate numbers and size (Wolke, 1992), and amount of liver glycogen and fat etc.

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APPENDIX 1. Sampling Catalogue and Map Of Locations

TABLE 1: SAMPLING CATALOGUE

Preliminary samples (water, sediment and fish) were collected from 4 stations on Westpoint Reservoir during the Fall of 1990 as follows:

			WATER	SEDIMENT
STATION	LOCATION	DATE	LAB #	LAB #
1	27 BRIDGE	11/7/90	8732	8733
2	NEW RIVER EMBAYMENT	11/7/90	8734	8735
3	LAGRANGE INTAKE	11/8/90	8736	8737
4	YELLOWJACKET CREEK	11/8/90	8738	8739

*Fish samples were lost in a freezer outage.

Spring 1991 sampling (water, sediment, and fish) were collected from 8 stations on the West Point Reservior during March and April as follows:

Location	Date	Lab Number		
		WATER	SEDIMENT	FISH
127 Bridge	3/25/91	2034	2039-41	3956-57 (Bass)
				3958 (Carp)
219 Bridge	3/27/91	2035	2042-44	
LaGrange Intake	3/20/91	2036	2045-47	3990 (Carp)
New River	3/27/91	2037	2048-50	3992 (Bass)
				4008 (Carp)
109 Bridge	3/21/91	2038	2051-53	
Dam (West Point)	4/11/91	2145	2148-50	3811 (Bass)
				3849 (Carp)
				3850 (Carp)
Yellowjacket Creek	4/11/91	2146	2151-53	3991 (Bass)
				3813 (Carp)
Wehadkee Creek	4/11/91	2147	2154-56	3812 (Bass)
				3851 (Carp)

TABLE 1 (continued).

Fall 1991 WATER samples were collected from 8 stations on West Point Reservoir as follows:

Location	Lab No.	VOA No.	BNA Number	Metals Number
LaGrange	6297	6298	6299	6300
New River	6305	6306	6307	6308
27 Bridge	6313	6314	6315	6316
Yellowjacket Creek	6321	6322	6323	6324
219 Bridge	6329	6330	6331	6332
109 Bridge	6337	6338	6339	6340
Dam (West Point)	6345	6346	6347	6348
Wehadkee Creek	6353	6354	6355	6356

Fall 1991 SEDIMENT samples were collected from 8 stations on West Point Reservoir as follows:

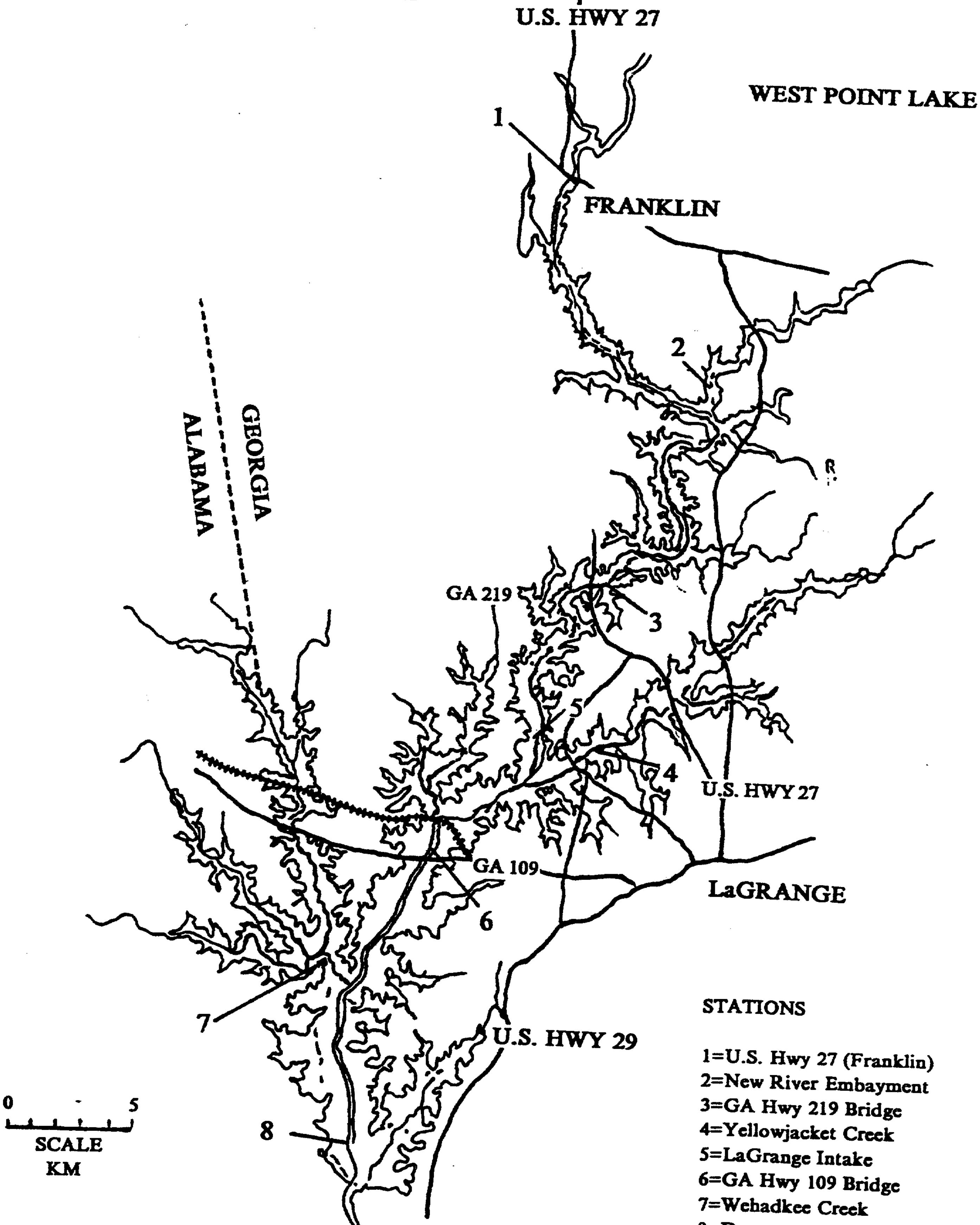
Location	Lab No.	VOA No.	BNA Number	Metals Number
LaGrange	6301	6302	6303	6304
New River	6309	6310	6311	6312
27 Bridge	6317	6318	6319	6320
Yellowjacket Creek	6325	6326	6327	6328
219 Bridge	6333	6334	6335	6336
109 Bridge	6341	6342	6343	6344
Dam (West Point)	6349	6350	6351	6352
Wehadkee Creek	6357	6358	6359	6360

TABLE 1. (continued):

Fall 1991 FISH samples were collected from 8 stations on West Point Reservoir as follows:

Location	Lab No.	Species	Fillet/Whole Fish
LaGrange	815	Bass 1-6	Fillet
LaGrange	816	Bass 1-6	Whole Fish
U.S. Hwy 27	817	Carp 1-6	Fillet
U.S. Hwy 27	818	Carp 1-6	Whole Fish
U.S. Hwy 27	819	Bass 1-6	Fillet
U.S. Hwy 27	820	Bass 1-6	Whole Fish
New River	821	Carp 1-6	Fillet
New River	822	Carp 1-6	Whole Fish
New River	823	Bass 1-6	Fillet
New River	824	Bass 1-6	Whole Fish
Wehadkee Creek	964	Carp 1-6	Fillet
Wehadkee Creek	965	Carp 1-6	Whole Fish
Yellowjacket Creek	966	Carp 1-6	Fillet
Yellowjacket Creek	967	Carp 1-6	Whole Fish
Yellowjacket Creek	968	Bass 1-6	Fillet
Yellowjacket Creek	969	Bass 1-6	Whole Fish
Dam Site	970	Bass 1-6	Fillet
Dam Site	971	Bass 1-6	Whole Fish
Dam Site	972	Carp 1-6	Fillet
Dam Site	973	Carp 1-6	Whole Fish
Wehadkee Creek	974	Bass 1-6	Fillet
Wehadkee Creek	975	Bass 1-6	Whole Fish
LaGrange Intake	976	Carp 1-6	Fillet
LaGrange Intake	977	Carp 1-6	Whole Fish

MAP OF STATIONS



APPENDIX 2. Parameters and Detection Limits for Water Samples

TABLE 2. WEST POINT RESERVOIR WATER SAMPLES: Water samples collected in Fall 1990, Spring 1991 and Fall 1991 were found to contain no detectable quantities of the listed analities.

Organic Compounds:	Detectability Limit(ppb)
Pesticides	
Aldrin	0.01 μg/l
α-BHC	0.01
β-BHC	0.01
δ-BHC	0.01
γ-BHC	0.01
Chlordane	0.10
4,4-DDD	0.02
4,4-DDE	0.01
4,4-DDT	0.02
Dieldrin	0.01
Endosulfan I	0.02
Endosulfan II	0.03
Endosulfan Sulfate	0.05
Endrin	0.02
Endrin Aldehyde	0.05
Heptachlor	0.01
Heptachlor Epoxide	0.01
Toxaphene	0.3
PCB-1016	0.3
PCB-1221	0.3
PCB-1232	0.3
PCB-1242	0.3
PCB-1248	0.3
PCB-1254	0.3
PCB-1260	0.3
Methoxychlor	0.3
HCB	—
Mirex	0.07
Pentachloroanisole	—
Chlorpyrifos	—

TABLE 2: WEST POINT RESERVOIR WATER SAMPLES (continued): Water samples collected in the Fall 1990, Spring 1991 and Fall 1991 were found to contain no detectable quantities of the listed analities.

Base/neutral/acid semi-volatile extraction

Organic Compounds:	Detectability Limit (ppb)
Acenaphthene	10
Acenaphthylene	10
Anthracene	10
Benzo(a)Anthracene	10
Benzo(a)Pyrene	10
Benzo(b)Fluroanthene	10
Benzo(GHI)Perylene	10
Benzo(K)Fluoranthene	10
Bis(2-Chloroethoxy)Methane	10
Bis(2-Chloroethyl)Ether	10
Bis(2-Chloroisopropyl)Ether	10
Bis(2-Ethylhexyl)Phthalate	10
4-Bromophenyl Phenyl Ether	10
2-Chloronaphthalene	10
4-Chlorophenyl Phenyl Ether	10
Crysene	10
1,2-Dichlorobenzene	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
Diethyl Phthalate	10
Dimethyl Phthalate	10
Di-N-Butyl Phthalate	10
Di-N-Octyl Phthalate	10
2,4-Dinitrotoluene	10
2,6-Dinitrotoluene	10
Fluoranthene	10

TABLE 2: WEST POINT RESERVOIR WATER SAMPLES (continued): Water samples collected in the fall 1990, Spring 1991 and Fall 1991 were found to contain no detectable quantities of the listed analities.

