TENNESSEE VALLEY AUTHORITY

Resource Group
River Basin Operations
Water Resources

CHICKAMAUGA RESERVOIR EMBAYMENT STUDY - 1990

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Chattanooga, Tennessee

December 1992

MASTER

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ACKNOWLEDGEMENTS

The authors are grateful to several people for their assistance and contributions to the preparation of this report. Larry R. Clark and R. Jim Ruane provided insightful comments and suggestions which greatly improved the final report. David J. Bruggink performed data management functions, statistical data analyses, and prepared many of the figures. Mary B. Collins and Henry F. Leckenby assisted greatly with data manipulations and computer graphics support. Jerry M. Foust, Edward (Drew) A. Thornton, and Daniel L. Stone provided pre-impoundment hypsographic data and streamflow estimates for the embayments. Wayne L. Wilson assisted with the acquisition of the embayment bathymetric data. Donald W. Anderson and Wayne L. Poppe provided direction and administrative assistance and set priorities to allow completion of this report.

EXECUTIVE SUMMARY

Embayments are important areas of reservoirs that need to be considered when assessments are made to support water quality management plans. In 1990, an assessment of the water quality and aquatic resources of Chickamauga Reservoir embayments was initiated. Fifteen major embayments, comprising approximately 20 percent of the surface area of Chickamauga Reservoir, were surveyed April through September 1990. Cause-effect relationships among a number of physical, chemical, biological, morphologic, and environmental conditions were examined. Embayment morphology, particularly depth and detention time, were found to be major factors affecting embayment water quality, productivity, trophic status, and other biological processes in the embayments. The limnologic characteristics of deeper embayments with longer detention times, were more similar to natural lakes than reservoirs, with the water quality characteristics of the embayments exhibiting a much wider range of conditions than the water quality of the main river.

Findings (and recommendations) of the Chickamauga embayment study are as follows:

- Nutrient loadings to each embayment could be estimated using land use classifications for each watershed, derived from SPOT satellite imagery. For embayments with detention times greater than 5-10 days, empirical loading rate models for natural lakes show potential for estimating embayment nutrient concentrations.

- Embayment chlorophyll-a concentrations (and phytoplankton abundance) were highly correlated with total phosphorus. Blue-green algae were found to be dominant in all but two the embayments. Surface coverage of aquatic macrophytes correlated well with higher water clarity and a historical loss of embayment volume.

- General agreement was found between embayment classification based on bottom fauna community structure and classifications based on trophic status indices. Extremely low benthic invertebrate abundance and taxa richness at two upper Hiwassee River sampling stations (HRM's 13.4 and 20.0) indicated a perturbed environment which should be further examined.

•Embayment fish abundance and biomass were positively correlated with macrophyte coverage. The data suggest that fish biomass may be negatively correlated with application rates of pesticides in the watershed and warrants further study. Fish health of largemouth bass and fish size were found to be inversely related, with fish health in the embayments significantly poorer than that of the Tennessee River.

•Hydroacoustic surveys were shown to be a quick, relatively inexpensive and effective method to estimate reservoir embayment volumes. Several embayments have lost approximately half of their original volume (storage capacity) due to sedimentation and filling. The hydroacoustic techniques show much promise and should be better utilized and developed for routine use.

•It is recommended that embayment mixing be investigated and modeled. Both "tidal" mixing effects between the embayment and the main reservoir due to reservoir operations (i.e. water surface level fluctuations) and the convective mixing effects due to diurnal heating and cooling need to be better understood.

•The biotic/abiotic relationships examined in Chickamauga Reservoir embayments need to be explored in other reservoir embayment systems, with particular attention given to large embayments formed by the confluence of major tributary river systems (e.g. Hiwassee, Elk, Duck, Big Sandy, etc.).

•Further examination of the cause of poor fish health in Chickamauga Reservoir embayments is recommended. In addition, relationships between aquatic macrophyte coverage and water clarity (turbidity, color, etc.) and concentrations of metals (esp. copper and lead) in sediment should be more thoroughly investigated.

•Concentrations of heavy metals in sediment: lead in Waconda Bay (180 mg/kg); mercury in Agency Creek (0.82 mg/kg); nickel in Possum Creek (77 mg/kg); and, zinc in Agency Creek (410 mg/kg) were relatively high and should be further investigated.

A summary of the ecological characteristics of the Chickamauga Reservoir embayments is shown in figure ES-1. Each embayment was evaluated based on five ecological indicators: trophic status, dissolved oxygen, sediment quality, benthic invertebrates, and fish health. (A summary of the method used to evaluate each embayments ecological characteristics, based on these five indicators, is given in Appendix G.)

Figure ES-1. Summary of Ecological Characteristics of Chickamauga Reservoir Embayments, 1990

INTRODUCTION

The objectives of this report are three-fold: (1.) assess physical, chemical, and biological conditions in the major embayments of Chickamauga Reservoir; (2.) compare water quality and biological conditions of embayments with main river locations; and (3.) identify any water quality concerns in the study embayments that may warrant further investigation and/or management actions.

Embayments are important areas of reservoirs to be considered when assessments are made to support water quality management plans. In general, embayments, because of their smaller size (water surface areas usually less than 1000 acres), shallower morphometry (average depth usually less than 10 feet), and longer detention times (frequently a month or more), exhibit more extreme responses to pollutant loadings and changes in land use than the main river region of the reservoir. Consequently, embayments are often at greater risk of water quality impairments (e.g. nutrient enrichment, filling and siltation, excessive growths of aquatic plants, algal blooms, low dissolved oxygen concentrations, bacteriological contamination, etc.).

Much of the secondary beneficial use of reservoirs occurs in embayments (viz. marinas, recreation areas, parks and beaches, residential development, etc.). Typically embayments comprise less than 20 percent of the surface area of a reservoir, but they often receive 50 percent or more of the water-oriented recreational use of the reservoir. This intensive recreational use creates a potential for adverse use impacts if poor water quality and aquatic conditions exist in an embayment.

In 1989, several recommendations were made to improve understanding of the factors affecting water quality in reservoir embayments (Butkus, 1989). In 1990, an assessment of the water quality and aquatic resources of Chickamauga Reservoir embayments was initiated. Fifteen major embayments, comprising

approximately 20 percent of the surface area of Chickamauga Reservoir, were surveyed. In addition to the assessment of the embayments, water quality and biological data were also collected at ten monitoring locations in the main channel of the Tennessee and Hiwassee Rivers to document differences between embayment and main channel water quality conditions (figure 1). The Chickamauga Reservoir Water Quality and Aquatic Resource Assessment (i.e. Chickamauga Embayment Study) was comprised of seven tasks:

- Task 1 - Assessment of Fish Community and Health Conditions;
- Task 2 - Fish Abundance Hydroacoustic Surveys;
- Task 3 - Aquatic Plant Acreage and Percent Cover;
- Task 4 - Abundance and Diversity of Benthic Macroinvertebrates;
- Task 5 - Physical/Chemical Characteristics of Water and Sediment (to include estimations of embayment volumes and filling);
- Task 6 - Land Use Characteristics, Nutrient Load Estimates, and Embayment Eutrophication Model Testing;
- Task 7 - Planktonic Algal Assessment (to include chlorophyll and fluorometric analyses to estimate algal biomass) with percent composition and enumeration of major algal groups.

This report presents the results of these activities and the information collected, with particular attention given to Tasks 5 and 6. Physical, chemical and biological characteristics of each embayment are examined, the trophic status of the embayments is assessed, effects of sedimentation and embayment filling are quantified, land use and nutrient loadings to each embayment are estimated, and phosphorus loading rate models are examined for their applicability to embayments. Empirical cause-effect relationship models are proposed to describe some biotic-abiotic relationships (e.g. morphometry, water chemistry, land use, algal populations, aquatic macrophytes, fish health and abundance, etc.

Individual reports describe in greater detail, findings of: Task 1-Fish Community and Health Assessment (Hevel and Hickman, 1992) and (Brown, 1991); Task 2-Fish Abundance Hydroacoustic Surveys (Wilson, 1991); Task 4-Abundance and Diversity of Benthic Macroinvertebrates (Lakin and Poppe, 1992); and Task 7-Planktonic Algal Assessment (Baker and Poppe, 1992).

FIGURE 1
CHICKAMAUGA RESERVOIR EMBAYMENT STUDY - 1990

HYDROLOGIC OVERVIEW OF WATER YEAR 1990

Many water quality characteristics (nutrients, suspended and dissolved solids, bacteria, water clarity, dissolved oxygen, color, etc.) are affected by the impact of rainfall and subsequent runoff. During periods of low rainfall, when runoff is minimal, streamflow is derived principally from the base flow of groundwater. Groundwater contains greater concentrations of dissolved minerals than does surface drainage because of increased water/soil/rock contact and longer groundwater residence time. During periods of high rainfall, streamflow is principally derived from more rapid overland runoff that allows less time for mineral dissolution. Consequently, lower concentrations of dissolved constituents are added to a river during heavy rainfall and subsequent high flows. However, periods of intense rainfall and high overland flows wash off or "flush" a watershed and transport soil particles to streams, particularly from urban and agricultural areas. This carries large loads of nonpoint source pollutants (nutrients, suspended solids, bacteria, etc.) to streams.

The Chickamauga Reservoir watershed averages approximately 52 inches (132 cm) of precipitation annually. March is usually the wettest month and October usually the driest. In the first half of WY 1990 (October 89-March 90) the Tennessee River watershed above Chattanooga received a higher than average amount of rainfall, 29.65 inches compared to the long term average (1890-1990) of 25.22 inches, with resultant high runoff, (figure 2). During the second half of the water year (April 90-September 90), rainfall was substantially below normal, (i.e. 19.60 inches compared to the long term average of 25.49 inches), with below normal runoff (figure 2). The net result was that during the period of April-September 1990, when the Chickamauga Embayment Study sampling activities were being conducted, there was a 23% deficit in precipitation, with resultant runoff about 18% below

average (total runoff was 1.75 inches below the long term average of 9.51 inches, for April-September).

Daily discharge, water surface elevation, and rainfall accumulation data at Chickamauga dam in 1990 reflect these regional trends (figure 3). During 1990, discharge from Chickamauga dam averaged 27,400 cubic feet per second (cfs) from April-September, just slightly below the long term average discharge (1960-1989) of 27,700 cfs, for April-September. (Annually, discharge averages approximately 33,000 cfs (1960-1989) at Chickamauga dam). Between April and September, rainfall at Chickamauga dam was higher than the long term average and also higher than the regional rainfall. Rainfall at Chickamauga dam totaled 26.7 inches from April-September 1990 compared with the long term Chickamauga dam average (1935-1979) of 24.2 inches and compared with a regional rainfall total of 19.60 inches in 1990.

Figure 2.
Precipitation and Runoff
Tennessee River Basin above Chattanooga, WY 1990

Precipitation Departures From 1890-1990 Average (Inches)
For The Tennessee River Basin, Above Chattanooga

Runoff Departures From 1875-1990 Average (Inches)
For The Tennessee River Basin, Above Chattanooga

Figure 3
Discharge, Water Surface Elevation, and Rainfall
Chickamauga Dam, WY 1990

MORPHOLOGIC CHARACTERISTICS OF CHICKAMAUGA EMBAYMENTS

Table 1 summarizes the morphometry of the major Chickamauga reservoir embayments and compares these characteristics with Chickamauga Reservoir. Generally the embayments near the downstream end of Chickamauga reservoir (near Chickamauga dam) are deeper and have longer detention times.

Table 2 compares characteristics of natural lakes, reservoirs, and the Chickamauga reservoir embayments. Reservoirs usually have greater watershed drainage areas, making the control of nutrients and allochthonous material very difficult. Also, reservoirs usually have greater surface areas, greater depths, shorter detention times, and greater overflow rates (areal water loads). With the exception of detention time and overflow rate (mean depth/detention time), table 2 shows that for many of these physical characteristics, the Chickamauga embayments more nearly resemble natural lakes than reservoirs. The physical characteristics (morphometry) of a water body (depth, volume, surface area, hydraulic detention time, etc.) have a very large effect on its intrinsic physical, chemical, biological processes and water quality characteristics. When a river is impounded the resulting reservoir exhibits a wide spatial variability in many water quality variables, (viz. forebay or lacustrine areas, transitional areas, free-flowing riverine areas, and embayment or backwater areas formed by the confluence of smaller tributary streams). The water quality characteristics of embayments are usually different from those of the main river region of a reservoir and often display a much wider variability than the water quality characteristics of the reservoir itself. Relative to their volume, some embayments have rather large drainage areas while some have small drainage areas. Some embayments are relatively shallow and have large water surface areas, while others are deep and have small surface areas. The sizes of the mouths through which embayments are connected with the main

Table 1

CHICKAMAUGA RESERVOIR EMBAYMENTS - MORPHOMETRIC DATA

EMBAYMENT	WATERSHED	+-----1990-----+									MEAN	MEAN	OVERFLOW	SHORELINE				
	DRAINAGE	+----- (683' MSL) -----+													DETENTION	TIME	RATE	DEVELOPMENT
	AREA	SURFACE	AREA	VOLUME		MEAN	DEPTH	MAXIMUM	DEPTH	SHORELINE					FLOW			INDEX
	(sq miles)	(acres)	(km ²)	(ac-ft)	(x10 ⁶ m ³)	(ft)	(m)	(ft)	(m)	(miles)	(cfs)	(days)	(m/yr)					
WACONDA BAY	2.6	144	0.58	1175	1.45	8.2	2.49	22	6.7	3.4	4	144	6.3	2.0				
WOLFTEVER CREEK (+SAV BAY)	96.6	946	3.83	5737	7.08	6.1	1.85	28	8.5	29.3	155	19	36.1	6.8				
WOLFTEVER CREEK (-SAV BAY)	56.4	550	2.23	3933	4.85	7.2	2.18	28	8.5	16.6	95	22	36.2	5.0				
SAVANNAH BAY	40.2	397	1.61	1804	2.23	4.5	1.39	18	5.5	12.7	60	14	35.9	4.6				
DALLAS BAY	9.9	827	3.35	7317	9.03	8.9	2.70	38	11.6	13.6	16	232	4.2	3.4				
SODDY CREEK	65.7	684	2.77	6950	8.57	10.2	3.10	38	11.6	19.0	105	33	34.0	5.2				
POSSUM CREEK	33.7	529	2.14	3794	4.68	7.2	2.19	30	9.1	15.3	54	35	22.5	4.8				
SALE CREEK	116.0	661	2.67	4841	5.97	7.3	2.23	32	9.8	10.8	186	13	61.9	3.0				
RICHLAND CREEK	81.2	319	1.29	1385	1.71	4.3	1.32	23	7.0	16.0	130	5	89.8	6.4				
MUD CREEK	7.6	397	1.61	1417	1.75	3.6	1.09	15	4.6	12.2	12	59	6.8	4.4				
GOODFIELD CREEK	24.9	144	0.58	645	0.80	4.5	1.37	12	3.7	4.8	40	8	61.2	2.9				
GUNSTOCKER CREEK	19.7	355	1.44	1751	2.16	4.9	1.50	15	4.6	7.8	32	28	19.6	3.0				
AGENCY CREEK	19.0	300	1.21	1392	1.72	4.6	1.41	16	4.9	9.2	30	23	22.3	3.8				
CANDIES CREEK	112.0	562	2.27	2324	2.87	4.1	1.26	12	3.7	17.6	179	7	70.4	5.3				
ROGERS CREEK	55.8	449	1.82	1897	2.34	4.2	1.29	10	3.0	10.9	89	11	43.9	3.7				
NORTH MOUSE CREEK	93.7	164	0.66	352	0.43	2.1	0.66	9	2.7	11.2	150	1	206.2	6.2				
SOUTH MOUSE CREEK	39.9	119	0.48	358	0.44	3.0	0.92	8	2.4	6.7	64	3	119.5	4.4				
CHICKAMAUGA RESERVOIR	20790	35400	143.26	628000	774.63	17.7	5.41	65	19.8	810	33099	10	197.5	30.7				
HIWASSEE RIVER ARM	2700	6500	26.32	65485	80.77	10.1	3.08	30	9.1	148	5660	6	192.7	13.1				

1. Volume and Surface Area information were obtained from hydroacoustic surveys conducted during the summer of 1990, see discussion in text of report.
2. Shoreline mileages are the sum of both the main shoreline and island shoreline mileages.
3. Estimates of Mean Flow to the embayments were provided by TVA-Data Management, using long term discharge records at five nearby stream gauging locations, resulting in a 1.60 cubic feet per second per square mile (cfsm) coefficient being used to estimate streamflows to the embayments.
4. Mean Detention Time (volume/mean flow) estimates assume complete mixing and a water surface elevation of 683 feet (MSL).
5. Overflow rate is the mean depth divided by the mean detention time, also referred to as the areal water load.
6. The Shoreline Development Index estimates the potential for shoreline development and is defined as the ratio of the length of the shoreline to twice the square root of the product of pi (3.1415) times the surface area of the embayment.

Table 2

COMPARISON OF NATURAL LAKES, RESERVOIRS, AND CHICKAMAUGA			
EMBAYMENTS (Modified from Thornton et.al., 1980)			
	Natural	USACOE	Chickamauga
	Lakes	Reservoirs	Embayments
Variable	(n=309) ^a	(n=107) ^a	(n=17) ^a
Drainage Area (km ²)	222	3228	91 (6.7-300) ^b
Surface Area (km ²)	5.6	34.5	1.5 (0.5-3.8)
Maximum Depth (m)	10.7	19.8	5.7 (2.4-11.6)
Mean Depth (m)	4.5	6.9	1.6 (0.7-3.1)
Shoreline Development Index	2.9	9.0	4.2 (2.0-6.4)
Mean Detention Time (yr)	0.74	0.37	0.05 (0.01-0.64)
Overflow Rate (m/yr)	6.5	19	33.2 (4.3-206)
Secchi Depth (m)	1.4	1.1	1.0 (0.4-1.8)
Total Phosphorus (μg/l)	54	39	22.6 (6-120)
Chlorophyll-a (μg/l)	14	8.9	10.8 (3.9-26.3)
Phosphorus Loading (g/m ² -yr)	0.87	1.7	0.55 (0.16-6.6)
^a Values are geometric means ^b Range in parentheses			

reservoir vary considerably and affect the amount of water exchange. Many embayments have natural narrow channels or manmade causeways that constrict flow and create two or more pool regions within the same embayment. Other embayments have a channelized bathymetry similar to that of the main river region of reservoirs and exhibit the same longitudinal hydrodynamic and water quality characteristics, (Butkus, 1989). All these factors, and others, affect the response of each embayment to nutrient loadings, sedimentation processes, and additions of organic matter.

One important water quality consideration not investigated in this study were the weekly, summer fluctuations of the water surface elevation of Chickamauga Reservoir. Between mid-May and mid-September, the pool level of Chickamauga Reservoir is raised and lowered on a weekly frequency for mosquito control, at a drain and fill rate of approximately 0.3 feet/day. This results in an approximate one foot lowering and raising of the pool level each week, (figure 3b). The effect on shallow embayments (e.g. North and South Mouse Creek embayments) results in the exchange of a substantial proportion of the embayments volume in addition to enhancing scouring, mixing, resuspension of sediment, etc., and further study is recommended. Investigations currently underway (Rizk, 1992) are providing additional understanding of these tidal like effects on embayment water exchange and resultant water quality conditions in the embayments.

WATER QUALITY

Materials and Methods

Physical/chemical measurements of water quality were made monthly (April-September) at 20 embayment sampling locations and at 10 main channel locations (7 on the Tennessee River and 3 on the Hiwassee River), table 3. Physical/chemical measurements of water, made at each location include: in situ water column measurements of temperature, dissolved oxygen, pH, and conductivity; nutrients (nitrite plus nitrate-nitrogen, organic nitrogen, ammonia-nitrogen, total phosphorus, and dissolved ortho phosphorus); organic carbon (total and soluble); alkalinity and hardness; fecal Coliform bacteria; and water clarity (Secchi depth, turbidity, suspended solids, and color), table 4. Water quality measurements, sample collections and sample handling followed standard practices accepted by the Environmental Protection Agency (EPA, 1979 and 40 CFR 136), US Geological Survey (USGS, 1977), and American Public Health Association (AWWA, WPCF, APHA, 1989) as specified in TVA quality assurance/quality control (QA/QC) procedures (TVA, 1990 and TVA, 1987). Laboratory analyses conformed to established QA/QC procedures (TVA, 1989). Specific QA/QC procedures for this project are discussed in Appendix A.

The field and laboratory data are tabulated in Appendix A-Physical/Chemical Characteristics of Water. All water quality data are stored and available on EPA's water quality data storage and retrieval (STORET) computer system.

In situ Measurements

In situ measurements of temperature, dissolved oxygen, pH, and conductivity were made monthly at all 30 sampling locations (figure 1 and table 3). These data are tabulated in Appendix A. Plots of in situ measurements of temperature, dissolved oxygen, and pH (figures 4a-4e) illustrate differences (and

Table 3

WATER QUALITY MONITORING LOCATIONS
CHICKAMAUGA EMBAYMENT STUDY, APRIL-SEPTEMBER 1990

	RIVER	STORET			
MAIN CHANNEL	MILE	CODE	WATER	SEDIMENT	ALGAE
Tennessee River	472.3	475358	X	X	X
Tennessee River	478.2	475302	X	X	X
Tennessee River	490.5	475265	X	X	X
Tennessee River	496.5	475266	X	X	X
Tennessee River	506.6	475804	X	X	X
Tennessee River	518.0	475363	X	X	X
Tennessee River	529.9	475364	X		X
Hiwassee River	7.4	475366	X	X	X
Hiwassee River	13.4	477245	X	X	X
Hiwassee River	20.0	475908	X	X	X
EMBAYMENT					
Waconda Bay	0.95	477228	X	X	X
Wolftever Creek	4.2	477229	X	X	X
Wolftever Creek	5.65	477230	X	X	X
Savannah Bay	2.95	477231	X	X	X
Dallas Bay	0.9	477232	X	X	X
Soddy Creek	1.7	477233	X	X	X
Soddy Creek	4.0	477234	X	X	X
Possum Creek	2.0	477235	X	X	X
Sale Creek	1.3	477236	X	X	X
Sale Creek	2.0	477237	X	X	X
Richland Creek	0.5	475909	X	X	X
Richland Creek	2.8	477238	X	X	X
Mud Creek	1.3	477239	X	X	X
Goodfield Creek	0.9	477240	X	X	X
Gunstocker Creek	0.85	477241	X	X	X
Agency Creek	0.65	477242	X	X	X
Candies Creek	1.5	477243	X	X	X
Rogers Creek	1.5	477244	X	X	X
North Mouse Creek	0.5	477246	X	X	X
South Mouse Creek	1.1	477247	X	X	X

Table 4

PHYSICAL/CHEMICAL MEASUREMENTS - WATER
CHICKAMAUGA EMBAYMENT STUDY, WY 1990

Water - Monthly (April through September)

EPA Storet Code	Description	Units	Detection Limits
Field Measurements ^a			
00010	Temperature	°C	--
00300	Dissolved Oxygen	mg/l	--
00400	pH	Std. units	--
00094	Conductivity	micromhos/cm	--
00078	Secchi Depth	meters	0.1 meters
31616	Fecal Coliform	colonies/100 mL	1/100 mL
Laboratory Measurements ^b			
00403	pH	Std. units	--
00410	Total Alkalinity	mg/l	1 mg/l
00900	Total Hardness	mg/l	1 mg/l
00080	Color	PCU	1 PCU
00081	Apparent Color	PCU	1 PCU
82079	Turbidity	NTU	1.0 NTU
00530	Suspended Solids	mg/l	1 mg/l
00605	Organic Nitrogen	mg/l	0.02 mg/l
00610	Ammonia Nitrogen	mg/l	0.01 mg/l
00630	Nitrite & Nitrate Nitrogen	mg/l	0.01 mg/l
00665	Total Phosphorus	mg/l	0.002 mg/l
00671	Dissolved Ortho phosphorus	mg/l	0.002 mg/l
00680	Total Organic Carbon	mg/l	0.2 mg/l
00681	Soluble Organic Carbon	mg/l	0.2 mg/l
(32211	Chlorophyll-a	µg/l	1 µg/l) ^c

^aIn situ Hydrolab® measurements of temperature, dissolved oxygen, pH, and conductivity were made from the water surface to the bottom of the water column at appropriately spaced depth intervals.

^b Grab samples were collected monthly at a 1-meter depth for all laboratory analyses, except chlorophyll-a.

^c Chlorophyll-a samples were composited from the photic zone, and were collected and analyzed twice monthly. (See Aquatic Biology discussion in text).

similarities) between embayment and main channel stratification patterns and water quality. The figures show stronger thermal stratification and concentration gradients for dissolved oxygen (DO) and pH at embayment sampling locations compared to main channel, run-of-the-river sampling locations.

Close examination of figures 4a-4e gives evidence of embayment hydrodynamic mixing events which invite further investigation. Two embayments with long detention times, Waconda Bay (144 days) and Dallas Bay (232 days) behaved differently with respect to temperature, DO, and pH. Figure 4b shows that in the first part of July, Waconda Bay experienced a mixing event that prevented DO from decreasing below 4 mg/l. On the other hand, nearby Dallas Bay did not mix during the same time and DO concentrations dropped to less than 2 mg/l in the lower 3 meters. Why this mixing event happened in Waconda Bay and not Dallas Bay is not immediately obvious and deserves further study - perhaps differences in depth, volume, oxygen demand, constriction or size of the mouth of the embayment, etc? TVA is attempting to better understand the hydrodynamics of embayment circulation patterns and exchange of water between the embayment and the reservoir (Rizk, 1992 and TVA, 1992). Particular attention needs to be given to embayment convective circulation induced by solar heating and nighttime cooling (James and Barko, 1991; and Monismith et.al., 1990) and to the effect of reservoir operation patterns on water surface elevation fluctuations (i.e. "tidal-like" mixing events) and water exchange in embayments.

Temperature - The upstream run-of-the-river sampling locations (TRM's 529.9, 518.0, 506.6, 496.5 and HRM's 13.4 and 20.0) were well mixed throughout the summer. However moving downstream, the run-of-the-river sampling locations (TRM's 472.3, 478.2, 490.5 and HRM 7.4) became increasingly stratified. Only 2 of the 10 run-of-the-river sampling locations had maximum temperature differences, ΔT 's, (water surface temperature minus bottom temperature) greater than 2°C (i.e. TRM 478.2 with a ΔT of 2.1°C and HRM with a ΔT of 6.2, both in June). The highest temperature measured among the 10 run-of-the-river sampling locations was 28.7°C, in July near Chickamauga dam at TRM 472.3.

Embayments were more strongly stratified, with 18 of the 20

Figure 4a
Temperature, Dissolved Oxygen and pH Isopleths
Chickamauga Reservoir Embayments

Figure 4b

Temperature, Dissolved Oxygen and pH Isopleths

Chickamauga Reservoir Embayments

Figure 4c
Temperature, Dissolved Oxygen and pH Isopleths
Chickamauga Reservoir Embayments

Figure 4d
Temperature, Dissolved Oxygen and pH Isopleths
Chickamauga Reservoir Embayments

Figure 4e
Temperature, Dissolved Oxygen and pH Isopleths
Chickamauga Reservoir Embayments

Figure 5
Maximum Surface Water Temperatures
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

embayment sampling locations having ΔT 's exceeding 2°C , with the greatest degree of stratification observed in June in Wolftever Creek embayment (ΔT 's of 7.9°C) and Richland Creek embayment (ΔT 's of 6.2°C). Highest temperatures were also observed in the embayments. Maximum temperatures exceeded 27°C in only 3 of 10 of the run-of-the-river sampling locations, while 17 of 20 of the embayment sampling locations had temperatures exceeding 27°C . Maximum embayment surface water temperatures ranged from 25.8°C in North Mouse Creek embayment to 30.2°C in Dallas Bay (figure 5). The highest average (mean) temperature of 25.2°C was observed in Savannah Bay (table 5).

The embayment overflow rate (a measure of the displacement rate of water in an embayment, see table 1) was found to be highly inversely correlated with average water temperature (at 1-meter depth), with a correlation coefficient of -0.81 . This implies that embayment water temperature is physically controlled by embayment depth and detention time.

Dissolved Oxygen - DO stratification patterns were similar to temperature patterns, in that well mixed conditions exist in the upstream portions of the Tennessee and Hiwassee rivers on Chickamauga Reservoir, with increasing DO stratification occurring as the water flows downstream into the more lacustrine portions of the reservoir. Low DO's were observed in the upper end of Chickamauga Reservoir in July and September (3 to 4 mg/l) due to low DO releases from Watts Bar dam. Seasonally, highest DO's (equal to or exceeding 10 mg/l at all but 5 of the 30 sampling locations) were found in April.

Stronger oxyocline development occurred in embayments than in the open water portions of Chickamauga reservoir. Only 2 of the 10 run-of-the-river sampling locations (TRM 478.2 and 490.5) had ΔDO 's greater than 4 mg/l (water surface concentration minus bottom concentration); while 18 of 20 of the embayment sampling locations had ΔDO 's equal to or greater than 4 mg/l. DO's less than 2 mg/l were not measured at any of the run-of-the-river sampling locations, but DO's less than 2 mg/l were consistently observed at more than half of the embayment sampling locations. Maximum embayment DO concentrations were observed in Soddy Creek embayment and Dallas

Figure 6

Minimum Dissolved Oxygen Concentrations, 1-meter depth

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Bay, 12.2 mg/l and 12.0 mg/l, respectively. Minimum embayment DO concentrations, at 1-meter depth, ranged from 3.6 mg/l in Candies Creek embayment to 8.0 mg/l in Possum Creek embayment (figure 6). The highest average (mean) DO concentrations were found on the Hiwassee River at mile 20.0 and in Goodfield Creek embayment, 9.2 mg/l and 8.2 mg/l respectively (table 5).

In the embayments, DO concentrations (at 1-meter depth) were found to be correlated with water clarity (Secchi depth, turbidity, and suspended solids) and organics (total organic carbon and organic nitrogen). Correlations of Secchi depth, turbidity, and suspended solids with DO were 0.86, -0.84, and -0.82, respectively. Total organic carbon and organic nitrogen correlations with DO were -0.77 and -0.76, respectively. These data suggest that the greater the load of suspended organic matter (viz. oxygen demanding material) in the embayments, the lower the concentrations of DO.

A simple empirical regression model to predict average summer DO concentrations at the 1-meter depth in Chickamauga reservoir embayments accounted for over 80% of the variance in the data, relating DO with temperature and water clarity:

Dissolved Oxygen, mg/l @ 1-m =

$$0.006 + 1.40(\text{Secchi, m}) + 0.280(\text{Temperature, } ^\circ\text{C @ 1-m})$$

where: $R^2 = 0.83$; $F = 42.1$; $\text{prob}>F = 0.0001$; $n = 20$.

pH - High pH values were observed coincident with high DO concentrations (figures 4a-4e), indicative of periods of high photosynthetic activity. Values of pH equal to or exceeding 8.5 were measured at 14 of the 20 embayment sampling locations, but at only 1 of the 10 run-of-the-river sampling locations (HRM 7.4), denoting greater productivity in the embayments. In many of the embayments, the strong DO and pH gradients persist throughout the summer, with near surface pH's greater than 8.5 and near bottom concentrations of DO less than 1 mg/l.

In the embayments, both temperature and DO were found to be correlated with pH (0.79 and 0.78, respectively), implying higher pH's (and higher rates of photosynthesis) in warmer, higher oxygenated embayment water.

Conductivity - The influence of watershed inflows is shown in the conductivity levels observed in the embayments. Of the fifteen embayments, five (Wolftever/Savannah, Goodfield, Candies, North Mouse, and South Mouse) had significantly higher conductivity levels (greater than 200 umhos/cm) and three (Soddy, Possum, and Sale) had lower conductivity levels (less than 150 umhos/cm) than the reservoir, table 5. These eight embayments have detention times less than 35 days, i.e. higher inflow to volume ratios. Three embayments (Waconda Bay, Dallas Bay, and Mud Creek) with long detention times, i.e. lower inflow to volume ratios had conductivity levels similar to the reservoir suggesting a greater reservoir effect on embayments with longer detention times.

Embayments to the northwest of the reservoir (Dallas Bay, Soddy Creek, Possum Creek, Sale Creek, and Richland Creek) generally had lower conductivities; while those to the southeast (Wolftever Creek, Savannah Bay, South Mouse, and Candies Creek) generally had higher conductivities.

Embayments As Unique Water Quality Units

In an attempt to demonstrate the uniqueness of the water quality characteristics of embayments, two statistical techniques - cluster analysis and principal component analysis - were used to examine differences (and similarities) between embayment and main channel chemical water quality characteristics. Monthly water chemistry samples collected at a 1-meter depth, and in situ Hydrolab® measurements (temperature, DO, pH and conductivity) also made at a 1-meter depth were used in the cluster and principal component analyses. The mean concentrations of nineteen water quality variables (temperature, DO, pH, conductivity, Secchi depth, fecal coliform, alkalinity, turbidity, color, hardness, organic-nitrogen, ammonia-nitrogen, nitrite plus nitrate-nitrogen, total nitrogen, total phosphorus, dissolved phosphorus, total nitrogen/total phosphorus ratio, total organic carbon, and chlorophyll-a) were used. Three variables (suspended solids, apparent color, and soluble organic carbon) were not included in the analyses because they were found

TABLE 5
CHICKAMAUGA EMBAYMENT STUDY
WATER QUALITY SUMMARY
SUMMER AVERAGES (APRIL-SEPTEMBER 1990)

Location	Temperature (°C)	Dissolved Oxygen (mg/l)	pH (std. units)	Conductivity (umhos/cm)	Secchi Depth (m)	Fecal Coliform (#/100 ml)	Alkalinity (mg/l)	Hardness (mg/l as CaCO ₃)	Turbidity (NTU)	True Color (PCU)	Apparent Color (PCU)
Main Channel											
Tennessee River Mile 472.3	23.8	6.9	7.4	156	1.3	10.0	58.2	80.2	5.9	14.2	20.7
Tennessee River Mile 478.19	23.6	6.9	7.4	158	1.1	11.7	59.4	92.3	5.3	14.5	21.0
Tennessee River Mile 490.47	22.3	7.1	7.5	165	1.1	11.7	55.2	77.2	4.9	13.7	18.2
Tennessee River Mile 496.50	21.7	6.3	7.4	164	1.2	10.0	62.7	75.3	4.9	13.7	18.2
Tennessee River Mile 506.6	22.1	5.6	7.4	167	2.0	10.0	64.3	83.2	4.0	11.5	15.3
Tennessee River Mile 518.0	21.6	6.1	7.5	168	1.6	10.0	63.7	81.3	6.0	10.2	14.0
Tennessee River Mile 529.9	21.2	6.0	7.6	170	1.2	10.0	65.8	82.8	6.2	13.7	17.3
Hiwassee River Mile 7.4											
Hiwassee River Mile 13.4	19.8	8.1	7.3	134	1.0	44.0	32.0	77.3	10.3	30.0	34.7
Hiwassee River Mile 20.0	18.7	9.2	7.3	70	1.7	393.3	17.3	81.2	6.7	25.4	28.0
Embayments											
Waconda Bay 0.95	24.0	7.3	7.7	158	1.0	16.7	59.7	85.3	7.8	15.8	20.5
Wolftever Creek 4.2	24.1	7.2	7.8	206	1.2	10.0	91.2	93.2	5.1	14.5	18.3
Wolftever Creek 5.65	23.7	6.7	7.7	229	0.7	10.0	103.3	89.2	11.5	17.3	23.0
Savannah Bay 2.95	25.2	6.7	7.9	243	0.6	86.7	117.5	99.8	15.5	19.7	24.7
Dallas Bay 0.9	24.6	6.6	7.8	164	1.3	10.0	60.8	80.2	4.5	12.4	15.3
Soddy Creek 1.7	23.3	6.4	7.5	151	1.8	14.0	52.5	78.3	2.2	9.4	11.4
Soddy Creek 4.0	24.1	6.8	7.6	140	1.7	10.0	47.5	79.7	3.0	12.5	16.5
Possum Creek 2.0	23.6	6.5	7.6	154	1.8	10.0	48.0	76.8	2.2	11.2	13.5
Sale Creek 1.3	22.6	6.2	7.5	148	1.7	10.0	55.7	80.7	2.7	12.7	14.7
Sale Creek 2.0	22.5	6.5	7.4	136	1.5	10.0	51.7	80.3	3.1	13.2	16.7
Richland Creek 0.5	22.1	6.4	7.6	164	1.4	18.3	64.5	86.0	4.3	12.8	16.8
Richland Creek 2.8	22.9	6.7	7.7	168	1.1	30.0	65.2	84.2	5.5	14.2	18.5
Mud Creek 1.3	24.5	5.7	7.8	170	0.8	13.3	70.5	82.2	10.4	15.0	20.8
Goodfield Creek 0.9	23.8	8.2	8.1	204	0.7	18.3	88.5	87.7	10.8	15.8	21.8
Gunstocker Creek 0.85	23.3	6.3	7.5	151	0.8	18.3	43.7	83.5	13.3	22.5	28.7
Agency Creek 0.65	23.0	6.3	7.4	146	1.0	11.7	43.8	77.3	7.8	23.3	29.5
Candies Creek 1.5	21.8	5.5	7.5	210	0.5	701.8	69.2	88.6	23.7	49.2	59.2
Rogers Creek 1.5	23.3	7.2	7.6	152	0.9	113.5	41.3	79.7	9.8	24.2	31.8
North Mouse Creek 0.5	21.6	6.5	7.8	253	0.6	16.7	119.7	123.3	16.8	40.8	56.2
South Mouse Creek 1.1	22.3	6.1	7.7	227	0.4	504.2	98.5	112.3	37.7	59.2	68.3

Hydrolab* measurements (temperature, dissolved oxygen, pH, and conductivity) are averaged over the water column; other data are the average of measurements made at 1-meter depth. Chlorophyll-a data are the average of samples composited within the photic zone and collected twice monthly.