Organic Compounds:	Detectability Limit (ppb)
Fluorene	10
Hexachlorobenzene	10
Hexachlorobutadiene	10
Hexachloroethane	10
Ideno(1,2,3-CD)Pyrene	10
Naphthalene	10
N-Butyl Benzyl Phthlate	10
Nitrobenzene	10
N-Nitrosodiphenylamine	10
Phenanthrene	10
Pyrene	10
1,2,4-Trichlorobenzene	10
2,-Chlorophenol	10
2,4-Dichlorophenol	10
2,4-Dimethylphenol	10
2,4-Dinitrophenol	100
2-Nitrophenol	10
4-Nitrophenol	25
Pentachlorophenol	25
Phenol (single compound)	10
2,4,6-Trichlorophenol	10
Volatile organic analysis	
Bromoform	1
Carbon Tetrachloride	1
Chlorobenzene	1
Chlorodibromomethane	1
Chloroform	1
Cis-1,3-Dichloropropene	1
Dichlorobromomethane	1
1,1-Dichloroethane	1
1,2-Dichloroethane	1
1,1-Dichloroethylene	1

TABLE 2: WEST POINT RESERVOIR WATER SAMPLES (continued): Water samples collected in the fall 1990, Spring 1991 and Fall 1991 were found to contain no detectable quantities of the listed analities.

Organic Compounds:	Detectability Limit (ppb)
1,2-Dichloropropane	1
Ethylbenzene	1
Methylene Chloride	10
Styrene	1
1,1,2,2-Tetrachloroethane	1
Tetrachloroethylene	1
Toluene	1
1,2-Trans-Dichloroethylene	1
1,3-Dichloropropene	1
1,1,1-Trichloroethane	1
1,1,2-Trichloroethane	1
Trichloroethylene	1
Trichlorofluoromethane	1
Vinyl Chloride	5
O-Xylene	1
Metals	
Antimony	10
Arsenic	0.4
Beryllium	10
Cadmium	4
Chromium, Total	7
Copper	6
Lead	20
Nickel	15
Selenium	0.33
Silver	7
Thallium	60
Zinc	2

NOTES FOR TABLE 2:

Samples were not collected from the following locations in the fall of 1990: 219 Bridge, 109 Bridge, Dam or Wehadkee Creek.

The following organic compounds were inadvertently omitted from the VOA and BNA water sample analysis since they are not included in EPA Method 624,625: 1,2 diphenylhydrazine, 4,6 dinitro-o-cresol, parachloro-meta-cresol, acetone, acrylonitrile, carbon disulfide, 2-hexanone, isopropyl acetate,methyl-ethyl-ketone and methyl-isobutyl-ketone. The GC-MS total ion chromatographic tracing contained no unidentified components.

The following metals were not determined on samples collected in the FALL 1990: Sb, Be, Ag or Tl.

TABLE 3: WEST POINT RESERVOIR WATER SAMPLES:

Results of Hg analysis conducted on water samples collected in Fall 1990, Spring 1991, and Fall 1991.

LOCATION	MERCURY ANALYSIS ON WATER SAMPLES (ppb)		
	FALL 1990	SPRING 1991	FALL 1991
LaGrange Intake	<.04	1.17	<0.4
New River	0.18	1.46	<0.4
27 Bridge	<.04	0.88	<0.4
Yellowjacket Creek	0.14	<0.4	<0.4
219 Bridge	N.A.	1.46	<0.4
109 Bridge	N.A.	0.60	<0.4
Dam	N.A.	<0.4	<0.4
Wehadkee Creek	N.A.	<0.4	<0.4

*N.A. = Not Analyzed

APPENDIX 3. Parameters and Detection Limits for Sediment Samples

TABLE 4: WEST POINT RESERVOIR SEDIMENT SAMPLES: Sediment samples collected in the Fall 1990, Spring 1991 and Fall 1991 were found to contain no detectable quantities of the listed analities.

Compound	Detectability Limit
ORGANIC COMPOUNDS	
VOLATILES	
Benzene	5
Bromoform	5
Carbon tertachloride	3
Chlorobenzene	6
Chlorodibromomethane	3
Chloroform	2
Cis-1,3-Dichloropropene	5
Dichlorobromomethane	3
1,1-Dichloroethane	3
1,2-Dichloroethane	3
1,1-Dichloroethylene	5
1,2-Dichloropropane	6
Ethylbenzene	8
Methylene Chloride	5
1,1,2,2-Tetrachloroethane	7
Tetrachloroethylene	5
Toluene	6
1,2-Trans-Dichloroethylene	5
Trans-1-3,-Dichloropropene	5
1,1,1-Trichloroethane	4
1,1,2-Trichloroethane	5
Trichloroethylene	5
Trichlorofluoromethane	10
Vinyl Chloride	10
O-Xylene	10

TABLE 4: WEST POINT RESERVOIR SEDIMENT SAMPLES: Sediment samples collected in the Fall 1990, Spring 1991 and Fall 1991 were found to contain no detectable quantities of the listed analities.

Compound	Detectability Limit (ppb)
ORGANIC COMPOUNDS	
PESTICIDES	
Aldrin	1
γBHC	1
δ-BHC	1
Chlordane	5
4,4-DDD	2
4,4-DDE	1
4,4-DDT	2
Dieldrin	2
Endosulfan I	2
Endosulfan II	3
Endosulfan Sulfate	5
Endrin	2
Endrin Aldehyde	5
Heptachlor	1
Heptachlor Epoxide	1
Toxaphene	20
PCB-1016	6
PCB-1221	6
PCB-1232	6
PCB-1242	6
PCB-1248	6
PCB-1254	6
PCB-1260	6
Methoxychlor	10
HCB	1
Pentachloroanisole	–
Chlorpyrifos	2
METALS	
Antimony	3 mg/kg
Beryllium	1 mg/kg
Silver	1 mg/kg
Thallium	5 mg/kg

NOTES FOR TABLE 4:

Samples were not collected from the following locations in the fall of 1990: 219 Bridge, 109 Bridge, Dam or Wehadkee Creek.

The following organic compounds were inadvertently omitted from the VOA and BNA sediment analysis since they are not included in EPA Method 624,625: 1,2 diphenylhydrazine, 4,6 dinitro-o-cresol, parachloro-meta-cresol, acetone, acrylonitrile, carbon disulfide, 2-hexanone, isopropyl acetate,methyl-ethyl-ketone and methyl-isobutyl-ketone. The GC-MS total ion chromatographic tracing contained no unidentified components.

TABLE 5: WEST POINT RESERVOIR SEDIMENT SAMPLES: Results of elemental analysis conducted on sediment samples collected during the Fall 19[illegible] Spring 1991 and the Fall of 1991.

LOCATION	ELEMENTAL ANALYSIS ON SEDIMENT SAMPLES (PPM)								
	As			Se			Hg		
	FALL 1990	SPRING 1991	FALL 1991	FALL 1990	SPRING 1991	FALL 1991	FALL 1990	SPRING 1991	FALL 1991
LaGrange Intake	0.38	0.60	0.29	0.09	0.25	0.048	<.04	<0.04	<0.02
New River	1.55	1.41	0.74	0.30	0.33	0.183	0.18	0.20	<0.02
27 Bridge	1.44	2.03	1.00	0.13	0.34	0.125	<.04	0.17	0.046
Yellowjacket Creek	1.75	0.77	0.46	0.28	0.016	0.066	0.14	<0.04	<0.02
219 Bridge	NA	0.30	0.09	NA	0.075	0.048	NA	<0.04	<0.02
109 Bridge	NA	0.14	0.12	NA	0.033	0.048	NA	0.12	<0.02
Dam	NA	3.41	0.33	NA	0.26	0.22	NA	<0.04	<0.02
Wehadkee Creek	NA	0.54	1.33	NA	0.18	0.125	NA	<0.04	<0.02

The following elements were not detected in any of the sediment samples at the analytical limit of detection given in ():
Sb (3ppm), Be (1 ppm), Ag (1 ppm) and Tl (5 ppm). *N.A. = Not Analyzed

TABLE 5: WEST POINT RESERVOIR SEDIMENT SAMPLES (CONTINUED): Results of elemental analysis conducted on sediment samples collected during the Fall 1990, Spring 1991 and the Fall of 1991.

LOCATION	ELEMENTAL ANALYSIS ON SEDIMENT SAMPLES (PPM)								
	Cd			Cr			Ni		
	FALL 1990	SPRING 1991	FALL 1991	FALL 1990	SPRING 1991	FALL 1991	FALL 1990	SPRING 1991	FALL 1991
LaGrange Intake	<1.0	2.0	<1.0	16.0	12.0	6.0	<1.0	10.0	3.0
New River	<1.0	2.0	2.0	20.0	15.0	10.0	7.0	8.0	6.0
27 Bridge	<1.0	3.0	1.0	10.0	17.0	12.0	<1.0	7.0	6.0
Yellowjacket Creek	<1.0	2.0	4.0	30.0	8.0	2.0	<1.0	5.0	8.0
219 Bridge	NA	3.0	4.0	NA	13.0	13.0	NA	13.0	15.0
109 Bridge	NA	<1.0	<1.0	NA	3.0	7.0	NA	1.0	3.0
Dam	NA	3.0	4.0	NA	22.0	89.0	NA	9.0	39.0
Wehadkee Creek	NA	<1.0	4.0	NA	5.0	42.0	NA	2.0	5.0

The following elements were not detected in any of the sediment samples at the analytical limit of detection given in ():
Sb (3ppm), Be (1 ppm), Ag (1 ppm) and Tl (5 ppm). *N.A. = Not Analyzed

TABLE 5: WEST POINT RESERVOIR SEDIMENT SAMPLES (CONTINUED): Results of elemental analysis conducted on sediment samples collected during the Fall 1990, Spring 1991 and the Fall of 1991.

LOCATION	ELEMENTAL ANALYSIS ON SEDIMENT SAMPLES (PPM)								
	Cu			Pb			Zn		
	FALL 1990	SPRING 1991	FALL 1991	FALL 1990	SPRING 1991	FALL 1991	FALL 1990	SPRING 1991	FALL 1991
LaGrange Intake	32.0	7.0	4.0	59.0	32.0	12.0	45.0	45.0	15.0
New River	29.0	16.0	7.0	63.0	40.0	21.0	77.0	90.0	33.0
27 Bridge	5.0	16.0	13.0	14.0	42.0	26.0	29.0	59.0	71.0
Yellowjacket Creek	22.0	8.0	16.0	102.0	26.0	35.0	29.0	15.0	34.0
219 Bridge	NA	12.0	10.0	NA	35.0	27.0	NA	52.0	44.0
109 Bridge	NA	5.0	9.0	NA	4.0	6.0	NA	33.0	13.0
Dam	NA	18.0	12.0	NA	40.0	29.0	NA	32.0	26.0
Wehadkee Creek	NA	3.0	16.0	NA	16.0	21.0	NA	2.0	14.0

The following elements were not detected in any of the sediment samples at the analytical limit of detection given in ():
Sb (3ppm), Be (1 ppm), Ag (1 ppm) and Tl (5 ppm). *N.A. = Not Analyzed

TABLE 6: WEST POINT RESERVOIR SEDIMENT SAMPLES: Results of base/neutral/acid semi-volatile GC-MS analysis conducted on sediment samples collected during the Fall 1990, Spring 1991 and the Fall of 1991.