TABLE 5 (continued)

CHICKAMAUGA EMBAYMENT STUDY
WATER QUALITY SUMMARY
SUMMER AVERAGES (APRIL-SEPTEMBER 1990)

Location	Suspended Solids (mg/l)	Organic Nitrogen (mg/l)	Ammonia Nitrogen (mg/l)	Nitrate + Nitrite Nitrogen (mg/l)	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Dissolved Ortho Phosphorus (mg/l)	TN/TP Ratio	Total Organic Carbon (mg/l)	Dissolved Organic Carbon (mg/l)	Chlorophyll-a (ug/l)
Main Channel											
Tennessee River Mile 472.3	4.2	0.16	0.02	0.19	0.37	0.020	0.005	39.58	1.85	1.82	9.2
Tennessee River Mile 478.19	4.0	0.21	0.02	0.18	0.40	0.023	0.006	18.94	2.03	1.87	8.7
Tennessee River Mile 490.47	3.5	0.18	0.02	0.22	0.43	0.023	0.009	19.19	2.00	1.87	10.3
Tennessee River Mile 496.50	3.3	0.14	0.04	0.27	0.45	0.025	0.014	18.75	1.85	1.80	6.1
Tennessee River Mile 506.6	2.5	0.16	0.05	0.29	0.50	0.023	0.013	22.06	1.85	1.77	2.4
Tennessee River Mile 518.0	5.5	0.17	0.04	0.27	0.48	0.022	0.008	24.31	1.92	1.75	3.7
Tennessee River Mile 529.9	5.3	0.19	0.03	0.27	0.49	0.027	0.009	19.19	1.87	1.73	5.2
Hiwassee River Mile 7.4	6.5	0.32	0.03	0.12	0.47	0.032	0.006	15.75	2.95	2.60	8.5
Hiwassee River Mile 13.4	6.8	0.17	0.08	0.19	0.43	0.037	0.016	14.10	2.77	2.50	3.2
Hiwassee River Mile 20.0	5.8	0.13	0.01	0.16	0.29	0.018	0.007	23.41	1.28	1.20	1.7
Embayments											
Waconda Bay 0.95	6.2	0.18	0.02	0.14	0.34	0.018	0.004	21.56	1.98	1.88	10.2
Wolftever Creek 4.2	3.8	0.25	0.01	0.05	0.31	0.023	0.004	15.92	2.38	2.17	11.0
Wolftever Creek 5.65	10.8	0.35	0.01	0.03	0.40	0.032	0.003	15.77	2.87	2.55	10.3
Savannah Bay 2.95	16.3	0.54	0.01	0.02	0.57	0.042	0.003	15.10	3.50	2.97	15.3
Dallas Bay 0.9	4.0	0.23	0.01	0.06	0.30	0.011	0.004	28.19	2.15	1.98	8.9
Soddy Creek 1.7	1.8	0.16	0.01	0.06	0.23	0.009	0.004	30.06	1.93	1.78	7.1
Soddy Creek 4.0	1.8	0.15	0.01	0.05	0.22	0.007	0.003	34.15	1.82	1.67	3.9
Possum Creek 2.0	1.2	0.12	0.01	0.07	0.20	0.006	0.004	35.96	1.77	1.62	4.9
Sale Creek 1.3	2.7	0.17	0.01	0.11	0.29	0.010	0.004	33.19	1.95	1.77	5.6
Sale Creek 2.0	2.7	0.17	0.02	0.08	0.28	0.010	0.003	34.11	2.00	1.78	4.7
Richland Creek 0.5	3.5	0.29	0.01	0.14	0.45	0.023	0.004	22.94	2.07	1.83	10.3
Richland Creek 2.8	5.2	0.27	0.01	0.09	0.37	0.025	0.004	22.28	2.25	1.93	12.0
Mud Creek 1.3	9.8	0.37	0.03	0.08	0.48	0.025	0.005	23.84	2.82	2.47	12.7
Goodfield Creek 0.9	10.8	0.30	0.01	0.04	0.36	0.030	0.006	14.56	2.38	2.00	12.2
Gunstocker Creek 0.85	13.8	0.39	0.01	0.03	0.43	0.040	0.005	13.15	2.88	2.50	19.2
Agency Creek 0.65	6.7	0.38	0.01	0.05	0.45	0.030	0.005	16.49	2.80	2.50	24.0
Candies Creek 1.5	20.2	0.38	0.02	0.07	0.47	0.042	0.011	12.55	3.12	2.85	16.1
Rogers Creek 1.5	8.2	0.28	0.01	0.04	0.33	0.040	0.006	8.37	2.73	2.47	19.8
North Mouse Creek 0.5	15.3	0.39	0.02	0.34	0.75	0.047	0.013	19.67	2.68	2.35	10.2
South Mouse Creek 1.1	38.8	0.83	0.02	0.21	1.06	0.120	0.022	12.01	3.75	3.38	26.3

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to be redundant, being very highly correlated ($r \geq 0.98$) to turbidity, color, and total organic carbon, respectively. Prior to the cluster and principal components analyses, $\log_e$ transformations were performed on the means of all the variables.

Table 5 summarizes the water quality of the thirty Chickamauga Reservoir Embayment Study sampling locations, tabulations of the raw data are given in Appendix A.

Cluster Analysis - Cluster analysis is a technique that accomplishes the sorting of objects into groups or clusters based on their overall resemblance to one another. The advantage of using cluster analysis is that it can consider a large number of characteristics (19 variables) and place similar entities (i.e. sampling locations) into groups or "clusters." In this analysis, the 30 sampling locations were examined for similarities based on the 19 water quality characteristics and sorted into natural groupings or clusters (viz. embayments and/or main channel). The cluster analysis was performed using the SAS (1989) CLUSTER procedure. The data were standardized to mean 0 and variance 1 and the average linkage algorithm using Euclidean distances was employed. The results of the analysis are displayed in a hierarchical tree-like structure called a dendrogram. Although the identification of groups of clusters from a dendrogram can be somewhat subjective, the results of this cluster analysis indicate several logical clusters based on embayment versus main channel water quality characteristics (figure 7). The lower the average distance, the greater the similarity between the sampling locations.

On the abscissa at about 1.0 average distance, three major groupings are obvious: (1.) clusters A, B, C, and D - sampling locations which exhibit lacustrine water quality characteristics; (2.) cluster E and Hiwassee River mile 13.4 - sampling locations which are riverine in character; and (3.) cluster F - three embayments tributary to the upper Hiwassee River - Candies Creek, South Mouse Creek, and North Mouse Creek - characterized by low water clarity and high nutrient concentrations. (Two remaining

Figure 7

Cluster analysis dendrogram of Chickamauga Reservoir monitoring locations. The dendrogram is based on an average linkage algorithm using Euclidean distance as a measure of similarity.

"outlier" locations - Savannah Bay and Hiwassee River mile 20.0 exhibit individually unique water quality characteristics and do not cluster with any other locations.)

Cluster E, the most tightly clustered (i.e. most similar) of the six clusters (A, B, C, D, E, and F) is comprised of main channel, upstream Tennessee River locations - TRM's 529.2, 518.0, 506.6, and 496.5. These four Tennessee River locations are riverine in character with generally lower temperature, lower chlorophyll, lower organic carbon, and higher nutrients. The three Tennessee River sampling locations in the lacustrine portion of Chickamauga Reservoir - TRM's 472.3, 478.2, and 490.5 - cluster with embayments (cluster A) rather than with the upstream, more riverine, locations (cluster E). The sampling locations in cluster A (as well as those in clusters B, C, and D) have generally higher temperatures, higher chlorophyll's, higher the two sampling locations most similar are TRM 478.2 and Waconda organic carbons, and lower nutrients. Of all the cluster pairs, Bay 0.95, average distance = 0.24. These two sampling locations are physically located quite close to one another in the downstream portion of the reservoir and have quite similar water quality (table 5).

Another tightly clustered grouping (cluster D), is comprised of the downstream embayments on the northwest side of Chickamauga reservoir - Dallas Bay, Soddy Creek, Possum Creek and Sale Creek. These four embayments are characterized by low nutrients, moderate chlorophyll, high water clarity, low conductivity and are the most oligotrophic of all the embayments. Cluster C, is a grouping of embayments near the mouth of the Hiwassee River - Agency Creek, Gunstocker Creek, Rogers Creek, and Hiwassee River mile 7.4.¹ Cluster B is a grouping of generally turbid, high

¹Note that the sampling location near the mouth of the Hiwassee River (HRM 7.4) clusters with embayment locations, indicating lacustrine rather than riverine water quality characteristics. For the purposes of this study, by definition, embayments were those tributary water bodies with surface areas less than ca 1000± acres. Consequently, because of its large size, the embayment formed by the confluence of the Hiwassee and Tennessee rivers, was excluded. It is recommended that as more is learned about the water quality of embayments, future studies consider large tributary river embayments such the Hiwassee, Elk, Duck, etc.

conductivity, hard water embayments.

With the possible exception of the cluster F - Candies Creek, South Mouse Creek, and North Mouse Creek - the remaining sampling locations - Savannah Bay, and Hiwassee River 20.0 - are rather unique. This is particularly true for Hiwassee River 20.0, which has unique water quality characteristics (low temperature, high DO, low conductivity, low alkalinity, low nutrients) compared to the other monitoring locations (table 5).

Principal Components Analysis - Principal components analysis (PCA) is a multivariate technique for examining relationships among several quantitative variables (e.g. water quality characteristics). PCA reduces a set of data with many variables to a small number of linear combinations (principal components) of the variables that retain as much of the information in the original variables as possible. In this analysis, using the Chickamauga reservoir water quality data (table 5) to investigate the differences (and similarities) among the embayment and main channel sampling locations, the first two linear combinations - principal component one (PC1) and principal component two (PC2) - of the 19 water quality variables at each sampling location were plotted as coordinate points. This ordination technique arranges the sampling locations such that their relative positions to the axes and to each other provide information about their similarities and differences. By observing those locations most similar (or different) based on their relative coordinate positions, underlying factors that are responsible for the patterns can often be identified. Sampling locations located at opposite ends of an axis are quite dissimilar and those located in close proximity are similar. The principal components analysis was performed using the SAS (1989b) PRINCOMP procedure. Figure 8 is a plot of the first principal component (PC1 on the abscissa) versus the second principal component (PC2 on the ordinate) of the 19 water quality variables for each of the 30 Chickamauga reservoir sampling locations. These first two principal components explain 71% of the variance

Figure 8

Plot of First and Second Principal Component, Analysis Results
Indicating Water Quality Relationships Among Chickamagua Reservoir
Monitoring Locations, 1990 (Lines enclose groupings determined from
cluster analysis)

of the 19 water quality variables, with PC1 accounting for 46% and PC2 accounting for 25%. For each of the sampling locations, the first principal component value (distance along the abscissa) was found to be highly correlated with Secchi depth, turbidity, color, total phosphorus, and total nitrogen; and the second principal component value (distance along the ordinate) was found to be highly correlated with temperature, pH, ammonia-nitrogen, nitrite plus nitrate-nitrogen, and dissolved ortho phosphorus. These correlations are shown below:

<u>PC1</u>	<u>Ln(Secchi)</u>	<u>Ln(Turbidity)</u>	<u>Ln(Color)</u>	<u>Ln(T. Nitrogen)</u>	<u>Ln(T. Phosphorus)</u>
Correlation Coefficient (r)	-0.93	0.95	0.81	0.87	0.95
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	<0.001
<u>PC2</u>	<u>Ln(Temperature)</u>	<u>Ln(pH)</u>	<u>Ln(NH₄)</u>	<u>Ln(NO₃)</u>	<u>Ln(Diss. Ortho Phosphorus)</u>
Correlation Coefficient (r)	0.84	0.88	-0.72	-0.79	-0.72
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	<0.001

Those embayments with high turbidity, high color, high total nitrogen and phosphorus concentrations are located to the extreme right on the abscissa; while those embayments with low turbidity, low color, low total nitrogen and phosphorus concentrations are located to the extreme left on the abscissa (PC1). Those embayments with high temperature, high pH, and low nitrite plus nitrate-nitrogen and dissolved ortho phosphorus are located at the top of the ordinate; while those locations with low temperature, low pH, and higher nitrite plus nitrate-nitrogen and dissolved ortho phosphorus are located near the bottom of the ordinate (PC2). In comparison with the cluster analysis shown in figure 7, many of these same groupings can be identified in figure 8. The embayments labeled cluster D in figure 7 (Soddy Creek, Possum Creek, Sale Creek, and Dallas Bay) are likewise shown in close proximity with one another in figure 8, reflecting their similar water quality characteristics. The same is evident with other natural groupings. For example, compare the figure 7 clusters labeled A (TRM 472.3, TRM 478.2, TRM 490.5, Waconda Bay, and Richland Creek) and labeled E (TRM 496.5, TRM 506.6, TRM 518.0, and TRM 529.9) with the close proximity of these

embayments and sampling location's in figure 8.

It is evident that the water quality of the embayments encompasses a wider range of conditions than the main channel of the Tennessee or Hiwassee rivers. In general, embayments are warmer, less turbid, have higher pH's, higher chlorophyll, and are lower in nutrients. However, embayments tributary to the Hiwassee River, in particular, Candies Creek, North Mouse Creek, and South Mouse Creek, have much lower water clarity and higher total nutrient concentrations than any of the sampling locations, embayment or main channel.

Nutrients and Biochemical Measurements

Nutrients and biochemical measurements include the various forms of nitrogen (organic nitrogen, ammonia nitrogen, and nitrite plus nitrate nitrogen), phosphorus (total and dissolved ortho phosphorus), organic carbon (total and soluble) and chlorophyll-a.

Biological productivity (net algal photosynthesis) in aquatic ecosystems is primarily controlled by the availability of light, temperature, and nutrients (i.e. nitrogen and phosphorus). During the summer, under conditions of adequate light and temperature, primary productivity is usually highest and limited by available nutrients.

Total nitrogen to total phosphorus ratios (TN/TP) are often used to examine which nutrient limits plant growth (given suitable light and temperature conditions) in freshwater ecosystems. TN/TP ratios (mg:mg) less than 7 generally indicate conditions that limit primary productivity due to a deficiency of nitrogen ("nitrogen limited"), while TN/TP ratios greater than 15 indicate conditions that limit primary production due to a deficiency of phosphorus ("phosphorus limited"). Possum Creek, Soddy Creek, Sale Creek, and Dallas Bay embayments all show evidence of phosphorus limitation, with mean dissolved ortho phosphorus (the only form of phosphorus assimilated by cells) concentrations less than 0.005 mg/l and average TN/TP ratios

greater than 25. On the other hand, Rogers Creek embayment - with a maximum measured summertime TN/TP ratio of 12.7 and a mean of only 8.4 - may occasionally be nitrogen limited, although chlorophyll-a concentrations as high as 48 $\mu\text{g/l}$ were observed in July.

Phosphorus and Primary Productivity - To investigate the effects of phosphorus as a limiting nutrient on primary productivity, chlorophyll-a concentrations, which indirectly measure primary productivity, were examined as a function of total phosphorus concentrations. The relationship between chlorophyll-a and phosphorus in natural lakes is well documented (Dillon and Rigler, 1974; Carlson, 1977; Schindler, 1978; and Rast and Lee, 1978). However, the relationship between chlorophyll-a and phosphorus on main stream, run-of-the-river reservoirs is less clearly defined, with light limitations often cited for poor relationships and lower primary productivity (Placke, 1983; and Higgins and Kim, 1981). Figure 9 examines the relationships between chlorophyll-a and total phosphorus concentrations in Chickamauga Reservoir. The figure contrasts the poor chlorophyll-a vs. phosphorus relationship for those sampling locations on the main stream portion of the reservoir ($R^2=0.03$) with the good relationship for the embayment sampling locations ($R^2=0.79$). This indicates there is not a direct cause/effect relationship between phosphorus and chlorophyll-a in the main stream of Chickamauga Reservoir. However, there is an apparent relationship between phosphorus and chlorophyll-a in the embayments - inferring embayments are more similar to natural lakes than reservoirs.

The simple empirical model shown in figure 9 to predict average summertime chlorophyll-a concentrations in the Chickamauga Reservoir embayments based on average summertime total phosphorus concentrations, and accounted for approximately 80% of the variability in the chlorophyll-a data, is:

$$\ln(\text{Chlorophyll-a, } \mu\text{g/l}) = 4.762 + 0.629[\ln(\text{Phosphorus, mg/l})]$$

where: $R^2 = 0.79$; $F = 67.8$; $\text{prob}>F = 0.0001$; $n = 20$

Figure 9

TOTAL PHOSPHORUS vs. CHLOROPHYLL-a
CHICKAMAUGA RESERVOIR, SUMMER AVERAGES - 1990

Figure 10 illustrates the distribution of average chlorophyll-a concentrations measured in the Chickamauga Reservoir embayments. The greatest chlorophyll-a concentrations were measured at South Mouse Creek, Agency Creek, and Rogers Creek embayments, averaging 26.3, 24.0, and 19.8 $\mu\text{g/l}$, respectively (table 5). Maximum chlorophyll-a concentrations greater than 40 $\mu\text{g/l}$ were measured in all three of these embayments (Appendix A) which are indicative of nuisance algal conditions. Often coincident with these high chlorophyll-a concentrations, were high pH's (pH's ≥ 8.0) and high dissolved oxygen concentrations (percent saturation values $\geq 110\%$). Those embayments giving evidence of phosphorus limiting conditions (Dallas Bay, Soddy Creek, Sale Creek, and Possum Creek) had the lowest chlorophyll-a concentrations, averaging less than 10 $\mu\text{g/l}$.

Considering only water quality data collected in Chickamauga Reservoir embayments, chlorophyll-a was also found to correlate with several other water quality characteristics, as shown below:

Correlations of Ln(Chlorophyll-a) vs. :

<u>Embayment Locations (n=20)</u>	<u>Total Phosphorus</u>	<u>Ratio TN/TP</u>	<u>Total Organic Carbon</u>	<u>Organic Nitrogen</u>	<u>Suspended Solids</u>	<u>Secchi Depth</u>	<u>Mean Depth</u>
Correlation Coefficient (r)	0.88	-0.87	0.84	0.84	0.80	-0.76	-0.66
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002

Correlations of chlorophyll-a with phosphorus and with TN/TP ratios are expected, and have been discussed. Correlations of chlorophyll-a with organic carbon and organic nitrogen is also expected, resulting from the organic matter produced during algal photosynthesis. The correlations of chlorophyll-a with suspended solids, water clarity (Secchi depth), and embayment depth is interesting. In part, suspended solids are increased and water clarity is decreased due to the production of algal matter during photosynthesis. But it can also be hypothesized that shallow embayments result in higher chlorophyll-a concentrations due to the resuspension of bottom (nutrient rich) material, thereby resulting both directly and indirectly in higher suspended solids

Figure 10
Average Chlorophyll-a Concentrations
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

and lower water clarity.

Nutrients and Suspended Solids - Man's activities and his use of the land resources within the watershed largely affects the amounts of nutrients carried into a body of water by rainfall runoff and point source wastewater discharges. Much of the nutrient load is adsorbed to soil and suspended material in this rainfall runoff and wastewater. Consequently, when rainfall runoff carries large amounts of suspended material into the water resulting in an increase in turbidity, suspended solids, and color, the concentration of nutrients is also increased. With an increase in nutrients there is an increase in productivity and chlorophyll-a concentrations.

Two simple linear models (figure 11) to predict average summertime total nitrogen and total phosphorus concentrations in the Chickamauga Reservoir embayments, based solely on the average suspended solids concentrations, were developed. The models, given below, explain 92% and 82% of the variability of the average total phosphorus and total nitrogen concentrations, respectively, in the Chickamauga reservoir embayments:²

$$\text{Total Phosphorus, mg/l} = 0.0048 + 0.0027(\text{Suspended Solids, mg/l})$$

$$\text{where: } R^2 = 0.92; F = 196.0; \text{prob}>F = 0.0001; n = 20$$

and

$$\text{Total Nitrogen, mg/l} = 0.2280 + 0.0204(\text{Suspended Solids, mg/l})$$

$$\text{where: } R^2 = 0.82; F = 83.8; \text{prob}>F = 0.0001; n = 20$$

²Deleting the suspended solids value 38.8 mg/l (South Mouse Creek embayment, figure 11), the equations become:

$$\text{Total Phosphorus, mg/l} = 0.0087 + 0.0021(\text{Suspended Solids, mg/l})$$

$$R^2 = 0.79, (n = 19)$$

and

$$\text{Total Nitrogen, mg/l} = 0.2429 + 0.0181(\text{Suspended Solids, mg/l})$$

$$R^2 = 0.59, (n = 19)$$

Figure 11

CHICKAMAUGA RESERVOIR EMBAYMENTS
SUMMER AVERAGES, 1990

Highest concentrations of phosphorus and nitrogen were measured in North and South Mouse Creek embayments (the shallowest two embayments), while lowest concentrations of these nutrients were measured in Soddy Creek, Possum Creek, and Sale Creek embayments (three of the deeper embayments), table 5 and figures 12 and 13. Note the spatial similarities between the nutrient concentration patterns of figures 12 and 13 as well as the spatial similarities between nutrient concentrations and chlorophyll-a concentrations, figure 10.

The water quality data collected from the 20 embayment sampling locations also give evidence of many other relationships between nutrients, suspended solids, turbidity, color, and chlorophyll-a concentrations:

Chickamauga Reservoir Embayment Sampling Locations (n=20)

	Suspended					Dissolved	Total	Dissolved	
Total Phosphorus vs. . . .	Solids	Turbidity	Secchi	Color	Phosphorus	Nitrogen	Oxygen	Chlorophyll-a	
Correlation Coefficient (r)	0.96	0.95	-0.76	0.87	0.89	0.93	-0.77	0.77	
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
	Suspended					Organic	Total	Dissolved	
Total Nitrogen vs. . . .	Solids	Turbidity	Secchi	Color	Nitrogen	Phosphorus	Oxygen	Chlorophyll-a	
Correlation Coefficient (r)	0.91	0.89	-0.75	0.83	0.93	0.93	-0.81	0.65	
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	
	Suspended					Total	Total	Dissolved	
T. Nitrogen/T. Phosphorus	Solids	Turbidity	Secchi	Color	Nitrogen	Phosphorus	Oxygen	Chlorophyll-a	
Correlation Coefficient (r)	-0.63	-0.66	0.86	-0.58	-0.54	-0.67	0.65	-0.81	
Level of Significance (P)	0.003	0.002	<0.001	0.007	0.014	0.001	0.002	<0.001	

Total phosphorus, total nitrogen, and TN/TP ratios were also found to correlate with the mean depth of the embayments with coefficients of correlation of -0.65, -0.71, and 0.67, respectively. This suggests lower concentrations of nutrients in deeper embayments and higher TN/TP ratios (phosphorus limiting conditions) in deeper embayments. One can infer that the deeper embayments more efficiently remove suspended material, effectively removing adsorbed nutrients; and that the shallower embayments (more affected by wind) resuspend bottom sediment rich in nutrients with the resultant increases in turbidity, suspended solids, nutrients, and productivity (chlorophyll-a).

Figure 12

Average Total Phosphorus Concentrations
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 13

Average Total Nitrogen Concentrations

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Organic Carbon - Total organic carbon (TOC) concentrations varied little among the among the run-of-the-river sampling locations on the Tennessee River (1.9-2.0 mg/l), but were considerably higher at the embayment sampling locations. Fourteen of twenty embayment sampling locations had TOC concentrations exceeding 2.0 mg/l, with concentrations ranging from about 1.8 mg/l (Possum Creek) to 3.8 mg/l (South Mouse Creek). The low chlorophyll-a and organic nitrogen concentrations at Hiwassee River mile (HRM) 13.4, indicate limited primary productivity. However, the high organic carbon concentrations, 2.8 mg/l (and high color - 30 PCU) measured at this location are a result of the discharges of a large paper company between HRM's 16.5 and 18.1. Soluble organic carbon (SOC) concentrations were slightly lower and paralleled the total organic carbon concentrations ($r=0.99$). TOC and SOC were both highly positively correlated with organic nitrogen and chlorophyll-a concentrations (primary productivity), and suspended solids and turbidity.

Other Physical/Chemical/Bacteriological Measurements

These include water clarity (Secchi depth, turbidity, suspended solids, true and apparent color), alkalinity, hardness, and fecal coliform bacteria. Water clarity is affected by rainfall/runoff events which wash suspended material into the water. In addition to physical factors, biological factors also affect (and are affected by) water clarity. The amount of light available for photosynthesis and aquatic plant growth is a function of the water clarity. Suspended solids, turbidity, and color reflect and/or absorb light, decreasing the photosynthetic potential of the water column. Water clarity is diminished by photosynthesis with the production of algal cells (suspended solids) and the addition of chlorophyll pigments (color).

Water Clarity - Secchi depth is a simple physical/visual measure of water clarity. A simple rule of thumb is that twice the Secchi depth is approximately equal to the photic zone, i.e.

the zone in which there is enough light available to sustain photosynthesis. The lower limit (maximum depth) of the photic zone is defined as that depth at which only 1% of light incident upon the water's surface is still present in the water column.

All the water clarity measures (turbidity, suspended solids, and color) were correlated among themselves and with Secchi depth, as shown below:

Correlations of Water Clarity (Mean Secchi Depth) vs. :

<u>All Locations (n=30)</u>	<u>Turbidity</u>	<u>Suspended Solids</u>	<u>Color</u>	<u>Chlorophyll-a</u>	
Correlation Coefficient (r)	-0.77	0.75	-0.66	-0.73	
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	

<u>Embayment Locations (n=20)</u>	<u>Turbidity</u>	<u>Suspended Solids</u>	<u>Color</u>	<u>Chlorophyll-a</u>	<u>Mean Depth</u>
Correlation Coefficient (r)	-0.82	-0.80	-0.71	-0.72	0.75
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	<0.001

These correlations show that embayment water clarity was correlated with productivity and mean embayment depth, (viz. shallow embayments with high productivity, turbidity and color). This suggests high algal productivity and little net deposition and/or the resuspension of bottom sediment in shallower embayments. Correlations of ($\log_e$) of Secchi depth, turbidity, suspended solids, color, and chlorophyll-a with mean embayment depth were found to be 0.74, -0.73, -0.73, -0.74, and -0.66, respectively. Further evidence of resuspension (and wash out) of bottom sediment in shallow embayments is the negative correlation found between turbidity and the percent of volatile solids in bottom sediment, -0.67.

North and South Mouse Creek and Candies Creek embayments are shallow (mean depth less than 1 meter), with low Secchi depths, high chlorophyll-a concentrations, and high concentrations of turbidity, suspended solids, and color. Dallas Bay, Soddy Creek, Sale Creek, and Possum Creek had greater water clarity reflecting their relatively greater depths (mean depth greater than two

Figure 14
Average Secchi Depths
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 15
Average Turbidity

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

meters), lower productivity and lower chlorophyll-a concentrations. Figures 14 and 15, graphically illustrate mean Secchi depths and turbidity concentrations among the fifteen studied Chickamauga reservoir embayments. It is interesting to note the obvious similarities between these two figures and figure 10, chlorophyll-a concentrations.

Alkalinity and Hardness - Alkalinity is a measure of a water's buffering capacity, i.e. its capacity to receive acids or bases without change to its pH. In the pH range of 6.5-8.5, the alkalinity of fresh water is primarily a measure of the bicarbonate (HCO_3^-) ion. Hardness is a measure of the capacity of water for precipitating soap. Hardness in natural water is primarily a measure of calcium and magnesium ions, which together neutralize soap by forming insoluble precipitates of calcium and magnesium carbonates.

Mean concentrations of alkalinity and hardness ranged from a high of 120 mg/l and 123 mg/l as CaCO_3 , respectively, in North Mouse Creek embayment to a low of 17 mg/l (alkalinity) at Hiwassee River Mile 20.0 and 73 mg/l as CaCO_3 (hardness) at Hiwassee River Mile 7.4 (table 5). Changes in the amounts of calcium, magnesium, and bicarbonate ions affect the amount of dissolved solids in water and its conductivity. Alkalinity and hardness were found to be highly correlated and also correlated with conductivity as shown below:

Correlations of Mean Alkalinity vs.:

	<u>All Locations (n=30)</u>		<u>Embayment Locations (n=20)</u>	
	<u>Hardness</u>	<u>Conductivity</u>	<u>Hardness</u>	<u>Conductivity</u>
Correlation Coefficient (r)	0.79	0.95	0.84	0.95
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001

Figures 16 and 17, depict average alkalinity and hardness concentrations among the Chickamauga reservoir embayment. The similarities between alkalinity and hardness are apparent.

Figure 16
Average Alkalinity

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 17
Average Hardness

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Fecal Coliform Bacteria - Fecal coliform bacteria are an indicator of the amount of untreated domestic and animal waste entering a body of water. Fecal coliform bacteria are found in large numbers in the feces of all warm blooded mammals and although not pathogenic in themselves are used as indicators of disease causing organisms in water. No relationship was found between fecal coliform bacteria and the number of embayment septic tank systems, estimated based on the number of shoreline residences, table 14. However, two embayment locations, South Mouse Creek and Candies Creek, gave evidence of fecal coliform contamination, with mean concentrations of 504 and 702 fecal coliform colonies per 100 mL of water, respectively. The data are indicative of non-point source urban storm water runoff, with highest concentrations of fecal coliform bacteria (greater than 2000 colonies per 100 mL) being measured after rain events. [As will be discussed in the section - Land Use and Nutrient Loadings, South Mouse Creek and Candies Creek have had a history of severely impacted water quality due to large discharges of poorly treated domestic wastewater and non-point source urban runoff.]

Measures of Trophic Status

A Trophic State Index (TSI) can be of great value to a lake manager and lake users to assess the trophic status of a lake or reservoir. It can be used to summarize the many physical, chemical, and biological measures of trophic status, and to provide a means of comparison of present conditions with past conditions or future planned changes. However the utility of a TSI for assessing the trophic status of embayments has not been investigated. The subjective decision as to which variables should be part of a trophic state index and what algorithms should be used to combine the variables has resulted in a variety of indices. Three lake trophic state indices (TSI) were selected and examined to investigate their applicability for use in assessing the trophic status of embayments - EPA-NES (1974),

Carlson (1977), and Porcella et al. (1980).

As part of the National Eutrophication Survey, in 1974 EPA developed a trophic state index based on a percentile ranking of six water quality parameters (median total phosphorus, median dissolved phosphorus, median inorganic nitrogen, mean chlorophyll-a, mean Secchi depth, and minimum dissolved oxygen) measured on approximately 200 lakes and reservoirs, ranging from oligotrophic to hypereutrophic, in the northeast and central United States (EPA 1974). To compute the trophic state index for a given lake or reservoir, a water quality parameter (e.g. chlorophyll-a) was given a percentile rank (0-100%) based on the percentage of the original 200 lakes which exceed that parameter. The final trophic state index is simply the sum of the percentile ranks for each of the six parameters (the measured values for Secchi depth and minimum dissolved oxygen are subtracted from fixed values so that all parameters contribute in a positive way to the final index ranking). Therefore, the trophic state index value could theoretically vary from 0 (eutrophic) to 600 (oligotrophic). General classification ranges were presented: 500-600 oligotrophic; 420-499 mesotrophic; 300-419 eutrophic; and below 300 nuisance conditions may be expected. The EPA-NES TSI is not recommended for (1.) water bodies with hydraulic detention times less than five days, (2.) water bodies with extensive macrophyte infestations. In the first case, the high flow through will increase turbidities and flush nutrients, with primary productivity remaining relatively low in spite of high loading rates. In the second case, macrophytes may compete effectively with algae for the available nutrients with the result that nutrient levels are low, chlorophyll-a concentrations are low (low algal populations), and Secchi depths relatively high (fewer algae and enhancement of sedimentation in the macrophyte beds).

Another TSI, and one which is widely and reliably used, is one developed by Carlson (1977). Carlson's TSI uses summer values for Secchi depth, total phosphorus concentration, or

chlorophyll-a concentration, or a combination of all three. The TSI ranges from 0 (oligotrophic) to 100 (eutrophic) and relates Secchi depth with phosphorus concentrations and chlorophyll-a concentrations such that a ten point change in the TSI value represents a halving of the Secchi depth and a doubling of the algal biomass, as shown below:

CARLSON'S TROPHIC STATE INDEX

TSI (0-100)	Secchi Depth (meters)	Surface Phosphorus ($\mu\text{g/l}$)	Surface Chlorophyll ($\mu\text{g/l}$)	Classification
0	64	0.75	0.04	Oligotrophic
10	32	1.5	0.12	"
20	16	3	0.34	"
30	8	6	0.94	"
40	4	12	2.61	Mesotrophic
50	2	24	7.23	"
60	1	48	20	Eutrophic
70	0.5	96	55.5	"
80	0.25	192	154	"
90	0.125	384	426	"
100	0.0625	768	1180	"

The TSI's are calculated according to the following regression equations, developed using the data in the above table:

$$TSI_{SD} = 60 - 14.4 \ln(SD)$$

$$TSI_{C-a} = 9.81 \ln(C-a) + 30.6$$

$$TSI_{TP} = 14.42 \ln(TP) + 4.15$$

The following equation has been used to combine all three TSI values:

$$TSI = (TSI_{SD} + TSI_{C-a} + TSI_{TP}) / 3$$

Carlson's TSI Secchi depth values may be misleading as a trophic state indicator in highly turbid (non-algal) water bodies or those with extensive macrophytes. It makes no sense to measure Secchi depth, phosphorus, and algal chlorophyll in a lake infested with aquatic macrophytes, because it would result in a low and unrealistic TSI's (oligotrophy) when in fact the lake is severely infested with aquatic plants.

In the above two example TSI's, both assume phosphorus limited lakes, as is the case with the Chickamauga embayments (all but perhaps one embayment-Rogers Creek-are obviously phosphorous limited during the summer growing season). However,

both TSI's do not address aquatic macrophyte communities in their trophic status evaluation, and about a third of the fifteen Chickamauga reservoir embayments have approximately 15% or more of their surface area covered with aquatic macrophytes (see table 21). The third measure of trophic status, Porcella et. al. (1980), is based on five water quality parameters, one of which is percent of surface area infested with aquatic macrophytes. The other four parameters are chlorophyll-a, Secchi depth, total phosphorus, and dissolved oxygen deficit. (In addition, the Porcella index has the flexibility of being able to substitute total nitrogen concentrations in place of total phosphorus concentrations in nitrogen limited water bodies). Porcella et. al. actually refer to their trophic index as a Lake Evaluation Index (LEI). The LEI is an adaptation of the Carlson TSI in that it incorporates the three Carlson regression equations for Secchi depth, total phosphorus, and chlorophyll-a (LEI_{sp} , LEI_{c-a} , and LEI_{tp} - see equations, above); as well as equations for variables total nitrogen, dissolved oxygen deficit, and aquatic macrophytes (LEI_{TN} , LEI_{DO} , and LEI_{AM}). Like the Carlson TSI, the LEI also ranges from 0 (oligotrophic) to 100 (eutrophic). Concentrations of the other variables (total nitrogen, dissolved oxygen deficit, and aquatic macrophytes) are transformed to LEI_{TN} , LEI_{DO} , and LEI_{AM} variables, respectively, as shown in the following table:

PORCELLA'S LAKE EVALUATION INDEX

LEI_{xx} (0-100)	Total Nitrogen ($\mu g/l$)	Net Dissolved Oxygen (mg/l)	Surface Area Macrophytes (percent)	Classification
0	5.2	0.0	0	Oligotrophic
10	10.4	1.0	10	"
20	20.8	2.0	20	"
30	41.6	3.0	30	"
40	83.2	4.0	40	Mesotrophic
50	167.0	5.0	50	"
60	333.0	6.0	60	Eutrophic
70	666.0	7.0	70	"
80	1330.0	8.0	80	"
90	2670.0	9.0	90	"
100	5330.0	10.0	100	"

Where: Net Dissolved Oxygen (Net DO) is defined the absolute difference between the equilibrium concentration of DO, E_{DO} , (at a given temperature and depth) and the measured concentration of DO, M_{DO} , weighted by the fraction (of the total volume) of water at that temperature and depth, ΔV_i , and summed over the entire water column, i.e.:

$$\text{Net DO} = \sum [|(E_{DO} - M_{DO})_i| \Delta V_i / V].$$

The LEI variables are calculated according to the following equations, developed using the data in the table above:

$$LEI_{TN} = 14.42 \ln(TN) - 23.8$$

$$LEI_{DO} = 10 \text{ Net DO}$$

$$LEI_{AM} = \text{Percent AM}$$

The following equation combines all five LEI variables to yield the final LEI (if nitrogen is limiting, LEI_{TN} is substituted for LEI_{TP}):

$$LEI = [0.5 (LEI_{AM} + LEI_{C-a}) + LEI_{DO} + LEI_{SD} + LEI_{TP}] / 4.$$

Table 6 gives the results of the calculations for each of the three trophic state indices for each of the fifteen Chickamauga embayments (20 sampling locations). It is interesting to note that the EPA-NES TSI and Carlson TSI trophic classifications agree quite closely, and although the LEI classification generally parallels the EPA-NES and Carlson TSI's it assesses a lower trophic status to the embayments, with none of the Chickamauga Reservoir embayments being classified as eutrophic using Porcella's LEI. The addition of the aquatic macrophyte (LEI_{AM}) and dissolved oxygen deficit (LEI_{DO}) variables, results in the LEI's assessment of a lower degree of eutrophication than Carlson's TSI for the Chickamauga embayments - particularly for those embayments with no aquatic macrophytes. All three of the trophic state indices (shown in table 6) are highly correlated:

Correlation Coefficients, (n=20)

	EPA-NES TSI	Carlson's TSI-Avg	Porcella's LEI
EPA-NES TSI	1.00	-0.95	-0.88
Carlson's TSI-Avg		1.00	0.85
Porcella's LEI			1.00

(All correlations are significant at the 0.0001 level)

Figures 18, 19, and 20 graphically illustrate the computed trophic state indices for each of the three indexes. All reflect

Table 6

COMPARISON OF TROPHIC STATE INDICES
CHICKAMAUGA RESERVOIR EMBAYMENTS

	EPA-NES TSI		CARLSON'S TSI-Avg		PORCELLA'S LEI	
EMBAYMENT	TROPHIC CLASS		TROPHIC CLASS		TROPHIC CLASS	
WACONDA BAY 0.95	393	E	52.72	E	39.49	O
WOLFTEVER CREEK 4.2	401	E	53.09	E	38.20	O
WOLFTEVER CREEK 5.65	359	E	56.92	E	42.02	M
SAVANNAH BAY 2.95	340	E	60.82	E	42.92	M
DALLAS BAY 0.9	392	E	48.78	M	36.15	O
SODDY CREEK 1.7	423	M	45.20	M	36.67	O
SODDY CREEK 4.0	461	M	42.15	M	34.83	O
POSSUM CREEK 2.0	441	M	42.13	M	38.45	O
SALE CREEK 1.3	446	M	45.49	M	37.96	O
SALE CREEK 2.0	454	M	45.03	M	36.21	O
RICHLAND CREEK 0.5	398	E	52.04	E	36.46	O
RICHLAND CREEK 2.8	358	E	53.17	E	41.84	M
MUD CREEK 1.3	329	E	55.88	E	40.03	M
GOODFIELD CREEK 0.9	372	E	56.82	E	37.80	O
GUNSTOCKER CREEK 0.85	326	E	59.78	E	42.05	M
AGENCY CREEK 0.65	321	E	57.83	E	39.97	O
CANDIES CREEK 1.5	289	E	60.69	E	42.81	M
ROGERS CREEK 1.5	331	E	58.74	E	40.38	M
NORTH MOUSE CREEK 0.5	303	E	58.84	E	41.94	M
SOUTH MOUSE CREEK 1.1	230	E	68.57	E	48.89	M

Where:

O-Oligotrophic
M-Mesotrophic
E-Eutrophic

EPA-NES TSI

>500
420-499
<419

Carlson's TSI

<40
40-50
>50

Porcella's LEI

<40
40-50
>50

Figure 18
EPA-NES Trophic State Index
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 19
Carlson's Trophic State Index-Average
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 20
Lake Evaluation Index
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

the same spatial patterns of Dallas Bay, Soddy Creek, Possum Creek, and Sale Creek embayments being oligotrophic to mesotrophic, with Candies Creek and South Mouse being eutrophic to highly eutrophic.