LOCATION	BASE/NEUTRAL/ACID SEMI VOLATILE ANALYSIS BY GC-MS (VALUES IN PPB)											
	Phthalates			Pyrene			Fluoranthene			Benzopyrene		
	Fall '91	Spring '91	Fall '91	Fall '90	Spring '91	Fall '91	Fall '90	Spring '91	Fall '91	Fall '90	Spring '91	Fall '91
LaGrange Intake	45.5	32.2	576	<10	<10	<10	<10	<10	<10	<10	<10	<12
New River	114	40	715	<10(T)	<10(T)	50	<10	<10	48	<10	<10	18
27 Bridge	<10	72	<10	<10	<10	81	<10	<10	92	<10	<10	55
Yellowjacket Creek	77.2	27.1	716	<10	<10	<10	<10	<10	<10	<10	<10	<12
219 Bridge	N.A.	48	32	N.A.	<10	<10	N.A.	<10	<10	N.A.	<10	<12
109 Bridge	N.A.	14	<10	N.A.	<10	<10	N.A.	<10	<10	N.A.	<10	<12
Dam	N.A.	<10	<10	N.A.	<10	92	N.A.	<10	101	N.A.	<10	<12
Wehadkee Creek	N.A.	34	853	N.A.	<10	<10	N.A.	<10	<10	N.A.	<10	<12

N.A. - not analyzed; (T)- material present but at levels below accurate quantitation.

Phthalates = sum of phthalates present (butylbenzylphthalate(6.0 ppb), Bis(2-Ethylhexyl)phthalate(6.0 ppb), Di-n-octylphthalate(6.0 ppb), Dimethylphthalate(4.0 ppb), Di-n-butylphthalate(6.0 ppb)). Analytica limit of detection given in().

The following BASE/NEUTRAL/ACID SEMI-VOLATILE compounds were not detected in sediment samples at a detection limit given in(): Phenol(4.0 ppb), bis(2-Chloroethy)ether(12.0 ppb), 2-Chlorophenol(8. ppb), 1,3-Dichlorobenzene(4.0ppb), 1,4-Dichlorobenzene(10.0ppb), Benzylalcohol(10.0ppb), 1,2-Dichlorobenzene(4.0ppb), 2-Methylphenol(10.0ppb), bis(2-Chloroisopropy)ether(12.0ppb), 4-Methylphenol(10. ppb), N-Nitroso-di-n-propylamine(12.0 ppb), Hexachloroethane(4.0 ppb), Nitrobenzene(4.0 ppb), Isophorone(6.0 ppb), 2-Nitrophenol(8.0 ppb), 2,4-Dimethylphenol(6.0 ppb), Benzoic acid(50.0 ppb), bis(2 Chloroethoxy)methane(12.0 ppb), 2,4-Dichlorophenol(6.0 ppb), 1,2,4-Trichlorobenzene(6.0 ppb), Naphthalene(4.0 ppb), 4-Chloroaniline(10.0 ppb), Hexachlorobutadiene(2.0 ppb), 4-Chloro-3-methylphenol(6. ppb), 2-Methylnaphthalene(10.0 ppb), Hexachlorocyclopentadiene(20.0 ppb), 2,4,6-Trichlorophenol(6.0 ppb), 2,4,5-Trichlorophenol(6.0 ppb), 2-Chloronaphthalene(4.0 ppb), Acenaphthylene(8.0 ppb), 2,(Dinitrotoluene(4.0ppb), 3-Nitroaniline(10.0ppb), Acenaphthene(4.0ppb), 2,4-Dinitrophenol(84.0ppb), 4-Nitrophenol(6.0ppb), Dibenzofuran(20.0ppb), 2,4-Dinitrotoluene(12.0ppb), Diethylphthalate(44.0ppb), 4 Chlorophenyl-phenylther(10.0 ppb), Fluorene(4.0 ppb), 4-Nitroaniline(10.0 ppb), 4,6-Dinitro-2-methylphenol(48.0 ppb), N-Nitrosodiphenylamine(4.0 ppb), 4-Bromophenyl-phenylether(4. ppb), Hexachlorobenzene(4.0 ppb), Pentachlorophenol(8.0 ppb), Anthracene(4.0 ppb), 3,3-Dichlorobenzidine(34.0 ppb), Benzo(a)anthracene(16.0 ppb), Chrysene(6.0 ppb), Benzo(b)fluoranthene(10.0 pb), Benzo(k)fluoranthene(6.0 ppb), Benzo(a)pyrene(6.0 ppb), Indeno(1,2,3-cd)pyrene(8.0 ppb), Dibenzo(a,h)anthracene(6.0 ppb), Benzo(g,h,i)perylene(10.0 ppb).

TABLE 7. WEST POINT RESERVOIR SEDIMENT SAMPLES: Results of nitrogen analysis conducted on sediment samples during the Fall 1990 and Fall 1991.

PS#	COLLECTION DATE	LOCATION	NITROGEN (PPM)
8727	11/7/90	LaGrange Intake	301
8733	11/7/90	U.S. Hwy 27 Bridge	134
8739	11/8/90	Yellow Jacket Creek	356
6302/6303	11/24/91	LaGrange Intake	214
6309/6312	11/24/91	New River	569
6317	11/24/91	U.S. Hwy 27 Bridge	400
6325	11/24/91	Yellow Jacket Creek	261
6334/6335	11/25/91	Ga. Hwy 219 Bridge	231
6342/6343	11/25/91	Ga. Hwy 109 Bridge	234
6350/6351	11/26/91	Dam	188
6358/6359	11/26/91	Wehadkee Creek	320

Total kjeldahl N was determined by AOAC Method 976.05, Official Methods of Analysis of the Assoc. of Official Analytical Chemist, 15th Edition, 1990.
Nitrogen content was determined on frozen samples in November 1992.
Note: Nitrogen concentrations for the Spring sampling period was not determined.

TABLE 8. WEST POINT RESERVOIR SEDIMENT SAMPLES: Results of phosphorus analysis conducted on sediment samples for Fall 1990, Spring 1991, and Fall 1991.

PS#	COLLECTION DATE	LOCATION	PHOSPHORUS (PPM)
8733	11/7/90	U.S. Hwy 27 Bridge	181
8735	11/7/90	New River	530
8737	11/8/90	LaGrange Intake	868
8739	11/8/90	Yellow Jacket Creek	583
2041	3/25/91	U.S. Hwy 27 Bridge	155
2044	3/27/91	Ga. Hwy 219 Bridge	437
2047	3/20/91	LaGrange Intake	163
2050	3/27/91	New River	340
2053	3/21/91	Ga. Hwy 109 Bridge	135
2150	4/11/91	Dam	108
2153	4/11/91	Yellow Jacket Creek	185
2156	4/11/91	Wehadkee Creek	20
6304	11/24/91	LaGrange Intake	154
6312	11/24/91	New River	216
6320	11/23/91	U.S. Hwy 27 Bridge	239
6328	11/25/91	Yellow Jacket Creek	657
6336	11/25/91	Ga. Hwy 219 Bridge	285
6344	11/25/91	Ga. Hwy 109 Bridge	122
6352	11/26/91	Dam	99

A 1 gm sample was transferred to a 150 ml Pyrex beaker. HNO_3 (10ml) was added, and the sample was allowed to soak thoroughly. Five ml of 60% $HClO_4$ was added and the sample was heated on a hot plate (slowly at first) until frothing ceased. The sample was heated until HNO_3 was almost evaporated. Ten milliliters of HNO_3 was added and the sample was heated to white fumes. The sample was allowed to cool, 10 ml HCL (1+1) was added and the sample was make to volume in a 100 ml volumetric flask. Elemental analysis was conducted using an ICP spectrophotometer.

NOTE: Most Georgia Piedmont lakes are mesotrophic with mean total P levels of 300-400 ppm. Sediments from the fertilized fish pond at Rock Eagle 4-H Camp, Eatonton, GA contain a mean total P level of 737 ppm (data of Dr. R. Rashke, EPA, Athens, GA).

APPENDIX 4. Complete Data Sets for Whole Fish and Filet Fish Samples

TABLE 9: WEST POINT RESERVOIR WHOLE FISH SAMPLES: Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	BASS (WHOLE FISH) 1991 (PPM)									
	As		Se		Hg		Cr		Cu	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	NA	<0.069	NA	0.691	NA	0.02	NA	<1.0	NA	<1.0
New River	0.072	<0.04	0.93	0.53	<0.04	0.09	6.0	<1.0	1.0	<1.0
27 Bridge	0.09	<0.04	0.67	0.601	0.05	0.15	45.0	<1.0	3.0	<1.0
Yellowjacket Creek	0.05	<0.04	0.74	0.39	<0.04	0.03	1.0	<1.0	<1.0	<1.0
Dam	0.13	<0.04	0.92	0.74	<0.04	0.04	4.0	<1.0	1.0	<1.0
Wehadkee Creek	0.03	<0.04	0.87	0.801	<0.04	0.11	4.0	<1.0	<1.0	<1.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in (). *N.A. = Not Analyzed

TABLE 9: WEST POINT RESERVOIR WHOLE FISH SAMPLES (CONTINUED): Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	BASS (WHOLE FISH) 1991 (PPM)					
	Pb		Ni		Zn	
	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	NA	<2.0	NA	<1.0	NA	15.0
New River	<2.0	<2.0	3.0	<1.0	13.0	19.0
27 Bridge	<2.0	<2.0	22.0	<1.0	19.0	19.0
Yellowjacket Creek	<1.0	<2.0	<1.0	<1.0	16.0	19.0
Dam	<1.0	<2.0	1.0	<1.0	9.0	14.0
Wehadkee Creek	<1.0	<2.0	1.0	<1.0	11.0	12.0

*N.A. = Not Analyzed

TABLE 9: WEST POINT RESERVOIR WHOLE FISH SAMPLES (CONTINUED): Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	CARP (WHOLE FISH) 1991 (PPM)									
	As		Se		Hg		Cr		Cu	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	0.037	<0.04	0.69	1.24	0.25	0.06	4.0	<1.0	2.0	<1.0
New River	0.035	<0.04	1.00	0.79	0.11	0.02	5.0	<1.0	<2.0	2.0
27 Bridge	0.025	<0.04	0.96	0.511	0.10	0.04	6.0	<1.0	3.0	5.0
Yellowjacket Creek	0.05	<0.04	0.74	1.79	<0.04	0.07	1.0	<1.0	<1.0	<1.0
Dam	0.04 0.03	<0.04	0.82 1.03	0.85	0.10 0.04	0.07	1.0 6.0	<1.0	1.0 2.0	<1.0
Wehadkee Creek	<0.02	<0.04	0.58	1.14	<0.04	<0.02	3.0	<1.0	2.0	<1.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in (). Two carp composites were identified as coming from dam location. *N.A. = Not Analyzed

TABLE 9: WEST POINT RESERVOIR WHOLE FISH SAMPLES (CONTINUED): Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	CARP (WHOLE FISH) 1991 (PPM)					
	Pb		Ni		Zn	
	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	<2.0	<2.0	2.0	<1.0	50.0	94.0
New River	<3.0	<2.0	1.0	<1.0	43.0	75.0
27 Bridge	2.0	<2.0	2.0	<1.0	47.0	91.0
Yellowjacket Creek	<1.0	<2.0	<1.0	<1.0	16.0	84.0
Dam	<2.0 <2.0	<2.0	<1.0 2.0	<1.0	11.0 46	66.0
Wehadkee Creek	<2.0	<2.0	<1.0	2.0	36.0	119.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in ().
*N.A. = Not Analyzed

TABLE 10: WEST POINT RESERVOIR FISH FILET SAMPLES: Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	BASS (FILET FISH) 1991 (PPM)									
	As		Se		Hg		Cr		Cu	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	NA	<0.04	NA	0.61	NA	0.05	NA	<1.0	NA	<1.0
New River	0.026	<0.04	0.75	0.49	0.22	0.08	2.0	<1.0	2.0	<1.0
27 Bridge	0.046	0.058	0.50	0.631	<0.04	0.15	4.0	<1.0	<1.0	<1.0
Yellowjacket Creek	0.04	<0.04	0.84	0.48	0.30	0.08	2.0	<1.0	<1.0	<1.0
Dam	0.08	<0.04	1.5	0.79	0.21	0.03	<1.0	<1.0	1.0	<1.0
Wehadkee Creek	0.05	<0.04	0.75	0.651	<0.04	0.06	1.0	<1.0	1.0	<1.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in ().*N.A. = Not Analyzed

TABLE 10: WEST POINT RESERVOIR FISH FILET SAMPLES (CONTINUED): Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	BASS (FILET FISH) 1991 (PPM)					
	Pb		Ni		Zn	
	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	NA	<2.0	NA	<1.0	NA	11.0
New River	<1.0	<2.0	<1.0	<1.0	9.0	15.0
27 Bridge	<2.0	<2.0	2.0	<1.0	5.0	11.0
Yellowjacket Creek	<1.0	<2.0	<1.0	<1.0	9.0	13.0
Dam	<1.0	<2.0	<1.0	<1.0	4.0	6.0
Wehadkee Creek	<1.0	<2.0	<1.0	<1.0	9.0	13.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in ().
*N.A. = Not Analyzed

TABLE 10: WEST POINT RESERVOIR FISH FILET SAMPLES (CONTINUED): Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	CARP (FILET) 1991 (PPM)									
	As		Se		Hg		Cr		Cu	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	0.039	<0.04	1.03	0.97	0.24	0.10	4.0	<1.0	2.0	<1.0
New River	0.035	<0.04	0.90	0.83	<0.04	0.04	5.0	<1.0	2.0	<1.0
27 Bridge	<0.02	<0.04	0.95	0.75	0.21	0.06	1.0	<1.0	3.0	<1.0
Yellowjacket Creek	0.04	<0.04	0.84	0.691	0.30	0.06	2.0	<1.0	<1.0	1.0
Dam	0.07 0.04	<0.04	1.02 0.92	0.82	0.32 0.10	0.02	1.0 7.0	<1.0	<1.0 <1.0	<1.0
Wehadkee Creek	0.043	<0.04	1.54	1.52	<0.04	0.06	5.0	<1.0	2.0	<1.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in ().*N.A. = Not Analyzed

TABLE 10: WEST POINT RESERVOIR FISH FILET SAMPLES (CONTINUED): Results of elemental analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	CARP (FILET) 1991 (PPM)					
	Pb		Ni		Zn	
	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	<2.0	<2.0	2.0	<1.0	13.0	21.0
New River	<2.0	<2.0	3.0	<1.0	14.0	40.0
27 Bridge	<2.0	<2.0	<1.0	<1.0	17.0	56.0
Yellowjacket Creek	<1.0	<2.0	<1.0	<1.0	9.0	29.0
Dam	<2.0 <2.0	<2.0	<1.0 3.0	<1.0	11.0 13.0	26.0
Wehadkee Creek	<2.0	<2.0	2.0	<1.0	12.0	16.0

Sb(5ppm), Be (1ppm), Ag (1ppm) and Tl (10 ppm) were not detected in any sample at the analytical limit of detection given in ().
*N.A. = Not Analyzed

TABLE 11: WEST POINT RESERVOIR WHOLE FISH SAMPLES: Results of pesticide analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	BASS (WHOLE FISH) 1991 (PPM)							
	PCB		CHLORDANE		PC ANISOLE		DDT & MET	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	NA	1.12	NA	0.705	NA	<0.02	NA	0.097
New River	0.227	0.938	<0.03	0.422	<0.01	0.104	0.035	0.104
27 Bridge	0.12	1.18	0.178	0.56	<0.01	<0.02	0.021	<0.01
Yellowjacket Creek	0.233	0.52	0.034	0.21	<0.01	<0.02	0.058	0.038
Dam	0.31	<0.03	<0.03	0.346	<0.01	<0.02	0.101	0.107
Wehadkee Creek	0.15	0.51	<0.03	<0.03	<0.01	<0.02	0.061	0.133

The following pesticides were found to be non-detectable in fish tissues at the level given in ( ):Aldrin(0.01 ppm), a-BHC(0.01 ppm), B-BHC(0.01 ppm),Y-BHC(0.01 ppm), o-BHC(0.01 ppm), Dieldrin(0.01 ppm), Endosulfan I(0.02 ppm), Endosulfan II(0.03 ppm), Endosulfan Sulfate (0.05 ppm), Endrin(0.01 ppm), Endrin Aldehyde (0.05 ppm), Heptachlor(0.01 ppm), Heptachlor Epoxide(0.01 ppm), Toxaphene(0.10 ppm), Methoxychlor (0.05 ppm), HCB(0.01 ppm), Mirex(0.10 ppm) Chlorpyrifos(0.04 ppm).

*N.A. = Not Analyzed

MET = Metabolites

TABLE 11: WEST POINT RESERVOIR WHOLE FISH SAMPLES: Results of pesticide analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	CARP (WHOLE FISH) 1991 (PPM)							
	PCB		CHLORDANE		PC ANISOLE		DDT & MET	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	0.251	0.933	0.022	0.157	<0.01	<0.02	<0.01	<0.01
New River	0.895	1.57	0.539	0.580	<0.01	0.055	<0.01	<0.01
27 Bridge	0.049	0.25	0.051	0.230	<0.01	<0.02	0.113	<0.01
Yellowjacket Creek	0.07	<0.03	<0.03	<0.03	<0.01	<0.02	0.03	0.10
Dam	0.180 0.230	0.886	0.26 0.13	0.260	0.017 0.010	<0.02	0.090 0.11	0.137
Wehadkee Creek	0.081	0.26	<0.03	<0.03	<0.01	0.012	0.08	0.099

The following pesticides were found to be non-detectable in fish tissues at the level given in ( ):Aldrin(0.01 ppm), a-BHC(0.01 ppm), B-BHC(0.01 ppm),Y-BHC(0.01 ppm), o-BHC(0.01 ppm), Dieldrin(0.01 ppm), Endosulfan I(0.02 ppm), Endosulfan II(0.03 ppm), Endosulfan Sulfate (0.05 ppm), Endrin(0.01 ppm), Endrin Aldehyde (0.05 ppm), Heptachlor(0.01 ppm), Heptachlor Epoxide(0.01 ppm), Toxaphene(0.10 ppm), Methoxychlor (0.05 ppm), HCB(0.01 ppm), Mirex(0.10 ppm) Chlorpyrifos(0.04 ppm).

*N.A. = Not Analyzed

MET = Metabolites

TABLE 12: WEST POINT RESERVOIR FISH FILET SAMPLES: Results of pesticide analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	BASS (FILET) 1991 (PPM)							
	PCB		CHLORDANE		PC ANISOLE		DDT & MET	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	NA	0.361	NA	0.207	NA	<0.02	NA	0.045
New River	<0.03	0.370	<0.03	0.125	<0.01	<0.02	<0.01	0.016
27 Bridge	0.042	0.202	<0.03	0.12	<0.01	<0.02	<0.01	0.021
Yellowjacket Creek	<0.03	0.167	<0.03	0.140	<0.01	<0.02	<0.01	0.022
Dam	<0.03	0.158	<0.03	<0.03	<0.01	<0.02	<0.01	0.012
Wehadkee Creek	<0.03	0.050	<0.03	<0.03	<0.01	<0.02	<0.01	0.012

*N.A. = Not Analyzed

The following pesticides were found to be non-detectable in fish tissues at the level given in ( ):Aldrin(0.01 ppm), a-BHC(0.01 ppm), B-BHC(0.01 ppm),Y-BHC(0.01 ppm), o-BHC(0.01 ppm), Dieldrin(0.01 ppm), Endosulfan I(0.02 ppm), Endosulfan II(0.03 ppm), Endosulfan Sulfate (0.05 ppm), Endrin(0.01 ppm), Endrin Aldehyde (0.05 ppm), Heptachlor(0.01 ppm), Heptachlor Epoxide(0.01 ppm), Toxaphene(0.10 ppm), Methoxychlor (0.05 ppm), HCB(0.01 ppm), Mirex(0.10 ppm), Chlorpyrifos(0.04 ppm).

MET = Metabolites

TABLE 12: WEST POINT RESERVOIR FISH FILET SAMPLES (continued): Results of pesticide analysis conducted on fish samples collected during the Spring and Fall of 1991.

LOCATION	CARP FILET 1991 (PPM)							
	PCB		CHLORDANE		PC ANISOLE		DDT & MET	
	SPR.	FALL	SPR.	FALL	SPR.	FALL	SPR.	FALL
LaGrange Intake	0.176	0.318	0.016	0.082	<0.01	<0.02	0.042	0.012
New River	0.141	0.819	0.013	0.375	<0.01	0.025	0.018	0.043
27 Bridge	0.181	1.28	0.018	0.89	<0.01	0.024	0.027	<0.01
Yellowjacket Creek	0.16	0.306	<0.03	<0.03	<0.01	<0.02	<0.01 (T)	0.049
Dam	0.033 0.054	0.288	<0.03 <0.03	<0.03	<0.01 <0.01	<0.02	0.02 0.03	0.072
Wehadkee Creek	0.054	0.25	<0.03	0.03	<0.01	<0.02	0.03	0.131

*N.A. = Not Analyzed.

The following pesticides were found to be non-detectable in fish tissues at the level given in ( ):Aldrin(0.01 ppm), a-BHC(0.01 ppm), B-BHC(0.01 ppm),Y-BHC(0.0: ppm), o-BHC(0.01 ppm), Dieldrin(0.01 ppm), Endosulfan I(0.02 ppm), Endosulfan II(0.03 ppm), Endosulfan Sulfate (0.05 ppm), Endrin(0.01 ppm), Endrin Aldehyd (0.05 ppm), Heptachlor(0.01 ppm), Heptachlor Epoxide(0.01 ppm), Toxaphene(0.10 ppm), Methoxychlor (0.05 ppm), HCB(0.01 ppm), Mirex(0.10 ppm) Chlorpyrifos(0.04 ppm).

MET = Metabolites

TABLE 13. WHOLE AND FILET FISH SAMPLES: Mean Values for Bass and Carp Contaminant Analysis. Summary of values for all sites combined.

	BASS				CARP			
	Whole (ppm)		Filet (ppm)		Whole (ppm)		Filet (ppm)	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
As	0.07	ND	0.05	0.01	0.03	ND	0.04	ND
Se	0.83	0.63	0.87	0.61	0.83	1.05	1.03	0.93
Hg	0.01	0.07	0.15	0.08	0.09	0.05	0.17	0.06
Cr	12.0	ND	1.9	ND	3.7	ND	3.6	ND
Cu	1.0	ND	1.0	ND	1.6	1.2	1.5	0.2
Pb	ND	ND	ND	ND	0.3	ND	ND	ND
Ni	5.4	ND	0.4	ND	1.2	0.3	1.6	ND
Zn	13.6	16.3	7.2	11.5	35.5	88.2	12.7	31.3
PCB	0.21	0.71	0.01	0.22	0.25	0.65	0.11	0.54
Chlor	0.04	0.31	ND	0.10	0.15	0.21	0.01	0.24
PCA	ND	0.02	ND	ND	0.004	0.01	ND	0.01
DDT	0.055	0.081	ND	0.02	0.062	0.059	0.025	0.052

ND = not detectable

TABLE 14. COMPREHENSIVE CONTAMINANT ANALYSIS RESULTS FOR BASS AND CARP.