Because the high flow through of those embayments with short hydraulic detention times often decreases water clarity (limiting productivity) and flushes nutrients, in spite of high loading rates, the tendency is to over estimate the trophic status using the EPA-NES TSI and Carlson TSI. North Mouse Creek, South Mouse Creek and Candies Creek have short detention times (1, 3 and 7 days, respectively) and high nutrient concentrations (tables 1 and 5). Consequently it is not appropriate to apply the EPA-NES and Carlson trophic state indices to these embayments with their short hydraulic detention times (<5 days). For example, the NES-TSI predicts nuisance trophic conditions for water bodies with TSI values less than 300. This is not necessarily the case for North Mouse Creek, South Mouse Creek, and Candies Creek embayments with NES-TSI's of 303, 230, and 289, respectively. Although all three embayments are highly eutrophic, they do exhibit classic nuisance trophic conditions. All have average summer water column dissolved oxygen concentrations greater than 5.0 mg/l and less than 1% of their surface areas are covered with aquatic macrophytes. Further, while Candies Creek embayment's summertime algal populations are dominated by blue-green algae (greens 19.5%, diatoms 13.2%, and blue-greens 56.9%), North Mouse Creek embayment has a more balanced algal population (greens 34.5%, diatoms 19.6%, and blue-greens 36.5%), and South Mouse Creek embayment supports a large diatom population (greens 25.5, diatoms 36%, and blue-greens 31.5%). (Algal data are presented in Appendix F and the Aquatic Biology section, below.)

Porcella's LEI appears to be appropriate only for those embayments with appreciable surface coverage of macrophytes. Compared with the EPA-NES and Carlson TSI, those embayments with no or little aquatic macrophytes (<15% surface area coverage) were assessed a lower trophic status using the LEI.

SEDIMENT QUALITY

Materials and Methods

At each of 29 locations (table 3) bottom sediment samples were collected once during the summer. Samples were not collected in the tailrace of Watts Bar dam (TRM 529.9) because of the lack of suitable substrate. These samples were analyzed for selected metals, total and volatile solids, particle size and selected trace organics (organochlorine pesticides and PCB's), as specified in table 7. Sample collections and sample handling followed standard practices accepted by the Environmental Protection Agency (EPA, 1979 and 40 CFR 136) and US Geological Survey (USGS, 1977) as specified in TVA quality assurance/quality control (QA/QC) procedures (TVA, 1990 and TVA, 1987). Laboratory analyses conformed to established QA/QC procedures (TVA, 1989).

Sediment samples were collected from a boat by deploying a cleaned stainless steel Ekman or Ponar dredge. At each location, the top three centimeters of one or more dredged samples was composited into a cleaned stainless steel pan until enough sediment was gathered to fill the sample containers. The sample was thoroughly composited and mixed, placed in clean glass containers, packed on ice, and transported to the laboratory for analysis. The data are tabulated in Appendix B-Physical/Chemical Characteristics of Sediment. All sediment data are stored and available on EPA's water quality data storage and retrieval (STORET) computer system.

Particle Size Distribution

Bottom sediment contains significantly higher concentrations of metals than are found in the water. Concentrations of metals in lake water usually are in the parts per billion (ppb or $\mu\text{g/l}$) range, while concentrations of metals in sediment often are in the parts per million (ppm or mg/kg) range. For example, typical zinc concentrations in sediment of approximately 200 mg/kg , are

Table 7

PHYSICAL/CHEMICAL MEASUREMENTS - SEDIMENT
CHICKAMAUGA EMBAYMENT STUDY, WY 1990

EPA Storet Code	Description	Units	Detection Limits
<u>Metals</u>			
01108	Aluminum	mg/kg	5 mg/kg
01028	Cadmium	mg/kg	1 mg/kg
00917	Calcium	mg/kg	10 mg/kg
01029	Chromium	mg/kg	5 mg/kg
01043	Copper	mg/kg	2 mg/kg
01170	Iron	mg/kg	1 mg/kg
01052	Lead	mg/kg	5 mg/kg
00924	Magnesium	mg/kg	1 mg/kg
01053	Manganese	mg/kg	0.5 mg/kg
71921	Mercury	mg/kg	0.1 mg/kg
01068	Nickel	mg/kg	5 mg/kg
01093	Zinc	mg/kg	10 mg/kg
<u>Solids</u>			
70318	Total solids	Percent	0.1%
70322	Total volatile solids	Percent	0.1%
80203	Particle size, <0.062 mm diameter	Percent	0.1%
80204	Particle size, <0.125 mm diameter	Percent	0.1%
80206	Particle size, <0.50 mm diameter	Percent	0.1%
80208	Particle size, <2.0 mm diameter	Percent	0.1%
<u>Organochlorine Pesticides and PCB's</u>			
39333	Aldrin	µg/kg	10 µg/kg
39076	α - Benzene Hexachloride (BHC)	µg/kg	10 µg/kg
34257	β - Benzene Hexachloride (BHC)	µg/kg	10 µg/kg
39343	γ - Benzene Hexachloride (Lindane)	µg/kg	10 µg/kg
34262	δ - Benzene Hexachloride (BHC)	µg/kg	10 µg/kg
39351	Chlordane	µg/kg	10 µg/kg
34354	Endosulfan Sulfate	µg/kg	10 µg/kg
34364	α - Endosulfan	µg/kg	10 µg/kg
34359	β - Endosulfan	µg/kg	10 µg/kg
34369	Endrin Aldehyde	µg/kg	10 µg/kg
39301	p,p DDT	µg/kg	10 µg/kg
39311	p,p DDD	µg/kg	10 µg/kg
39321	p,p DDE	µg/kg	10 µg/kg
39383	Dieldrin	µg/kg	10 µg/kg
39393	Endrin	µg/kg	10 µg/kg
39413	Heptachlor	µg/kg	10 µg/kg
39423	Heptachlor Epoxide	µg/kg	10 µg/kg
39491	PCB-1221	µg/kg	100 µg/kg
39495	PCB-1232	µg/kg	100 µg/kg
39499	PCB-1242	µg/kg	100 µg/kg
39503	PCB-1248	µg/kg	100 µg/kg
39507	PCB-1254	µg/kg	100 µg/kg
39511	PCB-1260	µg/kg	100 µg/kg
39514	PCB-1016	µg/kg	100 µg/kg
39519	PCB's, Total	µg/kg	100 µg/kg
39403	Toxaphene	µg/kg	500 µg/kg

10,000 times greater than typical zinc concentrations in lake water of approximately 20 µg/l. Many trace metals (cadmium, copper, lead, mercury, zinc, etc.) persist in sediments, providing a historical record of past conditions, and can bioaccumulate in bottom dwelling organisms. Under changing environmental conditions (e.g. pH, DO, Eh, bacterial action) some metals can dissolve into the water column and have a more direct impact on organisms higher in the food chain, or precipitate out of solution and have less impact on aquatic plants and animals. One of the most significant factors controlling sediment/trace metal interactions is particle size or grain size of the sediment. In reservoirs most sediment is composed of material smaller than 2.0 mm, diameter. In WY 1990, 99% of the sediment collected at the 29 sampling locations was composed of material that is equal to or smaller than 2.0 mm diameter (table 8).

Table 8

SEDIMENT PARTICLE SIZE AND CLASS
CHICKAMAUGA EMBAYMENT STUDY, WY 1990

<u>Class/Description</u>	<u>Nominal Diameter</u>	<u>Average % Composition for 29 Chickamauga Locations</u>
Silt and clay	<62 µm	85.6%
Very fine sand	62-125 µm	6.1%
Medium-fine sand	125-500 µm	6.8%
Coarse sand	0.5-2.0 mm	0.8%
Gravel	>2.0 mm	0.6%

(Total Solids, 52.4 %)

(Total Volatile Solids, 6.9%)

Generally, smaller particle sizes (as well lower percent total solids and higher percent volatile solids) were found in the sediments in embayments compared with sediment collected from the main channel locations of the Hiwassee River and those main channel locations in the riverine portion of the Tennessee River.

Figure 21

Sediment Particle Size Distributions Chickamauga Embayment Study - 1990

Figure 21 (continued)

Sediment Particle Size Distributions Chickamauga Embayment Study - 1990

These differences between the sediment size distributions of embayment vs. riverine main channel locations are evident in figure 21. Previous studies have shown that trace metal concentrations are strongly correlated with decreasing grain size (Horowitz, 1985).

Metals

The sediments were analyzed for the following twelve metals: aluminum, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, and zinc. Cadmium was not detected in any of the samples. Overall, of the 11 metals with detectable concentrations in sediment, most fell within the normal range of concentrations that have been observed in the Tennessee river system (table 9 and Appendix B), although lead concentrations in Waconda Bay (180 mg/kg) and nickel concentrations in Possum Creek embayment (77 mg/kg) were higher than had been previously observed in Tennessee River sediment. Relative distributions of the concentrations of six heavy metals (chromium, copper, lead, mercury, nickel, and zinc) in sediment are plotted for each of the 29 sampling locations (figure 22).³ In the embayments, the high concentrations of lead (180 mg/kg) in Waconda Bay, nickel (77 mg/kg) in Possum Creek, and zinc (410 mg/kg) in Agency Creek are evident. Also, to be noted are the comparatively high concentrations of mercury found in Agency Creek and Waconda Bay of 0.82 and 0.75 parts per billion (ppb), respectively, and the comparatively high concentrations of chromium found in Richland Creek of 67 ppb.

No sediment quality criteria have been promulgated for metals in sediment. Consequently, equilibrium partitioning coefficients were used to very roughly estimate approximate

³No quality criteria for metals in sediment have been promulgated. EPA Region V guidelines for the classification of freshwater sediments (EPA, 1977) lists concentrations of cadmium >6 mg/kg, chromium >75 mg/kg, copper >50 mg/kg, lead >60 mg/kg, mercury >1 mg/kg, nickel >50 mg/kg, and zinc >200 mg/kg as indicative of heavily polluted sediments.

Table 9

SEDIMENT - METALS CONCENTRATIONS - SUMMARY
CHICKAMAUGA RESERVOIR EMBAYMENT STUDY, WY 1990
(all units in mg/kg, dry weight)

<u>Metal</u>	<u>Chickamauga Reservoir (1990)</u>	<u>Tennessee River (1980-1990)^a</u>	<u>EPA Region V Guidelines^b</u>	<u>Location^c</u>
Aluminum range	15000-59000 (n=29)	--	--	Mud Creek 1.3
Cadmium range	<0.1 (n=29)	<0.1-10 (n=100)	>6	--
Calcium range	710-7800 (n=29)	--	--	Savannah Bay 2.95
Chromium range	5-67 (n=29)	11-85 (n=100)	>75	Richland Creek 0.5
Copper range	7-69 (n=29)	4-98 (n=100)	>50	Hiwassee River 7.4
Iron range	19000-52000 (n=29)	13990-56400 (n=64)	>25000	Tennessee R. 472.3
Lead range	23-180 (n=29)	8-120 (n=98)	>60	Waconda Bay 0.95
Magnesium range	1500-4700 (n=29)	--	--	Mud Creek 1.3
Manganese range	390-5200 (n=29)	420-5300 (n=62)	>500	Tennessee R. 472.3
Mercury range	<0.1-0.82 (n=29)	<0.1-1.9 (n=100)	>1	Agency Creek 0.65
Nickel range	11-77 (n=29)	7-74 (n=98)	>50	Possum Creek 2.0
Zinc range	44-750 (n=29)	52-490 (n=100)	>200	Hiwassee River 7.4

^a STORET summary of TVA data for metals in sediment from the mainstem of the Tennessee River, 1980-1990.

^b EPA guidelines for heavily polluted sediment. (EPA, 1997, "Guidelines for the Pollutational Classification of Great Lakes Harbor Sediments", USEPA, Region V, April, 1977.)

^c Chickamauga Reservoir Embayment Study monitoring location with highest sediment concentration of metal.

equilibrium concentrations for these metals in the water column. These estimated equilibrium water column concentrations were then compared with water quality criteria for the protection of fish and aquatic life, as shown below, table 10. The equilibrium partitioning coefficient (K_p) is defined as the ratio of the metal concentration in sediment (C_s) to the metal concentration in water (C_w). Equilibrium concentrations of metals in water

Figure 22

CONCENTRATIONS OF METALS IN SEDIMENT CHICKAMAUGA RESERVOIR 1990

were calculated, based on literature K_p values (Delos, 1983).

All estimated concentrations of the metals in water were well below the State of Tennessee's water quality criteria for fish and aquatic life. However, K_p values are quite site specific, resulting in a wide variability (uncertainty) of literature K_p values for a particular metal. Because the estimated equilibrium concentrations in water are within one order of magnitude of the fish and aquatic life criterion, the high concentrations of lead in Waconda Bay and mercury in Agency Creek may warrant further study.

TABLE 10
ESTIMATED EQUILIBRIUM WATER COLUMN CONCENTRATIONS

Location	Metal	Sediment Concentration, C_s	Equilibrium Partitioning Coefficient, K_p^a	Estimated Equilibrium Concentration in Water, C_w	Fish and Aquatic Life Criterion ^b
		(mg/kg)	($\times 10^6$ l/kg)	(ug/l)	(ug/l)
Waconda Bay	Pb	180	0.78	0.23	1
Possum Creek	Ni	77	1.92	0.04	88
Agency Creek	Hg	0.82	0.21	0.004	0.012
Agency Creek	Zn	410	0.92	0.45	59
Richland Creek	Cr	67	1.55	0.04	100

^a K_p values for lakes, corrected for suspended solids concentrations (Delos, et al, 1983). ($K_p =$ equilibrium concentration in sediment, $[C_s]$, divided by equilibrium concentration in water column, $[C_w]$.)

^b Tennessee Water Quality Criteria for protection of Fish and Aquatic Life, assumes hardness of 50 mg/l (TDEC, 1991).

Organochlorine Pesticides and PCB's

The sediment samples also were analyzed for eighteen pesticides (aldrin, four isomers of benzene hexachloride, chlordane, dieldrin, three isomers of DDT, two isomers of endosulfan, endosulfan sulfate, endrin, endrin aldehyde, heptachlor, heptachlor epoxide, and toxaphene); and seven Aroclors of PCB (Appendix B). With three exceptions, no pesticides nor PCB's were detected in the sediment samples. Low concentrations of DDT in sediment were detected at three locations: Tennessee River mile 496.5 (23 $\mu\text{g/kg}$); Richland Creek mile 0.5 (26 $\mu\text{g/kg}$); and South Mouse Creek mile 1.1 (12 $\mu\text{g/kg}$).

EMBAYMENT BATHYMETRY

Introduction

The physical characteristics of a water body play an important role in its chemical and biological water quality processes, particularly its response to nutrient and sediment loads. As a body of water ages, it slowly fills with detritus and sediment. This filling process can occur both internally, by the addition of autochthonous organic plant matter from macrophytes, algae, etc. and externally, by the addition of allochthonous organic matter, silt, and sediment carried into the water from the surrounding watershed. Man's activities usually accelerate both these internal and external processes. The addition of nutrients (nitrogen and phosphorus) resulting from anthropogenic activity (detergents, fertilizers, wastewater, etc.) promotes excessive plant growth. Land use practices (viz. urbanization, deforestation, agriculture, etc.) increase soil erosion and lake siltation. This eroded soil is often rich in sorbed nutrients and organic matter. With the decomposition of the organic matter, dissolved oxygen is depleted, anoxia develops, and reduction and dissolution of phosphates and nitrates occurs. Consequently, this filling process not only leads to a loss of volume but also to the release of nutrients through mineralization and release from original lake bottom sediment. As volume is lost, substantial shallow areas can develop and foster the growth of macrophytes. Ultimately these plants, as they decay, promote further filling and losses of dissolved oxygen and release of organics and nutrients.

The response of a water body to loadings (nutrients, organic matter, silt, etc.) is largely dependent on its bathymetry. Shallow lakes have a higher potential to support algal blooms and aquatic plants because the regenerative (nutrient rich) bottom sediment is so close to the photic zone and ample shallow water areas are available for aquatic plant colonization. Deep lakes

with small shallow water areas have less potential to support algal growths and aquatic plants because the regeneration of nutrients from the deep sediment is remote from the photic zone (often isolated by stratification) and small relative to the volume of the lake; and light limitations restrict the growth of rooted plants to only a very small area around the waters edge. Earlier, the relationship between embayment depth and water clarity was discussed, from which one might infer a relationship between depth and trophic status. In fact many studies on north temperate lakes have shown relationships between mean depth and standing crop of phytoplankton and benthic macroinvertebrates (Rawson, 1957); fish production (Hayes, 1957); and chlorophyll-a (Sakamoto, 1966). In this Chickamauga Embayment Study, significant relationships were found between mean depth and trophic state, fish abundance (number/cubic meter), chlorophyll-a ($\mu\text{g/l}$), Secchi depth (water clarity), and nutrients (mg/l). Correlation coefficients between mean depth and these parameters are shown below:

Correlations of Mean Depth vs.:

<u>Embayment Locations (n=20)</u>	<u>Carlson's TSI</u>	<u>Total Nitrogen</u>	<u>Total Phosphorus</u>	<u>Chlorophyll-a</u>	<u>Fish Abundance</u>	<u>Secchi Depth</u>
Correlation Coefficient (r)	-0.79	-0.71	-0.65	-0.65	0.63	0.75
Level of Significance (P)	<0.001	<0.001	0.002	0.002	0.003	<0.001

The Chickamauga Embayment Study data also show a weak inverse relationship between the abundance of certain algal species (number per liter) and mean depth which was significant at the 0.02 level. Discussions of the algal, benthic macroinvertebrate, and fisheries data are given in the section, Aquatic Biology - Physical/Chemical Relationships, below.

Since embayment depth is such an important factor in controlling water quality and aquatic biological processes, an evaluation of embayment bathymetry and sedimentation rates was conducted for the each of the major Chickamauga Reservoir embayments. Figure 23 illustrates a relative comparison and the

Figure 23

Mean Depth

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

spatial distribution of mean depths for each of the embayments.

Materials and Methods

The primary method used in the past by TVA to determine embayment volumes consists of acquiring cross-sectional data from geometrically homogeneous reaches, relating the incremental area of those data to the original pre-impoundment topography, and computing incremental volumes. This computational procedure, or "Constant Factor Method", is an accepted standard for several federal agencies (TVA, 1968). This method is satisfactory for calculating main channel and tributary reservoir volumes, but it does not yield very accurate estimates of volumetric changes in embayments. Recently, it has been shown (Stone and Tschantz, 1991), that bathymetric data resulting from using hydroacoustic survey equipment can be reliably used (and at a much lower cost) to make embayment volume surveys.

The method of acquiring bathymetric data consists of positioning an acoustic transmitter-receiver just below the water surface suspended from a boat that is equipped with appropriate data logging equipment, (BioSonics, 1988). Calibration testing determined the depth sounding precision of the acoustic signal to be ± 0.05 feet, which was more than satisfactory for this study (Stone and Tschantz, 1991). In each embayment, diagonal (zig-zag) transects from bank to bank were followed by the boat as it traversed back and forth across an embayment at a constant speed. The transects were plotted on standard USGS topographic quadrangle maps (1:24,000). Concurrently, water depth soundings ("z" coordinate data) were recorded at equal time intervals such that the water depths could be superimposed on the digitized transects ("x" and "y" coordinate data) by equally spacing the sounding data across the length of each diagonal transect. An independently digitized shoreline (from USGS/TVA 1:24,000 quadrangles) was added to the three dimensional coordinate data. The resulting bathymetric contours were developed and plotted as shown in the example in figure 24, using smoothing routines in

Bathymetric Contour Map Derived From Hydroacoustic Survey Data
(Dallas Bay - 1990)

Golden Software's SURFER (Surfer, 1990). A complete set of these bathymetric plots for the Chickamauga Reservoir embayments is given in Appendix C. SURFER was next used to compute surface areas and volumes at one foot increments from the bottom of each embayment to the normal summer pool level of 683.0 Mean Sea Level (MSL). The surface areas and volumes given at 683.0 MSL in table 1 are a result of these SURFER computations.

To make comparisons between the 1924 pre-impoundment embayment volumes and the 1990 embayment volumes, surface areas at one foot increments were plotted versus depth. The 1924 and 1990 volumes were computed as the total "area under the surface area versus depth curve".⁴ For the 1990 data, the surface areas (determined by SURFER) at one foot increments using the hydroacoustic data were plotted. For the 1924 data, surface areas (determined by TVA's constant factor method) at one foot increments using the original topographic surveys were plotted. These data (elevation, surface area, and volume) are given in Appendix C.

Results and Discussion

These hypsographic plots (figures 25a-25c) comparing 1924 surface areas and volumes with 1990 surface areas and volumes show the effects of sedimentation and filling in each embayment. For example, Goodfield Creek embayment has completely filled in the deepest 9-10 feet (elevation 665 to 675) resulting in little or no surface area or volume until about 11 feet above the original bottom. Similar filling patterns are evident in several

⁴It was noted that the SURFER volume calculations gave approximately 3.5% smaller average volumes (@683 feet MSL) for the embayments than did the standard TVA "area under the curve" method. For example, compare the 1990 embayment volumes in table 1 (SURFER method) with the 1990 embayment volumes in table 11 (TVA method). Consequently, to make comparisons between 1924 and 1990 embayment volumes and avoid a bias between the two different computational methods for estimating the embayment volumes, the standard TVA "area under the curve" method was used for estimating volumes for both 1924 and 1990.

Figure 25a
Comparative Hypsographic Plots (1924 vs. 1990)
Chickamauga Reservoir Embayments

Figure 25b
Comparative Hypsographic Plots (1924 vs. 1990)
Chickamauga Reservoir Embayments

Figure 25c
Comparative Hypsographic Plots (1924 vs. 1990)
Chickamauga Reservoir Embayments

of the other embayments (Savannah Bay, Richland Creek, Rogers, Creek, Candies Creek) although not as dramatic. Overall, embayment filling ranges from a low of 7.1% of the original volume in Waconda Bay to a high of 55% on Possum Creek (table 11 and figure 26). Three embayments on the northwest side of Chickamauga Reservoir (Soddy Creek, Possum Creek, and Sale Creek) have received large amounts of sediment, all in excess of 3000 acre-feet, table 11. Ratios of embayment sediment volume to embayment surface area yield average accumulated sediment depths ranging from five feet (Soddy Creek) to 8.5 feet (Possum Creek). It is estimated that over 200, 250, and 400 acres of land have been strip mined for coal in Possum, Sale, and Soddy Creek watersheds, respectively, (Eagle, 1992). In the 1960's and 1970's, prior to the passage of the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87), steep slope surface mining activities were common practice along the eastern slopes of Waldens Ridge of the Cumberland Plateau, in the headwaters of these watersheds.⁵ Present suspended solids and turbidity data collected in these embayments are relatively low, indicating the strip mine reclamation activities have been effective. Three other embayments, Wolftever Creek/Savannah Bay, Goodfield Creek, and Candies Creek, have lost approximately 40-45% of their original volume. Suspended solids and turbidity data are relatively high in these embayments (table 5), indicating that active erosion/sedimentation is occurring in these watersheds, and that better land use practices are needed.

There has been very little change over time in surface areas of the embayments (at 683 feet MSL). About half of the embayments have slightly greater and about half slightly less

⁵Assuming strip mining activities took place over an approximate twenty year period during the 1960's and 1970's, sedimentation rates are estimated to have exceeded 10 cm/yr in these embayments. This is roughly ten times the average sediment accumulation rate of mainstem Tennessee River reservoirs.

Table 11
Sedimentation/Filling of Chickamauga Reservoir Embayments

	+----- 0683.0 MEAN SEA LEVEL -----+								CUMULATIVE				
	1924				1990				SEDIMENTATION/FILLING		PERCENT (%)	RATIO VOLUME/S AREA (feet)	SURFACE AREA (% CHANGE) 0683 0680
	VOLUME (ac-ft)	(x10 ³ m ³)	SURFACE AREA (acres)	(ha)	VOLUME (ac-ft)	(x10 ³ m ³)	SURFACE AREA (acres)	(ha)	TOTAL (ac-ft)	(x10 ³ m ³)			
WACONDA BAY	1292	1594	134	54.2	1200	1480	144	58.2	92	113	7.1	0.69	7.4 6.7
WOLFTEVER CREEK (+SAVANNAH BAY)	10127	12491	898	363.4	6045	7456	946	383.0	4082	5035	40.3	4.55	5.4 -18.0
WOLFTEVER CREEK (-SAVANNAH BAY)	7152	8822	501	202.7	4145	5113	550	222.5	3007	3709	42.0	6.00	9.8 -22.9
SAVANNAH BAY	2975	3670	397	160.7	1900	2344	397	160.5	1075	1326	36.1	2.71	-0.1 -9.9
DALLAS BAY	10678	13171	760	307.6	7427	9161	827	334.5	3251	4010	30.4	4.28	8.8 -24.1
SODDY CREEK	10971	13533	732	296.2	7124	8787	684	276.7	3847	4745	35.1	5.26	-6.6 -26.4
POSSUM CREEK	8716	10751	563	227.8	3923	4839	529	214.0	4793	5912	55.0	8.51	-6.1 -35.3
SALE CREEK	9393	11586	672	271.9	4932	6084	661	267.3	4461	5503	47.5	6.64	-1.7 -41.2
RICHLAND CREEK	2778	3427	310	125.5	1460	1801	319	129.0	1318	1626	47.4	4.25	2.8 -39.1
MUD CREEK	2530	3121	383	155.0	1491	1839	397	160.8	1039	1282	41.1	2.71	3.7 -32.3
GOODFIELD CREEK	1225	1511	139	56.3	650	802	144	58.2	575	709	46.9	4.14	3.4 -17.9
GUNSTOCKER CREEK	2037	2513	345	139.6	1794	2213	355	143.7	243	300	11.9	0.70	2.9 -5.0
AGENCY CREEK	1793	2212	296	119.8	1431	1765	300	121.4	362	447	20.2	1.22	1.4 -3.9
CANDIES CREEK	4214	5198	671	271.5	2362	2913	562	227.3	1852	2284	43.9	2.76	-16.3 -39.6
ROGERS CREEK	2677	3302	479	193.8	1939	2392	449	181.9	738	910	27.6	1.54	-6.2 -8.3
NORTH MOUSE CREEK	612	755	170	68.8	398	491	164	66.3	214	264	35.0	1.26	-3.6 -36.1
SOUTH MOUSE CREEK	379	467	136	55.0	351	433	119	48.0	28	35	7.4	0.21	-12.8 -1.9

1924 surface area data were determined using pre-impoundment topographic survey data, while 1990 surface area data were determined using 1990 hydroacoustic data. Both sets of surface areas were plotted versus depth/elevation, and embayment volumes were determined by integration of the areas under the surface area versus elevation curves. (See further discussion in text.)

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Figure 26
Embayment Filling
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

surface areas in 1990 than 1924. Overall, the average change in surface area among the embayments was less than 1% (table 11). This is expected, since most sedimentation/filling would occur below the normal pool level (elevation 683 feet, MSL). Any changes in water surface area which might occur would most likely be due to man's activities (e.g. shoreline development, construction of roads, bridges, etc.). The greatest changes in water surface were Dallas Bay, with about 9% greater surface area in 1990 than 1924 (shoreline development?) and Candies Creek with about 16% less surface area in 1990 than 1924. Some of this loss of surface area in the Candies Creek embayment is due to filling for construction of the Lower River Road causeway across the upper end of the embayment and the resultant filling which has occurred in the backwater area upstream of the causeway.

In spite of the small changes in embayment surface area at normal pool elevation, the sedimentation/filling results in a significant loss in embayment surface area at lower pool levels. For example, at elevation 680 feet MSL, all the Chickamauga Reservoir embayments, have less surface area, some as much as one-third less, table 11. This loss of surface area limits near shore boat access, increases available habitat for aquatic macrophytes, and promotes resuspension of nutrient rich, near shore sediment with resultant decreased water clarity and greater potential for eutrophication.

Correlations between embayment filling and the size and depth of the embayments as well as strip mining activities in the watershed were significant. However, only weak correlations were found between land use (table 12) within the watershed (agriculture, forest, urban, etc.) and embayment filling (table 11). This suggests that for the Chickamauga Reservoir embayments, sedimentation and filling are largely a function of bathymetric characteristics (i.e. embayment depth and volume resulting in greater embayment internal settling velocities and greater trapping efficiencies) and strip mining activities; and less a function of watershed land use.

These correlations are given below, for each of the Chickamauga embayments (tables 5, 11, and 12):

<u>Embayment Filling, acre-feet (n=17)</u>	<u>Embayment</u>			<u>Watershed</u>			
	<u>Volume</u>	<u>Surface Area</u>	<u>Mean Depth</u>	<u>Stripmine Area</u>	<u>Forest Area</u>	<u>Cropland Area</u>	<u>Urban Area</u>
Correlation Coefficient (r)	0.86	0.84	0.67	0.65	0.53	0.14	0.14
Level of Significance (P)	<0.001	<0.001	0.003	0.005	0.028	0.590	0.583

A simple two variable linear model to predict filling of the Chickamauga Reservoir embayments, was found to explain almost 85% of the variation in the data, where:

$$\text{Embayment Filling, ac-ft} = 4.821(\text{Embayment surface area, acres}) + \\ + 5.715(\text{Strip Mined area, acres}) - 603.78$$

where: $R^2 = 0.84$; $F = 35.6$; $\text{prob}>F = 0.0001$; $n = 17$

LAND USE, NUTRIENT LOADINGS, AND EUTROPHICATION MODELS

Introduction

To assess and manage the response of a water body to nutrients, one of the most important pieces of needed information is an understanding of the water body's nutrient budget. Human activity (including land use), watershed characteristics, and climate (rainfall/dry deposition) are the general determinants of nutrients to lakes. The nutrient loading is empirically related to the nutrient concentration in the water, which is a function of the hydrologic and geomorphologic characteristics of the lake/embayment. In turn, nutrient concentrations are causally linked with algal productivity, water clarity, dissolved oxygen, etc., which are all empirically interrelated (figure 27). The most commonly quantified and useful component of this nutrient budget is the annual nutrient loading from the watershed. A nutrient budget provides a measure of the impact of land use on water quality that may be used to guide land use planning. This nutrient load can be estimated in several ways. Direct measurement of nutrient inputs during an entire year is an effective but costly approach, but reflects conditions only for the year of sampling. An alternative and less costly approach, that does not require a year of intensive monitoring, is the estimation of nutrient loading based on particular land use categories within the watershed. This method is based on nutrient export coefficients for different types of land use and requires only limited site specific data. The method is amenable to linkage with simple lake nutrient loading and response models for assessing different management scenarios under changing land use and anthropogenic activities.

A nutrient export coefficient is a unit measure of pollutant runoff expressed as mass per unit area per unit time (e.g. 1.0 kg P/ha-yr) for a specific land use. Export coefficients have been

Figure 27
Schematic of Nutrient Loading and Lake Response

Schematic of Nutrient Loading and Lake Response (after Reckhow, et al., 1980)

measured and reported in the literature for various types of land use. The method of estimating the annual nutrient load for a water body entails the following: (1.) determine the drainage basin/watershed boundaries for the body of water; (2.) divide the watershed into homogeneous land use types, e.g. urban, forest, pasture, row crops, water, etc.; (3.) select an appropriate export coefficient from the literature to represent the nutrient runoff for each land use type based on comparable factors such as precipitation, runoff, total land area, eco-region, type of crops, etc.; and (4.) multiply the export coefficient times the area for each land use type and then sum these products over the entire watershed. In practical applications high, most likely, and low export coefficients are selected for each land use type. The calculated high and low nutrient loading estimates represent the error or uncertainty in predicting the nutrient loading estimates. Using this method, nutrient loads to each of the Chickamauga reservoir embayments were estimated.

Land Use Classification

SPOT (1989) imagery, acquired September 6, 1986, was used to classify land use within each of the Chickamauga embayment watersheds. Computer aided land use classification techniques (ERDAS, 1990) were employed, with the following qualifications. Three watersheds (Rogers Creek, North Mouse, and South Mouse) were not covered in the September 1986 SPOT image and were consequently classified manually using National High Altitude Photography (NHAP, 1983) flown between 1981 and 1985. In addition, SPOT imagery did not provide adequate resolution to allow classification of agricultural lands into cropland (cultivated) and pasture (non-cultivated). Consequently, in each watershed, the proportion of crop and pasture land for those parcels classified as agricultural was provided by the Soil Conservation Service, based on the 1987 National Resources Inventory (NRI, 1987). The SPOT imagery and resultant land use classifications are given in table 12 and figures 28a - 28d.

Table 12
SPOT Land Use Classifications
Chickamauga Embayment Watersheds
(September 1986)

EMBAYMENT	WATERSHED (ha)	URBAN		AGRICULTURE		CROP LAND (CULTIVATED)		PASTURE (NON-CULTIVATED)		FOREST	
		(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
WACONDA BAY	784	33.21	260	24.38	191	0.00	0	24.38	191	36.81	289
WOLFTEVER CR (+SAVANNAH BAY)	25014	9.23	2308	36.95	9242	8.13	2033	28.82	7209	52.88	13228
WOLFTEVER CR (-SAVANNAH BAY)	14399	13.81	1989	21.67	3120	4.77	687	16.90	2434	63.44	9135
SAVANNAH BAY	10615	3.01	320	57.67	6122	12.69	1347	44.98	4775	38.56	4093
DALLAS BAY	2687	18.71	503	21.91	589	4.82	130	17.09	459	49.74	1337
SODDY CREEK	16989	5.36	911	11.63	1976	2.56	435	9.07	1541	81.38	13826
POSSUM CREEK	8814	7.08	624	12.83	1131	2.82	249	10.01	882	78.00	6875
SALE CREEK	29911	5.43	1624	22.43	6709	4.94	1476	17.49	5233	70.94	21219
RICHLAND CREEK	21309	8.29	1766	30.16	6427	12.05	2567	18.11	3859	60.88	12973
MUD CREEK	2115	11.12	235	60.33	1276	24.13	510	36.20	766	21.57	456
GOODFIELD CREEK	6496	4.8	312	35.33	2295	13.08	849	22.25	1446	57.97	3766
GUNSTOCKER CREEK	5263	1.7	89	54.55	2871	20.18	1062	34.37	1809	41.20	2168
AGENCY CREEK	5193	5.68	295	35.89	1864	13.28	689	22.61	1174	56.38	2928
CANDIES CREEK	28799	2.04	587	43.71	12588	1.75	503	41.96	12084	53.34	15361
ROGERS CREEK	14388	0.50	72	25.48	3666	4.08	586	21.40	3080	72.45	10424
NORTH MOUSE CREEK	24356	7.44	1811	46.35	11289	1.85	452	44.49	10837	45.52	11087
SOUTH MOUSE CREEK	10142	36.46	3697	24.09	2443	3.85	391	20.23	2052	38.75	3930

For the land classified as agriculture, the percentages for crop (cultivated) and pasture (non-cultivated) land were provided by the Soil Conservation Service based on the 1987 National Resources Inventory (NRI, 1987).