	BASS FILET			CARP FILET			FDA ACTION LEVEL	U.S. EPA CRITERIA LEVELS			
								CARCINOGENS[1]			TOXICS[2]
	MEAN (ppm)	RANGE (ppm)	TIME	MEAN (ppm)	RANGE (ppm)	TIME		10^{-6}	10^{-5}	10^{-4}	
As	0.05	0.04-0.08	S	0.04	ND-0.07	S	NA	0.0062	0.062	0.62	---
Se	0.87	0.50-1.50	S	1.03	0.84-1.54	S	NA	---	---	---	5.4
Hg	0.15	ND-0.30	S	0.17	ND-0.32	S	1.0	---	---	---	1.0
Cr[3]	1.9	ND-4.0	S	3.6	1.0-7.0	S	NA	---	---	---	53.8
Cu	1.0	ND-2.0	S	1.5	ND-3.0	S	NA	---	---	---	---
Pb	ND	ND	S & F	ND	ND	S & F	NA	---	---	---	---
Ni	0.4	ND-2.0	S	1.6	ND-3.0	S	NA	---	---	---	215
Zn	11.5	6.0-15.0	F	31.3	16.0-56.0	F	NA	---	---	---	---
PCB[4]	0.22	0.05-0.37	F	0.54	0.25-1.28	F	2.0	0.0014	0.014	0.14	---
Chlor.	0.10	ND-0.21	F	0.24	ND-0.089	F	0.3	0.0083	0.083	0.83	---
PCA[5]	ND	ND	F	0.008	ND-0.025	F	NA	0.09	0.9	9.0	---
DDT[6]	0.021	0.012-0.045	F	0.052	ND-0.131	F	5.0	0.0316	0.316	3.16	---

[1]Values for carcinogens are derived using U.S. EPA's cancer potency factors and assumptions of 6.5 g fish consumption/day for 70 years. [2]Values for toxics are derived from U.S. EPS's reference doses (RFD). [3]Cr criteria is for CrVI, the value for CRIII is significantly higher. [4]PCB criteria is for arochlor mixtures 1242, 1254, 1232, 1248, 1260 and 1016. [5]PCA criteria is for parent compound, pentachlorophenol. [6]DDT criteria is for DDT and DDE.

S = Spring F = Fall ND = Not detectable NA = Not analyzed

APPENDIX 5. Parameters and Complete Data Sets for Fish Health Assessment

TABLE 15. NECROPSY CLASSIFICATION

Length	Total length in mm
Weight	Weight in gm
Eyes	Normal (N) Exopthalmia (E1 E2)* Hemorrhagic (H1 H2)* Blind (B1 B2)* Missing (M1 M2)*, Other (OT)*
Gills	Normal (N) Frayed (F)* Clubbed (C)* Marginate (M)* Pale (P)* Other (OT)*
Pseudobranch	Normal (N) Swollen (S)* Lithic (L)* Swollen and Lithic (SL)* Inflamed (I)* Other (OT)*
Thymus	No Hemorrhage (0), Mild Hemorrhage (1)* Moderate Hemorrhage (2)* Severe Hemorrhage (3)*
Fins	No erosion (0) Mild Erosion No Bleeding (1)* Moderate Erosion/Hemorrhage (2)* Severe Erosion (3)*
Opercles	No shortening (0) Mild Shortening (1)* Severe shortening (2)*
Spleen	Black (B) Red (R) Granular (G)* Nodular (NO)* Enlarged (E)* Other (OT)*
Hind Gut	No Inflammation (0) Mild (1)* Moderate (2)* Severe (3)*
Kidney	Normal (N) Swollen (S)* Mottled (M)* Granular (G)* Urolithic (U)* Other (OT)*
Liver	Red (A) Light red (B) Fatty (C)* Nodular (D)* Focal discoloration (E)* General Discoloration (F)* Other (OT)*
Skin	No erosion (0); Mild erosion (1); Moderate erosion (2); Severe erosion (3)
Parasite Load	No parasites (0); Mild parasite load (1); Moderate parasite load (2); severe parasite load (3)
Mesenteric Fat	Internal body fat expressed with regard to amount present None (0); Little, less than 50% of ceaca covered (1); 50% of ceaca covered (2); More than 50% of ceaca covered (3); Ceaca completely covered (4)
Bile	Yellow/straw colored, empty or partially full (0); Yellow/straw colored, full and distended (1); Light green color (2); dark green (3)

*Denotes a pathological condition which received a numerical substitution of 30 in the quantitative health assessment index. Conditions which were rated with a number received substitutitutions of 10 for 1; 20 for 2 and 30 for 3; except for mesenteric fat and bile. These factors were rated but ratings were not entered into the health assessment index.

TABLE 16. FISH HEALTH CONDITIONS, DESIGNATIONS AND SUBSTITUTED VALUES

Tissue/Organ	Condition	Designation	Value
SKIN	Normal; No aberrations	0	0
	Mild skin aberrations	1	10
	Moderate skin aberrations	2	20
	Severe skin aberrations	3	30
GILLS	Normal; no apparent aberrations	N	0
	Frayed; "ragged" appearing	F	30
	Clubbed; swelling at tips of lamellae	C	30
	Marginate; light, discolored margin at tips	M	30
	Pale; very light in color	P	30
	Other; any observation not listed above	OT	30
FINS	No active erosion	0	0
	Light active erosion	1	10
	Moderate active erosion; some hemorrhaging	2	20
	Severe active erosion with hemorrhaging	3	30
EYES	No aberrations; "clear eyes"	N	0
	Opaque eyes (one or both)	B	30
	Swollen, protruding eye (one or both)	E	30
	Hemorrhaging or bleeding (one or both)	H	30
	Missing eye or eyes	M	30
	Other; any manifestation not listed above	OT	30
PARASITES	No observed parasites	0	0
	Few observed parasites	1	10
	Moderate parasite infestation	2	20
	Numerous parasites	3	30
THYMUS	No hemorrhage	0	0
	Mild hemorrhage	1	10
	Moderate hemorrhage	2	20
	Severe hemorrhage	3	30
SPLEEN	Normal; red, very dark red, black	B	0
	Granular; rough appearance	G	0
	Nodular; contains nodules of varying sizes	NO	30
	Enlarged	E	30
	Other; aberrations not listed above	OT	30
HINDGUT	Normal; no reddening	0	0
	Slight reddening	1	10
	Moderate reddening	2	20
	Severe reddening	3	30

TABLE 16. Continued.

KIDNEY	Normal; firm, dark red, relatively flat	N	0
	Swollen; enlarged wholly or in part	S	30
	Mottled; gray discoloration	M	30
	Granular; in appearance and texture	G	30
	Urolithiasis; nephrocalcinosis	U	30
	Other; any aberrations not described above	OT	30
LIVER	Normal; solid red or light red	A	0
	"Fatty" liver; "coffee with cream" color	C	30
	Nodules in the liver; cyst/nodules	D	30
	Focal discoloration; localized color change	E	30
	General discoloration; change throughout liver	F	30
	Other; deviations not fitting above categories	OT	30
HEMATOCRIT	"Normal" range	>30.5	0
	Outside normal range	≤30.5	30
IEUCOCRIT	"Normal" range	< 4	0
	Outside normal range	≥ 4	30
SERUM PROTEIN	"Normal" range	>2.5 &<6	0
	Outside normal range	≥6 & ≤2.5	30

TABLE 17. **WEST POINT LAKE - BASS:** Summary of Data Presented as Mean ± Standard Deviation

Station	Weight (gm)	Length (mm)	Condition (Ktl)	Hematocrit %	Leukocrit %	Serum Protein g/dL	Liver/ Somatic Index
Hwy 27							
Spr. 91	1000±415 A	402±47 A	1.5±0.4 A	39.9±9.7 AB *	0.4±0.2 A *	4.3±1.0 A *	
Fall 91	1299±490 AC	430±51 AC	1.6±0.2 A	46.8±5.9 A	1.3±0.3 AB	5.7±1.4 AB	0.009±0.002 A
New River							
Spr. 91	873±308 A	387±38 A	1.4±0.2 A	36.3±9.9 A *	1.3±1.1 B	3.7±1.2 A *	
Fall 91	898±552B	381±54 B	1.5±0.1 AB	49.0±7.5 AB	1.2±0.6 ABC	5.1±1.6 A	0.106±0.361 A
LaGrange In.							
Spr. 91	994±554 A	392±58 A	1.5±0.3 A	38.7±5.4 A *	0.5±0.3 A *	5.9±1.1 B	
Fall 91	1300±671 AC	426±71 AC	1.5±0.1 AB	51.8±8.7 AB	1.4±0.6 A	5.5±1.5 AB	0.009±0.002 A
Yellowjacket							
Spr. 91	932±343 A	393±40 A	1.5±0.1 A *	46.6±10.2 BC	1.2±0.8 B	6.3±0.8 BC	
Fall 91	1166±512 AB	411±49 ABC	1.6±0.2 A	45.2±7.1 A	0.9±0.4 CD	6.0±1.6 AB	0.011±0.002 A
Wedhadkee							
Spr. 91	1054±434 A	413±45 A	1.4±0.2 A	45.8±10.1 BC *	1.3±0.6 B	6.8±0.6 C	
Fall 91	932±346 AB	400±48 AB	1.4±0.2 B	56.3±11.7 B	0.9±0.3 CB	6.0±1.1 AB	0.008±0.001 A
Dam							
Spr. 91	952±291 A *	408±37 A *	1.4±0.1 A *	48.1±6.9 C	1.3±0.7 B *	6.2±1.5 BC	
Fall 91	1433±463 C	449±47 C	1.5±0.1 A	54.5±12.7 B	0.5±0.3 D	6.1±1.0 B	0.007±0.001 A

[a]Values in a column for a particular sampling time followed by the same letter are not significantly different at $p \leq 0.05$.
*Values within a cell are significantly different at $p \leq 0.05$

TABLE 18. **WEST POINT LAKE - CARP**: Summary of Data Presented as Mean ± Standard Deviation

Station Collection	Weight (gm)	Length (mm)	Condition (Ktl)	Hematocrit %	Leukocrit %	Serum Protein g/dL	Liver/ Somatic Index
Hwy. 27							
Spr. 91	1254±350 AB	449±31 A	1.4±0.1 A	33.4±5.0 AB *	1.1±0.4 A	2.6±0.8 AC	NA
Fall 91	1384±733 AB	467±60 AB	1.4±0.1 A	37.7±4.2 A	1.2±0.6 A	2.9±1.1 A	
New River							
Spr. 91	1212±272 A	448±35 A	1.3±0.1 AB	35.8±8.2 AB	1.4±0.4 A *	1.6±0.6 B *	NA
Fall 91	1198±186 A	447±24 A	1.3±0.1 AB	37.0±5.4 A	0.9±0.4 BC	2.7±1.1 A	
LaGrange In.							
Spr. 91	1517±373 B	492±42 B	1.3±0.1 BC	33.9±5.1 AB	1.3±0.5 A *	2.2±0.7 AB	NA
Fall 91	1720±560 BC	505±59 BC	1.3±0.1 B	35.2±5.9 AB	0.7±0.3 B	2.4±0.7 A	
Yellowjacket							
Spr. 91	1487±347 B *	494±34 B *	1.2±0.1 C *	32.5±8.8 A	1.2±1.0 A	3.0±1.4 AC	NA
Fall 91	2191±740 C	535±49 C	1.4±0.2 A	34.0±5.5 AB	0.8±0.4 BC	2.8±0.7 A	
Wedhadkee							
Spr. 91	1801±277 C *	523±16 C	1.3±0.1 BC *	39.1±8.0 B *	1.4±0.7 A	3.3±1.2 C	NA
Fall 91	2289±611 D	543±53 C	1.4±0.1 A	31.3±7.0 B	1.0±0.4 AB	2.5±0.6 A	
Dam							
Spr. 91	2317±576 D	545±31 C *	1.4±0.1 A	31.0±11 A	1.5±1.1 A	3.1±1.3 C	NA
Fall 91	2840±863 E	586±59 D	1.4±0.1 AB	35.5±9.1 AB	1.1±0.2 AC	2.8±1.0 A	

*Values in a column for a particular sampling time followed by the same letter are not significantly different at $p \leq 0.05$.
*Values within a cell are significantly different at $p \leq 0.05$.

TABLE 19. COMPARISON OF FISH HEALTH ASSESSMENT INDEX - BASS.

Site	Spring 1991		Fall 1991	
	Without Hematological Values	With Hematological Values	Without Hematological Values	With Hematological Values
U. S. Hwy 27	80.0±21.0 a	86.0±26.1 a	80.0±28.6 a	90.0±35.4 a
New River	88.0±29.1 a	96.0±40.3 a	80.7±15.3 a	94.7±25.0 a
LaGrange	77.3±32.0 a	91.3±36.6 a	86.7±25.7 a	106.7±32.8 ab
Yellowjacket	88.0±23.4 a	106.0±24.4 a	76.7±19.9 a	88.7±18.1 a
Wehadkee	84.0±21.0 a	104.0±18.8 a	80.8±23.1 a	93.3±25.3 a
Dam	91.3±17.7 a	104.7±25.0 a	108.7±22.9 b	126.7±29.9 b

[a]Values in a column followed by the same letter are not significantly different at $p \leq 0.05$.

TABLE 20. COMPARISON OF FISH HEALTH ASSESSMENT INDEX - CARP

Site	Spring 1991		Fall 1991	
	Without Hematological Values	With Hematological Values	Without Hematological Values	With Hematogical Values
U. S. Hwy 27	56.7±28.2 a	78.7±38.5 a	74.0±30.7 a	92.0±34.5 a
New River	39.3±22.5 a	77.3±29.6 a	57.3±18.7 ab	73.3±22.6 a
LaGrange	42.7±24.6 a	64.7±26.7 a	57.5±29.3 ab	85.0±34.5 a
Yellowjacket	40.0±21.7 a	58.0±29.6 a	45.8±28.7 b	70.8±37.5 a
Wehadkee	44.0±33.3 a	56.0±44.4 a	60.0±25.9 ab	92.0±35.9 a
Dam	45.0±30.8 a	79.3±33.4 a	66.7±23.9 ab	94.2±31.8 a

[a]Values in a column followed by the same letter are not significantly different at $p \leq 0.05$.

TABLE 21. LARGEMOUTH BASS FALL 1991 SAMPLE: Results of Pearson's Correlation test between contaminants and various health indices.

	SEDIMENT CONTAMINANTS			WHOLE FISH CONTAMINANTS	
	PYRENE	FLUORANTHENE	BENZOPYRENE	PCB	CHLORDANE
HAI	0.27766*	0.28614*	-0.10910	-0.09137	0.10151
KtL	0.06611	0.08185	-0.07492	-0.05296	0.13435
Hematocrit	0.00283	0.00374	-0.19645	-0.00342	-0.11302
Leucocrit	-0.15194	-0.16894	0.30655*	0.23498	0.37750*
Serum Protein	-0.02030	-0.00374	-0.11332	-0.09934	-0.16155
Liv/Somatic Index	0.09061	0.02244	0.21374	0.99946*	0.27984*

*Denotes significance at $p < 0.05$.

TABLE 22. COMMON CARP FALL 1991: Results of Pearson's Correlation test between contaminants and various health indices.

	SEDIMENT CONTAMINANTS			WHOLE FISH CONTAMINANTS	
	PYRENE	FLUORANTHENE	BENZOPYRENE	PCB	CHLORDANE
HAI	0.24365	0.25193	0.22347	-0.00012	0.06964
Klt	0.05599	0.06879	0.10689	-0.26573*	0.16656
Hematocrit	0.24267	0.23755	0.24004	0.14686	0.24588
Leucocrit	0.31979*	0.32822*	0.27648*	-0.08280	0.06339
Serum Protein	0.06958	0.07659	-0.04279	-0.09692	-0.09739

TABLE 23. SUSPECTED TUMORS IN BASS AS OBSERVED GROSSLY

Site	Fall 1990	Spring 1991	Fall 1991
Hwy 27	4 2 splenic lipomas 2 liver	3 splenic lipomas	3 splenic lipomas
New River	1 splenic lipomas	2 splenic lipomas	2 splenic lipomas
LaGrange In.	2 1 splenic lipoma 1 liver	0	2 1 splenic lipoma 1 visceral mass
Yellowjacket	4 3 splenic lipomas 1 visceral mass	2 1 papilloma-like 1 visceral mass	3 splenic lipomas
Wedhadkee	0	1 visceral mass	3 splenic lipomas
Dam	0	1 splenic lipoma	2 1 splenic lipoma 1 visceral mass

TABLE 24. SUSPECTED TUMORS IN CARP AS OBSERVED GROSSLY

Site	Fall 1990	Spring 1991	Fall 1991
Hwy 27	0	0	2 1 testicular 1 liver
New River	0	0	1 swim bladder
LaGrange In	0	0	1 liver
Yellowjacket	0	0	1 liver
Wedhadkee	0	0	1 liver
Dam	0	2 1 testicular 1 liver	2 1 liver 1 ovary

Fig. 1. Comparison of largemouth bass hematocrits during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 1 BASS HEMATOCRITS

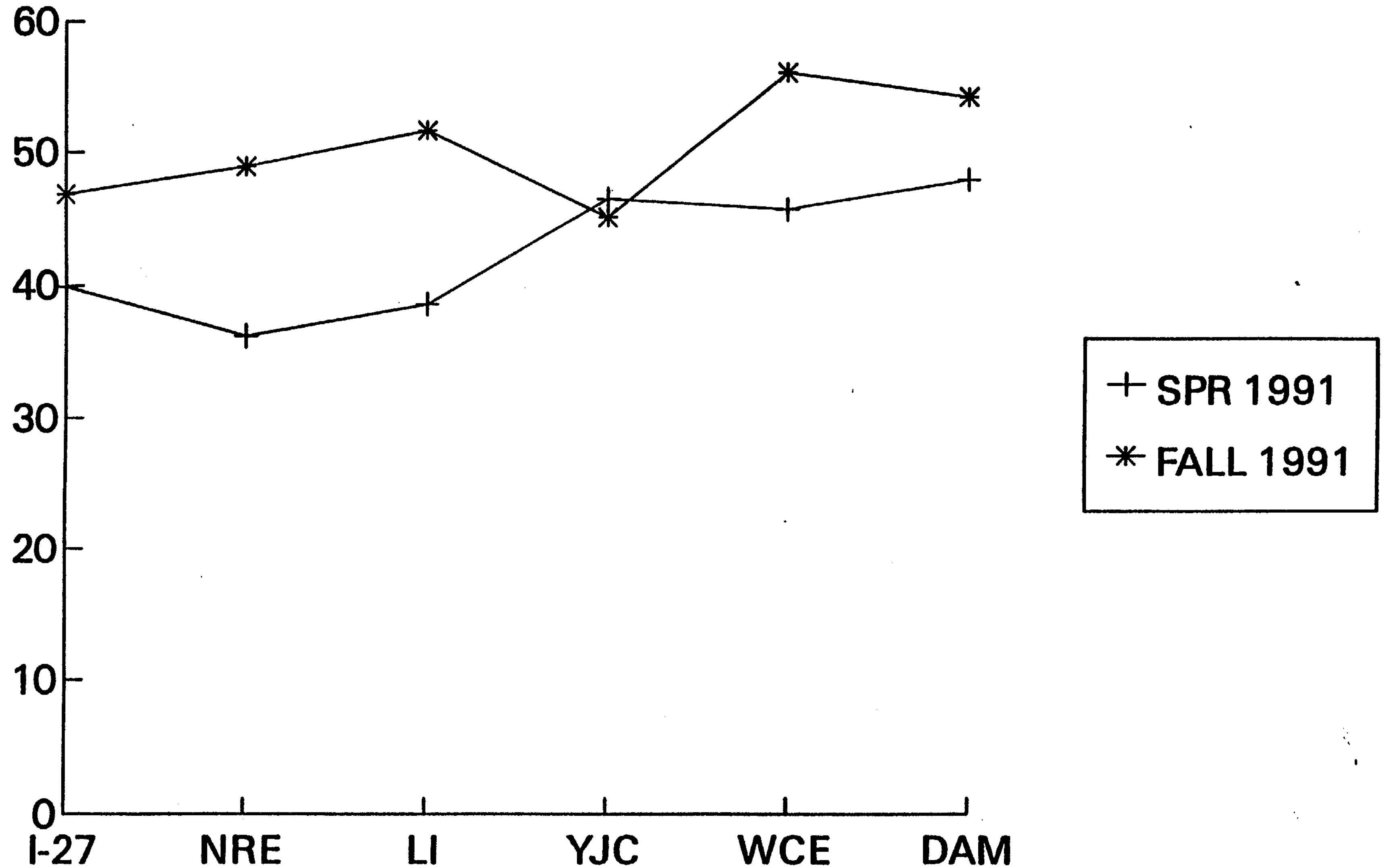


Fig. 2. Comparison of common carp hematocrits during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 2 CARP HEMATOCRITS