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WOLFTEVER CREEK WATERSHED

SAVANNAH BAY WATERSHED

WACONDA BAY & HARRISON BAY WATERSHED

LEGEND

URBAN WHITE
 AGRI BROWN
 FOREST GREEN
 WATER BLUE

LAND USE CLASSIFICATION SUMMARY

WATERSHED	HECTARES	URBAN (%)	AGRI (%)	FOREST (%)	WATER (%)
WOLFTEVER CREEK	14399	13.81	21.67	63.44	1.08
SAVANNAH BAY	10615	3.01	57.67	38.56	0.76
WACONDA BAY & HARRISON BAY	3644	17.72	11.15	50.51	20.61
WACONDA BAY	784	33.21	24.38	36.81	5.60

Figure 28a

CHICKAMAUGA EMBAYMENT WATERSHEDS SPOT IMAGERY-SEPT 1986

DALLAS BAY WATERSHED

SODDY CREEK WATERSHED

SALE CREEK WATERSHED

POSSUM CREEK WATERSHED

LAND USE CLASSIFICATION SUMMARY

WATERSHED	HECTARES	URBAN (%)	AGRI (%)	FOREST (%)	WATER (%)
DALLAS BAY	2687	18.71	21.91	49.74	9.65
SODDY CREEK	16989	5.36	11.63	81.38	1.62
POSSUM CREEK	8814	7.08	12.83	78.00	2.09
SALE CREEK	29911	5.43	22.43	70.94	1.20

Figure 28b

CHICKAMAUGA EMBAYMENT WATERSHEDS SPOT IMAGERY-SEPT 1986

RICHLAND CREEK WATERSHED

MUD CREEK WATERSHED

GOODFIELD CREEK WATERSHED

LEGEND

URBAN WHITE
 AGRI BROWN
 FOREST GREEN
 WATER BLUE

LAND USE CLASSIFICATION SUMMARY

WATERSHED	HECTARES	URBAN (%)	AGRI (%)	FOREST (%)	WATER (%)
RICHLAND CREEK	21309	8.29	30.16	60.88	0.67
MUD CREEK	2115	11.12	60.33	21.57	6.98
GOODFIELD CREEK	6496	4.80	35.33	57.97	1.90

Figure 28c

CHICKAMAUGA EMBAYMENT WATERSHEDS SPOT IMAGERY-SEPT 1986

GUNSTOCKER CREEK WATERSHED

AGENCY CREEK WATERSHED

CANDIES CREEK

LEGEND

URBAN WHITE
 AGRI BROWN
 FOREST GREEN
 WATER BLUE

LAND USE CLASSIFICATION SUMMARY

WATERSHED	HECTARES	URBAN (%)	AGRI (%)	FOREST (%)	WATER (%)
GUNSTOCKER CREEK	5263	1.7	54.55	41.20	2.55
CANDIES CREEK	28799	2.04	43.71	53.34	0.91
AGENCY CREEK	5193	5.68	35.89	56.38	2.05

Figure 28d

CHICKAMAUGA EMBAYMENT WATERSHEDS SPOT IMAGERY-SEPT 1986

Nutrient Loading Estimates

The total annual mass loading of nutrients into each of the Chickamauga embayments was estimated by summing the annual nitrogen and phosphorus contributions from each of the nonpoint sources plus the point sources. Using the estimates of land use (table 12); carefully selected export coefficients, soil retention coefficients, and estimates of concentrations of nutrients in treated domestic waste (table 13); and known point source domestic wastewater discharges and estimates of septic tank systems immediately adjacent to the embayments (table 14), the annual mass loadings (kg/yr) to each embayment were calculated as follows:

$$M = (EC_c \times A_c) + (EC_p \times A_p) + (EC_f \times A_f) + (EC_u \times A_u) + (EC_a \times A_l) + [EC_{st} \times N.C.Y. \times (1 - S.R.)] + P.S.I.$$

where: M = Annual mass loading (kg/yr)

EC_c = Export coefficient for crop land (kg/ha-yr)

EC_p = Export coefficient for pasture land (kg/ha-yr)

EC_f = Export coefficient for forest land (kg/ha-yr)

EC_u = Export coefficient for urban land (kg/ha-yr)

EC_a = Export coefficient for atmospheric input
(kg/ha-yr)

EC_{st} = Export coefficient for septic tank systems
impacting the embayment (kg/(capita-yr)-yr)

A_c = Area of crop/cultivated land (ha)

A_p = Area of pasture/non-cultivated land (ha)

A_f = Area of forest land (ha)

A_u = Area of urban land (ha)

A_l = Area of lake (ha)

N.C.Y. = Number of Capita years in watershed serviced
by septic tank systems impacting the embayment

S.R. = Soil retention coefficient (dimensionless)

P.S.I. = Point Source Input (kg/yr)

Table 13

NUTRIENT EXPORT COEFFICIENTS (kg/ha-yr)
CHICKAMAUGA EMBAYMENT WATERSHEDS

<u>LAND USE</u>	<u>NUTRIENT</u>	<u>LOWER BOUND</u>	<u>UPPER BOUND</u>	<u>BEST ESTIMATE</u>	<u>LOCATION/REFERENCE</u>
Agriculture Cropland, EC _c	Total P	0.40	17.64	2.0	N. Alabama-corn (Bradford, 1974) N. Mississippi-soybeans (McDowell et al, 1978)
	Total N	3.29	46.5	9.0	
Pasture, EC _p	Total P	0.14	1.46	0.3	Various US, (Reckhow, et al, 1980)
	Total N	1.48	13.0	5.0	
Forest, EC _f	Total P	0.01	0.275	0.1	Oak Ridge (Henderson, et al, 1977, Henderson and Harris, 1975) Georgia (Krebs and Golley, 1977)
	Total N	1.7	3.1	2.2	
Urban, EC _u	Total P	0.43	4.85	1.0	Knoxville (Betson, 1978)
	Total N	1.56	14.95	5.0	
Atmospheric, EC _a	Total P	0.54	3.67	0.7	Knoxville (Betson, 1978) Oak Ridge/Sewanee, (Kelly, 1991) Oak Ridge (Henderson, et al, 1977)
	Total N	8.9	24.8	16.0	
Septic Tank, EC _{st} (kg/capita-yr)	Total P	0.80	3.0	1.2	Various US (Reckhow, 1980 and EPA-NES, 1974)
	Total N	2.15	8.2	4.0	
Soil Retention Coefficient, S.R.	Total P	0.9	0.4	0.75	(Shannon and Brezonik, 1972 and Dillon and Rigler, 1975)
	Total N	0.6	0.1	0.4	
Point Source (mg/l) Waste, P.S.I.	Total P	4.0	15.0	7.0	(Gakstatter, 1978)
	Total N	10.0	50.0	20.0	

Table 14

POINT SOURCE INPUT-DOMESTIC WASTEWATER DISCHARGES^a
and
ESTIMATES OF SEPTIC SYSTEMS ADJACENT TO EMBAYMENTS^b
CHICKAMAUGA EMBAYMENT WATERSHEDS

<u>Point Source Domestic Wastewater Discharges</u>		
<u>Name</u>	<u>Location</u>	<u>Remarks</u>
Candies Creek Watershed		
Holiday Inn I-75 South Cleveland	UNT to Harris Creek mile 1.5	0.05 mgd package plant
Bachman Memorial Children's Home, Inc.	UNT to Brymer Creek mile 0.3	0.01 mgd package plant
Blue Spring Elementary School	Blue Spring Branch mile 1.1	0.01 mgd package plant
Hopewell Elementary School	Greasy Creek mile 0.8	0.0075 mgd package plant
Richland Creek Watershed		
Rhea Co. High School	UNT to L. Richland Creek mile 8.5	0.045 mgd package plant
Sale Creek Watershed		
Laurelbrook Sanitarium and School	Brush Creek mile 2.5	0.016 mgd package plant
Wolftever Creek Watershed		
Grindstone Estates Mobile Home Park	UNT to L. Wolftever Creek mile 2.0	0.0638 mgd extended aeration package plant
North Mouse Creek Watershed		
Holiday Inn I-75, Mt Verd Rd, Athens	Liberty Branch mile 0.6	0.023 mgd package plant
E.K. Baker Elementary School	Spring Creek mile 18.7	0.017 mgd extended aeration package plant
Riceville Elementary School	UNT to Dry Valley Branch mile 5.4	0.02 mgd package plant
Niota Sewage Treatment Plant	L. North Mouse Creek mile 4.1	0.35 mgd, tertiary treatment
South Mouse Creek Watershed		
Postlight Mobile Home Manor	UNT to S. Mouse Creek mile 11.6	0.02 mgd package plant

Estimates of Septic Systems Adjacent to Embayments

<u>Embayment</u>	<u>Number of Dwellings^b</u>	<u>Estimated N.C.Y.^c</u>
Waconda Bay	84	221
Wolftever Creek	147	387
Savannah Bay	173	455
Dallas Bay	92	242
Soddy Creek	86	226
Possum Creek	82	216
Sale Creek	48	126
Richland Creek	71	187
Mud Creek	28	74
Goodfield Creek	8	21
Gunstocker Creek	33	87
Agency Creek	51	134
Candies Creek	47	124
Rogers Creek	19	50
North Mouse Creek	0	0
South Mouse Creek	0	0

^a Cox, J.P. 1989. Surface Water Resources Issues Analysis: Hiwassee River Watershed, TVA, Water Resources, Water Quality Department, TVA/WR/WQ--90/3.

Cox, J.P. 1992. Surface Water Resources Issues Analysis: Nickajack and Chickamauga Reservoirs Watershed, TVA, Water Resources, Water Quality Department, (in preparation).

^b Powers, H. Personal communication, April 25, 1990. (Estimates are based on the number of permitted boat docks from TVA's Land Resources, 26(a) data files, Athens, TN).

^c N.C.Y. = Number of capita years, where:

N.C.Y. = number of dwellings x number of persons per dwelling x percent of year lived in dwelling. Estimate assumes: (1.) three fourth of the dwellings are permanent (~300 days/yr) and one fourth of the dwellings are seasonal (~60 days/yr); and (2.) four residents per dwelling.

Example for Waconda Bay: $N.C.Y. = 4 \{ (300/365 \times 63) + (60/365 \times 21) \} = 221$

The actual computational procedure is made easier by use of a spreadsheet application developed by Reckhow (EUTROMOD, 1989). Details, with an example application of the method are given in Reckhow (1980). Key considerations for estimating nutrient loads to the Chickamauga reservoir embayments are given below.

Nutrient export coefficients (table 13) were selected to be representative of east Tennessee and north Alabama soil and atmospheric/precipitation conditions. The soil retention (S.R.) coefficient is an estimate of how well the septic system immobilizes the nutrients. This coefficient may range from 0 to 1.0. For example, if all of the septic system phosphorus is assumed to eventually reach the embayment, a S.R. coefficient of 0 is used. If none of the phosphorus is assumed to reach the embayment, a S.R. coefficient of 1.0 is used. Common literature values were used for S.R. coefficients (table 13).

Drainage areas of all but one of the Chickamauga embayment watersheds are greater than 2000 hectares, ranging from approximately 800 hectares (Waconda Bay) to approximately 30000 hectares (Sale Creek), table 12. These watersheds, with their respective land use types, are very much larger than the experimental land use plots used to determine the export coefficients reported in the literature. There is much evidence that a percentage of nutrients that are transported in surface runoff on a large watershed will be trapped in that watershed before reaching the surface water body. The primary controlling factor is the distance of the land exporting the nutrients from the water body. Assuming that sediment delivery is an adequate indicator of nutrient delivery, Reckhow et. al. (1989) have proposed using Sediment Delivery Ratios (SDR) after Maner (1958) to estimate the effect of nutrient trapping in the watershed. The SDR is the ratio of the sediment loss in a watershed to the gross erosion of sediment, and in effect is the ratio of the actual measured sediment runoff from a watershed to the total amount of sediment transported (eroded), but not actually removed from the watershed. Maner (1958) found that sediment delivery in

large watersheds was a function of the length of the watershed (measured along the mainstem stream) and defined sediment delivery ratio (S.D.R.) as:

$$\ln(\text{S.D.R.}) = 1.01 - 0.34 \ln(D)$$

where: D = one half the length of the mainstem stream of the watershed.

To approximate the effect of nutrient trapping within a watershed as a function of distance from the embayment, all nutrient loads to each embayment were categorized into one of three zones, each of which was assigned a different nutrient attenuation factor. The nutrient attenuation factor (AF) is defined as:

$$\text{AF} = 1 - \text{S.D.R.}$$

Zone 1. with an attenuation factor of 0 (no attenuation), includes those wasteloads which discharge directly into the embayment/waterway. All point source wastewater discharges and adjacent septic systems (table 14) were assumed to discharge directly into the embayment and/or waterway.

Zone 2. with an attenuation factor of 0.25, includes those land uses immediately adjacent (± 150 meters) to the embayment, e.g. wildlife management areas, TVA public lands, etc.

Zone 3. with an attenuation factor of 0.80 to 0.92 (computed using equations 9.0 and 10.0, above), includes those remaining land uses more distant and with less of a direct impact on the embayment.

Appendix D summarizes for each watershed the allocation of land uses within each of the three zones and the attenuation factor ($1 - \text{S.D.R.}$) used in each zone. In each watershed, equation 8.0, above, was used to calculate the nutrient loads, applying the appropriate attenuation factors in each of the three zones (Appendix D). The total annual nutrient load to each

embayment was calculated as the sum of the nutrient loads from each of the three zones.

Table 15 presents a detailed breakdown of the estimated total annual nutrient loads according to land use type and nutrient source inputs for each of the Chickamauga reservoir embayments. Note that low, middle, and high nutrient loading estimates are given for each nutrient source category. Rast and Lee (1978) suggest that these middle or "best estimate" export coefficients approximate the measured loadings by a factor of $\pm 100\%$. The range between the low and high estimates, therefore, are an indication of the uncertainty of the loading rate estimates. They are a result of the uncertainty in selecting and applying the most appropriate export coefficients for each nutrient source category and land use (table 13). Figures 29 and 30 illustrate the "best estimate" (using the middle loadings estimate) for total annual phosphorus and nitrogen loadings to the Chickamauga reservoir embayments.

Comparing these middle or best estimates (table 15) among the Chickamauga reservoir embayments, estimated annual loadings for phosphorus range from a high of 4399 kg/yr for North Mouse Creek embayment to a low of 196 kg/yr for Waconda Bay. Estimated annual nitrogen loadings are highest for Wolftever Creek embayment, 50194 kg/yr, and lowest for Waconda Bay, 2209 kg/yr. The nutrient loads for those embayments with small watersheds (relative to their water surface area) are generally dominated by precipitation/atmospheric deposition sources (e.g. Dallas Bay, Waconda Bay, and Mud Creek). The nutrient loads to those embayments with large watershed to water surface area ratios (e.g. Richland Creek, Sale Creek, and Goodfield Creek) are often dominated by agricultural nutrient sources.

North Mouse Creek embayment appears to be unique in that over 85% of its phosphorus load (table 15) is estimated to be due to domestic wastewater sources (see also Appendix D). The estimated total annual phosphorus load to North Mouse Creek

Table 15

ESTIMATED ANNUAL NUTRIENT LOADINGS TO
CHICKAMAUGA RESERVOIR EMBAYMENTS

Phosphorus Loading Estimates - By Category

WACONDA BAY WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	7.20	15.42	75.04
Forest	0.73	7.32	20.13
Urban	28.27	65.75	318.89
Precipitation	31.44	40.75	213.67
Septic Tanks	17.68	66.30	397.80
Point Sources	0.00	0.00	0.00
TOTAL	85.32	195.54	1025.53

Nitrogen Loading Estimates - By Category

WACONDA BAY WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	76.07	257.00	668.20
Forest	124.44	161.04	226.92
Urban	102.57	328.75	982.96
Precipitation	518.16	931.52	1443.86
Septic Tanks	190.06	530.40	1630.98
Point Sources	0.00	0.00	0.00
TOTAL	1011.30	2208.71	4952.92

WOLFTEVER CREEK (+SAVANNAH BAY) WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	204.45	698.80	5204.31
Forest	16.40	164.00	451.00
Urban	111.31	258.85	1255.42
Precipitation	206.84	268.12	1405.72
Septic Tanks	67.36	252.60	1515.60
Point Sources	352.61	617.07	1322.29
TOTAL	958.96	2259.43	11154.34

WOLFTEVER CREEK (+SAVANNAH BAY) WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	1947.25	6096.15	21119.10
Forest	2788.00	3608.00	5084.00
Urban	403.81	1294.25	3869.81
Precipitation	3408.97	6128.48	9499.14
Septic Tanks	724.12	2020.80	6213.96
Point Sources	881.52	1763.05	4407.62
TOTAL	10153.67	20910.73	50193.63

WOLFTEVER CREEK (-SAVANNAH BAY) WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	66.09	226.08	1684.58
Forest	11.36	113.58	312.34
Urban	91.68	213.20	1034.02
Precipitation	120.16	155.76	816.61
Septic Tanks	30.96	116.10	696.60
Point Sources	352.61	617.07	1322.29
TOTAL	672.85	1441.79	5866.45

WOLFTEVER CREEK (-SAVANNAH BAY) WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	629.34	1969.85	6828.70
Forest	1930.86	2498.76	3520.98
Urban	332.59	1066.00	3187.34
Precipitation	1980.34	3560.16	5518.25
Septic Tanks	332.82	928.80	2856.06
Point Sources	881.52	1763.05	4407.62
TOTAL	6087.47	11786.62	26318.95

Table 15 (continued)

Phosphorus Loading Estimates - By Category

Loading (kg/yr)	SAVANNAH BAY WATERSHED		
	Low	Middle	High
Agriculture	164.11	549.53	4043.27
Forest	4.62	46.24	127.16
Urban	17.61	40.96	198.66
Precipitation	86.69	112.37	589.15
Septic Tanks	36.40	136.50	819.00
Point Sources	0.00	0.00	0.00
TOTAL	309.43	885.60	5777.22

Nitrogen Loading Estimates - By Category

Loading (kg/yr)	SAVANNAH BAY WATERSHED		
	Low	Middle	High
Agriculture	1572.40	4946.02	16858.96
Forest	786.06	1017.26	1433.41
Urban	63.90	204.80	612.35
Precipitation	1428.72	2568.48	3981.14
Septic Tanks	391.30	1092.00	3357.90
Point Sources	0.00	0.00	0.00
TOTAL	4242.38	9828.56	26243.76

Loading (kg/yr)	DALLAS BAY WATERSHED		
	Low	Middle	High
Agriculture	24.02	81.98	610.08
Forest	3.43	34.31	94.36
Urban	45.01	104.67	507.65
Precipitation	180.66	234.18	1227.80
Septic Tanks	19.36	72.60	435.60
Point Sources	0.00	0.00	0.00
TOTAL	272.47	527.75	2875.49

Loading (kg/yr)	DALLAS BAY WATERSHED		
	Low	Middle	High
Agriculture	228.84	716.65	2480.06
Forest	583.32	754.89	1063.70
Urban	163.29	523.35	1564.82
Precipitation	2977.49	5352.80	8296.84
Septic Tanks	208.12	580.80	1785.96
Point Sources	0.00	0.00	0.00
TOTAL	4161.06	7928.49	15191.38

Loading (kg/yr)	SODDY CREEK WATERSHED		
	Low	Middle	High
Agriculture	49.46	180.23	1390.63
Forest	15.83	158.28	435.27
Urban	64.89	150.90	731.86
Precipitation	149.42	193.70	1015.53
Septic Tanks	18.08	67.80	406.80
Point Sources	0.00	0.00	0.00
TOTAL	297.68	750.90	3980.09

Loading (kg/yr)	SODDY CREEK WATERSHED		
	Low	Middle	High
Agriculture	461.96	1423.30	5200.92
Forest	2690.76	3482.16	4906.68
Urban	235.40	754.50	2255.96
Precipitation	2462.72	4427.36	6862.41
Septic Tanks	194.36	542.40	1667.88
Point Sources	0.00	0.00	0.00
TOTAL	6045.20	10629.72	20893.85

Loading (kg/yr)	POSSUM CREEK WATERSHED		
	Low	Middle	High
Agriculture	29.71	101.55	756.32
Forest	9.48	94.82	260.77
Urban	35.57	82.72	401.19
Precipitation	115.57	149.81	785.42
Septic Tanks	17.28	64.80	388.80
Point Sources	0.00	0.00	0.00
TOTAL	207.61	493.70	2592.49

Loading (kg/yr)	POSSUM CREEK WATERSHED		
	Low	Middle	High
Agriculture	282.96	885.85	3068.98
Forest	1612.03	2086.15	2939.58
Urban	129.04	413.60	1236.66
Precipitation	1904.69	3424.16	5307.45
Septic Tanks	185.76	518.40	1594.08
Point Sources	0.00	0.00	0.00
TOTAL	4114.48	7328.16	14146.74

Table 15 (continued)

Phosphorus Loading Estimates - By Category

SALE CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	130.48	460.83	3496.53
Forest	20.44	204.43	562.20
Urban	63.98	148.80	721.68
Precipitation	144.35	187.12	981.03
Septic Tanks	10.08	37.80	226.80
Point Sources	88.43	154.75	331.61
TOTAL	457.76	1193.73	6319.84

Nitrogen Loading Estimates - By Category

SALE CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	1230.49	3821.67	13599.54
Forest	3475.39	4497.57	6337.48
Urban	232.13	744.00	2224.56
Precipitation	2379.06	4276.96	6629.29
Septic Tanks	108.36	302.40	929.88
Point Sources	221.07	442.14	1105.36
TOTAL	7646.50	14084.74	30826.11

RICHLAND CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	189.93	766.26	6214.77
Forest	15.40	154.03	423.59
Urban	139.67	324.82	1575.38
Precipitation	69.67	90.31	473.47
Septic Tanks	14.96	56.10	336.60
Point Sources	132.64	232.13	497.41
TOTAL	562.27	1623.65	9521.21

RICHLAND CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	1712.72	5121.38	20577.54
Forest	2618.53	3388.68	4774.96
Urban	506.72	1624.10	4856.06
Precipitation	1148.19	2064.16	3199.45
Septic Tanks	160.82	448.80	1380.06
Point Sources	331.61	663.22	1658.04
TOTAL	6478.59	13310.34	36446.10

MUD CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	75.38	298.62	2401.67
Forest	1.07	10.72	29.47
Urban	23.78	55.30	268.21
Precipitation	86.83	112.55	590.10
Septic Tanks	5.92	22.20	133.20
Point Sources	0.00	0.00	0.00
TOTAL	192.98	499.39	3422.65

MUD CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	684.30	2058.15	8122.04
Forest	182.21	235.80	332.26
Urban	86.27	276.50	826.74
Precipitation	1431.03	2572.64	3987.59
Septic Tanks	63.64	177.60	546.12
Point Sources	0.00	0.00	0.00
TOTAL	2447.45	5320.69	13814.74

GOODFIELD CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	88.59	351.15	2824.96
Forest	6.04	60.39	166.07
Urban	21.41	49.80	241.53
Precipitation	31.41	40.72	213.48
Septic Tanks	1.68	6.30	37.80
Point Sources	0.00	0.00	0.00
TOTAL	149.13	508.36	3483.84

GOODFIELD CREEK WATERSHED			
Loading (kg/yr)	Low	Middle	High
Agriculture	804.04	2417.85	9546.98
Forest	1026.63	1328.58	1872.09
Urban	77.69	249.00	744.51
Precipitation	517.71	930.72	1442.62
Septic Tanks	18.06	50.40	154.98
Point Sources	0.00	0.00	0.00
TOTAL	2444.13	4976.55	13761.17

Table 15 (continued)

Phosphorus Loading Estimates - By Category

Loading (kg/yr)	GUNSTOCKER CREEK WATERSHED		
	Low	Middle	High
Agriculture	108.83	444.14	3620.71
Forest	3.36	33.64	92.51
Urban	5.24	12.19	59.12
Precipitation	77.59	100.58	527.34
Septic Tanks	6.96	26.10	156.60
Point Sources	0.00	0.00	0.00
TOTAL	201.99	616.65	4456.29

Nitrogen Loading Estimates - By Category

Loading (kg/yr)	GUNSTOCKER CREEK WATERSHED		
	Low	Middle	High
Agriculture	977.28	2911.29	11832.69
Forest	571.88	740.08	1042.84
Urban	19.02	60.95	182.24
Precipitation	1278.84	2299.04	3563.51
Septic Tanks	74.82	208.80	642.06
Point Sources	0.00	0.00	0.00
TOTAL	2921.83	6220.16	17263.34

Loading (kg/yr)	AGENCY CREEK WATERSHED		
	Low	Middle	High
Agriculture	67.51	267.58	2152.59
Forest	4.70	46.99	129.23
Urban	18.89	43.93	213.06
Precipitation	65.57	84.99	445.61
Septic Tanks	10.72	40.20	241.20
Point Sources	0.00	0.00	0.00
TOTAL	167.39	483.70	3181.69

Loading (kg/yr)	AGENCY CREEK WATERSHED		
	Low	Middle	High
Agriculture	612.75	1842.65	7275.30
Forest	798.86	1033.82	1456.75
Urban	68.53	219.65	656.75
Precipitation	1080.64	1942.72	3011.22
Septic Tanks	115.24	321.60	988.92
Point Sources	0.00	0.00	0.00
TOTAL	2676.02	5360.44	13388.94

Loading (kg/yr)	CANDIES CREEK WATERSHED		
	Low	Middle	High
Agriculture	186.14	514.55	3304.36
Forest	13.76	137.63	378.48
Urban	20.19	46.96	227.76
Precipitation	122.77	159.14	834.37
Septic Tanks	9.92	37.20	223.20
Point Sources	315.03	551.30	1181.35
TOTAL(See footnote)	668.04	1447.18	6150.37

Loading (kg/yr)	CANDIES CREEK WATERSHED		
	Low	Middle	High
Agriculture	1872.80	6112.99	18231.73
Forest	2339.68	3027.82	4266.47
Urban	73.26	234.80	702.05
Precipitation	2023.41	3637.60	5638.28
Septic Tanks	106.64	297.60	915.12
Point Sources	787.57	1575.14	3937.85
TOTAL(See footnote)	7203.36	14886.08	33691.50

Loading (kg/yr)	ROGERS CREEK WATERSHED		
	Low	Middle	High
Agriculture	85.59	296.44	2224.64
Forest	11.50	115.03	316.33
Urban	3.38	7.85	38.07
Precipitation	98.22	127.32	667.54
Septic Tanks	4.00	15.00	90.00
Point Sources	0.00	0.00	0.00
TOTAL(See footnote)	202.69	561.64	3336.59

Loading (kg/yr)	ROGERS CREEK WATERSHED		
	Low	Middle	High
Agriculture	812.00	2534.10	8873.25
Forest	1955.51	2530.66	3565.93
Urban	12.25	39.25	117.36
Precipitation	1618.82	2910.24	4510.87
Septic Tanks	43.00	120.00	369.00
Point Sources	0.00	0.00	0.00
TOTAL(See footnote)	4441.58	8134.25	17436.41

Table 15 (continued)

Phosphorus Loading Estimates - By Category

Loading (kg/yr)	Low	Middle	NORTH MOUSE CREEK WATERSHED High
Agriculture	146.96	358.54	2046.68
Forest	9.84	98.41	270.63
Urban	65.76	152.92	741.66
Precipitation	35.80	46.41	243.32
Septic Tanks	0.00	0.00	0.00
Point Sources	2138.87	3743.03	8020.77
TOTAL	2397.23	4399.30	11323.06

Nitrogen Loading Estimates - By Category

Loading (kg/yr)	Low	Middle	High
Agriculture	1517.76	5046.83	14003.49
Forest	1672.99	2165.04	3050.74
Urban	238.56	764.60	2286.15
Precipitation	590.07	1060.80	1644.24
Septic Tanks	0.00	0.00	0.00
Point Sources	5347.18	10694.36	26735.89
TOTAL	9366.55	19731.63	47720.52

Loading (kg/yr)	Low	Middle	SOUTH MOUSE CREEK WATERSHED High
Agriculture	48.13	151.53	1072.27
Forest	4.46	44.57	122.55
Urban	172.39	400.90	1944.37
Precipitation	25.90	33.58	176.05
Septic Tanks	0.00	0.00	0.00
Point Sources	110.54	193.44	414.51
TOTAL(See footnote)	361.41	824.01	3729.75

Loading (kg/yr)	Low	Middle	High
Agriculture	469.00	1494.90	4865.03
Forest	757.60	980.43	1381.52
Urban	625.40	2004.50	5993.46
Precipitation	426.93	767.52	1189.66
Septic Tanks	0.00	0.00	0.00
Point Sources	276.34	552.68	1381.70
TOTAL(See footnote)	2555.28	5800.03	14811.35

Footnote: Estimated total annual nutrient loadings in these watersheds (Candies Creek, Rogers Creek, and South Mouse Creek) are likely low, see discussion in text.

Figure 29

**Estimated Annual Phosphorus Loadings
Chickamauga Reservoir Embayments**

Chickamauga Reservoir Embayment Study

Figure 30
Estimated Annual Nitrogen Loadings
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

embayment (4400 kg/yr) is approximately double the phosphorus load to any other of the Chickamauga reservoir embayments. The Niota sewage treatment plant discharges 0.35 mgd into Little North Mouse Creek mile 4.1 (table 14). Total nitrogen to total phosphorus ratios of the estimated nutrient loads to the embayment is approximately 4.5, indicative of the excess phosphorus loadings. North Mouse Creek embayment should be considered as candidate for implementation of best management practices to diminish and control the large phosphorus loads. Particular attention should be given to the installation of phosphorus removal technologies/equipment at the sewage treatment plant.

Phosphorus Loading Rate Models

Several authors have proposed empirical "black box" models to predict in-lake phosphorus concentrations based on a lake's phosphorus loading and a few simple physical attributes (e.g. mean depth, mean detention time, etc.) of the lake. If phosphorus loading rate models are applicable to some or all of the Chickamauga reservoir embayments, they will be of help in testing various water quality management scenarios for their effects on improving embayment water quality and trophic status. The high TN/TP ratios for the Chickamauga reservoir embayments (table 5), and in most freshwater systems, are indicative that phosphorus is the critical (limiting) nutrient in controlling primary production in these embayments. Because of the limited manageability of the other two primary factors controlling primary production (i.e. light and temperature) man's ability to limit excessive eutrophication usually hinges on his ability to reduce and/or control phosphorus. There are several other practical reasons which favor the control of phosphorus in limiting excessive eutrophication: (1.) phosphorus primarily originates from allochthonous (external) sources, rather than sources within the water body; (2.) nitrogen, unlike phosphorus, can be transported and assimilated by algae and bacteria from the

atmosphere across the air-water interface, making it much more difficult to control; (3.) in culturally impacted water bodies, the proportion of the total phosphorus attributable to man is typically higher than for any other growth limiting nutrient (e.g. Candies Creek and North Mouse Creek embayments); (4.) phosphorus removal from waste water is technologically possible; and (5.) nonpoint phosphorus pollution may be restricted with best management land use practices.

Four empirical models are examined for their ability to predict embayment phosphorus concentrations (table 5) based on the estimated annual phosphorous loading to each embayment, L ($\text{g}/\text{m}^2\text{-yr}$), table 15, and influent phosphorus concentrations, L_r/z (mg/l), table 16. The four phosphorus loading rate models are: (1.) Vollenweider (1975 and 1976); (2.) Larsen-Mercier (1976); (3.) Walker (1977); and (4.) Reckhow (1988). We will limit our discussion to the application of these models to the Chickamauga reservoir embayments.⁶

The Vollenweider model examines in-lake phosphorus concentrations as a function of areal phosphorus loading (L) and areal water load (the mean depth:mean detention time ratio, z/r). The "middle" total annual estimated phosphorus loads (table 15) are plotted versus the areal water loads for each of the Chickamauga Reservoir embayments (figure 31). The $L_0 = 0.1$ and $L_0 = 0.3$ lines are Vollenweider's estimate of "permissible" and "dangerous" phosphorus loadings, and are used as guidelines for trophic status classification. The plotted embayments generally agree with the Trophic State Index (table 6) classifications (e.g. eutrophic, mesotrophic, and oligotrophic), although all of the embayments plotted somewhat lower (more oligotrophic) than expected, based on the TSI classifications in table 6.

⁶The reader who is interested in a review of the formulation and philosophy of these "black box" models and an examination of their empirical approaches is encouraged to refer to the original citations, above, and to a review report by Reckhow (1979).

Table 16

COMPARISON OF MEASURED VERSUS PREDICTED PHOSPHORUS CONCENTRATIONS
AVERAGE SUMMERTIME CONCENTRATIONS - CHICKAMAUGA RESERVOIR EMBAYMENTS

	+-----Estimated-----+			Measured Average Embayment Concentration (mg/L)	Predicted Average Embayment Concentration			
	Total	L,	LT/z,		Vollenweider	Larsen-	Walker	Reckhow
	Annual	Areal	Influent		(1975,1976)	Mercier	(1977)	(1988)
	-----Loading----- (kg/yr)	-----2----- (g/m ² -yr)	Concentration (mg/L)			(mg/L)		
WACONDA BAY EMBAYMENT				0.0183				
low estimate	85.32	0.1466	0.0232		0.0090	0.0148	0.0150	0.0155
middle estimate	195.54	0.3360	0.0531		0.0206	0.0339	0.0345	0.0297
high estimate	1025.53	1.7621	0.2784		0.1079	0.1779	0.1808	0.0946
WOLFTEVER CREEK (+Savannah Bay) EMBAYMENT				0.0233				
low estimate	959.22	0.2504	0.0069		0.0054	0.0057	0.0057	0.0063
middle estimate	2259.88	0.5900	0.0164		0.0128	0.0135	0.0135	0.0138
high estimate	11155.30	2.9126	0.0808		0.0632	0.0668	0.0665	0.0544
WOLFTEVER CREEK (-Savannah Bay) EMBAYMENT				0.0317				
low estimate	673.11	0.3018	0.0083		0.0065	0.0068	0.0068	0.0073
middle estimate	1442.24	0.6467	0.0179		0.0140	0.0146	0.0145	0.0145
high estimate	5867.40	2.6311	0.0727		0.0569	0.0593	0.0591	0.0476
SAVANNAH BAY EMBAYMENT				0.0417				
low estimate	309.43	0.1922	0.0054		0.0042	0.0045	0.0045	0.0050
middle estimate	885.60	0.5501	0.0153		0.0120	0.0130	0.0129	0.0135
high estimate	5777.22	3.5883	0.0999		0.0781	0.0846	0.0841	0.0701
DALLAS BAY EMBAYMENT				0.0113				
low estimate	272.47	0.0813	0.0192		0.0057	0.0112	0.0115	0.0125
middle estimate	527.75	0.1575	0.0371		0.0111	0.0216	0.0222	0.0210
high estimate	2875.49	0.8584	0.2021		0.0602	0.1178	0.1210	0.0688
SODDY CREEK EMBAYMENT				0.0079				
low estimate	297.68	0.1075	0.0032		0.0024	0.0025	0.0025	0.0028
middle estimate	750.90	0.2711	0.0080		0.0062	0.0063	0.0062	0.0066
high estimate	3980.09	1.4369	0.0423		0.0327	0.0332	0.0331	0.0275
POSSUM CREEK EMBAYMENT				0.0060				
low estimate	207.61	0.0970	0.0043		0.0030	0.0034	0.0033	0.0039
middle estimate	493.70	0.2307	0.0102		0.0071	0.0080	0.0080	0.0086
high estimate	2592.49	1.2114	0.0538		0.0372	0.0418	0.0418	0.0357

Table 16 (continued)

COMPARISON OF MEASURED VERSUS PREDICTED PHOSPHORUS CONCENTRATIONS
AVERAGE SUMMERTIME CONCENTRATIONS - CHICKAMAUGA RESERVOIR EMBAYMENTS

	+-----Estimated-----+			Measured Average Embayment Concentration (mg/L)	Predicted Average Embayment Concentration			
	Total	L,	LT/z,		Larsen-			
	Annual	Areal	Influent		Vollenweider	Mercier	Walker	Reckhow
	-----Loading----- (kg/yr)	----- (g/m ² -yr)	Concentration (mg/L)		(1975,1976)	(1976)	(1977)	(1988)
<hr/>								
SALE CREEK EMBAYMENT				0.0102				
low estimate	457.82	0.1715	0.0028		0.0024	0.0024	0.0023	0.0026
middle estimate	1193.84	0.4471	0.0072		0.0062	0.0061	0.0061	0.0065
high estimate	6320.08	2.3671	0.0382		0.0329	0.0325	0.0323	0.0289
RICHLAND CREEK EMBAYMENT				0.0241				
low estimate	562.37	0.4359	0.0049		0.0044	0.0044	0.0043	0.0047
middle estimate	1623.81	1.2588	0.0140		0.0126	0.0126	0.0125	0.0129
high estimate	9521.57	7.3811	0.0822		0.0740	0.0739	0.0733	0.0642
MUD CREEK EMBAYMENT				0.0250				
low estimate	192.98	0.1199	0.0177		0.0071	0.0130	0.0130	0.0148
middle estimate	499.39	0.3102	0.0458		0.0185	0.0335	0.0337	0.0341
high estimate	3422.65	2.1259	0.3136		0.1267	0.2298	0.2307	0.1561
GOODFIELD CREEK EMBAYMENT				0.0300				
low estimate	149.13	0.2562	0.0042		0.0036	0.0037	0.0037	0.0040
middle estimate	508.36	0.8735	0.0143		0.0123	0.0125	0.0125	0.0129
high estimate	3483.84	5.9860	0.0979		0.0841	0.0859	0.0853	0.0720
GUNSTOCKER CREEK EMBAYMENT				0.0400				
low estimate	201.99	0.1403	0.0072		0.0047	0.0057	0.0057	0.0065
middle estimate	616.65	0.4282	0.0219		0.0145	0.0175	0.0174	0.0179
high estimate	4456.29	3.0946	0.1582		0.1047	0.1262	0.1259	0.0935
AGENCY CREEK EMBAYMENT				0.0300				
low estimate	167.39	0.1383	0.0062		0.0043	0.0050	0.0050	0.0057
middle estimate	483.70	0.3998	0.0179		0.0124	0.0146	0.0145	0.0153
high estimate	3181.69	2.6295	0.1180		0.0815	0.0959	0.0956	0.0768
CANDIES CREEK EMBAYMENT (See footnote)				0.0417				
low estimate	668.04	0.2943	0.0042		0.0037	0.0037	0.0037	0.0040
middle estimate	1447.18	0.6375	0.0091		0.0079	0.0081	0.0080	0.0085
high estimate	6150.37	2.7094	0.0385		0.0337	0.0342	0.0340	0.0326

Table 16 (continued)

COMPARISON OF MEASURED VERSUS PREDICTED PHOSPHORUS CONCENTRATIONS
AVERAGE SUMMERTIME CONCENTRATIONS - CHICKAMAUGA RESERVOIR EMBAYMENTS

	+-----Estimated-----+			Measured Average Embayment Concentration (mg/L)	Predicted Average Embayment Concentration			
	Total Annual -----Loading----- (kg/yr)	L, Areal (g/m ² -yr)	LT/z, Influent Concentration (mg/L)		Vollenweider (1975,1976)	Larsen- Mercier (1976)	Walker (1977)	Reckhow (1988)
					(mg/L)			
ROGERS CREEK EMBAYMENT (See footnote)				0.0400				
low estimate	202.69	0.1114	0.0025		0.0021	0.0022	0.0022	0.0025
middle estimate	561.64	0.3086	0.0070		0.0057	0.0061	0.0060	0.0066
high estimate	3336.59	1.8333	0.0418		0.0340	0.0361	0.0358	0.0341
NORTH MOUSE CREEK EMBAYMENT				0.0467				
low estimate	2398.78	3.6181	0.0175		0.0167	0.0167	0.0165	0.0170
middle estimate	4402.01	6.6395	0.0322		0.0307	0.0306	0.0303	0.0306
high estimate	11328.87	17.0873	0.0828		0.0790	0.0786	0.0781	0.0746
SOUTH MOUSE CREEK EMBAYMENT (See footnote)				0.1200				
low estimate	361.49	0.7531	0.0063		0.0058	0.0058	0.0058	0.0062
middle estimate	824.15	1.7170	0.0144		0.0133	0.0133	0.0132	0.0137
high estimate	3730.05	7.7709	0.0650		0.0600	0.0601	0.0596	0.0562

Footnote: Estimated total annual phosphorus loadings and influent phosphorus concentrations to these embayments (Candies Creek, Rogers Creek, and South Mouse Creek) and the resultant predicted average embayment summertime concentrations are likely low, see discussion in text.

Figure 31
Vollenweider's Phosphorus Loading Criteria Applied
To the Chickamauga Reservoir Embayments

The "up-arrows" above Candies, Rogers, and South Mouse embayments indicate that the estimated phosphorus loadings to these embayments are probably low (see discussion, below).

Mathematically Vollenweider's model is expressed as:

$$P, \text{ mg/l} = \frac{L}{z (1/\tau + \sigma)}$$

where: P = in-lake phosphorus concentration, mg/l;

L = annual areal phosphorus loading, g/m²-yr
(phosphorus loading/surface area of lake);

z = mean depth of lake, m;

τ = mean detention time, years; and

σ = sedimentation coefficient, years⁻¹
($\sigma \approx 10/z$).

The Larsen-Mercier model examines in-lake phosphorus concentrations as a function of influent phosphorus concentration ($L\tau/z$) and the fraction of influent phosphorus retained in the lake (R_p). The "middle" estimated phosphorus influent phosphorus concentrations (table 16) are plotted versus the phosphorus retention coefficient for each of the Chickamauga Reservoir embayments (figure 32). The lines in figure 32 are estimates of influent phosphorus loadings to be used as guidelines for trophic status classification. As with the Vollenweider plots, the embayments plotted using the Larsen-Mercier criteria also generally fit the Trophic State Index (table 6) classifications (e.g. eutrophic, mesotrophic, and oligotrophic). However, the Larsen-Mercier classifications are in better agreement with the TSI classifications, although they are still slightly lower (more oligotrophic) than expected, based on the TSI values in table 6.

Figure 32
Larsen-Mercier Phosphorus Loading Criteria Applied
To the Chickamauga Reservoir Embayments

Mathematically the Larsen-Mercier model is expressed as:

$$P, \text{ mg/l} = \frac{L\tau}{z} (1-R_p)$$

where: R_p = phosphorus retention coefficient, and

$$R_p = \frac{1}{1 + 1.12(1/\tau)^{0.49}}$$

$L\tau/z$ = influent phosphorus concentration, mg/l;

τ = mean detention time, years.

The Walker model examines in-lake phosphorus concentrations as a function of influent phosphorus concentration ($L\tau/z$) and the mean detention time of the lake (τ). Mathematically, it is expressed as:

$$P, \text{ mg/l} = \frac{L\tau}{z} \left(\frac{1}{1 + 0.824\tau^{0.454}} \right)$$

where: $L\tau/z$ = influent phosphorus concentration, mg/l;

τ = mean detention time, years.

While the above three general models were developed from data primarily on north temperate lakes, the Reckhow model examines in-lake phosphorus concentrations based on data collected in 70 southeastern lakes and reservoirs, using influent phosphorus concentration, detention time, and an empirically derived parameter termed the phosphorus trapping parameter. Mathematically, it is expressed as:

$$\log (P, \text{ mg/l}) = \log \left(\frac{L\tau/z}{1 + k\tau} \right)$$

where: $L\tau/z$ = influent phosphorus concentration, mg/l;

τ = mean detention time, years; and

k = phosphorus trapping parameter, years⁻¹, and

$$k = 3.0 \left(\frac{L\tau}{z} \right)^{0.53} (\tau)^{-0.75} (z)^{0.58}$$

For each of the Chickamauga reservoir embayments, the low, middle, and high phosphorus loading estimates, table 15, were used to estimate low, middle, and high areal phosphorus loading, L ($\text{g}/\text{m}^2\text{-yr}$) and influent phosphorus concentrations, L/z (mg/l), table 16. These low, middle, and high estimates are used as input criterion for these four empirical phosphorus loading models. Using these estimates, low, middle, and high average embayment summertime phosphorus concentrations were predicted. These low, middle, and high phosphorus predictions were then compared with actual measured average summertime phosphorus concentrations (table 16).⁷ With the exception of Candies Creek, South Mouse Creek and Rogers Creek embayments (which are discussed below), the measured phosphorus concentrations fell within the range of the predicted phosphorus concentrations.

Table 16 shows that the predictions of all four models are quite similar; however, the Vollenweider model generally predicted slightly lower phosphorus concentrations than did the other three models. The middle estimate predictions of the Vollenweider model were approximately 15% lower than the predictions of the other three models. The Reckhow model gave the smallest range of predicted phosphorus concentrations (high estimate prediction - low estimate prediction). The range of the predicted phosphorus concentrations of the Reckhow model were approximately 25% less than the range of the other models. A comparison of the four empirical models (table 17), shows that the Chickamauga reservoir embayment data base (tables 1 and 5,

⁷If actual instream, influent phosphorus concentrations had been available or measured, these data would have been used as input to the models (e.g. L/z) instead of the estimates of the low, middle, and high influent phosphorus concentrations based on land use estimates. If such had been the case, the predicted embayment phosphorus concentrations, from each of the models, could have been compared directly with the measured embayment phosphorus concentrations. It is highly recommended that future embayment studies use measured influent phosphorus concentrations or loadings rather than estimates based on land use and point source discharges.

and table 16) best meets the constraints of the Walker and Reckhow models. Because the Reckhow model was developed from a data base of 70 U.S. southeastern lakes and reservoirs which were more tightly defined and more similar to the Chickamauga Reservoir embayments (geography, climate, size, depth, trophic state, etc.) than the larger Walker data base of 105 north temperate lakes, (or the more oligotrophic north temperate lakes of the Vollenweider and Larsen-Mercier models); and because the Reckhow model has generally smaller ranges of predicted phosphorus concentrations than the other models, the Reckhow model appears to be the most appropriate model of the four examined for estimating Chickamauga Reservoir embayment summertime phosphorus concentrations based on estimated phosphorous loadings. Only two embayments, North and South Mouse Creeks, because of their short detention times of 0.003 and 0.008 years (1 and 3 days), respectively, fall outside the bounds of the Reckhow data base. Consequently, when the Reckhow model is applied to the North and South Mouse Creek embayments (and all embayments with detention times less than 5-10 days), it must be used with caution and some reservation.

As mentioned above, examination of table 16, reveals that the predicted ranges of embayment summertime phosphorus concentrations for Candies Creek, South Mouse Creek and Rogers Creek embayments fall below the observed, measured average summertime phosphorus concentrations. It is suggested that this discrepancy is a result of under estimation of influent nutrient loadings to these two embayments rather than a weakness or shortcoming of the models, (particularly since all four models similarly under estimate the measured embayment phosphorus concentrations in Candies Creek, South Mouse Creek and Rogers embayments).

South Mouse Creek Embayment - Until recently, the Cleveland Sewage Treatment Plant (STP) discharged over 5 mgd of wastewater into South Mouse Creek at mile 9.6. This large wasteload is not

Table 17
Comparison of Phosphorus Loading Models (After Reckhow, 1979)

Model	Data Base	Significant Constraints	Comments
Vollenweider	unspecified	unknown	Underestimate phosphorus in highly enriched lakes
Larsen-Mercier	20 north temperate lakes, primarily oligotrophic	$P < 0.012 \text{ mg/l}$ $L\tau/z < 0.025 \text{ mg/l}$	Underestimate phosphorus in lakes with $L\tau/z > 0.300 \text{ mg/l}$
Walker	105 north temperate lakes	$P < 0.9 \text{ mg/l}$ $L\tau/z < 1.0 \text{ mg/l}$	None
Reckhow	70 southeastern US lakes and reservoirs	$z: 1.5-41.3 \text{ m}$ $\tau: 0.015-3.2 \text{ yr}$ $z/\tau: 2.26-605 \text{ m/yr}$ $L\tau/z: 0.015-0.411 \text{ mg/l}$ $P: 0.005-0.133 \text{ mg/l}$	None

Where: z = mean depth, meters;
 τ = mean detention time, years;
 z/τ = areal loading (overflow rate) meters/year;
 $L\tau/z$ = Influent phosphorus concentration, mg/l; and
 P = in-lake summertime phosphorous concentration, mg/l.

included in the point source loading estimates given in tables 15 and 16. (Tables 14, 15, and 16 include only those wasteloads existing during 1990). In February 1988, Cleveland's STP was upgraded and the discharge was moved to Hiwassee River mile 15.5. Prior to this time, the Cleveland STP had a history of frequent bypasses caused by rainfall/runoff infiltration and inflow which severely impacted the water quality of South Mouse Creek (Cox, 1989). However, the high concentrations of phosphorus observed in the South Mouse Creek embayment (table 5) during the summer of 1990, indicate that South Mouse Creek and embayment are still being impacted by urban storm water runoff and/or washout of previously deposited nutrients from the South Mouse streambed and embayment sediment. For example, the two highest phosphorous concentrations, 0.16 mg/l and 0.27 mg/l, of the six monthly samples collected in South Mouse Creek embayment were collected during periods of rainfall, 2.73" on May 10, 1990 and 0.80" on July 10-11, 1990, respectively. (These two rain event samples also had the highest organic nitrogen concentrations of the six samples collected in South Mouse Creek embayment.) Because of the past history of storm sewer overflows, very heavy nutrient loadings, and the high measured summertime nutrient (and fecal coliform) concentrations observed in South Mouse Creek embayment (table 5), it is apparent there is an appreciable loading to South Mouse Creek embayment that is not attributable solely to land use (table 12) and is not accounted for in the nutrient loading estimates given in table 15. Based solely on the high nutrient concentrations measured in South Mouse Creek embayment (table 5), it can be estimated that additional nutrient loads, not shown in table 15, are attributable to internal processes in the South Mouse Creek system (viz. storm sewer overflow and recycling/washout of nutrients from stream bed and embayment sediment), particularly after periods of rainfall and high stream velocities. These internal processes are thought to be at least as large or larger than the nutrient loads attributable to the existing land uses and point sources (table 15). Using the

Reckhow phosphorus loading model, one can estimate the contribution of the additional phosphorus loading to South Mouse Creek embayment, by increasing total estimated loadings until predicted concentrations approximate measured concentrations. For example, increasing the estimated influent phosphorus loads to South Mouse Creek embayment (table 16) by 250%, from 361-3730 kg/yr (low-high estimate) to 904-9325 kg/yr (low-high estimate), yielded a predicted range of embayment phosphorus concentrations of 0.015-0.127 mg/l, compared with the average measured summertime South Mouse Creek embayment phosphorus concentration of 0.120 mg/l. The difference between the original estimated phosphorus loadings, based on current land use and existing point sources (361-3730 kg/yr), and the estimated increased loadings (904-9325 kg/yr), is an approximation of the internal loadings in the South Mouse Creek stream/embayment system. These internal loadings are 543-5595 kg/yr, or about one and one-half times greater than the current land use and existing point source loadings. Given the short mean detention time of South Mouse Creek embayment (3 days), these large internal phosphorus loads are expected to decrease as urban storm water runoff problems are corrected and the internal bedload reserve of phosphorus is washed out of the stream/embayment system and/or taken up during primary production, ultimately being carried out of the South Mouse Creek embayment and into the Hiwassee River. As a result, in time, measured concentrations of nutrients in South Mouse Creek are expected to diminish until an equilibrium is reached at which time measured phosphorus concentrations will more closely agree with the predicted concentrations, (based on the now existing land uses and point sources in the South Mouse watershed).

Candies Creek Embayment - Until just six months before sampling activities began for the Chickamauga Embayment Study the Candies Creek Sanitation District operated a 0.5 mgd sewage treatment plant (STP) which had a history of serious problems with effluent quality, (Cox, 1989). The STP which discharged to

Candies Creek at mile 17.5, was connected to the Cleveland STP in October 1989, (Murphy, 1992). After only a six month respite, the wasteload legacy of the Candies Creek STP on Candies Creek embayment was still evident based on 1990 water quality data (table 5). Although the STP wasteloads to Candies Creek have stopped, impacts were still observable. Total nitrogen and total phosphorus concentrations in Candies Creek embayment were high, averaging 0.47 mg/l and 0.042 mg/l, respectively, the third highest among the thirty monitoring locations (table 5). (Also, fecal coliform concentrations in Candies Creek embayment averaged over 700 organisms/100 ml, higher than any other of the Chickamauga Embayment Study monitoring locations.) Like South Mouse Creek, samples collected during rainfall, on May 10, 1990 and July 11, 1990, had the highest concentrations of any samples collected in Candies Creek embayment for total phosphorus and organic nitrogen. Non-point source effects, particularly urban storm water runoff, are suspect. These high concentrations may also be indicative of nutrient loads attributable to internal recycling/washout processes in South Mouse Creek stream bed and South Mouse Creek embayment sediment. If an assumption is made that the 0.5 mgd STP wasteload to Candies Creek did not end, and it is added to the existing estimated nutrient loads in Candies Creek watershed (table 15), the total annual phosphorus load would be estimated to be 3433 kg/yr-16520 kg/yr (low-high estimate). Using these loadings, which include the 0.5 mgd STP waste discharge, as input to the Reckhow model results in predicted average summertime phosphorus concentrations in Candies Creek embayment of 0.019 - 0.078 mg/l, compared with the average measured summertime embayment phosphorus concentration of 0.042 mg/l. Obviously the streambed channel/embayment system has only just begun to recover after the diversion of the 0.5 mgd wasteload. It is anticipated that over a period of a few years, internal loading to the embayment from the streambed will decrease and equilibrium conditions will be reached. At this time, predicted embayment nutrient concentrations will more

closely match measured concentrations.

Rogers Creek Embayment -The other embayment in which measured phosphorus concentrations were greater than predicted concentrations was Rogers Creek embayment (table 16). Table 15 shows that two-thirds of the total loadings in Rogers Creek Watershed are attributable to agricultural sources, however not included in these estimates are non-point source loadings attributable to intensive livestock operations (land use classifications for livestock operations cannot be identified using SPOT imagery). Animal waste has been identified as a serious nonpoint source problem by the Soil Conservation Service in McMinn County and particularly in Rogers Creek watershed. McMinn County is the largest Grade A dairy county in Tennessee with about 105 dairies. It also has about 100 chicken broiler houses, of which 50-60 store litter in open piles, (Cox, 1989). Many of the dairies keep cattle semi-confined, and only about 40 are considered to have adequate animal waste management facilities, (Cox 1989). The excessive loading to Rogers Creek is also exacerbated by allowing cattle to water directly in the stream. Increasing estimated phosphorus loadings to Rogers Creek by approximately 50% (to estimate additional animal waste loadings) from 203-3337 kg/yr to 305-5006 kg/yr results in predicted embayment phosphorus concentrations of 0.004-0.049 mg/l, which concurs with the measured embayment phosphorus concentration of 0.040 mg/l.

A primary advantage of using phosphorus loading models is the testing of various water quality management scenarios and assessing the predicted results. For example, it was earlier suggested that phosphorus loading be decreased to North Mouse Creek embayment by the application of improved treatment technologies to the point source discharges, which account for approximately 85% of the total phosphorus load to the North Mouse Creek embayment. Using the middle phosphorus loading estimates for North Mouse Creek embayment (table 15) as input to the Reckhow model, one can predict the resulting embayment phosphorus

concentration if these phosphorus loads are reduced. A 50% reduction of the estimated "point source" phosphorus loads/discharges in the North Mouse Creek watershed (table 15) will result in a predicted decrease in average embayment summertime phosphorus concentration from 0.031 mg/l to 0.018 mg/l, for the embayment. Based on phosphorus concentrations, this decrease would theoretically result in a reclassification of the trophic status from eutrophic to mesotrophic for North Mouse Creek embayment.

AQUATIC BIOLOGY - PHYSICAL/CHEMICAL INTER-RELATIONSHIPS

Introduction

The intent of the following discussion is to examine biotic/abiotic relationships and inter-relationships between various aquatic biological parameters (phytoplankton, benthic organisms, aquatic macrophytes, and fish populations) and physical/chemical/environmental parameters (morphometry, water quality, sediment quality, sedimentation rates, land use classifications, pesticide application rates, etc.). Correlation and multiple regression techniques (SAS, 1989b) were employed to determine which physio-chemical variables or factors were best able to predict the various aquatic biological parameters. However, statistical significance should not necessarily imply cause-effect relationships, especially when there is a large number of intercorrelated independent variables. Raw data for each of the aquatic biological parameters is presented with limited discussion and interpretations. The reader is encouraged to review the individual reports for a more detailed interpretation and discussion of the phytoplankton (Baker and Poppe, 1992) benthic (Lakin and Poppe, 1992), fish community (Hevel and Hickman, 1992), fish health (Brown, 1991), and aquatic macrophyte (Burns, et.al., 1990) data.

Algae

Materials and Methods - Phycological sampling was conducted biweekly from April through September at the locations shown in table 3. All samples were collected over the original river or tributary channel using a low volume 12 volt peristaltic pump with attached hose. A single one-liter sample was collected from a 1-meter depth at each station for phytoplankton enumeration and phytopigment (chlorophyll-a) concentrations. Samples were placed in the dark and on ice until laboratory processing. Algal and

chlorophyll-a samples were processed and analyzed as specified in TVA QA/QC procedures (TVA 1987, 1989). Chlorophyll-a results were discussed in the Water Quality section - Nutrients and Biochemical Measurements. Phytoplankton enumeration samples were agitated and a 5 ml or 10 ml aliquot was poured into a counting chamber and allowed to settle. Algal cells were enumerated at the generic level by counting every cell within a 40x field for one pass across the chamber. Conversion factors of 10191 or 5096 were used to obtain cells per liter estimates of cell density for the 5 and 10 ml aliquots, respectively.

Results and Discussion - Algal data tabulations are presented in Appendix F and are summarized in Table 18. Total algal populations were lowest in the spring (April) and greatest in the late summer (September). During the sampling period (April-September) most embayments were dominated by Cyanobacteria (blue-greens) which accounted for 50-70% of the total algal population. Chlorophyta (greens algae) and Chrysophyta (diatoms) each accounted for 15-25% of the total population. Cryptophyta, Euglenophyta, and Pyrrophyta populations together, usually made up less than 10% of the total algae population. Figures 33a-33e present the biweekly algal distributions at each of the 30 Chickamauga Embayment Study sampling locations from April through September and show seasonal patterns of the algal abundance. The successional sequence of algal abundance was similar to patterns observed in previous studies, as described by Harris (1986). Seasonal Chrysophyte (diatom) populations are generally greatest in the spring (April) and lowest in the summer months when Cyanobacteria (blue-green) populations dominated. Had algal samples been collected in the autumn (October), diatom populations would likely have show a resurgence along with a die off of the blue-greens (Daley et. al., 1981). During the April-September sampling period, total algal density generally

Table 18
PHYTOPLANKTON ENUMERATION/DISTRIBUTION SUMMARY
CHICKAMAUGA EMBAYMENT STUDY (APRIL-SEPTEMBER, 1990)

LOCATION	AVERAGE +-----AVERAGE OF BIWEEKLY ALGAL DISTRIBUTIONS-----+					
	NUMBER CELLS/LITER	CHLOROPHYTA %	CHRYSOPHYTA %	CYANOBACTERIA %	CRYPTOPHYTA %	OTHER %
TENNESSEE RIVER						
TENNESSEE RIVER MILE 472.3	13434795	18.7	19.0	55.3	6.0	1.0
TENNESSEE RIVER MILE 478.2	13756831	21.5	22.2	50.1	5.5	0.7
TENNESSEE RIVER MILE 490.5	12128309	20.8	18.6	55.1	4.7	0.9
TENNESSEE RIVER MILE 496.5	8887478	18.6	19.2	56.2	5.1	0.9
TENNESSEE RIVER MILE 506.6	3865446	22.6	16.6	55.8	4.7	0.3
TENNESSEE RIVER MILE 518.0	7146498	18.0	15.8	61.6	4.2	0.4
TENNESSEE RIVER MILE 529.9	9410847	17.3	19.3	58.4	4.3	0.8
HIWASSEE RIVER						
HIWASSEE RIVER MILE 7.4	11422764	21.5	15.1	56.8	5.7	0.8
HIWASSEE RIVER MILE 13.4	2232755	34.2	21.7	32.7	10.0	1.3
HIWASSEE RIVER MILE 20.0	2035158	36.0	22.2	33.6	7.7	0.5
EMBAYMENT LOCATIONS						
WACONDA BAY MILE 0.95	21778799	14.0	19.5	62.2	2.9	1.3
WOLFTEVER CREEK MILE 4.2	29351099	16.1	13.9	67.1	2.0	0.9
WOLFTEVER CREEK MILE 5.65	38485292	15.3	11.6	69.7	2.4	0.9
SAVANNAH BAY MILE 2.95	42750226	13.5	17.2	65.7	2.9	0.7
DALLAS BAY MILE 0.9	22016636	16.2	17.7	62.1	3.2	0.8
SODDY CREEK MILE 1.7	12778495	20.6	18.1	55.9	4.7	0.6
SODDY CREEK MILE 4.0	12586925	23.3	21.3	51.0	3.7	0.6
POSSUM CREEK MILE 2.0	9825143	21.5	22.2	52.6	3.3	0.4
SALE CREEK MILE 1.3	17253363	16.7	19.7	60.0	2.9	0.7
SALE CREEK MILE 2.0	15129003	16.6	20.4	59.0	3.5	0.6
RICHLAND CREEK MILE 0.5	36431664	17.3	11.0	68.0	3.2	0.5
RICHLAND CREEK MILE 2.8	44474543	22.7	11.4	63.4	1.9	0.7
MUD CREEK MILE 1.3	41268918	13.6	11.9	71.2	2.3	1.0
GOODFIELD CREEK MILE 0.9	29616065	20.2	10.6	65.5	2.7	1.0
GUNSTOCKER CREEK MILE 0.85	26041711	17.5	17.4	60.1	3.6	1.4
AGENCY CREEK MILE 0.65	19995946	16.8	11.3	66.4	4.1	1.4
CANDIES CREEK MILE 1.5	15681709	19.5	13.2	61.8	4.3	1.2
ROGERS CREEK MILE 1.5	17542417	20.4	16.4	56.9	5.2	1.1
NORTH MOUSE CREEK MILE 0.5	6283215	34.5	19.6	36.5	8.5	1.0
SOUTH MOUSE CREEK MILE 1.1	11497293	25.5	36.0	31.5	5.6	1.4

Figure 33a

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

Figure 33b

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

TRM 529.9

WACONDA BAY 0.95

DALLAS BAY 0.9

HRM 7.4

HRM 13.4

HRM 20.0

Figure 33c

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA FMBAYMENT STUDY

Figure 33d

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

SALE CREEK 1.3

SALE CREEK 2.0

RICHLAND CREEK 0.5

RICHLAND CREEK 2.8

MUD CREEK 1.3

GOODFIELD CREEK 0.9

Figure 33e

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMRAYMENT STUDY

GUNSTOCKER CREEK 0.85

AGENCY CREEK 0.65

CANDIES CREEK 1.5

ROGERS CREEK 1.5

SOUTH MOUSE CREEK 1.1

NORTH MOUSE CREEK 0.5

increased as the summer progressed, due primarily to the increase in the blue-green algae populations, with intermittent periods of bloom (June and late-August) and die off (July), Appendix F.

The predominant algal taxa at all but four of the thirty sampling locations was cyanobacteria (blue-greens), with Mud Creek embayment having the greatest average percent of blue-green algae, greater than 70% (table 18, figure 34). Blue-green algae are considered a nuisance because, being mostly filamentous, they can form large, unsightly, floating mats. In high densities they can emit foul odors, crowd out less harmful algal populations, release toxins, and seriously deplete oxygen levels as their large colonies decompose. They can assimilate nitrogen from the atmosphere and are thus not usually limited by available water column nitrogen concentrations. In addition, they can regulate their buoyancy and position themselves vertically in the water column to find atmospheric nitrogen (and light). These factors allow blue-green algae to out compete other algae under limiting nutrient conditions, and dominate phytoplankton populations. Figure 34 illustrates the average summertime percent blue-green populations in each of the Chickamauga Reservoir embayments. Comparison of figures 34 and 35 shows that those embayments with the greatest algal populations are also likely to have the highest percent blue-green populations.

Multiple regression models were developed relating the average of the summer biweekly percentages (arc sine square root transformed) of the two dominant algal species (chlorophyta and cyanobacteria), table 18, to physical/chemical characteristics of the embayments, tables 1 and 5. The best models were:

Arc Sine[Square Root (%Chlorophyta)] =

$4.22 - 1.21[\text{Ln}(\text{Temperature, } ^\circ\text{C @1-m})] + 0.03(\text{Mean Depth, meters})$

where: $R^2 = 0.58$; $F = 11.8$; $\text{Prob}>F = 0.001$; $n = 20$; and,

Arc Sine[Square Root (%Cyanobacteria)] =

$-5.94 + 2.21[\text{Ln}(\text{Temperature, } ^\circ\text{C @1-m})] - 0.08(\text{Mean Depth, meters})$

where: $R^2 = 0.57$; $F = 11.5$; $\text{Prob}>F = 0.001$; $n = 20$.

Figure 34

Blue-Green Algae - Average Biweekly Percent
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 35
Total Algal Populations
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

These models suggests that deep embayments with cold temperatures had greater percent populations of chlorophyta (greens) than did shallow, warm embayments, which were more likely to be dominated by cyanobacteria (blue-greens).

Principal components analysis of algal percent composition (arcsine square root transformation) was performed using unstandardized data. The first component (PC1) explained 92.4% of the variance. Correlation coefficients between relative abundance of taxonomic groups and the first component were:

Algal Group	----- PC1 -----	
	Correlation	Prob>F
Chlorophyta	0.923	<0.0001
Chrysophyta	0.951	<0.0001
Cryptophyta	0.789	<0.0001
Cyanobacteria	-0.998	<0.0001

PC1 apparently reflects competitive interactions between Cyanobacteria and the other algae groups.

Significant correlations between the first principal component and environmental parameters were as follows:

PC1	Temperature	% Cultivated Area	Cultivated Area	Hardness	Overflow
Correlation coefficient	-0.57	-0.55	-0.50	0.49	0.48
Level of Significance (P)	0.009	0.01	0.03	0.03	0.03

Shallow embayments with warm temperatures, agricultural land use in the watershed, low hardness and low overflow rate tended to have low PC1 scores, and have algae communities dominated by Cyanobacteria. The effects of temperature on phytoplankton are complex. Algae species have definite temperature optima and ranges. Temperature effects algae growth rates, nutrient uptake and can influence the competitive ability of different species (Harris 1986). Cyanobacteria generally have a higher temperature optimum than most other algae groups (Wetzel 1983) and appear to have an increased competitive advantage in warmer embayments. This study compared the average algae densities throughout the study period. Detailed examination of competitive phytoplankton interactions should consider the seasonal succession of the

phytoplankton community, since seasonal variability in taxa composition is probably much greater than spatial variability.

Spatially, highest total densities of algae occurred in the upstream end of Richland Creek embayment, averaging over 44 million cells/liter (table 18 and figure 35). Bloom populations of algae greater than 115 million cells/liter (Appendix F) were found in Richland Creek in late August 1990, of which over 92% of the algae were cyanobacteria (blue-greens). Lowest densities of algae occurred at two upper Hiwassee River stations averaging just over 2 million cells/liter. Among the embayment sampling locations, the lowest numbers occurred at North Mouse Creek embayment, a tributary to the Hiwassee River, averaging under 6.5 million cells/liter.

The multiple regression model explaining the highest percent of the variance in average summer total algal abundance for all of the Chickamauga Reservoir embayments was:

$$\begin{aligned} \text{Ln}(\text{Total algae, cells/liter}) = & \\ & 5.43 + 0.96[\text{Ln}(\text{Total Phosphorus, mg/l})] \\ & - 1.09[\text{Ln}(\text{Color, PCU})] + 5.79[\text{Ln}(\text{Temperature, } ^\circ\text{C @1-m})] \\ \text{where: } R^2 = 0.77 \text{ } F = 17.5; \text{ Prob}>F = 0.0001; n = 20. \end{aligned}$$

Examination of the relationship between summer averages of total algae density and total phosphorus for the Chickamauga embayments (figure 36a) shows a strong relationship if only the Tennessee River embayments are considered. Figure 36a shows that algal densities in the Hiwassee Embayments are lower than would be expected based on the empirical phosphorus relationship. The inclusion of color and temperature in the multiple regression model of all embayments (above) accounts for differences between the Tennessee River and Hiwassee River arms of Chickamauga Reservoir. Embayments on the Hiwassee River generally had lower water temperature and higher color than sites on the Tennessee River arm. Water temperatures in the Hiwassee River are lower than the Tennessee River section due to hypolimnetic releases from Appalachia Dam.

Figure 36

**TOTAL PHOSPHORUS vs. ALGAL DENSITY
CHICKAMAUGA RESERVOIR EMBAYMENTS - 1990**

**TOTAL PHOSPHORUS vs. CHLOROPHYLL-a
CHICKAMAUGA RESERVOIR EMBAYMENTS - 1990**

If the Hiwassee River embayments, represented by the darkened symbols in figure 36, are not included in the regression model, and only Tennessee River embayments are considered, the best regression model (figure 36a) was:

$$\begin{aligned} \text{Ln(Total algae, cells/liter)} &= \\ &20.22 + 0.79[\text{Ln(Total Phosphorus, mg/l)}] \\ \text{where: } R^2 &= 0.89; F = 98.7; \text{Prob}>F = 0.0001; n = 14. \end{aligned}$$

While algae density (cells/liter) in Hiwassee River embayments, especially North Mouse and South Mouse was lower than expected based on their total phosphorus concentrations these sites did not deviate from the chlorophyll-a to phosphorus model shown earlier in figure 9b. For all embayments, the regression model relating chlorophyll-a to phosphorus (figure 9b) was:

$$\begin{aligned} \text{Ln(Chlorophyll-a, } \mu\text{g/l)} &= \\ &4.76 + 0.63[\text{Ln(Total Phosphorus, mg/l)}] \\ \text{where: } R^2 &= 0.79; F = 67.8; \text{Prob}>F = 0.0001; n = 20. \end{aligned}$$

For Tennessee River embayments only, the regression model relating chlorophyll-a to phosphorus (figure 36b) was:

$$\begin{aligned} \text{Ln(Chlorophyll-a, } \mu\text{g/l)} &= \\ &4.76 + 0.64[\text{Ln(Total Phosphorus, mg/l)}] \\ \text{where: } R^2 &= 0.86; F = 71.4; \text{Prob}>F = 0.0001; n = 14. \end{aligned}$$

Therefore, for Chickamauga Reservoir embayments, the chlorophyll-a versus total phosphorus relation is nearly identical, irrespective of embayment groupings (i.e. Tennessee River embayments or Hiwassee River embayments).

However, the apparent (algal density vs phosphorus relationship) discrepancy between the Tennessee River and Hiwassee River embayments is due to different algae communities. The lower algae populations in the Hiwassee embayments, especially North Mouse and South Mouse, tended to have higher proportions of green algae and diatoms than the Tennessee River embayments. Green algae and diatoms are generally larger and

have higher concentrations of chlorophyll-a than blue-green algae which were dominant in Tennessee River embayments.

Consequently, when possible, algae biomass or volume should be used rather than densities for assessing factors determining phytoplankton abundance. Use of algae density as a measure of primary productivity can provide misleading results as illustrated. In this study, if differences in size or productivity of different types of planktivores are not taken into account, temperature and color could mistakenly be interpreted as limiting productivity.

While the trophic dynamics of aquatic systems are complex, simple empirical relationships between algae productivity and nutrient concentrations or loading have repeatedly been found to explain a high proportion of variability in primary productivity. Phosphorus is often the principal factor limiting primary productivity in freshwater environments (Schindler 1977). Oglesby (1976a) found summer phytoplankton standing stocks to be highly correlated with dissolved phosphorus loading when mixing of the water column was taken into consideration. Phosphorus loading explained 97% of the variability in summer standing stock in deep lakes (>25 M). Vollenweider (1976) showed chlorophyll concentration in north temperate lakes depended on phosphorus loading adjusted for influences of basin and lake hydrology.

This study focused primarily on an inter-embayment analysis of average summer conditions. Seasonal changes in the phytoplankton community structure of Chickamauga reservoir embayments and relations to physical, chemical, and biological mechanisms should be further examined. A better understanding of how algae populations are affected by embayment circulation is needed. Surface water elevation of Chickamauga Reservoir is fluctuated one foot each week during the summer for mosquito control. We suggest examining effects of these fluctuations on embayment stratification, nutrient cycles, and phytoplankton communities.

Benthic Invertebrates

Materials and Methods - Benthic invertebrate samples were taken from 30 sites (table 19) on Chickamauga Reservoir in March, 1990. Samples were collected from 16 embayments (five embayments had two sampling stations), six sites on the Tennessee River and three sites on the Hiwassee River. Typically ten samples were taken along a transect running from one bank of the embayment or river to the other. At some sites, fewer than ten samples were taken. Most samples were taken using a Ponar dredge, however, a Peterson dredge was used in areas having rocky substrates.

On a few occasions extensive amounts of fine gravel or detritus were collected. Since organisms could not easily be separated from the substrate, these collections were subsampled. Animals were separated from the substrate material, sorted, counted, and identified in the field. Identifications were generally made at order, family or genera level.

The two dominant substrate categories in each sample were also recorded. Categories used included: silt, clay, detritus, sand, gravel and corbicula shells (often a major component of the substrate). The frequency (% of samples at each site) of each category were included as independent variables in correlation and regression analyses.

Benthic invertebrate data were analyzed using cluster analysis (SAS, 1989) and Principal Component Analysis (PCA), (SAS, 1989b). Input data were logarithms of the mean density (number per square meter) of each taxa at each site (table 20). Since zero values occurred, one was added to the densities before transformation. Rare taxa (occurring at fewer than three sites) were not included in these analyses. Both analyses were performed on non-standardized data, preserving the variability within individual populations (Pielou 1969; Sprules 1977). Cluster analyses were performed on the entire data set of 30 sampling locations, and separately on the 21 embayment sampling locations only. Ward's minimum variance method was used to help identify embayment grouping (Ward, 1963).