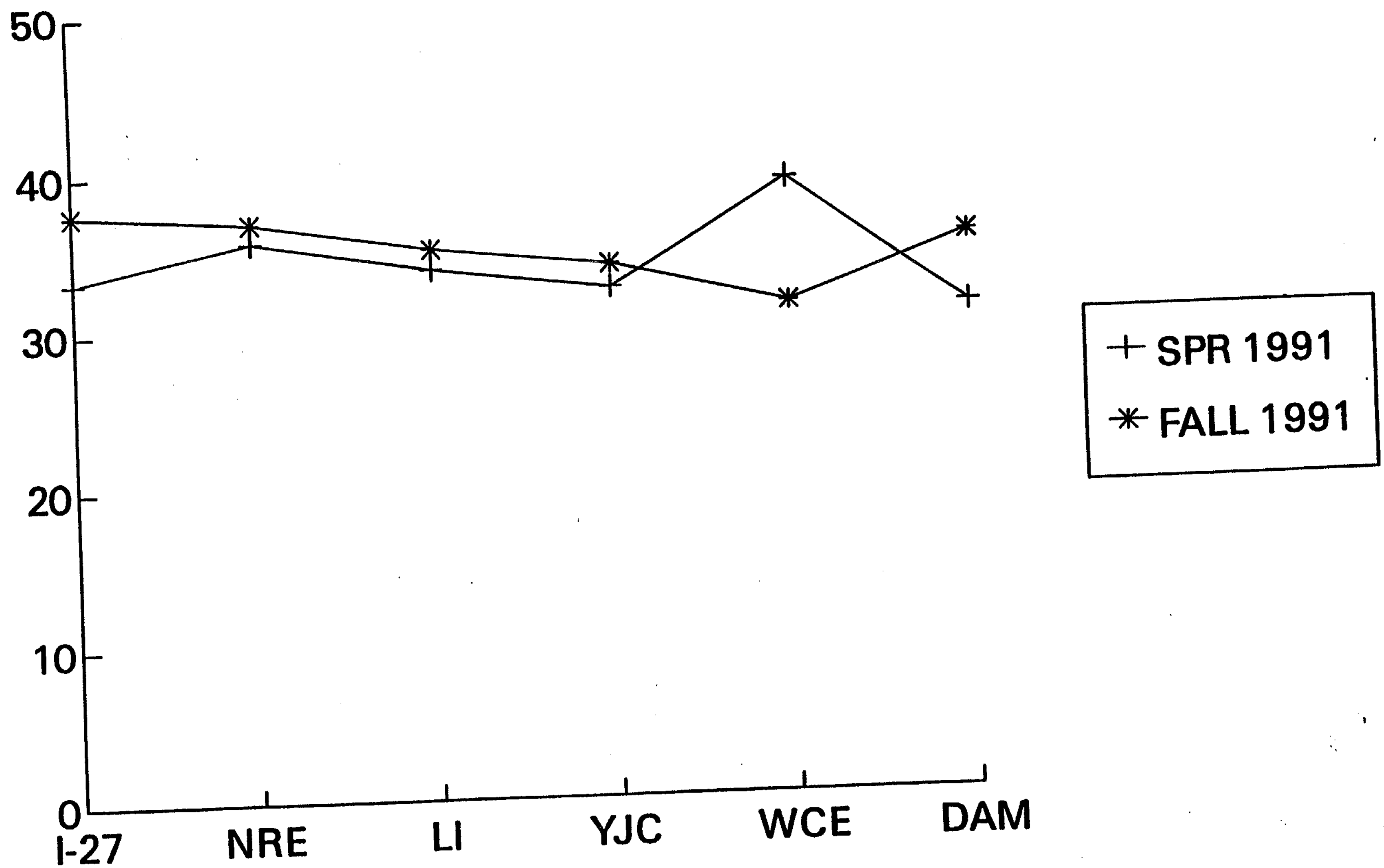


Fig. 3. Comparison of largemouth bass leucocrits during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 3 BASS LEUCOCRITS

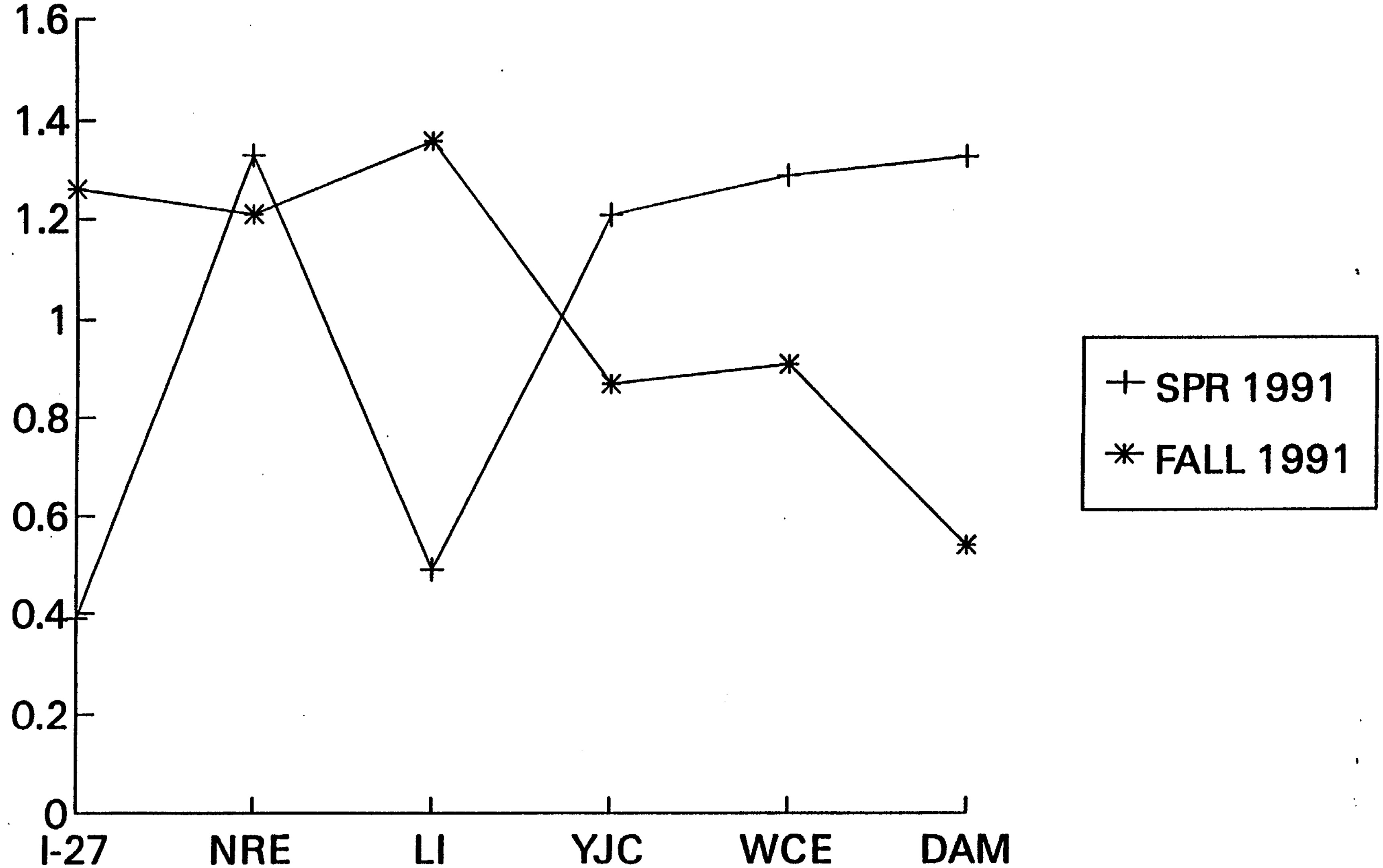


Fig. 4. Comparison of common carp leucocrits during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig.4 CARP LEUCOCRITS

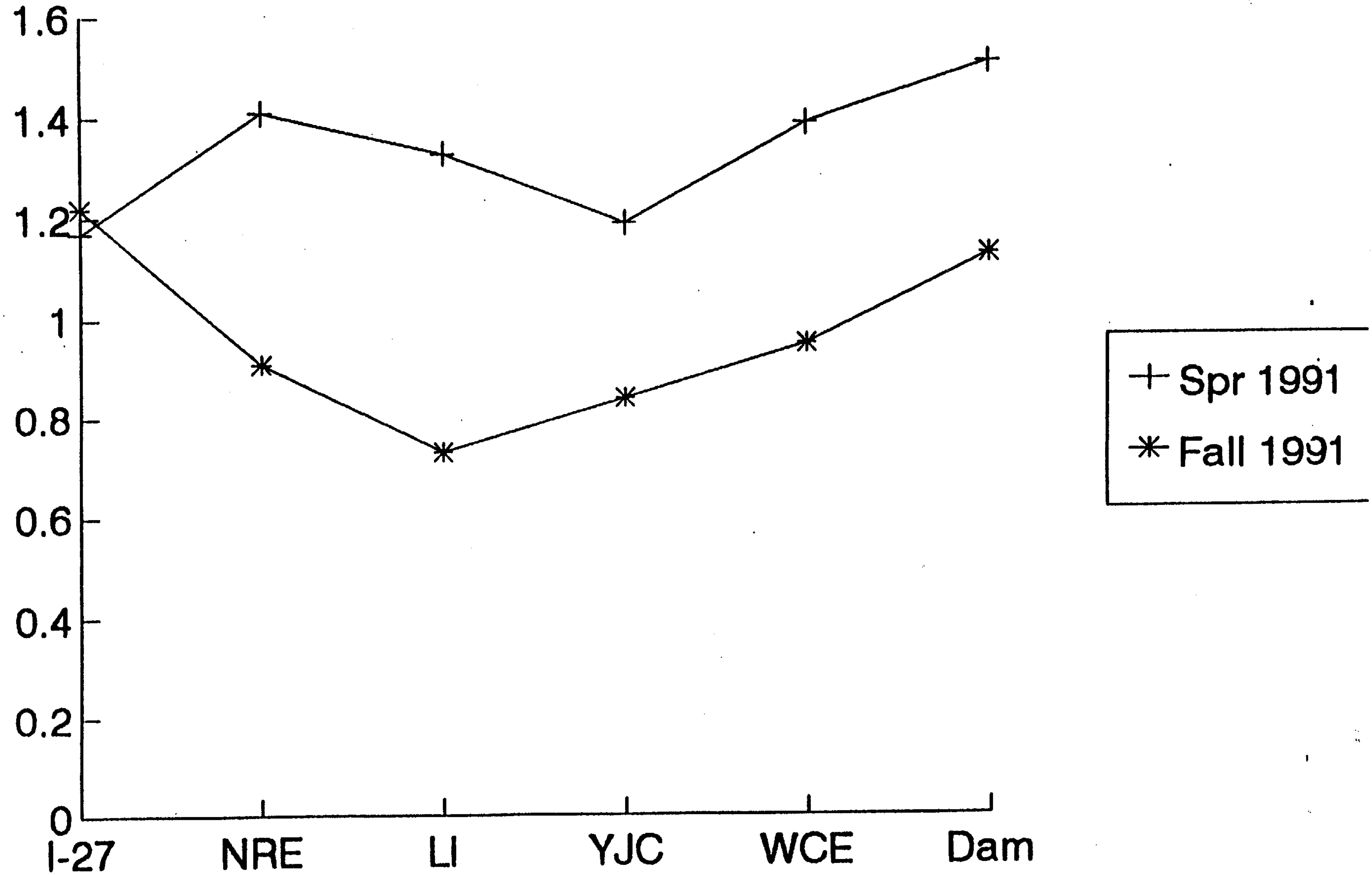


Fig. 6. Comparison of largemouth bass serum protein during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 6 BASS SERUM PROTEIN