Table 19
BENTHIC INVERTEBRATE SAMPLING LOCATIONS
CHICKAMAUGA EMBAYMENT STUDY, 1990

	RIVER	DATE OF	TYPE OF
MAIN CHANNEL	MILE	SAMPLING	SAMPLE
Tennessee River	472.3	3-13-90	Ponar
Tennessee River	478.2	3-13-90	Ponar
Tennessee River	490.5	3-14-90	Ponar
Tennessee River	496.5	3-21-90	Ponar
Tennessee River	506.6	3-19-90	Ponar
Tennessee River	518.0	3-21-90	Ponar
Hiwassee River	7.4	3-15-90	Ponar
Hiwassee River	13.4	3-20-90	Ponar/Peterson
Hiwassee River	20.0	3-20-90	Peterson
EMBAYMENT			
Waconda Bay/Harrison Bay	2.0	3-13-90	Ponar
Wolftever Creek	4.1	3-13-90	Ponar
Wolftever Creek	5.4	3-13-90	Ponar
Savannah Bay	1.5	3-13-90	Ponar
Dallas Bay	1.5	3-14-90	Ponar
Soddy Creek	1.7	3-12-90	Ponar
Soddy Creek	4.0	3-12-90	Ponar
Possum Creek	2.0	3-14-90	Ponar
Sale Creek	1.3	3-22-90	Ponar
Sale Creek	2.0	3-21-90	Ponar
Richland Creek	0.5	3-19-90	Ponar
Richland Creek	2.9	3-19-90	Ponar
Mud Creek	1.0	3-19-90	Ponar
Goodfield Creek	1.0	3-21-90	Ponar
Gunstocker Creek	1.0	3-22-90	Ponar
Agency Creek	0.5	3-15-90	Ponar
Candies Creek	1.3	3-20-90	Ponar
Candies Creek	1.5	3-20-90	Ponar
Rogers Creek	1.5	3-20-90	Ponar
North Mouse Creek	0.5	3-20-90	Ponar
South Mouse Creek	1.1	3-20-90	Ponar

Table 20

BENTHIC INVERTEBRATE DATA

CHICKAMAUGA EMBAYMENT STUDY, 1990

Densities (numbers per square meter) of taxa occurring at three or more sites, total densities and number of benthic invertebrate taxa collected at each sampling location. Groupings identified by cluster analysis are indicated.

CLUSTER	SITE	ARACH- NOIDAE	OLIGO- CHAETA	ISOPODA	CAENIS	CERATOPO- GONIDAE	CHIRO- NOMIDAE	ODONATA	CORBICULA FLUMINEA	ELMIDAE	GAMMARUS	HEXAGENIA	HIRUDINEA	SPHAE- RIIDAE	NO. TAXA	TOTAL
1	HRM 13.4	0	0	0	0	0	0	0	43	0	0	0	0	0	1	43
1	HRM 20.0	0	26	0	0	0	0	0	79	0	0	0	0	26	3	132
1	TRM 518.0	0	17	0	0	0	67	0	417	0	250	0	0	233	6	1017
2	CANDIES 1.3	0	283	0	0	0	450	0	17	0	0	450	0	267	5	1467
2	HRM 7.4	17	367	0	0	200	633	17	167	0	0	1200	33	883	11	3600
2	SODDY 4.0	0	3900	50	0	0	3133	0	17	0	0	133	17	567	9	7850
2	TRM 472.3	0	967	0	0	33	1900	0	717	0	50	667	0	1450	7	5783
2	TRM 478.2	0	1600	0	0	17	1917	0	3467	0	217	917	0	4467	7	12600
2	TRM 490.5	0	2417	0	0	67	2200	33	1150	0	283	1150	0	2700	10	10050
2	TRM 496.5	0	1117	0	0	0	2433	0	1267	0	250	1883	17	2617	9	9633
2	TRM 506.6	0	1500	0	0	117	683	0	1033	0	67	250	0	50	8	3717
3	DALLAS BAY 1.5	0	950	0	33	83	5083	0	0	0	0	17	0	183	6	6350
3	POSSUM 2.0	0	267	0	0	67	5083	0	0	0	17	50	0	83	6	5567
3	SALE 1.3	0	883	0	133	133	2883	0	33	0	17	417	0	433	8	4933
3	SODDY 1.7	17	1050	0	17	50	6450	0	0	0	0	33	0	1600	7	9217
3	WOLFTEVER 4.1	17	4567	0	17	267	4183	0	0	0	0	17	0	183	9	10150
4	CANDIES 1.5	0	1767	0	33	233	1000	0	0	33	0	0	0	67	6	3133
4	MUD 1.0	0	533	0	67	500	3133	0	17	0	0	0	0	17	6	4267
4	SALE 2.0	0	2317	0	733	33	4867	17	0	0	100	0	67	67	9	8217
4	S. MOUSE 1.1	0	6333	0	133	0	267	0	33	433	0	0	0	33	7	7300
4	WACONDA BAY 2.0	0	500	0	17	17	3050	0	0	0	0	0	0	17	5	3600
5	AGENCY 0.5	0	4833	0	0	400	1483	0	0	0	0	17	0	0	4	6733
5	GOODFIELD 1.0	0	1850	17	0	133	4083	0	0	0	0	17	0	0	5	6100
5	GUNSTOCKER 1.0	0	317	0	0	367	867	0	0	0	0	0	0	17	4	1567
5	N. MOUSE 0.5	0	417	0	0	167	750	0	0	42	0	208	0	0	5	1583
5	RICHLAND 0.5	0	2933	0	0	33	4217	0	100	33	0	0	0	0	6	7333
5	RICHLAND 2.9	0	3367	0	0	50	1850	0	0	17	17	0	0	0	5	5300
5	ROGERS 1.5	0	3093	0	19	74	1870	0	0	148	0	93	0	0	6	5296
5	SAVANNAH BAY 1.5	0	817	0	0	217	467	0	0	0	0	0	0	0	3	1500
5	WOLFTEVER 5.4	0	1367	17	0	100	1233	0	0	0	0	0	0	0	7	2800

Principal Component analysis was only performed on the embayment sampling locations to investigate cause/effect relationships between the first and second principal component of the benthic invertebrates and selected physical/chemical variables of the embayments.

Since PCA is an ordination technique used to reduce the dimensions of a multi-species data set to a few dominant trends or sources of variance, it simplifies the identification of the dominant sources of variation in a system. In this analysis, each principal component is a linear combination of the log transformed benthic invertebrate densities collected at an embayment site. Principal components were interpreted by examining correlations of taxa densities with the principal components. Taxa with high positive or negative correlations account for much of the variance summarized by each of these trends. Similarly, relations among embayment sites were inferred from their PCA scores. These patterns were summarized using a bivariate plot of each site on the first two components (PC1 and PC2). The closer the sampling sites on this plot, the more similar their benthic invertebrate community. Finally, PC1 and PC2 values for each of the embayments were correlated with physical, chemical and biological parameters to investigate relationships between benthic communities and these environmental variables.

Results and Discussion - A total of 27 taxa were identified at thirty sites on Chickamauga Reservoir. Densities of taxa collected at three or more sites, total densities, and taxa richness (number of taxa identified) for each site are presented in table 20. Highest densities were collected at TRM 478.2 and Wolftever Creek mile 4.1. Lowest densities were at HRM 13.4 and HRM 20.0. HRM 13.4 and HRM 20.0 also had the lowest taxa richness while HRM 7.4 and TRM 490.5 had the highest.

Correlation and regression analysis were used to examine relations of benthic taxa richness and total density to

physio-chemical and biological characteristics of the embayments. These relations, however, should be interpreted cautiously since benthic samples were collected in March, months before most of the other physical, chemical and biological variables were collected. Physio-chemical and biological conditions during the previous year would have been more likely to effect spring benthic invertebrate populations. Statistically significant correlations of benthic taxa richness and total density with physio-chemical and biological characteristics of the embayment were as follows:⁸

<u>Ln(Benthic Density, #/m²)</u>	<u>%Pasture Area</u>	<u>Dissolved Oxygen</u>	<u>Sediment Manganese</u>	<u>Secchi</u>	
Correlation Coefficient (r)	-0.75	0.66	-0.64	0.61	
Level of Significance (P)	<0.001	0.001	0.002	0.003	
	<u>Turbidity</u>	<u>Carlson's TSI</u>	<u>%Macrophyte Area</u>		
Correlation Coefficient (r)	-0.61	-0.50	0.48		
Level of Significance (P)	0.003	0.02	0.02		
<u>Taxa Richness</u>	<u>Cumulative Filling</u>	<u>Macrophyte Area</u>	<u>Embayment Volume</u>	<u>Embayment Surface Area</u>	<u>Forested Area</u>
Correlation Coefficient (r)	0.72	0.66	0.66	0.62	0.59
Level of Significance (P)	<0.001	<0.001	0.001	0.002	0.004
	<u>Chlorophyll-a</u>	<u>%Agriculture Area</u>	<u>Carlson's TSI</u>	<u>Secchi</u>	
Correlation Coefficient (r)	-0.59	-0.58	-0.53	0.52	
Level of Significance (P)	0.005	0.006	0.01	0.01	

The best regression model for estimation of benthic invertebrate density was a function of the percentage of the embayment watershed classified as pasture, non-cultivated lands, and accounted for just over 55% of the variability:

$$\text{Ln[Benthic invertebrate density (No./m}^2\text{)]} = 10.17 - 3.46[\text{Arc Sin(Square Root (\% pasture land))}]$$

where: $R^2 = 0.56$; $F = 24.3$; $\text{prob}>F = 0.0001$; $n = 21$.

⁸Natural log transformations were performed on water chemistry data (dissolved oxygen, turbidity, chlorophyll-a) and arc sine square root transformations were performed on percentage data (% pasture, % macrophyte, % agriculture).

The best model for estimation of benthic invertebrate density using only physio-chemical and biological variables was a function of dissolved oxygen and accounted for approximately 43% of the variability:

$$\begin{aligned} \text{Ln[Benthic invertebrate density (No./m}^2\text{)]} &= \\ &1.27 + 3.45[\text{Ln(Dissolved Oxygen, mg/l @1-m)} \\ \text{where: } R^2 &= 0.43; F = 14.5; \text{prob}>F = 0.001; n = 21. \end{aligned}$$

Simple linear models were also developed to predict taxa richness. The best regression model for taxa richness was:

$$\begin{aligned} \text{Number of taxa} &= 4.65 + 0.0007 (\text{Cumulative fill, Ac-ft}) \\ \text{where: } R^2 &= 0.52; F=20.5; \text{prob}>F = 0.0002; n = 21. \end{aligned}$$

The best regression model for estimation of taxa richness using only physio-chemical and biological variables was a function of embayment surface area macrophyte coverage and accounted for approximately 44% of the variability:

$$\begin{aligned} \text{Number of taxa} &= 5.28 + 0.016 (\text{Macrophyte coverage, acres}) \\ \text{where: } R^2 &= 0.44; F = 14.8; \text{prob}>F = 0.001; n = 21. \end{aligned}$$

Benthic invertebrate density tended to be highest in oligotrophic or mesotrophic embayments with high dissolved oxygen concentration, extensive areas of aquatic macrophytes, low sediment manganese concentration and low percent of the watershed used for agriculture. Taxa richness was highest in large, clear oligotrophic or mesotrophic embayments with extensive macrophyte coverage, low chlorophyll-a concentration, and forested rather than agricultural land use in the watershed.

The importance of macrophyte to aquatic invertebrates is well known. Macrophyte habitat have been shown to support higher numbers of organisms (Gerking 1957 and Cyr and Downing 1988) and higher taxa richness (Wright et al. 1992) than the open water littoral zone. In Guntersville Reservoir, Alabama, Pardue and Webb (1985) found greater numbers of both taxa and organisms in macrophyte habitat as compared with open littoral zone, however, the differences were generally not significant. Macrophytes

increase habitat variety and the number of spatial niches available for colonization by macroinvertebrates. They also provide protection from predation. While few freshwater invertebrates consume living macrophyte tissue, plant-dwelling invertebrates, however, are able to exploit a variety of food resources including: epiphytic algae, trapped allochthonous material, and decaying macrophytes (Wright et al. 1992). Epiphytic invertebrates represent an important food source for fish, and can play a major role in the trophic structure of reservoirs where primary productivity is dominated by macrophytes and epiphytes.

Correlations with dissolved oxygen, chlorophyll-a, and trophic status all reflect decreased benthic invertebrate abundance and taxa richness in eutrophic embayments as compared with more oligotrophic embayments. Correlations with embayment volume probably indirectly reflect this same trend, since embayment morphometry was found to be a major factor influencing chemical and other biological processes in Chickamauga Reservoir embayments. In more productive embayments, littoral macrophytes can be eliminated as a result of light attenuation, while much of the benthic fauna below the hypolimnion can be eliminated due to reduced oxygen.

Surprisingly, significant correlations were found between benthic density and oxygen concentration at one meter but not with oxygen near the bottom. Bottom fauna samples were collected from a transect running from bank to bank, while water quality and sediment samples were taken from sites in the deeper part of the embayment. While oxygen concentration at the bottom would probably reflect conditions affecting benthos below the metalimnion, oxygen samples from one meter depth may better reflect oxygen concentrations in the productive littoral zone. Sample depths were not consistently recorded for the benthic samples.

A significant negative correlation was also found between benthic fauna abundance and sediment manganese concentration.

Manganese is a micronutrient, required in low amounts by plants and animals. In high concentrations, however manganese becomes toxic. Under anoxic conditions, manganese is released from sediments and can reach undesirable levels in the water column.

Cluster analysis - Relations among benthic invertebrate abundance data were summarized using cluster analysis for all sites and for a subset consisting of only the embayments. With the Tennessee and Hiwassee River main channel sites included, five benthic invertebrate assemblages were identified (figure 37). Cluster analysis of the embayment subset of the data grouped the sites into similar clusters (figure 38). Cluster "1" was not identified in the embayment analysis since only main channel sites made up this group. Figure 39 shows the geographic distribution of the four embayment site groups identified by cluster analysis.

The first group included TRM 518.0, HRM 13.4 and HRM 20.0 (figure 37). These sites were dominated by *Corbicula fluminea* and tended to have low taxa richness and low total abundance (table 20). *Oligochaeta*, *chironomidae*, and *ceratopogonidae*, which were collected in all or most of the other sites, were absent or rare in the first cluster. TRM 518.0 is located in the riverine portion of Chickamauga Reservoir, and is impacted the operation of Watts Bar Dam. Cobble and gravel are the dominant substrate, finer particles are swept away by periodic high flow rates. The benthic community structure at HRM 13.4 and HRM 20.0 indicated an extremely perturbed environment. Likely factors affecting the main channel Hiwassee River sites include higher stream velocities, siltation from the Copper Hill Basin, and releases from a pulp and paper mill at approximately Hiwassee River Mile 18. None of these sites were included in the embayments only cluster analysis, figure 38.

Cluster "2" was made up of the relatively unimpacted main channel sites along with two stations on large embayments. Tennessee River sites (excluding TRM 518.0), HRM 7.4, Soddy Creek

Figure 37
Cluster Analysis of Benthic Invertebrates - All Sites
(based on Wards minimum variance method)
Chickamauga Embayment Study, 1990

Figure 38
Cluster Analysis of Benthic Invertebrates - Embayment Sites
(based on Wards minimum variance method)
Chickamauga Embayment Study, 1990

mile 4.0, and Candies Creek mile 1.3 were included in this group (figure 37). Most of these sites had high taxa richness and were dominated by *Corbicula fluminea*, *Hexagenia* sp. and *sphaeriidae* (table 20) in addition to the ubiquitous taxa (*oligochaeta*, *chironomidae*, and *ceratopogonidae*). Soddy Creek mile 4.0 and Candies Creek mile 1.3 were also grouped together in the embayments only analysis (figure 38).

Clusters "3" through "5" were similar in both analyses. Dallas Bay, Soddy Creek mile 1.7, Possum Creek mile 2.0, Sale Creek mile 1.3 and Wolftever Creek mile 4.1 made up the third group (figures 37 and 38). All except Wolftever Creek mile 4.1 were located in the downstream portion and on the north-west side of Chickamauga reservoir (figure 39). *Caenis* sp., *Hexagenia* sp. and *sphaeriidae* along with the ubiquitous taxa were collected in most of these sites (table 20).

Cluster "4" included Sale creek mile 2.0, Waconda Bay/Harrison Bay 2.0, South Mouse Creek mile 0.5, Mud Creek mile 1.0, and Candies Creek mile 1.5 (figures 37 and 38). Taxa composition was similar to group three except *Caenis* sp. densities tended to be higher, and no *Hexagenia* sp. were collected (table 20). Substrate characteristics probably account differences in community structure between cluster three and cluster four. *Hexagenia* sp. is a burrower and requires a permeable substrate, while *Caenis* sp. is a crawler and requires structure such as aquatic plants, sticks, leaves and roots of terrestrial plants (Unzicker and Carlson 1982).

Seven embayments on the south-east side of the reservoir (figure 39), Wolftever Creek mile 5.4, Savannah Bay mile 1.5, Gunstocker Creek mile 1.0, North Mouse Creek mile 0.5, Rogers Creek mile 1.5, Agency Creek mile 0.5, and Goodfield Creek mile 1.0, plus the two sites on Richland Creek (miles 0.5 and 2.9) made up cluster "5" (figures 37 and 38). These sites had low taxa richness and were primarily made up of the ubiquitous taxa (table 20).

Figure 39

**Benthic Invertebrate Cluster Groups
Chickamauga Reservoir Embayments**

Chickamauga Reservoir Embayment Study

Based on results of cluster analysis, we rated the biotic integrity or quality of aquatic environment at each site. The biotic integrity of cluster "1" sites was "very poor". Cluster "2" sites, which included most of the Tennessee River and lower Hiwassee River main-channel sites were considered to be "good". Benthic fauna of embayments were generally in poorer condition than cluster "2" main-channel sites. Health of cluster "3" and "4" embayments were considered "fair" while cluster "5" sites were classified as "poor". This classification system is generally consistent with trophic status indices described earlier in this report (figures 18, 19, and 20). Most embayments on the south-east side of the reservoir, especially embayments of the Hiwassee River, were classified as "poor" based on their benthic fauna and eutrophic based on trophic status indices. Two notable exceptions, where trophic status and benthic classifications differed, were Candies Creek and South Mouse Creek embayments. Based on benthic data, South Mouse and upper Candies Creek were classified as "fair", while lower Candies Creek was classified as "good". Based on trophic state indices both embayments were classified as eutrophic. Overall health of the aquatic environment in the oligotrophic/mesotrophic embayments on the north-west side of the Reservoir was classified as "fair".

Principal Component Analyses (PCA) of Embayments - The first two principle components of the embayment benthic invertebrate analysis explained 49.6% of the variance in the data. The first component (PC1) accounted for 30.5% of the variance and the second (PC2) for 19.1%. PCA classified the embayments into the same groups identified by cluster analysis (figure 40).

The dominant trend in the data (PC1) appeared to be related to the embayment morphometry, trophic status, and macrophyte coverage. A low score on the abscissa was associated with embayments that were relatively small, shallow, relatively eutrophic and have little macrophyte growth, on the opposite end

Figure 40

Principal Component Analysis of Benthic Invertebrates
Chickamagua Reservoir Embayments (Lines enclose site groups
determined from cluster analysis, figure 38)

of this axis, higher scores were associated with larger, deeper, more oligotrophic embayments with extensive macrophyte coverage. Sphaeriidae ($r=0.95$, $P<0.001$), Caenis sp. ($r=0.50$, $P<0.02$), and Hexaginea sp. ($r=0.50$, $P<0.02$) had a significant positive correlation with PC1, while Ceratopogonidae had a inverse correlation with PC1 ($r=-0.44$, $P=0.05$). Sites having relatively high abundance of Sphaeriidae, Caenis sp., and Hexaginea sp. and low abundance of Ceratopogonidae would have high scores on PC1, while sites with high abundance of Ceratopogonidae and low abundance of Sphaeriidae, Caenis sp., and Hexaginea sp. would have high negative scores. Significant ($P < 0.01$) correlations of PC1 of the invertebrate data with the environmental variables are as follows:

Correlations of Benthic Invertebrate PC1 values vs.:

PC1	Volume	Cumulative Fill	Mean Depth	Macrophyte area	Carlson's TSI	Total Phosphorus
Correlation coefficient	0.76	0.72	0.69	0.69	-0.65	-0.65
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001	0.001	0.002

	Surface Area	Fish Chlorophyll	Fish abundance	Secchi	Turbidity
Correlation coefficient	0.64	-0.62	0.59	0.59	-0.58
Level of Significance (P)	0.002	0.003	0.006	0.007	0.007

This list of variables was similar to variables having high correlations with benthic density and taxa richness.

The secondary source of variability in the data (PC2) separates sites containing Caenis sp. ($r=0.78$, $P<0.001$) from those containing Hexagenia sp. ($r=-0.68$, $P=0.001$). Ammonia was positively correlated with PC2, although weakly ($r=0.52$, $P=0.02$). While ammonia is toxic at high concentrations, in this study most embayment ammonia levels were near detection limits. No other variable was significantly correlated with PC2. PC2 probably reflects differences in micro habitat characteristics for which adequate data were not available.

The benthic sampling regime employed in this study was chosen to provide cost effective information about bottom fauna of Chickamauga Reservoir and its embayments. Samples were processed and taxonomic identification was done in the field. Although field processing probably missed individuals which would have been picked with lab processing and information is lost using field identification, results of this study are promising, since general agreement was found between embayment classification based on bottom fauna community structure and classifications based on trophic status indices. Improvements in field taxonomic identification and better efforts to obtain consistent substrate identification are recommended for future similar studies.

This analysis concentrated on inter-embayment comparisons. Mean taxa densities were computed using all samples collected at each site. It is recommended that if similar studies are conducted in the future, that a stratified sampling scheme be used. Sample sites should probably be stratified by depth into littoral and profundal zones. In productive systems, the littoral zone can support a diverse benthic invertebrate community above the metalimnion. In contrast, since the profundal zone is commonly impacted by periods of oxygen reduction, species diversity is usually reduced, since few animals are adapted to these conditions (Wetzel 1983).

Aquatic Macrophytes

Materials and Methods - Aquatic macrophyte coverages were determined using color aerial photographs taken in late summer or early autumn. Aerial photography was acquired from a Beechcraft Aerocommander using a 9" x 9" mapping camera by TVA's Mapping Services Department. The processed negative film was inspected and appropriate prints made to allow coverage of each Chickamauga reservoir embayment. A transparent mylar overlay was attached to each print. Matchpoints were determined on sequential photographs to avoid overlap on the acreage determinations. The aquatic plant colonies were delineated on the mylar overlay and species determinations were checked for consistency and accuracy with ground truthed information. Scale for the photographs (approximately 1" = 600' or 1" = 1000') was calculated using structures of known size and the delineated plant colonies were plainmetered and data reported in acres, (Burns et al., 1990).

Results and Discussion - Aquatic macrophyte data are presented in table 21 for the Chickamauga reservoir embayments. Sale Creek embayment has the largest total acreage of aquatic macrophytes as well as the highest percentage of water surface area covered. Waconda Bay, North Mouse Creek, and South Mouse Creek embayments showed no infestations of aquatic macrophytes, in 1990. Figure 41 illustrates the geographical distribution of aquatic macrophytes among the Chickamauga reservoir embayments.

Correlation analysis was performed between macrophyte abundance and physical/chemical/environmental parameters. Two measures of each embayments macrophyte abundance, macrophyte surface area ($\log_n$ transformed) and percent surface area of aquatic macrophytes (arc sine square root transformed) were used. Parameters having the highest correlations were:

<u>Ln(Aquatic Weeds, acres)</u>	<u>Turbidity</u>	<u>Embayment Filling</u>	<u>Secchi</u>	<u>Suspended Solids</u>
Correlation coefficient (r)	-0.79	0.76	0.76	-0.74
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001

<u>Ln(Aquatic Weeds, acres)</u>	<u>Dissolved Oxygen</u>	<u>Depth Of Fill</u>	<u>Total Phosphorus</u>	<u>Chlorophyll a</u>
Correlation coefficient (r)	0.73	0.72	-0.70	-0.57
Level of Significance (P)	<0.001	<0.001	<0.001	0.009
<u>Aquatic Weeds, % surface area</u>	<u>Turbidity</u>	<u>Secchi</u>	<u>Depth Of Fill</u>	<u>Carlson's TSI</u>
Correlation coefficient (r)	-0.77	0.74	0.73	-0.72
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001
<u>Aquatic Weeds, % surface area</u>	<u>Embayment Filling</u>	<u>Suspended Solids</u>	<u>Total Phosphorus</u>	<u>Chlorophyll-a</u>
Correlation coefficient (r)	0.72	-0.71	-0.68	-0.60
Level of Significance (P)	<0.001	<0.001	<0.001	0.005

Correlations between macrophyte coverage and turbidity, suspended solids, and secchi depth reflect the importance of water clarity (i.e. light availability) as a limiting factor determining macrophyte abundance. Barko et. al. (1986) described light availability as one of the most important factors determining productivity, distribution and species composition of aquatic macrophytes. In Pickwick Reservoir, Alabama, macrophyte growth was related to light attenuation with macrophyte abundance reaching nuisance abundance in years when spring rainfall and turbidity were low (Peltier and Welch 1970).

Also interesting is the significant correlation between aquatic weeds and both depth of fill ratio and embayment filling (i.e. cumulative fill, acre-ft). One might hypothesize that embayments which fill most rapidly also provide better habitat for colonization by aquatic macrophytes due to the deposition of nutrient rich sediment in the shallow, littoral areas of the embayments. Sediments provide an important source of nutrients, principally P and N, which are relatively less available from the water column in most aquatic systems (Barko et. al., 1986). The relationship between sediment deposition and plant coverage is probably also due to increased sediment deposition rates within the macrophyte beds. Dense macrophyte growth reduces flow rates within macrophyte beds resulting in accelerated deposition of suspended sediment. Whether the correlation between macrophyte growth and fill are due to enhanced macrophyte growth in nutrient

Table 21
AQUATIC MACROPHYTE DATA, 1990
CHICKAMAUGA RESERVOIR EMBAYMENTS

EMBAYMENT	TOTAL ACRES	PERCENT COVERAGE	SPECIES/ACREAGES*
Waconda Bay	0.0	0.0	No Plants Visible
Wolftever Creek	35.9	9.2	Ms 20.2; Mix 15.7
Savannah Bay	16.1	5.4	Ms 16.1
Dallas Bay	40.5	6.3	Ms 38.8; Pn 1.7
Soddy Creek	94.3	15.6	Ms 81.8; Ms/Nm 12.5
Possum Creek	74.7	16.6	Ms 0.2; Nm/Nq 74.5
Sale Creek	229.3	34.1	Ms 201.8; Mix 26.8; Pn 0.7
Richland Creek	32.6	13.5	Ms 32.6
Mud Creek	47.8	15.4	Ms 23.2; Mix 24.6
Goodfield Creek**	>0.4	>0.3	Ms 0.4 (Partial Coverage)
Gunstocker Creek	8.4	2.5	Ms 5.6; Nm 0.3; Ms/Nm 2.5
Agency Creek	21.7	9.6	Ms 18.0; Ms/Pn 3.7
Candies Creek	0.4	0.1	Nm 0.4
Rogers Creek	22.5	5.4	Ms 22.5
North Mouse Creek	0.0	0.0	No Plants Visible
South Mouse Creek	0.0	0.0	No Plants Visible
*Ms - Eurasian Watermilfoil			
Nm - Spinyleaf Naiad, some Southern Naiad			
Nq - Southern Naiad			
Pn - American Pondweed			
Ch - Muskgrass			
Cd - Coontail			
Fa - Filamentous Algae			
** Photographs covered only about 60 percent of embayment;			
however, a dramatic decline in aquatic vegetation from			
previous years.			

Figure 41

Aquatic Macrophytes, Percent of Surface Area

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

rich deposited sediment or to increased sediment deposition in macrophyte beds can not be determined from this type of analysis. Both of these processes are probably operating.

The inverse relationship between chlorophyll-a concentrations and aquatic weed infestation may suggest a competitive productivity relationship. In embayments with large amounts of aquatic weeds, macrophytes may out compete algae for available light (since they are able to take up nutrients from sediments), resulting in lower water column concentrations of chlorophyll-a, and greater water clarity. In the more productive embayments increased phytoplankton density contributes to decreased light penetration. Consequently, the embayments with higher infestations of aquatic weeds also had lower trophic status, based on the Carlson TSI (and EPA-NES TSI).

Two aquatic macrophyte models were developed to estimate total acreage and the percent of water surface area infested with aquatic macrophytes for the Chickamauga reservoir embayments.

The two models account for approximately 75% of the variance of the total acreage and percent coverage data. The first model relates acres of aquatic macrophytes to turbidity of the embayment, and sediment copper concentration. The second model relates the percentage of embayment surface area infestation with turbidity and sediment lead concentration. These models are:

$$\begin{aligned}\text{Ln}(\text{Total macrophyte coverage, Acres}) = \\ 8.26 - 1.92[\text{Ln}(\text{Turbidity, NTU})] \\ - 0.070(\text{Sediment Copper, mg/kg})\end{aligned}$$

where: $R^2 = 0.75$; $F = 25.4$; $\text{prob} > F = 0.0001$; $n = 20$; and,

$$\begin{aligned}\text{Arc Sine} [\text{Square Root} (\% \text{ Macrophyte coverage})] = \\ 0.744 - 0.189[\text{Ln}(\text{Turbidity, NTU})] \\ - 0.002(\text{Sediment Lead, mg/kg})\end{aligned}$$

where $R^2 = 0.73$; $F = 23.4$; $\text{prob} > F = 0.0001$; $n = 20$.

Relationships between macrophyte abundance and sediment metals concentrations should be further examined. Although

copper is an ingredient in several herbicides, many compounds containing copper are not toxic since they are not biologically available. To assess copper toxicity, concentrations of specific forms of copper, rather than total copper in sediment would have to be determined. The significant relationship of lead to percent macrophyte coverage is driven by a single embayment, Waconda Bay, where sediment lead (and copper) concentrations are high and no macrophytes were found in 1990. It is recommended that bioassays be conducted using substrate from Waconda Bay, where lead and copper concentrations were high, (also, see recommendations - Sediment Quality section). These tests would determine if macrophyte growth is inhibited by substances in Waconda Bay substrate.

Macrophytes have a profound influence on both fish and invertebrate communities. In this study, macrophyte abundance was one of the most important factors determining fish abundance and biomass. This relationship is described in more detail in the following Fish Abundance and Fish Health Assessment section.

Fish Abundance and Fish Health Assessments

Materials and Methods - Pelagic (open water) fish community surveys were conducted in August at the Chickamauga Reservoir embayment locations listed in table 22. Mobile hydroacoustic techniques were used to estimate fish densities (number of fish per cubic meter of water) and to approximate the average fish size (length in centimeters) in each of the embayments. Additional details are given in Wilson (1991). Biomass of fish (kilograms per cubic meter) was estimated using the equation: $\text{Log}_{10}(\text{weight, grams}) = -5.06 + 3.00 \text{ Log}_{10}(\text{length, mm})$. This equation was developed using all gizzard and threadfin shad in TVA's fisheries data base, however, it is assumed that this relationship is representative of most fusiform fish (Wilson, 1992).

The general health and condition of fish in the embayments of Chickamauga Reservoir was assessed using a TVA modified Fish Health Assessment Index (FHAI). Largemouth bass (Micropterus salmoides) were selected as a representative species of warm water fish because of their ease of capture and their position in the food chain as a top predator. The fish were collected with standard reservoir electrofishing equipment and transported to a mobile laboratory for immediate examination. The FHAI summarized the examination of fifteen external and internal indicators of health. Parameters such as condition of liver, spleen, kidney, hematocrit, number of parasites, etc., were determined for each of fifteen individual fish (greater than 250 mm) in each embayment. Results were tabulated and a relative numerical FHAI value was calculated for each embayment. This index value is inversely related to the health of the fish in the embayment. Therefore, a fish with a relative high index is in poor health. Additional details are available in Brown (1991).

Results and Discussion - Fish community and fish health results are given in table 23. Average fish size was relatively

Table 22
FISHERIES SAMPLING LOCATIONS
CHICKAMAUGA RESERVOIR EMBAYMENTS

Embayment Name	Location	Sampling Dates
Waconda Bay	Mouth at TRM 477.5. South of Harrison Bay and John Patton Island.	8-6-90
Wolftever Creek	Mouth east of John Patton Island and southeast of Harrison Bay at Highway 58 Lower area = mile 1.0-2.3. Upper area = creek channel region immediately downstream of Savannah Bay. Middle area = mile 3.3-4.6	8-7-90
Savannah Bay	East of Snow Hill road bridge.	8-7-90
Dallas Bay	Mouth at TRM 480.5.	8-6-90
Soddy Creek	Mouth at TRM 487.5. Creek mile 1.0-2.5	8-7-90
Possum Creek	Mouth at TRM 489.7. Start just south of creek mile 2.0 and go to 3.8.	8-8-90
Sale Creek	Mouth at TRM 495.0. Lower area = creek mile 0.5-1.5. Middle area = creek mile 1.5-3.0. Upper area = creek channel mile 3.0-4.0	8-9-90
Richland Creek	Mouth at TRM 504.5. Start just west of Richland Boat Dock.	8-9-90
Mud Creek	Mouth at TRM 505.2. Start just north of first big slough.	8-9-90
Goodfield Creek	Mouth at TRM 514.5. Start south-east of bridge.	8-9-90
Gunstocker Creek	Mouth at Hiwassee River mile 6.5. Start just south of mouth.	8-14-90
Agency Creek	Mouth at Hiwassee River mile 7.8, just east of Highway 58 bridge.	8-14-90
Candies Creek	Mouth at Hiwassee River mile 12.8.	8-14-90
Rogers Creek	Mouth at Hiwassee River mile 12.1.	8-14-90
North Mouse Creek	Mouth at Hiwassee River mile 15.0.	8-14-90
South Mouse Creek	Mouth at Hiwassee River mile 15.6.	8-14-90

Table 23

FISH COMMUNITY AND FISH HEALTH DATA, 1990

CHICKAMAUGA RESERVOIR EMBAYMENTS

EMBAYMENT LOCATION	+----ABUNDANCE-----+		+----BIOMASS-----+		+----FISH SIZE-----+		+-----FISH HEALTH-----+		
	Fish/Cubic Meter	+ or - 95% C.L. ^a	Kg/Cubic Meter	+ or - 95% C.L. ^a	Target Strength (dB)	Fish Length (cm)	Health Assessment Index(HAI)	Standard Deviation	Coeffic. Variation
Waconda Bay	0.2260	0.1795	0.0003	0.0002	-53.03	3.7	98	41.80	42.51
Wolftever Creek - middle area	0.0790	0.0651	0.0008	0.0006	51.37	4.5	47	32.55	68.77
Wolftever Creek - upper area	0.0445	0.0235	0.0028	0.0015	-42.29	13.5			
Savannah Bay	0.0216	0.0152	0.0013	0.0010	-41.37	15.1	47	32.55	68.77
Dallas Bay	0.5346	0.1328	0.0006	0.0002	-53.95	3.3	78	37.38	47.72
Soddy Creek	1.5477	0.3025	0.0009	0.0002	-55.32	2.8	75	26.66	35.55
Possum Creek	1.0009	0.4044	0.0014	0.0005	-54.27	3.2	60	40.33	67.22
Sale Creek - lower	2.1337	0.7770	0.0009	0.0003	-55.85	2.6			
Sale Creek - middle	1.0438	0.3717	0.0010	0.0004	-54.87	3.0	55	38.62	70.65
Richland Creek	0.2102	0.1046	0.0001	0.0000	-51.99	4.2	47	33.40	71.57
Mud Creek	0.0361	0.0126	0.0011	0.0004	-44.50	10.3	47	35.15	75.32
Goodfield Creek	0.0366	0.0274	0.0018	0.0013	-43.45	11.7	44	22.45	51.02
Gunstocker Creek	0.5273	0.2424	0.0011	0.0005	-52.38	4.0	55	28.02	50.63
Agency Creek	0.8824	0.2795	0.0018	0.0006	-53.14	3.6	65	35.75	54.72
Candies Creek	0.5387	0.5131	0.0009	0.0009	-54.86	3.0	81	39.31	48.33
Rogers Creek	0.2929	0.1509	0.0006	0.0003	-52.74	3.8	71	35.38	49.59
North Mouse Creek	0.2547	0.1884	0.0016	0.0012	-48.75	6.2	b		
South Mouse Creek	0.0434	0.0359	0.0004	0.0004	-48.07	6.7	64	39.75	62.53

^a Ninety-five percent confidence limits^b No largemouth bass were captured in 1990; however, the FHI was 99 in 1991.

uniform over all embayments with the exception of Savannah Bay, the upper end of Wolftever Creek, Mud Creek, and Goodfield Creek embayments which showed larger average fish sizes (figure 42). Highest fish densities were observed in the lower area of Sale Creek embayment, followed in order by Soddy Creek and Possum Creek embayments (figure 43). Fish size and fish abundance data were inversely correlated ($r=-0.85$, $P<0.001$). Generally, those embayments with the greatest colonization of aquatic macrophytes also had the highest densities of fish. The correlation between embayment fish density and aquatic macrophyte acreage was 0.55. Fish biomass was highest in the upper end of Wolftever Creek, upper Sale Creek, Goodfield Creek, and Agency Creek embayments.

Significant correlations ($P<0.01$) of fish abundance, mean length, and biomass with environmental variables are below:⁹

<u>Ln(Fish Density, #/m³)</u>	<u>Fish Length</u>	<u>Conductivity</u>	<u>Alkalinity</u>	<u>Sediment Calcium</u>
Correlation coefficient (r)	-0.85	-0.80	-0.76	-0.70
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001
	<u>Secchi</u>	<u>Organic Nitrogen</u>	<u>Total Phosphorus</u>	<u>Macrophyte Area</u>
Correlation coefficient (r)	0.69	-0.67	-0.65	0.55
Level of Significance (P)	<0.001	0.001	0.002	0.01
<u>Fish Length, cm</u>	<u>Ln(Fish Density)</u>	<u>Conductivity</u>	<u>Alkalinity</u>	<u>Sediment Calcium</u>
Correlation coefficient (r)	-0.85	0.74	0.72	0.69
Level of Significance (P)	<0.001	<0.001	<0.001	<0.001
	<u>Secchi</u>	<u>Organic Carbon</u>	<u>Organic Nitrogen</u>	<u>Fish Health</u>
Correlation coefficient (r)	-0.58	0.55	0.54	-0.53
Level of Significance (P)	0.007	0.01	0.01	0.01
<u>Ln(Biomass, Kg/m³)</u>	<u>Methamidophos</u>	<u>Captafol</u>	<u>Carbaryl</u>	<u>Malathion</u>
Correlation coefficient (r)	-0.61	-0.60	-0.60	-0.60
Level of Significance (P)	0.004	0.005	0.005	0.005
	<u>Chlorothalonil</u>	<u>Sediment DDT</u>	<u>Total Pesticides</u>	<u>Cropland Area</u>
Correlation coefficient (r)	-0.60	-0.57	-0.53	-0.50
Level of Significance (P)	0.005	0.008	0.01	0.02

⁹Natural log transformations were performed on water quality variables (i.e. conductivity, alkalinity, organic nitrogen, etc.)

Figure 42
Fish Size
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

Figure 43
Fish Abundance

Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

The correlations suggest greater abundance of fish in the embayments characterized by the presence of aquatic macrophytes, increased water clarity, lower conductivity water, and lower trophic status. However, the correlations indicate that the larger fish occur in those embayments with higher conductivities, lower water clarity, and higher algal populations. Fish biomass was inversely related to pesticide application rates in the watersheds.

Simple linear models were developed to estimate fish abundance, fish size, and fish health as functions of physical, chemical/biological/environmental characteristics of the embayments. The best linear model for predicting fish abundance accounted for nearly 80% of the variability in the data:

$$\begin{aligned} \text{Ln}(\text{Fish Abundance, No./m}^3) = & \\ & 26.89 + 0.006(\text{Macrophytes, acres}) \\ & - 1.06[\text{Ln}(\text{Algae density, cells/liter})] \\ & - 2.55[\text{Ln}(\text{Alkalinity, mg/l})] \\ \text{where: } R^2 = 0.82; F = 25.1, \text{ Prob}>F = 0.0001; n = 20. \end{aligned}$$

The best regression model for fish biomass was:

$$\begin{aligned} \text{Ln}(\text{Fish Biomass, Kg/M}^3) = & \\ & -6.23 + 0.012 (\text{Macrophytes, acres}) \\ & - 0.54 (\text{Mean depth, Meters}) \\ & - 0.041 (\text{Methamidophus, lb active ingredient per yr}) \\ \text{where: } R^2 = 0.73; F = 14.3; \text{ Prob}>F = 0.0001; n = 20. \end{aligned}$$

The best linear model for predicting fish size was a function of average algae density and average conductivity:

$$\begin{aligned} \text{Fish Length, cm} = & \\ & -112.03 + 13.79[\text{Ln}(\text{Conductivity, umhos/cm})] \\ & 2.79[\text{Ln}(\text{Algae density, cells/liter})] \\ \text{where: } R^2 = 0.70; F = 20.0; \text{ Prob}>F = 0.0001; n = 20. \end{aligned}$$

Empirical models relating fish stocks or harvests to nutrient availability (Oglesby 1977b, Hanson and Leggett 1982,

Yurk and Ney 1989), total dissolved solids and the morphoedaphic index, i.e. total dissolved solids/mean depth (Jenkins 1967 and 1982), or primary productivity (Oglesby 1977b, Jones and Hoyer 1982) have been highly successful tools for fisheries management. The evidence presented in these and other nutrient/primary production to fishery productivity studies have shown oligotrophic waters support less fish biomass than more productive systems. In this study, however, none of these parameters were significantly correlated with fish biomass, while fish density was inversely related with conductivity, alkalinity and algae density.

Oglesby (1977b) described several situations where the fish yield to phytoplankton productivity relationships are not applicable. One of these situations is water bodies where primary productivity is dominated by macrophytes and/or epiphytes. Extensive macrophyte populations and resulting changes in trophic structure are probably the reason these relationships were not significant in the Chickamauga Reservoir embayments.

In Chickamauga Reservoir, macrophyte coverage was probably the most important determinant of fish abundance and biomass in the Chickamauga embayments (Scott, 1992). Dense colonies of macrophytes alter fish communities by adding physical structure and altering the trophic structure. In open water areas, primary productivity is dominated by phytoplankton and planktivores such as gizzard shad (Dorosma cepedianum) and threadfin shad (D. petenense) are usually the most abundant fish. In macrophyte beds, invertebrates feeding on epiphytic algae, decaying macrophytes, and trapped allochthonous material increase dramatically. Sunfish such as bluegill (Lepomis macrochirus) and redear sunfish (L. macrolophus) which feed heavily on invertebrates are typically the dominant fish.

During the 1985-1988 drought, clear warm water associated with low flows was favorable for macrophyte expansion. In 1988, macrophytes covered 21.5% of Chickamauga Reservoir with percent

coverage in the embayments being much higher. In 1989, high flows and turbidity reduced macrophyte coverage to 9.9% on Chickamauga Reservoir, the lowest since 1979. In 1990 when this study was completed macrophytes covered 6.0% of the reservoir. Macrophyte coverage in the embayments also dropped during this period. In 1988, over 50% of the surface area of three embayments was covered with macrophytes. Figure 44 shows the dramatic decrease in embayment macrophyte coverage between 1988 and 1990. Response time for fish communities to adjust to perturbations such as expansion and recession of macrophytes is not known. Fish community in the embayments of Chickamauga Reservoir in 1990 was probably still adjusting to the recent change from macrophyte to phytoplankton based system.

Mean depth was a significant parameter in the model of fish biomass. Previous studies have found mean depth to be important in predicting fish stocks (Rawson 1952). Mean depth is also a component of the morphoedaphic index (Ryder 1965). The principal reason mean depth is considered to have an important influence on productivity is that nutrients are used more efficiently in shallow systems (Oglesby 1977a).

In this study hydroacoustics were used to estimate fish density. Hydroacoustics is a relatively new tool of fisheries management and limitations of hydroacoustic techniques in relatively shallow reservoir embayments need to be further evaluated. Because of the draft requirements of the boat, accurate estimates of near shore, shallow water (less than one meter) fish densities are not well known. Most previous hydroacoustic applications were in a marine environments where water depth limitations did not effect the accuracy of the fish stock estimates.

The Fish Health Assessment Indices (FHAI) ranged from 44 in Goodfield Creek embayment to 98 in the area of Harrison Bay/Waconda Bay, figure 45, (higher FHAI's indicating poorer health). The average FHAI for the 15 embayment areas sampled was

Figure 44
 Aquatic Macrophyte Surface Area Coverage, 1988-1990
 Chickamauga Reservoir Embayments

Figure 45
Fish Health
Chickamauga Reservoir Embayments

Chickamauga Reservoir Embayment Study

63, which was considerably higher than an average of 48 for all TVA reservoirs, indicating poorer fish health in the embayments than in the reservoir system as a whole (Brown, 1991). Over ninety percent (182/202) of the fish examined were infested with parasites (mainly internal). The index of 98 recorded in the in the Waconda Bay area was the highest FHA1 value ever recorded in a TVA reservoir.

Significant correlations ($P < 0.05$) of fish health with environmental variables are given below:

<u>Fish Health (FHA1)</u>	<u>% Cropland</u>	<u>Cropland Area</u>	<u>Algae Density</u>	<u>Fish Length</u>
Correlation coefficient (r)	-0.75	-0.67	-0.58	-0.56
Level of Significance (P)	<0.001	0.002	0.01	0.01
<u>Fish Health (FHA1)</u>	<u>Sediment Lead</u>	<u>Detention Time</u>	<u>Sediment Mercury</u>	<u>Ln(Fish Density)</u>
Correlation coefficient (r)	0.55	0.54	0.52	0.46
Level of Significance (P)	0.02	0.02	0.02	0.04

Fish health appears to be best in embayments with larger populations of algae and a large percentage of the watershed in cropland. In addition, fish health is inversely related to fish size and positively related to fish abundance, indicating fish are in poorer health in embayments with high density of small fish. These relationships may reflect the impacts of overcrowding and stunting. The correlation with sediment lead concentration is driven by Waconda Bay, where lead concentrations were high and fish were in poor health.

The best regression model to estimate fish health was:¹⁰

$$\text{FHA1} = 369.62 - 18.98[\text{Ln}(\text{Algae density, cells/liter})] + 0.26 (\text{Sediment Lead, Mg/Kg}).$$

where: $R^2 = 0.66$; $F = 15.4$; $\text{prob} > F = 0.0001$; $n = 19$.

¹⁰Cropland and percent of watershed in cropland were not included in the model because these parameters would not be expected to directly affect fish health.

It is recommended that further fish health assessment studies be conducted to determine if improvement or further degradation occurs in these embayment communities. Also, bioassay procedures should be utilized to assess the impact of high concentrations of metals in sediment (e.g. lead concentration in Waconda Bay) on fish health. It is also recommended that future studies investigate the relationship between fish biomass and application of pesticides in the embayment watersheds.

SUMMARY AND RECOMMENDATIONS

Summary

The water quality characteristics of the Chickamauga Reservoir embayments exhibit a much wider range of conditions than the water quality of the main channel portion of the reservoir. Most of the embayments show much stronger stratification patterns than the main channel portion, frequently having higher near surface temperatures, dissolved oxygen concentrations, pH's, and chlorophyll-a concentrations. Embayment temperatures (measured at 1-meter depth) were found to be negatively correlated with the embayment overflow rate (a measure of the displacement rate of water in an embayment), implying that embayment water temperature is affected and controlled by the ratio of embayment depth to detention time. Embayment dissolved oxygen concentrations (measured at 1-meter depth) were positively correlated with water clarity and negatively correlated with organic carbon and organic nitrogen concentrations, suggesting the effects of autogenous oxygen demanding material on dissolved oxygen concentrations.

The deeper embayments which are tributary to the Tennessee River are generally less turbid, lower in nutrients, and have lower productivities (chlorophyll-a concentrations) than the Tennessee River. Embayments which are tributary to the Hiwassee River have the highest nutrient concentrations and highest chlorophyll-a concentrations. They are much warmer and have higher pH's than the Hiwassee River. Three shallow embayments, tributary to the Hiwassee River, Candies Creek, North Mouse Creek, and South Mouse Creek, have much lower water clarity, higher nutrient concentrations, and productivities.

An important conclusion is that mean embayment depth appears to be an important controlling factor in terms of embayment water quality, productivity, trophic status, and embayment

sedimentation rates. The limnologic characteristics of the deeper embayments with longer detention times, were more similar to natural lakes than reservoirs.

Simple empirical models were developed to estimate both summer chlorophyll-a concentrations based on total phosphorus concentrations, and total nitrogen and total phosphorus concentrations based on suspended solids concentrations for the Chickamauga reservoir embayments. Trophic status indices effectively assessed trophic conditions for most of the Chickamauga reservoir embayments; however, the TSI's were appropriate only for those embayments with hydraulic retention times of greater than 5-10 days. In addition, Porcella's Lake Evaluation Index is appropriate only for those embayments with appreciable surface infestations (>30% surface coverage) of aquatic macrophytes.

Concentrations of lead in sediment in Waconda Bay (180 mg/kg) and nickel in sediment in Possum Creek (77 mg/kg) were higher than has been previously observed in Tennessee River sediment. In addition, mercury concentrations in Agency Creek (0.82 mg/kg) were relatively high. With the exception of three samples with very low concentrations of DDT, no organochlorine pesticides nor PCB's were detected in sediment samples.

Hydroacoustic surveys were shown to be a quick, relatively inexpensive, and effective method to estimate sedimentation rates and filling of reservoir embayments. Several embayments (Possum Creek, Sale Creek, Richland Creek, Goodfield Creek) have lost almost half of their original volume due to sedimentation and filling. Watersheds draining the Waldens Ridge area of the Cumberland Plateau (Soddy, Possum, and Sale Creeks) have been particularly impacted by past steep slope surface coal mining activities. Regression models indicated that embayment filling appears to be a function of embayment bathymetry and land use within the watersheds, with deeper, larger embayments being more efficient sediment traps.

Nutrient loadings to the Chickamauga Reservoir embayments

were estimated using land use classifications derived from SPOT satellite imagery. Total annual estimated loadings of nitrogen and phosphorus were highest for Wolftever Creek and North Mouse Creek embayments, respectively. It is estimated that over 85% of the total phosphorus loading to North Mouse Creek embayment is due to point source domestic waste discharges. Total annual estimated loadings of nitrogen and phosphorus were lowest for Waconda Bay. Candies Creek embayment and South Mouse Creek embayment appear to receive large amounts of nutrient loadings not accounted for based on current land use and existing point source discharges. These unaccounted for loadings, are suspected to be from internal processes (within the watershed-stream bottom-embayment sediment system), the legacy of large wastewater treatment plant discharges which, until recently, discharged to these watersheds. As equilibrium conditions are reached, loadings to Candies Creek and South Mouse Creek embayments from these internal sources should diminish and water quality trophic conditions improve.

Four phosphorus loading rate models were examined and compared. The Reckhow (1988) southeastern lakes model was best suited for predicting Chickamauga reservoir embayment summertime phosphorus concentrations based on phosphorus loadings. However, the model should be used with caution for embayments with short detention times (< 5-10 days). Future investigations which apply this model (or other similar empirical models) to other Tennessee Valley reservoir embayments should include actual measured influent phosphorus concentrations, rather than estimated influent phosphorus concentrations based on land use classifications.

Algae, benthic invertebrate, aquatic macrophyte, and fisheries community and fish health data were presented and simple empirical regression models were formulated to estimate these aquatic biological parameters based on physical, chemical, and environmental parameters. Although many of these models were simple in form, they often represent a complex aggregation of

varying physical, chemical, and biological factors, and may be applicable only to the Chickamauga reservoir/embayment system. Better understanding of the biotic/abiotic processes and interactions (viz. the relationships between nutrients, productivity, and fisheries communities) is needed by extending these types of investigations to other Tennessee Valley reservoir/embayment systems.

Blue-green algae were found to be the dominant species in all but two (North and South Mouse Creek embayments) of the Chickamauga reservoir embayments, usually accounting for 50-70% of the total number of algal cells. Models to estimate the average summer percentage of greens and blue-greens (the two most dominant species) were found based on embayment depth and temperature. Models to estimate average summer total algal populations were developed based on average embayment total phosphorus, color, and temperature.

The benthic sampling regime employed in this study was chosen to provide cost effective information about bottom fauna of Chickamauga Reservoir. Samples were processed in the field and taxonomic identification was at a coarse level. General agreement was found between embayment classification based on bottom fauna community structure and classifications based on trophic state indices. Factors explaining most of the variance in benthic density were watershed land use (percent in pasture) and dissolved oxygen concentrations. Two factors explained most of the variance in the number of benthic taxa: loss of embayment volume due to sedimentation and filling; and surface macrophyte coverage. Extremely low benthic invertebrate abundance and taxa richness in a reach of the Hiwassee River (HRM's 13.4 - 20.0) indicated a perturbed environment which should be further examined.

Macrophytes have a influence on both fish and invertebrate communities. In this study, macrophyte abundance was one of the most important factors determining fish abundance and biomass. Surface coverage of aquatic macrophytes correlated well with

higher water clarity and a historical loss of embayment volume by filling. In addition, the data indicated a inverse relationship between aquatic macrophytes and concentrations of lead and mercury in sediment.

Fish abundance and fish size were found to be inversely related, and largest densities of fish occurred in those embayments with established colonies of aquatic macrophytes. Fish health and fish size were found to be inversely related. Fish health of the Chickamauga reservoir embayments was significantly poorer than that of the Tennessee river. Fish health and fish biomass were found to be inversely correlated with concentrations of lead and mercury in sediment and applications of pesticides in embayment watersheds.

Recommendations

One important factor affecting water quality, not investigated in this study, is the weekly, summer fluctuations of the water surface elevation of Chickamauga Reservoir. Between mid-May and mid-September, the pool level of Chickamauga Reservoir is raised and lowered on a weekly frequency for mosquito control, at a drain and fill rate of approximately 0.3 feet/day. This results in an approximate one foot lowering and raising of the pool level each week. The effect on shallow embayments (e.g. North and South Mouse Creek embayments) results in the exchange of a substantial proportion of the embayments volume in addition to enhancing scouring, mixing, resuspension of sediment, etc., and further study is recommended. Investigations currently underway (Rizk, 1992) are providing additional understanding of these tidal like effects on embayment water exchange and resultant water quality conditions in the embayments. It is recommended that mixing within embayments and between embayments and the main reservoir be investigated and modeled. Both "tidal" mixing effects due to reservoir operations and water surface level fluctuations and the convective mixing effects due to diurnal heating and cooling need to be better

understood.

This study focused primarily on an inter-embayment analysis of average summer conditions. Seasonal changes in the phytoplankton community structure of Chickamauga reservoir embayments and relations to physical, chemical, and biological mechanisms should be further examined. In addition, a better understanding of how algae populations are affected by embayment circulation is needed. Surface water elevation fluctuations of Chickamauga Reservoir during the summer for mosquito control, described above, needs to be examined for effects on embayment stratification, nutrient cycles, and phytoplankton communities.

Improvements in field taxonomic identification and better efforts to obtain consistent substrate identification are recommended for future similar studies. This analysis concentrated on inter-embayment comparisons with mean taxa densities computed using all samples collected at each site. It is recommended that if similar studies are conducted in the future, that a stratified sampling scheme be used. Sample sites should probably be stratified by depth into littoral and profundal zones. In productive systems, the littoral zone can support a diverse benthic invertebrate community above the metalimnion. In contrast, since the profundal zone is commonly impacted by periods of oxygen reduction, species diversity is usually reduced, since few animals are adapted to these conditions (Wetzel 1983).

It is recommended that bioassays be conducted using substrate from Waconda Bay, where lead and copper concentrations were high to determine if macrophyte growth is inhibited by these (or other) substances in Waconda Bay substrate.

It is recommended that further fish health assessment studies be conducted to determine if the poor fish health found in the Chickamauga embayments improves or further degradation occurs in these embayment communities. Also, bioassay procedures should be utilized to assess the impact of high concentrations of metals in sediment (e.g. lead and mercury concentrations in

Waconda Bay) on fish health. It is also recommended that future studies investigate the relationship between fish biomass and application of pesticides in the embayment watersheds.

The biotic/abiotic relationships found in Chickamauga Reservoir embayments need to be extended to other reservoir/embayment systems, and need to include large embayments formed by the confluence of major tributary river systems (e.g. Hiwassee, Elk, Duck, Big Sandy, etc.).

Concentrations of heavy metals in sediment: lead in Waconda Bay (180 mg/kg); mercury in Agency Creek (0.82 mg/kg); and, nickel in Possum Creek (77 mg/kg) were relatively high and should be further investigated.

REFERENCES

- 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants."
- AWWA, WPCF, APHA. 1989. Standard Methods for the Examination of Water and Wastewater, 17th Edition. American Water Works Association, Water Pollution Control Association, American Public Health Association.
- Baker, T. and W.L. Poppe. 1992. Planktonic Algal Assessment - Chickamauga Embayment Assessment. TVA, Water Resources, Aquatic Biology Department, Chattanooga TN, (draft).
- Barko, J.W., M.S. Adams, and N.I. Clesceri. 1986. Environmental Factors and their Consideration in the Management of Submerged Aquatic Vegetation: A Review. Journal of Aquatic Plant Management, 24:1-10.
- Betson, R.P. 1978. Bulk Precipitation and Streamflow Quality Relationships in an Urban Area. Water Resources Research, 14(6):1165-1169.
- Bradford, R.R. 1974. Nitrogen - Phosphorus Losses from Agronomy Plots in North Alabama. EPA 660/2-74-033.
- BioSonics. 1988. "Echo Signal Processor Operator's Manual Model 221 and Echo Integrator Model 281 Dual-Beam Processor," BioSonics Inc., Seattle, WA.
- Brown, A.M. 1991. "Chickamauga Embayment Study, Fish Health Assessment Index Results, 1990", TVA, Water Resources, Aquatic Biology Department, Norris TN.
- Burns, E.R., A.L. Bates, and D.H. Webb. 1990. Aquatic Plant Management Program--Current Status and Seasonal Workplan, 1990. TVA, Water Resources, Aquatic Biology Department.
- Butkus, S.R. 1989. Reservoir Embayments As Potential Units For Water Quality Management. TVA, Water Resources, Water Quality Department, TVA/WR/WQ--89/7.
- Carlson, R.E. 1977. A Trophic State Index for Lakes. Limnology and Oceanography, 22:361-369.
- Cyr, H., and J. A. Downing, 1988. Empirical Relationships of Phytomacrofaunal Abundance to Plant Biomass and Macrophyte bed Characteristics. Can. J. Fish Aquat. Sci. 45: 976-984.

- Cox, J.P. 1989. Surface Water Resources Issues Analysis: Hiwassee River Watershed, TVA, Water Resources, Water Quality Department, TVA/WR/WQ--90/3.
- Cox, J.P. 1992. Surface Water Resources Issues Analysis: Nickajack and Chickamauga Reservoirs Watershed, TVA, Water Resources, Water Quality Department, (draft).
- Daley, R.J., E.C. Carmack, C.B.J. Gray, C.H. Phare, S. Jasper, and R.C. Wiegand. 1981. The Effects of Upstream Impoundments on the Limnology of Kootenay Lake. British Columbia Council Science Report No. 117, Vancouver, B.C.
- Delos, C.G., W.L. Richardson, J.V. DePinto, D.W. Rogers, K. Rygwelski, R. Wethington, R.B. Ambiose, and J.P. St.John. 1983. Technical Guidance Manual for Performing Waste Load Allocations. Book II: Streams and River, Chapter 3: Toxic Substances, EPA.
- Dillon, P.J., and F.H. Rigler. 1974. The Phosphorus-Chlorophyll Relationship in Lakes. Limnology and Oceanography, 19:767-773.
- Dillon, P.J., and F.H. Rigler. 1975. A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status. J. Fish. Res. Board Can., 32(9):1519-1531.
- Eagle, Tim. 1992. Tennessee Division of Land Reclamation, Knoxville TN, Personal communication, September 1992.
- Environmental Protection Agency. 1974. "Nitrogen and Phosphorus in Wastewater Effluents," National Eutrophication Survey, Working Paper No. 22, GPO 697-032, Corvallis, Oregon.
- Environmental Protection Agency. 1974. "An Approach to a Relative Trophic Index For Classifying Lakes and Reservoirs," National Eutrophication Survey Working Paper No. 24, PB 242 336, Corvallis, Oregon.
- Environmental Protection Agency. 1977. "Guidelines for the Pollutational Classification of Great Lakes Harbor Sediments." USEPA Region V, April 1977.
- Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1979.
- ERDAS. 1990. Earth Resources Data Analysis Systems, Image Processing System User's Guide, Version 7.4. ERDAS, Inc., Atlanta, GA.

- EUTROMOD. 1989. (SELAKES Version 1.0) NALMS Lake Modeling Short Course, November 11, 1989, "A Watershed/Lake Modeling Procedure for Eutrophication Management, With an Emphasis on Uncertainty Analysis", an AS EASY AS spreadsheet application by K.H. Reckhow, Duke University, Durham NC 27706.
- Gakstatter, J.H., M.O. Allum, S.E. Dominguez, and M.R. Crouse. 1978. A Survey of Phosphorus and Nitrogen Levels in Treated Municipal Wastewater. Journal WPCF, April 1978: 718-722.
- Gerking, S. D. 1957. A Method for Sampling the Littoral Macrofauna and its Application. Ecology 38: 219-226.
- Gianessi, L. P. 1987. "Use of Selected Pesticides in Agricultural Crop Production in the TVA Region", December 1987, Renewable Resources Division, Resources for the Future, 1616 P Street, NW, Washington, DC 20036, TVA Division of Air and Water Resources, Purchase Order 87KSC-04824A.
- Hanson, J. M., and W. C. Leggett. 1982. Empirical Prediction of Fish Biomass and Yield. Can. J. Fish. Aquat. Sci. 39(2): 257-263
- Harris, G. P. 1986. Phytoplankton Ecology: Structure, Function, and Fluctuation. Chapman and Hall Ltd. London. 984pp.
- Jenkins, R. M. 1976. The Influence of Some Environmental Factors on Standing Crop and Harvest of Fishes in U. S. Reservoirs. In Proc. Reserv. Resourc. Symp. Am. Fish. Soc. Bethesda, Md. pp 298-321.
- Jenkins, R. M. 1982. The Morphoedaphic Index and Reservoir Fish Production. Trans. Am. Fish. Soc. 111:133-140.
- Hayes, F. R. 1957. On the Variation in Bottom Fauna and Fish Yield in Relation to Trophic Level and Lake Dimensions. Journal of Fisheries Research Board of Canada, 14(1):1-32.
- Henderson, G.S., and W.F. Harris. 1975. An Ecosystem Approach to Characterization of the Nitrogen Cycle in a Deciduous Forest Watershed. In: B. Bernier and C.H. Wingett (eds.) Forest Soils and Forest Land Management. Les Presses de l'Universite Laval, Quebec, Canada. 179-193pp.
- Henderson, G.S., A. Hunley, and W. Selvidge. 1977. Nutrient Discharge from Walker Branch Watershed. In: Watershed Research in Eastern North America-A Workshop to Compare Results. Vol. I, Feb. 28 - Mar. 3, 1977.

- Hevel, K.W. and G.D. Hickman. 1992. Fish Community Assessment of Selected Chickamauga Reservoir Embayments. TVA, Water Resources, Aquatic Biology Department, Norris TN, April 1992.
- Higgins, J.M. and B.R. Kim. 1981. Phosphorus Retention Models for Tennessee Valley Authority Reservoirs. Water Resources Research, 17(3): 571-576.
- Horowitz, A.J. 1985. A Primer on Trace Metal-Sediment Chemistry. USGS-Water Supply Paper 84-2277, 67 pp.
- James, W.F. and J.W. Barko. 1991. Estimation of Phosphorus Exchange Between Littoral and Pelagic Zones During Nighttime Convective Circulation. Limnology and Oceanography. 36(1): 179-187.
- Jones, J. R., and M. V. Hoyer. 1982. Sportfish Harvest Predicted by Summer Chlorophyll-a Concentration in Midwestern Lakes and Reservoirs. Trans. Am. Fish. Soc. 111(2):176-179.
- Kelly, J.M. 1991. TVA Atmospheric Science Department, Personal communication, July 12, 1991.
- Krebs, J.E. and F.B. Golley. 1977. Budget of Selected Mineral Nutrients for Two Watershed Ecosystems in the Southeastern Piedmont. NTIS PB 272 286.
- Lakin, K. and W.L. Poppe. 1992. Benthic Macroinvertebrate Community Assessment - Chickamauga Embayment Assessment. TVA, Water Resources, Aquatic Biology Department, Chattanooga TN (draft).
- Larsen, D.P. and H.T. Mercer. 1976. Phosphorus Retention Capacity of Lakes, J. Fish. Res. Board Can., 33:1741-1750.
- Maner, S.B. 1958. Factors Affecting Sediment Delivery Rates in the Red Hills Physiographic Area. Trans. American Geophysical Union, 39:669-675.
- McDowell, L.L., Ryan, M.E., McGregor, K.C., and Greer, J.D. 1978. Nitrogen and Phosphorus Losses in Runoff from No-till Soybeans. Winter Meeting ASAE, Dec 18-20, 1978.
- Monismith, S.G., J. Imberger, and M.L. Morison. 1990. Convective Motions in the Sidearm of a Small Reservoir. Limnology and Oceanography. 35(8): 1676-1702.
- Murphy, F. 1992. Cleveland, TN Utility District, Personal communication, January 1992.

- NHAP. 1983. "The Sky's the Limit!: The National High Altitude Photography Program." Department of the Interior, USGS, GPO Item No. 619-G-2. Washington, D.C.
- NRI. 1987. Basic Statistics: National Resources Inventory, U.S. Department of Agriculture, Soil Conservation Service and Iowa State Univ. Statistical Laboratory. Washington, DC.
- Oglesby, R. T. 1977a, Phytoplankton summer standing crop and annual productivity as functions of phosphorus loading and various physical factors. J. Fish. Res. Board Can. 34(12):2255-2270.
- Oglesby, R. T. 1977b, Relationships of fish yield to lake phytoplankton standing crop, production, and morphoedaphic factors. J. Fish. Res. Board Can. 34(12):2271-2279.
- Pardue, W. J., and D. H. Webb. 1985. A Comparison of Aquatic Macroinvertebrates Occurring in Association with Eurasian Watermilfoil (*Myriophyllum spicatum* L.) with those found in the open littoral zone. J. Freshwater Ecol. 3:69-79.
- Peltier, W. H., and E. B. Welch. 1970. Factors Affecting Growth of Rooted Aquatic Plants in a Reservoir. Weed Sci. 18:7-9.
- Pielou, E. C. 1969. An Introduction to Mathematical Ecology. Wiley-Interscience, Inc. New York, N. Y. 286 p.
- Placke, J.F. 1983. Trophic Status Evaluation of TVA Reservoirs. TVA, Office of Natural Resources, TVA/ONR/WR-83/7.
- Porcella, D.B., S.A. Peterson, and D.P. Larsen. 1980. Index to Evaluate Lake Restoration. J. Environmental Engineering Division, ASCE 106(EE6):1151-1169.
- Rast, W., and G.F. Lee. 1978. Summary Analysis of the North American U.S. Portion) OECD Eutrophication Project: Nutrient Loading-Lake Response Relationships and Trophic State. EPA-600/3-78-008.
- Rawson, D. S. 1952. Mean Depth and Fish Production of Large Lakes. Ecology 33:513-521.
- Rawson, D.S. 1955. Morphometry as a Dominant Factor in the Productivity of Large Lakes. Verh. Int. Ver. Limnology, 12:164-175.
- Reckhow, K.H. 1979. Quantitative Techniques for the Assessment of Lake Quality, EPA 440/5-79-015, January 1979, 146 pp.

- Reckhow, K.H., M.N. Beaulac, J.T. Simpson, and J.T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients, EPA 440/5-80-011, June 1980, 214 pp.
- Reckhow, K.H. 1988. Empirical Models for Trophic State in Southeastern U.S. Lakes and Reservoirs. Water Resources Bulletin, 24(4):723-734.
- Reckhow, K.H., J.P. Hartigan, and S. Coffey. 1989. "Lake Nutrient Budget Development for State-Level Applications", Proceed. of a National Conference on Enhancing States' Lake Mgmt. Programs, May 12-13, 1988, Chicago, IL. pp 45-52.
- Rizk, T.A. 1992. TVA Engineering Laboratory, Norris TN, Personal communication, September 1992.
- Ryder, R. A., 1965. A Method for Estimating the Potential Fish Production of North-temperate Lakes. Trans. Am. Fish. Soc. 94:214-218.
- Sakamoto, M. 1966. Primary Production by Phytoplankton Community in Some Japanese Lakes and Its Dependence on Lake Depth. Arch. Hydrobiol., 62:1-28.
- SAS Institute Inc. 1989. SAS/STAT Users Guide: Statistics, Version 6, Fourth Edition, Volume 1. Cary, NC: SAS Institute Inc., 943 pp.
- SAS Institute Inc. 1989b. SAS/STAT Users Guide: Statistics, Version 6, Fourth Edition, Volume 2. Cary, NC: SAS Institute Inc., 846 pp.
- Schindler, D. 1977. Evaluation of Phosphorus Limitation in Lakes. Science, 195:260-262.
- Shannon, E.E., and Brezonik, P.L. 1972. Relationships Between Lake Trophic State and Nitrogen and Phosphorus Loading Rates. Environmental Science and Technology, 26(8):719-725.
- SPOT User's Handbook. 1989. Reference Manual Volume 1 and 2, Edition 1, Volume 1 (SI/MR/88.0012a). USA SPOT Image Corporation, 1897 Preston White Drive, Reston, VA.
- Sprules, W. G. 1977. Crustacean Zooplankton Communities as Indicators of Limnological Conditions: An Approach Using Principal Components Analysis. J. Fish. Res. Board Can. 34: 962-975.

- Stone, D.L. and B.A. Tschantz. 1991. "Proposed Methodology To Update Embayment Sedimentation Data For TVA Reservoirs". In Proceedings of the 1991 National Conference-Hydraulic Engineering, Hydraulics Division, ASCE, Nashville, TN pp 740-745.
- SURFER. 1990. Surfer Information Manual, Version 4.0, Golden Software, Inc., Golden, CO.
- Tennessee Department of Environment and Conservation (TDEC). 1991. "General Water Criteria and Use Classifications for Surface Waters," Chapters 1200-4-3 and 1200-4-4, Nashville TN, December 1991.
- Tennessee Valley Authority. 1986. Sedimentation in TVA Reservoirs, Report No. 0-6693, TVA, Division of Water Control Planning, Knoxville, TN.
- Tennessee Valley Authority. 1987. Biological Resources Procedures Manual. TVA, Water Resources, Aquatic Biology Department.
- Tennessee Valley Authority. 1989. Laboratory Branch Quality Manual-Water and Wastewater. TVA, Water Resources, Water Quality Department.
- Tennessee Valley Authority. 1990. Engineering Procedures Manual. TVA, System Engineering, Data Systems Department.
- Tennessee Valley Authority. 1991. "Summarized Precipitation Data for the Tennessee River Basin-Above Chattanooga, Below Chattanooga, and Total Basin, 1890-1990." TVA, Water Resources.
- Tennessee Valley Authority. 1992. "Reservoir Water Quality-FY 1992 Workplans, Reservoir Water Quality Management and Water Resources and Ecological Monitoring." TVA, Water Resources, Water Quality Department, Chattanooga TN.
- Thorton, K.W., R.H. Kennedy, J.H. Carroll, W.W. Walker, R.C. Gunkel, and S. Ashby. 1980. "Reservoir Sedimentation and Water Quality - A Heuristic Model". In Proceedings of Symposium on Surface Water Impoundments. ASCE, Minneapolis, MN pp 654-661.
- Unzicker, J. D., and P. H. Carlson. 1982. Ephemeroptera. pp 3.18-3.97. In A. R. Bringham, W. U. Bringham, and A. Gniska, eds. 1982. Aquatic Insecta and Oligochaetes of North and South Carolina. Midwest Aquatic Enterprises. Mahomet, Illinois.

- US Department of Commerce. 1990. "Local Climatological Data-Monthly Summary, October 1989-September 1990, for Asheville, NC; Birmingham, AL; Bristol-Johnson City-Kingsport, TN; Chattanooga, TN; Huntsville, AL; Knoxville, TN; Memphis, TN; and Nashville, TN." National Climatic Data Center, Asheville, NC.
- US Geological Survey. 1977. National Handbook of Recommended Methods for Water Data Acquisition. USGS. Reston, Virginia.
- Vollenweider, R.A. 1975. Input-Output Models with Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol., 37(1):53-84.
- Vollenweider, R.A. 1976. Advances in Defining Critical Loading Levels for Phosphorus in Lake Eutrophication. Mem. Inst. Ital. Idrobiol., 33:53-83.
- Ward, J.H. 1963. Hierarchical Grouping to Optimize an Objective Function. Journal of the American Statistical Association, 58:236-244.
- Wetzell, R. G. 1983. Limnology. W. B. Sanders Co., Philadelphia, 676pp.
- Wilson, W.K. 1991. "Results of Hydroacoustic Estimates of Fish Abundance in Selected Chickamauga Reservoir Embayments," TVA, Water Resources, Aquatic Biology Department, Chattanooga TN.
- Wilson, W.K. 1992. TVA Aquatic Biology Department, Chattanooga, TN, Personal communication, October 1992.
- Wright, J. F., J. H. Blackburn, D. F. Westlake, M. T. Furse, and P. D. Armitage. 1992. Anticipating the Consequences of River Management for the Conservation of Macroinvertebrates. In: River Conservation and Management, P. J. Boon, P. Calow, and G. E. Petts (ed.). John Wiley and Sons, Chichester, UK. pp. 137-149.
- Yurk, J. J., and J. J. Ney. 1989. Phosphorus-Fish Community Biomass Relationships in Southern Appalachian Reservoirs: Can Lakes be Too Clean For Fish? Lake and Reservoir Management 5(2): 83-90.

APPENDICES

APPENDIX A
PHYSICAL/CHEMICAL CHARACTERISTICS OF WATER

Quality Assurance/Quality Control

The Chickamauga Embayment physical/chemical water sampling program incorporated three QA/QC measures. They were: (1.) collection of triplicate sets of samples at each sampling location to assess total overall variability (natural+analytical+collection/handling); (2.) preparation of sample container "blanks" each collection day to assess sample container contamination; and, (3.) preparation of sample filtration "blanks" with each set of filtered samples to assess sample filtration/handling contamination.

Triplicates - On one occasion, water samples at each of the thirty locations were collected and analyzed in triplicate to assess sample collection, analytical, and natural variability. Triplicate data are identified by the remarks codes "D1", "D2", and "D3", respectively, in Appendix A-5, for each individual measurement in a set of triplicates.

For each of the thirty sets of triplicates a standard error ($SE = \text{standard deviation} / \sqrt{3}$) and a coefficient of variation ($CV = \text{standard deviation} / \text{mean}$) were calculated. Using the calculated coefficient's of variation of the 14 laboratory analyzed parameters (table A-1) at 30 sampling locations, a cumulative frequency analysis of the 420 coefficient's of variation was performed. An examination of combined data for the 30 sets of triplicates, for the 14 parameters, revealed that approximately 10% of the triplicate measurements had a coefficient of variation that exceeded 18%. Over half of the triplicate measurements had a coefficient of variation less than or equal to 3% (figure A-1). Looking at the individual parameters (table A-1), color and organic nitrogen triplicates had the greatest coefficient of variation, averaging 13.9% and 11.2%, respectively. Suspended solids and total phosphorus were also relatively high with a coefficient of variation, averaging 10.9% and 10.5%, respectively. With the exception of laboratory pH, total and soluble organic carbon exhibited the smallest

Table A-1.