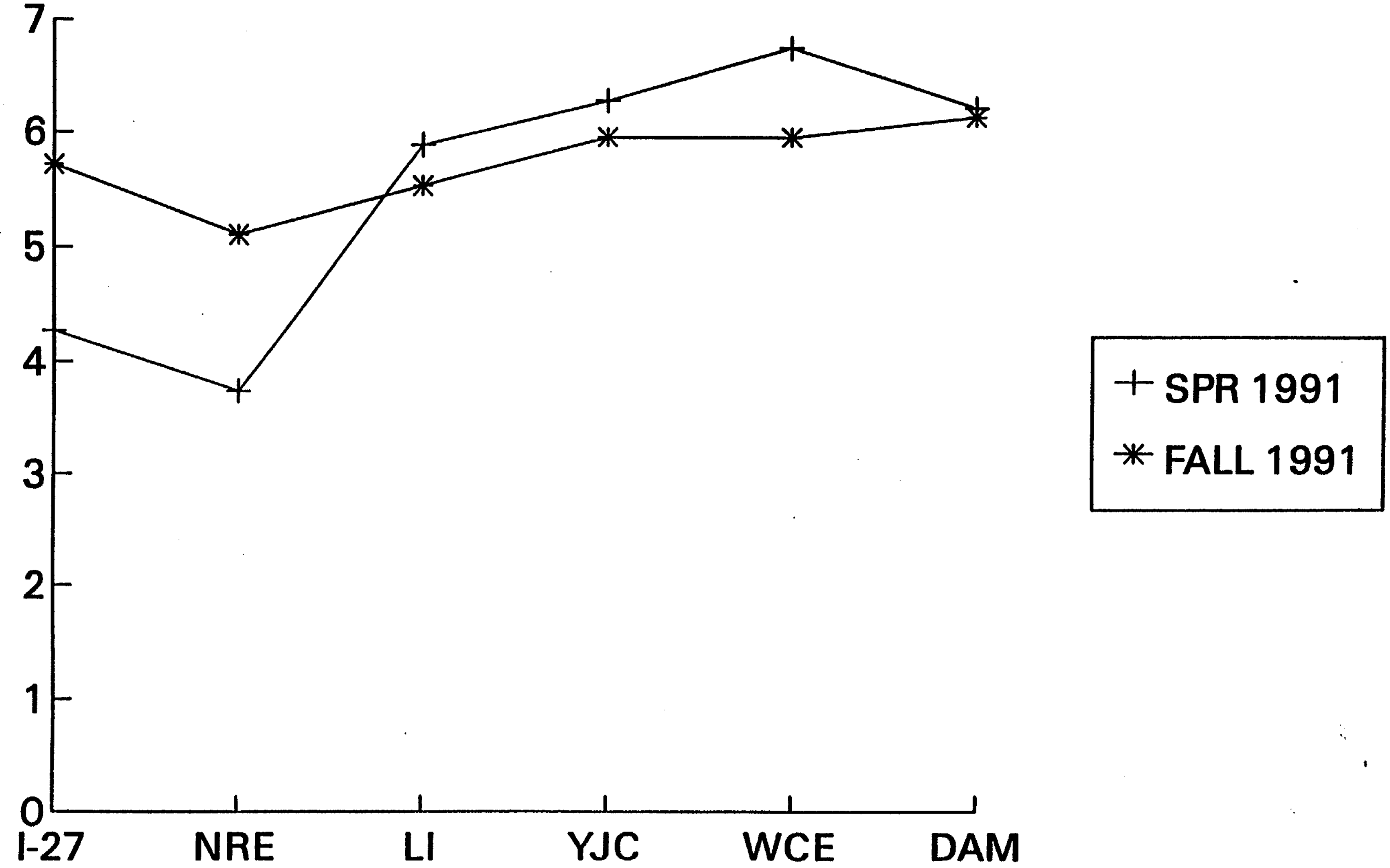


Fig. 7. Comparison of common carp serum protein during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 7 CARP SERUM PROTEIN

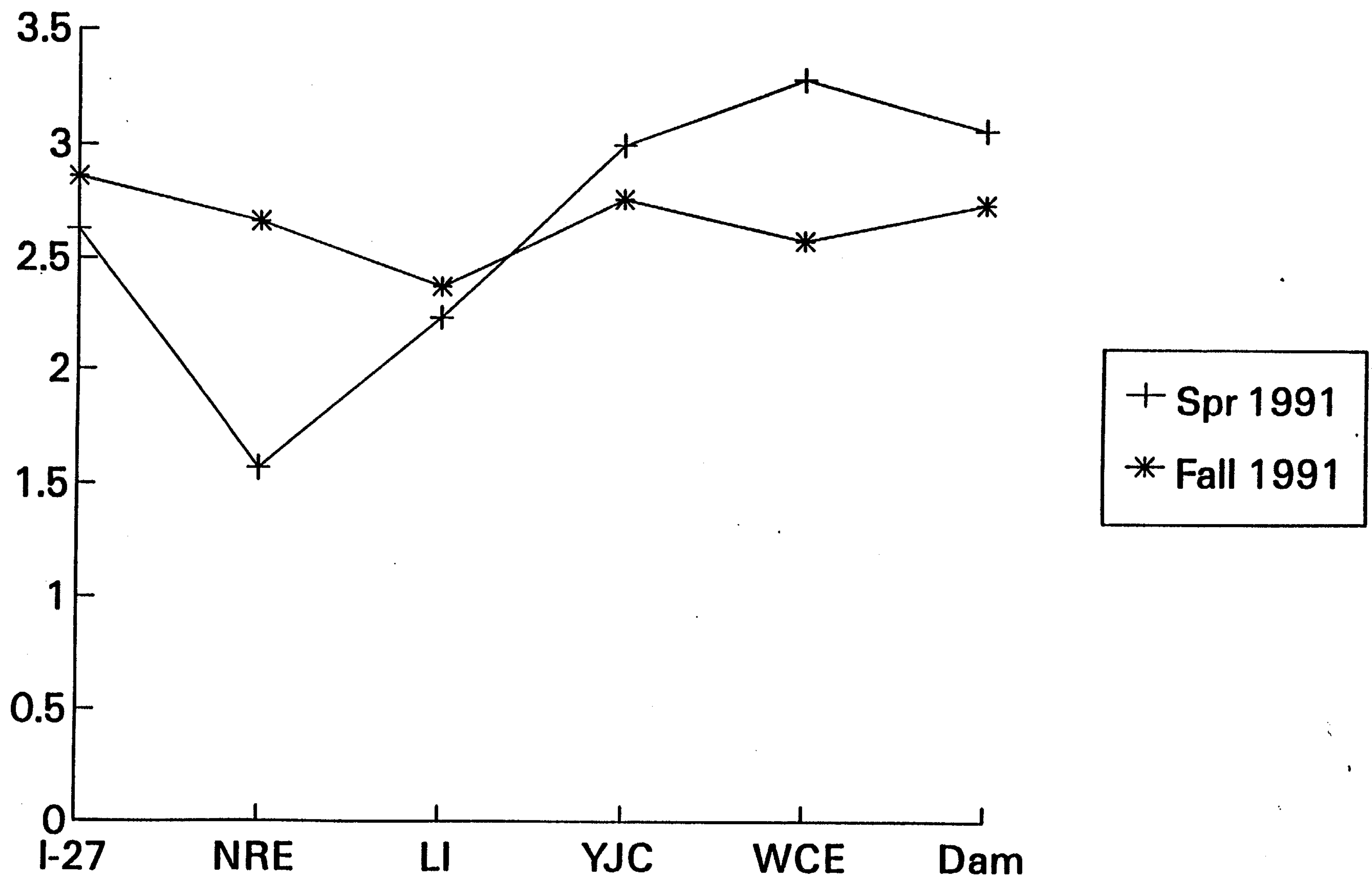


Fig. 8. Comparison of largemouth bass HAI during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 8 BASS HEALTH INDEX VALUES

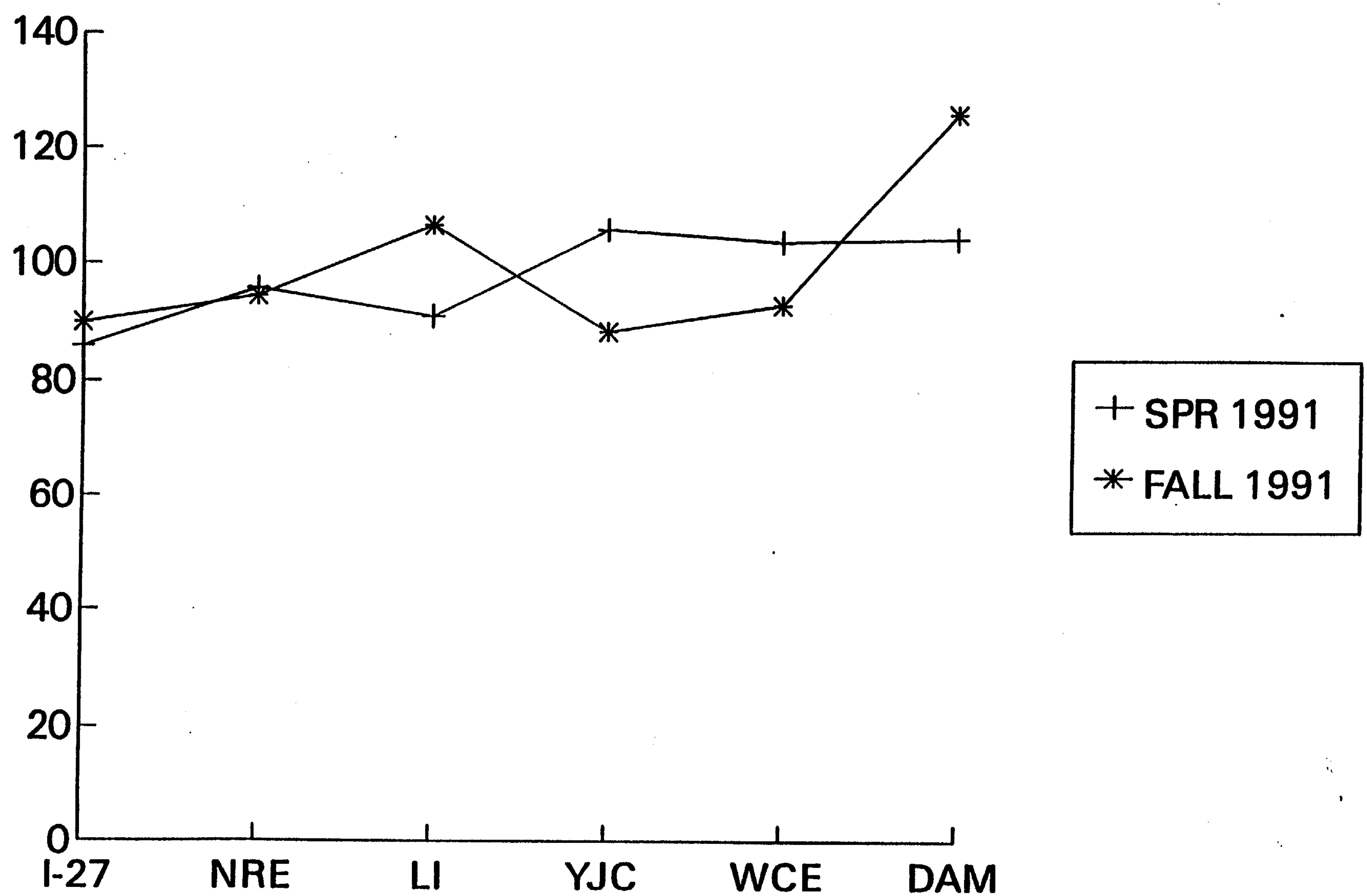


Fig. 9. Comparison of common carp HAI during the Fall and Spring 1991 sampling periods, beginning at the river site (Hwy 27) and ending with the dam site.

Fig. 9 CARP HEALTH INDEX VALUES