QUALITY ASSURANCE/QUALITY CONTROL DATA SUMMARY
CHICKAMAUGA EMBAYMENT STUDY, APRIL-SEPTEMBER 1990

TRIPLICATE SAMPLES

Variable	Number of Triplicates	Average Standard Error	Coefficient of Variation (%)	
			Mean	Range
Lab pH	30	0.03 units	0.61	0- 1.5
Alkalinity	30	1.13 mg/l	3.34	0- 9.8
True Color	30	1.33 PCU	13.86	0-35.4
Apparent Color	30	1.20 PCU	9.53	0-30.6
Turbidity	30	0.28 NTU	6.33	0-25.0
Suspended Solids	30	0.31 mg/l	10.86	0-35.4
Organic-Nitrogen	30	0.01 mg/l	11.25	0-33.4
Ammonia-Nitrogen	30	0.00 mg/l	8.59	0-35.4
Nitrite+Nitrate-Nitrogen	30	0.00 mg/l	3.96	0-35.4
Total Phosphorus	30	1.52 µg/l	10.48	0-40.9
Dissolved Ortho Phosphorus	30	0.18 µg/l	6.84	0-28.3
Total Organic Carbon	30	0.03 mg/l	2.44	0- 9.1
Soluble Organic Carbon	30	0.02 mg/l	1.84	0- 4.8
Hardness	30	3.84 mg/l	7.91	0-24.4

CONTAINER BLANK SAMPLES

Variable	Number	Detection Limits		High Value
		(units)	(% exceedance)	
True Color	36	1 PCU	0.0	-
Apparent Color	36	1 PCU	0.0	-
Turbidity	36	1 NTU	0.0	-
Suspended Solids	36	1 mg/l	0.0	1 mg/l
Organic-Nitrogen	36	0.02 mg/l	0.0	0.02 mg/l
Ammonia-Nitrogen	36	0.01 mg/l	8.3	0.02 mg/l
Nitrite+Nitrate-Nitrogen	36	0.01 mg/l	0.0	-
Total Phosphorus	36	2 µg/l	19.4	20 µg/l
Dissolved Ortho Phosphorus	11	2 µg/l	0.0	-
Total Organic Carbon	36	0.2 mg/l	61.1/11.1 ^a	1.4 mg/l
Soluble Organic Carbon	12	0.2 mg/l	75.0/25.0 ^a	9.3 mg/l
Hardness	36	1 mg/l	0.0	-

FILTRATION BLANK SAMPLES

Variable	Number	Detection Limits		High Value
		(units)	(% exceedance)	
Dissolved Ortho Phosphorus	22	2 µg/l	9.1	10 µg/l
Soluble Organic Carbon	19	0.2 mg/l	89.5/52.6 ^a	1.6 mg/l

^aThe first number is the percentage of organic carbon samples exceeding the laboratory detection limit of 0.2 mg/l. The second number is the percentage of organic carbon samples exceeding 0.4 mg/l, which the laboratory considers an action level indicating suspected sample contamination. (See discussion in the text.)

Figure A-1

Coefficients of Variation

coefficients of variation, averaging only 2.4% and 1.8%, respectively. Obviously, each individual water quality parameter has its own inherent naturally occurring variability. In addition, different methods of analysis have varying degrees of precision and accuracy. Improvements in analytical methods and further triplicate data examinations will provide additional insight for understanding and reducing the triplicate data variability in future water quality studies.

Container Blanks - A set of container blanks was collected on each water quality field survey. Container blanks are sample bottles filled in the field with Reagent Grade Type I water and handled in the same manner and analyzed for the same variables as actual reservoir water quality samples. This assesses the degree of contamination associated with the sample bottles and/or the sample handling processes. The raw data for the container blanks are tabulated in Appendix A, and are summarized in table A-1. These results indicate contamination of total phosphorus samples in approximately 19% of the "blank" containers. Table A-1 shows that organic carbon also is frequently detected in "blank" samples. However, because of instrument variability (± 0.1 mg/l) at or near the instrument's operational detection limit of 0.2 mg/l, and the variable quality of reagent grade water used in the field, carbon values equal to or less than 0.4 mg/l have been judged to be indicative of contaminant-free containers. Considering only organic carbon values greater than 0.4 mg/l, about 11% of the total organic carbon and 25% of the soluble organic carbon "blank" containers showed contamination, table A-1.

Filtration Blanks - "Filtration" blanks were prepared with each set of water samples whenever dissolved phosphorus and soluble organic carbon samples were collected. Filtration blanks were prepared in the field by filtering and handling Reagent Grade Type I water in exactly the same manner as the ambient reservoir water was handled and filtered. The filtration blank samples were analyzed for dissolved ortho phosphorus and soluble

organic carbon in the same manner as ambient water quality samples to assess variability due to field sample filtration techniques. The data (table A-1 and Appendix A) show that approximately 9% (2 of 22) of the dissolved ortho phosphorus filtration blank samples had detectable concentrations of phosphorus greater than the laboratory detection limit of 2 $\mu\text{g/l}$. Approximately 53% (10 of 19) of the soluble organic carbon filtration blank samples had detectable concentrations of carbon greater than 0.4 mg/l. This frequency of detection for "filtration" blank dissolved ortho phosphorus (9%) and soluble organic carbon (53%) is significantly higher than the frequency of detection for "container" blank dissolved ortho phosphorus (0%) and soluble organic carbon (25%), indicating a measurable filtration contamination problem.

Further, a comparison of the laboratory analyses performed on the paired samples for total and soluble organic carbon showed that in approximately 12% of the samples, soluble concentrations were higher than total. A similar comparison of total with dissolved ortho phosphorus concentrations revealed that in less than 1% of the samples, the dissolved concentrations exceeded the total concentrations. [In this report, for the purposes of data analysis and interpretation, in those few cases where the dissolved (or soluble) concentration was greater than the total, the dissolved concentration was set equal to the total concentration.]

Because these filtration contamination anomalies were infrequent and did not occur at all reservoir monitoring locations, we suspect this to be a result of a variable quality Reagent Grade Type I water and/or poor field handling or filtration technique. Improvements which are recommended (and to a large extent have already been implemented) include:

- (1.) an improved treatment system for the Reagent Grade Type I water with reverse osmosis pretreatment;
- (2.) a better grade of sample container be used for soluble organic carbon sample collections;
- (3.) ambient water collected for subsequent

filtrations for soluble organic carbon and/or dissolved ortho phosphorus be collected in appropriately cleaned glass containers rather than the plastic quart cubitainers which could be a potential source of organic carbon (and phosphorus) contamination; and (4.) organic carbon filtrations be performed using only a dichromate cleaned glass filtration apparatus with ground glass fittings rather than (as has been used in the past) a stainless steel and glass filtration apparatus with rubber fittings.

Because of the low frequency of occurrence of sample and filtration blank contamination and the low concentration levels when contamination was detected, ambient water quality data were not corrected for any background or blank contamination.

STORET RETRIEVAL DATE 91/12/16
CHICKAMAUGA EMBAYMENT STUDY
FINAL REPORT
WY90

PGM=RET

CHICK90
35 06 26.0 085 12 20.0 2
CHICKAMAUGA EMBAYMENTS - SEE DESCRIPTIVE PARAGRAPH
47065 TENNESSEE HAMILTON
TENNESSEE RIVER BASIN 040804
BLANK DATA
131TVAC 900505 06020001
0000 FEET DEPTH

/TYPA/AMBNT/STREAM

DATA LOCKED FOR 270 DAYS.

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS	00530 RESIDUE TOT NFLT MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	84129 DATA QUALITY
90/04/09	1000	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.2K	.3J	1K	1.0K	CONTR
90/04/09	1005	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.2K	.2	1K	1.0K	CONTR
90/04/10	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.020J	.002K	.2K	.6J	1K	1.0K	CONTR
90/04/11	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.2K	.3J	1K	1.0K	CONTR
90/04/11	1000	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.2K	9.3J	1K	1.0K	CONTR
90/04/12	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.2	.4J	1K	1.0K	CONTR
90/05/08	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.2K		1K	1.0K	CONTR
90/05/08	0905	WATER		1K	1K	1K	.020K	.010	.01K	.002K		.2K		1K	1.0K	CONTR
90/05/09	0900	WATER		1K	1K	1K	.020	.010K	.01K	.002K		.4		1K	1.0K	CONTR
90/05/09	0905	WATER		1K	1K	1K	.020	.010K	.01K	.002K		.3		1K	1.0K	CONTR
90/05/10	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.2		1K	1.0K	CONTR
90/05/10	0905	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.2K		1K	1.0K	CONTR
90/06/12	1030	WATER		1K	1K	1K	.020K	.010	.01K	.002	.002K	.3	.2	1K	1.0K	CONTR
90/06/12	1035	WATER		1K	1K	1K	.020K	.010K	.01K	.002		.2		1K	1.0K	CONTR
90/06/13	1000	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.2K	.2	1K	1.0K	CONTR
90/06/13	1005	WATER		1K	1K	1K	.020K	.010K	.01K	.003	.002K	.2K		1K	1.0K	CONTR
90/06/14	1300	WATER		1K	1K	1K	.020K	.010K	.01K	.020	.002K	.3	.4	1K	1.0K	CONTR
90/06/14	1305	WATER		1K	1K	1K	.020K	.010K	.01K	.003		.3		1K	1.0K	CONTR
90/07/10	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.5		1K	1.0K	CONTR
90/07/10	0905	WATER		1K	1K	1K	.020K	.010K	.01K	.003		.5		1K	1.0K	CONTR
90/07/11	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.3		1K	1.0K	CONTR
90/07/11	0905	WATER		1K	1K	1K	.020	.020	.01K	.002K		.3		1K	1.0K	CONTR
90/07/12	1100	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.2K		1K	1.0K	CONTR
90/07/12	1105	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.4		1K	1.0K	CONTR
90/08/14	0830	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.3		1K	1.0K	CONTR
90/08/14	1030	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.3		1K	1.0K	CONTR
90/08/15	0830	WATER		1K	1K	1K	.020K	.010K	.01K	.010		.4		1K	1.0K	CONTR
90/08/15	1030	WATER		1K	1K	1K	.020K	.010K	.01K	.010		.3		1K	1.0K	CONTR
90/08/16	0830	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.4		1K	1.0K	CONTR
90/08/16	1030	WATER		1K	1K	1K	.020K	.010K	.01K	.002K	.002K	.4		1K	1.0K	CONTR
90/09/11	0900	WATER		1K	1K	1K	.020	.020	.01K	.002K		1.4J		1K	1.0K	CONTR
90/09/11	0910	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		1.4J	1.4J	1K	1.0K	CONTR
90/09/12	0900	WATER		1K	1K	1K	.020K	.010K	.01K	.002K		.4		1K	1.0K	CONTR
90/09/12	0910	WATER		1K	1K	1	.020K	.010K	.01K	.002K		.4	.4	1K	1.0K	CONTR
90/09/13	0900	WATER		1K	1K	1K	.020K	.010	.01K	.002K		.4		1K	1.0K	CONTR
90/09/13	0910	WATER		1K	1K	1K	.020	.010K	.01K	.002K		.3	.3	1K	1.0K	CONTR

STORET RETRIEVAL DATE 91/12/16
CHICKMAUGA EMBAYMENT STUDY
FINAL REPORT
WY90

PGM=RET

CHICK90
35 06 26.0 085 12 20.0 2
CHICKAMAUGA EMBAYMENTS - SEE DESCRIPTIVE PARAGRAPH
47065 TENNESSEE HAMILTON
TENNESSEE RIVER BASIN 040804
BLANK DATA
131TVAC 900505 06020001
0000 FEET DEPTH

/TYPA/AMBNT/STREAM

DATA LOCKED FOR 270 DAYS.

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00671 PHOS-DIS ORTHO MG/L P	00681 D ORG C C MG/L	84129 DATA QUALITY
90/04/09	1100	WATER		.003	.8J	FILT
90/04/09	1105	WATER		.002K	.6J	FILT
90/04/10	1000	WATER		.002	.7J	FILT
90/04/10	1100	WATER		.002K	.8J	FILT
90/04/11	1100	WATER		.010	.4	FILT
90/04/11	1200	WATER		.002K	.8J	FILT
90/04/12	1000	WATER		.002	.7J	FILT
90/05/08	1100	WATER		.002K		FILT
90/05/09	1130	WATER		.002K		FILT
90/05/10	1130	WATER		.002K		FILT
90/06/12	1040	WATER		.002K	.4	FILT
90/06/12	1045	WATER		.002K	.2	FILT
90/07/12	1110	WATER		.002K	.2	FILT
90/08/14	0835	WATER		.002K	.4	FILT
90/08/15	0835	WATER		.002K	.4	FILT
90/08/16	0835	WATER		.002K	.4	FILT
90/09/11	0905	WATER		.002K	1.6J	FILT
90/09/11	0915	WATER		.002K	1.4J	FILT
90/09/12	0905	WATER		.002K	.6J	FILT
90/09/12	0915	WATER		.002K	.5J	FILT
90/09/13	0905	WATER		.002K	.4	FILT
90/09/13	0915	WATER		.002K	.4	FILT

STORET RETRIEVAL DATE 92/10/16
 475358 1017
 35 06 26.0 085 12 20.0 2
 CHICKAMAUGA RES. AT LIGHTED BUOY
 47065 TENNESSEE HAMILTON
 TENNESSEE RIVER BASIN 040801
 TENNESSEE RIVER 472.3
 131TVAC
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

06020001021 0000.710 ON

A-10

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICRONHO	DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICRONHO
90/04/11	1229	WATER	0.5	14.4	10.7	102.9%	7.9	121	90/06/14	0742	WATER	1	25.6	8.3	101.2%	7.8	162
90/04/11	1231	WATER	1	14.4	10.5	101.0%	7.9	122	90/06/14	0744	WATER	1.5	25.6	8.2	100.0%	7.8	162
90/04/11	1234	WATER	1.5	14.3	10.4	100.0%	7.8	121	90/06/14	0746	WATER	2	25.6	8.2	100.0%	7.8	162
90/04/11	1236	WATER	2	14.3	10.2	98.1%	7.8	121	90/06/14	0747	WATER	2.5	25.6	8.1	98.8%	7.7	162
90/04/11	1238	WATER	2.5	14.2	10.1	97.1%	7.8	121	90/06/14	0748	WATER	3	25.6	8.0	97.6%	7.7	162
90/04/11	1240	WATER	3	14.2	10.0	96.2%	7.8	121	90/06/14	0749	WATER	4	25.6	7.7	93.9%	7.8	162
90/04/11	1242	WATER	4	14.2	9.9	95.2%	7.8	120	90/06/14	0750	WATER	5	25.3	7.2	85.7%	7.4	162
90/04/11	1244	WATER	5	14.2	9.9	95.2%	7.7	121	90/06/14	0751	WATER	6	25.2	7.1	84.5%	7.4	162
90/04/11	1246	WATER	6	14.3	9.8	94.2%	7.7	121	90/06/14	0752	WATER	7	25.1	6.9	82.1%	7.4	162
90/04/11	1248	WATER	7	14.3	9.8	94.2%	7.7	120	90/06/14	0753	WATER	8	25.0	6.9	82.1%	7.4	162
90/04/11	1250	WATER	8	14.3	9.8	94.2%	7.7	120	90/06/14	0754	WATER	9	25.0	6.8	81.0%	7.3	162
90/04/11	1252	WATER	9	14.3	9.8	94.2%	7.7	120	90/06/14	0755	WATER	10	24.9	6.6	78.6%	7.3	161
90/04/11	1254	WATER	10	14.3	9.7	93.3%	7.7	120	90/06/14	0756	WATER	11	24.9	6.3	75.0%	7.2	161
90/04/11	1256	WATER	12	14.3	9.7	93.3%	7.7	121	90/06/14	0757	WATER	12	24.8	6.3	75.0%	7.2	161
90/04/11	1258	WATER	14	14.3	9.7	93.3%	7.7	120	90/06/14	0758	WATER	13	24.8	6.2	73.8%	7.2	161
90/04/11	1300	WATER	16	14.3	9.7	93.3%	7.7	120	90/06/14	0759	WATER	14	24.8	6.2	73.8%	7.2	162
90/04/11	1302	WATER	17	14.3	9.6	92.3%	7.7	119	90/06/14	0800	WATER	15	24.8	6.1	72.6%	7.2	160
90/05/10	1014	WATER	0.5	19.0	8.5	90.4%	7.5	134	90/06/14	0801	WATER	16	24.8	6.0	71.4%	7.2	160
90/05/10	1017	WATER	1	19.0	8.4	89.4%	7.5	134	90/06/14	0802	WATER	17	24.8	6.0	71.4%	7.2	159
90/05/10	1020	WATER	1.5	19.0	8.3	88.3%	7.5	134	90/06/14	0803	WATER	17.5	24.7	5.7	67.9%	7.1	158
90/05/10	1021	WATER	2	19.0	8.2	87.2%	7.5	134	90/07/12	1122	WATER	0.5	28.7	6.7	85.9%	7.6	173
90/05/10	1022	WATER	2.5	19.0	8.1	86.2%	7.5	134	90/07/12	1125	WATER	1	28.7	6.7	85.9%	7.6	173
90/05/10	1023	WATER	3	19.0	8.1	86.2%	7.5	134	90/07/12	1128	WATER	1.5	28.7	6.6	84.6%	7.6	173
90/05/10	1024	WATER	4	19.0	8.0	85.1%	7.5	134	90/07/12	1129	WATER	2	28.7	6.6	84.6%	7.6	173
90/05/10	1025	WATER	5	19.1	8.0	85.1%	7.4	134	90/07/12	1130	WATER	2.5	28.7	6.6	84.6%	7.6	173
90/05/10	1026	WATER	6	19.1	8.0	85.1%	7.4	134	90/07/12	1131	WATER	3	28.7	6.5	83.3%	7.6	173
90/05/10	1027	WATER	7	19.1	8.0	85.1%	7.4	134	90/07/12	1132	WATER	4	28.7	6.5	83.3%	7.6	173
90/05/10	1028	WATER	8	19.1	8.0	85.1%	7.4	134	90/07/12	1133	WATER	5	28.7	6.4	82.1%	7.6	173
90/05/10	1029	WATER	9	19.1	7.9	84.0%	7.3	136	90/07/12	1134	WATER	6	28.7	6.3	80.8%	7.6	174
90/05/10	1030	WATER	10	19.0	7.9	84.0%	7.3	134	90/07/12	1135	WATER	7	28.6	6.3	80.8%	7.6	173
90/05/10	1031	WATER	11	19.0	7.8	83.0%	7.3	134	90/07/12	1136	WATER	8	28.6	6.3	80.8%	7.6	174
90/05/10	1032	WATER	12	19.0	7.7	81.9%	7.3	134	90/07/12	1137	WATER	9	28.5	5.4	68.4%	7.6	175
90/05/10	1033	WATER	13	19.0	7.7	81.9%	7.3	134	90/07/12	1138	WATER	10	28.2	5.0	63.3%	7.5	174
90/05/10	1034	WATER	14	19.0	7.7	81.9%	7.3	133	90/07/12	1139	WATER	11	28.1	4.6	58.2%	7.4	174
90/05/10	1035	WATER	15	19.0	7.7	81.9%	7.3	133	90/07/12	1140	WATER	12	27.8	4.2	53.2%	7.4	174
90/05/10	1036	WATER	16	19.0	7.7	81.9%	7.3	133	90/07/12	1141	WATER	13	27.7	3.8	48.1%	7.3	174
90/05/10	1037	WATER	17	19.2	7.6	80.9%	7.2	133	90/07/12	1142	WATER	14	27.6	3.6	45.6%	7.3	174
90/05/10	1038	WATER	17.5	19.0	7.6	80.9%	7.2	131	90/07/12	1143	WATER	15	27.6	3.5	44.3%	7.3	173
90/06/14	0740	WATER	0.5	25.6	8.4	102.4%	7.8	162	90/07/12	1144	WATER	16	27.5	3.1	38.3%	7.2	173

STORET RETRIEVAL DATE 92/10/16
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 CHICKAMAUGA RES. AT LIGHTED BUOY
 47065 TENNESSEE HAMILTON
 TENNESSEE RIVER BASIN 040801
 TENNESSEE RIVER 472.3
 131TVAC
 0000 METERS DEPTH

PGM=RET

/TYPA/ANBNT/STREAM/SOLIDS

06020001021 0000.710 ON

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1209	WATER	0.5	1.02	10K								
90/04/11	1231	WATER	1				7.6	44	65	11.0	6	10	25
90/05/10	1014	WATER	0.5	1.10	10K								
90/05/10	1017	WATER	1			D1	7.5	46	59	6.5	6	30	32
90/05/10	1018	WATER	1			D2	7.6	46	63	8.0	6	25	32
90/05/10	1019	WATER	1			D3	7.5	46	57	5.0	4	20	23
90/06/14	0740	WATER	0.5	1.50	10K								
90/06/14	0742	WATER	1				7.6	60	78	5.0	5	20	25
90/07/12	1122	WATER	0.5	1.33	10K								
90/07/12	1125	WATER	1				7.8	70	99	5.0	3	15	20
90/08/16	1022	WATER	0.5	1.22	10K								
90/08/16	1025	WATER	1				7.8	62	83	5.0	3	10	15
90/09/13	1017	WATER	0.5	1.82	10K								
90/09/13	1019	WATER	1				7.6	67	97	3.0	2	5	7

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00688 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2+NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/11	1231	WATER	1		1.7	1.7J	.24	.01K	.31	.030	.005	
90/04/19	1200	WATER	1									4
90/05/10	1017	WATER	1	D1	1.8	1.6	.14	.02	.24	.020	.007	
90/05/10	1018	WATER	1	D2	1.9	1.7	.14	.02	.24	.020	.007	
90/05/10	1019	WATER	1	D3	1.8	1.8	.07	.04	.24	.020	.009	
90/05/11	1200	WATER	1									9
90/05/29	1200	WATER	1									7
90/06/12	1200	WATER	1									7
90/06/14	0742	WATER	1		1.9	1.8	.16	.01K	.14	.002	.002	
90/06/27	1200	WATER	1									5
90/07/10	1200	WATER	1									17
90/07/12	1125	WATER	1		2.0	2.0	.02K	.01K	.16	.030	.005	
90/07/30	1200	WATER	1									11
90/08/13	1200	WATER	1									10
90/08/16	1025	WATER	1		1.8	1.8	.20	.01K	.18	.020	.003	
90/08/28	1200	WATER	1									13
90/09/13	1019	WATER	1		1.9	1.9	.18	.04	.14	.020	.008	

STORET RETRIEVAL DATE 92/10/16

PGM=RET

475302 1026

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CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040801

TENNESSEE RIVER 478.19

131TVAC

HQ 06020001030 0000.450 OFF

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/11	1120	WATER	0.5	13.9	10.3	99.08	7.8	123	90/06/14	0820	WATER	0.5	25.8	8.9	108.58	8.1	162
90/04/11	1122	WATER	1	13.9	10.2	98.18	7.8	124	90/06/14	0822	WATER	1	25.8	8.7	106.18	8.0	162
90/04/11	1125	WATER	1.5	13.9	10.1	97.18	7.7	124	90/06/14	0825	WATER	1.5	25.8	8.5	103.78	7.9	163
90/04/11	1127	WATER	2	13.9	10.1	97.18	7.8	124	90/06/14	0826	WATER	2	25.6	8.0	97.68	7.6	163
90/04/11	1129	WATER	2.5	13.9	10.3	99.08	7.8	124	90/06/14	0827	WATER	2.5	25.5	7.9	94.08	7.6	164
90/04/11	1131	WATER	3	13.9	10.5	101.08	7.8	122	90/06/14	0828	WATER	3	25.5	7.9	94.08	7.6	164
90/04/11	1133	WATER	4	13.9	10.3	99.08	7.8	124	90/06/14	0829	WATER	4	25.5	7.8	92.98	7.6	164
90/04/11	1135	WATER	5	14.0	10.0	96.28	7.8	123	90/06/14	0830	WATER	5	25.3	7.6	90.58	7.5	164
90/04/11	1137	WATER	6	14.0	9.9	95.28	7.8	124	90/06/14	0831	WATER	6	25.1	7.4	88.18	7.5	164
90/04/11	1139	WATER	7	14.0	9.9	95.28	7.8	122	90/06/14	0832	WATER	7	25.0	7.2	85.78	7.4	164
90/04/11	1141	WATER	8	14.0	9.9	95.28	7.8	122	90/06/14	0833	WATER	8	24.8	6.9	82.18	7.3	163
90/04/11	1143	WATER	9	14.0	9.9	95.28	7.8	122	90/06/14	0834	WATER	9	24.6	6.8	81.08	7.3	164
90/04/11	1145	WATER	10	14.0	9.9	95.28	7.8	122	90/06/14	0835	WATER	10	24.5	6.8	80.08	7.3	163
90/04/11	1147	WATER	12	14.0	9.9	95.28	7.8	122	90/06/14	0836	WATER	11	24.5	6.6	77.68	7.3	163
90/04/11	1149	WATER	14	14.0	9.8	94.28	7.8	123	90/06/14	0837	WATER	12	24.4	6.6	77.68	7.3	163
90/04/11	1151	WATER	16	14.0	9.8	94.28	7.7	122	90/06/14	0838	WATER	13	24.4	6.5	76.58	7.3	163
90/04/11	1153	WATER	17.5	14.0	9.8	94.28	7.7	122	90/06/14	0839	WATER	14	24.4	6.4	75.38	7.2	162
90/05/10	1102	WATER	0.5	19.2	8.9	94.78	7.7	136	90/06/14	0840	WATER	15	24.4	6.3	74.18	7.2	163
90/05/10	1105	WATER	1	19.2	8.7	92.68	7.7	136	90/06/14	0841	WATER	16	24.3	6.2	72.98	7.2	163
90/05/10	1108	WATER	1.5	19.2	8.6	91.58	7.7	136	90/06/14	0842	WATER	17	24.2	5.8	68.28	7.2	163
90/05/10	1109	WATER	2	19.3	8.5	90.48	7.7	136	90/06/14	0843	WATER	17.3	24.1	5.4	63.58	7.1	164
90/05/10	1110	WATER	2.5	19.2	8.4	89.48	7.6	136	90/06/14	0844	WATER	18	23.9	4.7	55.38	7.1	165
90/05/10	1111	WATER	3	19.2	8.4	89.48	7.6	136	90/06/14	0845	WATER	19	23.7	4.1	48.28	7.0	166
90/05/10	1112	WATER	4	19.0	8.1	86.28	7.5	134	90/07/12	0910	WATER	0.5	28.2	6.3	79.78	7.8	173
90/05/10	1113	WATER	5	18.9	8.1	86.28	7.5	134	90/07/12	0913	WATER	1	28.2	6.2	78.58	7.7	173
90/05/10	1114	WATER	6	18.8	8.0	85.18	7.4	133	90/07/12	0916	WATER	1.5	28.2	6.1	77.28	7.7	173
90/05/10	1115	WATER	7	18.7	8.0	85.18	7.4	133	90/07/12	0917	WATER	2	28.2	6.1	77.28	7.7	174
90/05/10	1116	WATER	8	18.8	8.0	85.18	7.4	134	90/07/12	0918	WATER	2.5	28.2	6.0	75.98	7.7	174
90/05/10	1117	WATER	9	18.8	7.9	84.08	7.4	133	90/07/12	0919	WATER	3	28.2	6.0	75.98	7.6	174
90/05/10	1118	WATER	10	18.7	7.9	84.08	7.3	131	90/07/12	0920	WATER	4	28.2	5.9	74.78	7.6	174
90/05/10	1120	WATER	11	18.7	7.7	81.98	7.3	132	90/07/12	0921	WATER	5	28.2	5.8	73.48	7.6	174
90/05/10	1122	WATER	12	18.6	7.7	81.98	7.3	132	90/07/12	0922	WATER	6	28.2	5.8	73.48	7.6	174
90/05/10	1124	WATER	13	18.6	7.7	81.98	7.3	132	90/07/12	0922	WATER	7	28.1	5.7	72.28	7.6	175
90/05/10	1126	WATER	14	18.6	7.7	81.98	7.3	133	90/07/12	0923	WATER	8	28.1	5.6	70.98	7.6	174
90/05/10	1128	WATER	15	18.6	7.6	80.98	7.2	132	90/07/12	0923	WATER	9	28.1	5.5	69.68	7.5	175
90/05/10	1130	WATER	16	18.6	7.6	80.98	7.2	132	90/07/12	0924	WATER	10	28.0	5.4	68.48	7.5	175
90/05/10	1132	WATER	17	18.6	7.6	80.98	7.2	132	90/07/12	0925	WATER	11	27.8	5.2	65.88	7.5	176
90/05/10	1134	WATER	18	18.6	7.6	80.98	7.2	130	90/07/12	0926	WATER	12	27.5	4.8	59.38	7.5	176
90/05/10	1136	WATER	18.5	18.6	7.5	79.88	7.2	132	90/07/12	0927	WATER	13	27.5	4.7	58.08	7.4	176

STORET RETRIEVAL DATE 92/10/16

475302 1026

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CHICKAMAUGA RESERVOIR

47065 TENNESSEE

TENNESSEE RIVER BASIN

TENNESSEE RIVER 478.19

131TVAC

0000 METERS DEPTH

PGM=RET

HAMILTON

040801

HQ 06020001030 0000.450 OFF

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1120	WATER	0.5	1.08	20								
90/04/11	1122	WATER	1										
90/05/10	1102	WATER	0.5	.83	10K		7.8	44	59	12.0	9	15	25
90/05/10	1105	WATER	1										
90/06/14	0820	WATER	0.5	1.50	10K	D1	7.6	48	96	5.0	3	20	28
90/06/14	0821	WATER	0.5		10K	D2							
90/06/14	0822	WATER	0.5		10K	D3							
90/06/14	0822	WATER	1			D1	7.9	68	120	4.0	3	25	28
90/06/14	0823	WATER	1			D2	7.8		120	4.0	3	20	25
90/06/14	0824	WATER	1			D3	7.8	61		4.0		20	28
90/07/12	0910	WATER	0.5	1.27	10								
90/07/12	0913	WATER	1				7.8	69	91	5.0	3	20	25
90/08/15	0942	WATER	0.5	.78	10K								
90/08/15	0945	WATER	1				8.0	64	89	3.0	3	10	15
90/09/13	0756	WATER	0.5	1.27	10K								
90/09/13	0758	WATER	1				7.7	67	99	3.0	3	2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHOP MG/L P	32211 CHLORPHYL A UG/L CORRECTO
90/04/04	1200	WATER	1									4
90/04/11	1122	WATER	1									
90/04/19	1200	WATER	1		1.7	2.0J	.20	.01K	.30	.030	.005	6
90/05/10	1105	WATER	1		2.0	1.8	.18	.02	.21	.030	.009	5
90/05/11	1200	WATER	1									7
90/05/29	1200	WATER	1									9
90/06/12	1200	WATER	1									
90/06/14	0820	WATER	0.5	D1								
90/06/14	0821	WATER	0.5	D2								
90/06/14	0822	WATER	0.5	D3								
90/06/14	0822	WATER	1	D1	2.2	1.9	.18	.01K	.13	.020	.003	
90/06/14	0823	WATER	1	D2	2.2	1.9	.22	.01K	.13	.020	.002	
90/06/14	0824	WATER	1	D3	2.2	1.9	.16	.01K	.13	.020	.003	
90/06/27	1200	WATER	1									5
90/07/10	1200	WATER	1									14
90/07/12	0913	WATER	1		2.2	2.0	.32	.02	.17	.030	.004	14
90/07/30	1200	WATER	1									9
90/08/13	1200	WATER	1									
90/08/15	0945	WATER	1		2.0	1.9	.24	.01K	.09	.010	.004	14
90/08/28	1200	WATER	1									
90/09/13	0758	WATER	1		2.1	1.9	.13	.03	.16	.020	.010	

STORET RETRIEVAL DATE 92/10/16

PGM=RET

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CHICKAMAUGA RESERVOIR

47065 TENNESSEE HAMILTON

TENNESSEE RIVER BASIN 040801

TENNESSEE RIVER 490.47

131TVAC

06020001025 0005.740 ON

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

A-16

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/10	0830	WATER	0.5	13.5	11.5	108.5%	7.7	126	90/06/13	0914	WATER	10	23.2	6.3	72.4%	7.3	170
90/04/10	0832	WATER	1	13.5	11.3	106.6%	7.6	126	90/06/13	0915	WATER	10.5	23.2	6.3	72.4%	7.3	170
90/04/10	0835	WATER	1.5	13.4	11.1	104.7%	7.6	127	90/07/10	0903	WATER	0.5	27.2	7.3	90.1%	8.1	189
90/04/10	0837	WATER	2	13.4	11.0	103.8%	7.6	127	90/07/10	0906	WATER	1	27.2	7.9	97.5%	8.1	189
90/04/10	0839	WATER	2.5	13.4	10.9	102.8%	7.5	127	90/07/10	0909	WATER	1.5	27.2	7.8	96.3%	8.1	190
90/04/10	0841	WATER	3	13.4	10.8	101.9%	7.5	127	90/07/10	0910	WATER	2	27.2	7.8	96.3%	8.1	192
90/04/10	0843	WATER	4	13.4	10.7	100.9%	7.5	126	90/07/10	0911	WATER	2.5	27.2	7.7	95.1%	8.1	194
90/04/10	0845	WATER	5	13.4	10.7	100.9%	7.5	127	90/07/10	0912	WATER	3	27.2	7.7	95.1%	8.0	195
90/04/10	0847	WATER	6	13.4	10.6	100.0%	7.5	126	90/07/10	0913	WATER	4	27.1	7.2	88.9%	8.0	198
90/04/10	0849	WATER	7	13.4	10.6	100.0%	7.5	126	90/07/10	0914	WATER	4.3	27.0	6.2	76.5%	7.2	200
90/04/10	0852	WATER	8	13.4	10.5	99.1%	7.5	126	90/07/10	0914	WATER	4.6	26.3	5.0	61.0%	7.6	201
90/04/10	0855	WATER	9	13.4	10.5	99.1%	7.5	125	90/07/10	0915	WATER	5	26.0	4.3	52.4%	7.5	201
90/04/10	0858	WATER	9.5	13.4	10.4	98.1%	7.5	126	90/07/10	0915	WATER	6	25.7	3.7	45.1%	7.4	202
90/05/09	0812	WATER	0.5	18.5	8.7	91.6%	7.6	133	90/07/10	0916	WATER	7	25.5	3.4	40.5%	7.4	204
90/05/09	0815	WATER	1	18.5	8.4	88.4%	7.6	133	90/07/10	0916	WATER	8	25.5	3.2	38.1%	7.4	207
90/05/09	0818	WATER	1.5	18.5	8.3	87.4%	7.5	133	90/07/10	0917	WATER	9	25.4	3.1	36.9%	7.3	212
90/05/09	0819	WATER	2	18.5	8.2	86.3%	7.5	133	90/07/10	0917	WATER	10	25.4	2.9	34.5%	7.3	214
90/05/09	0820	WATER	2.5	18.4	8.1	85.3%	7.5	133	90/08/14	1000	WATER	0.5	26.2	6.8	82.9%	7.7	172
90/05/09	0821	WATER	3	18.4	8.0	84.2%	7.4	133	90/08/14	1003	WATER	1	26.2	6.6	80.5%	7.7	172
90/05/09	0822	WATER	4	18.2	7.7	81.1%	7.4	133	90/08/14	1006	WATER	1.5	26.1	6.2	75.6%	7.6	173
90/05/09	0823	WATER	5	18.0	7.6	80.0%	7.4	133	90/08/14	1007	WATER	2	26.1	6.0	73.2%	7.5	173
90/05/09	0824	WATER	6	17.9	7.5	78.9%	7.3	133	90/08/14	1007	WATER	3	26.0	5.7	69.5%	7.4	174
90/05/09	0825	WATER	7	17.8	7.5	78.9%	7.3	132	90/08/14	1007	WATER	4	26.0	5.6	68.3%	7.4	174
90/05/09	0826	WATER	8	17.7	7.4	77.9%	7.3	133	90/08/14	1008	WATER	5	26.0	5.5	67.1%	7.3	174
90/05/09	0827	WATER	9	17.6	7.4	77.9%	7.3	133	90/08/14	1008	WATER	6	26.0	5.5	67.1%	7.3	174
90/05/09	0830	WATER	10	17.6	7.4	77.9%	7.3	132	90/08/14	1008	WATER	7	26.0	5.4	65.9%	7.2	174
90/05/09	0833	WATER	10.5	17.4	7.2	74.2%	7.2	133	90/08/14	1009	WATER	8	26.0	5.4	65.9%	7.2	174
90/06/13	0900	WATER	0.5	23.8	8.8	103.5%	7.8	168	90/08/14	1010	WATER	9	26.0	5.4	65.9%	7.2	175
90/06/13	0902	WATER	1	23.8	8.6	101.2%	7.8	168	90/08/14	1011	WATER	10	26.0	5.4	65.9%	7.1	175
90/06/13	0904	WATER	1.5	23.8	8.4	98.8%	7.7	168	90/09/12	0756	WATER	0.5	26.4	5.5	67.1%	7.4	188
90/06/13	0905	WATER	2	23.7	8.2	96.5%	7.7	168	90/09/12	0758	WATER	1	26.4	5.3	64.6%	7.3	188
90/06/13	0906	WATER	2.5	23.7	8.1	95.3%	7.7	169	90/09/12	0800	WATER	1.5	26.4	5.2	63.4%	7.3	188
90/06/13	0907	WATER	3	23.7	7.9	92.9%	7.6	169	90/09/12	0801	WATER	2	26.4	5.1	62.2%	7.3	188
90/06/13	0908	WATER	4	23.4	6.9	79.3%	7.4	170	90/09/12	0801	WATER	3	26.4	5.0	61.0%	7.2	188
90/06/13	0909	WATER	5	23.2	6.7	77.0%	7.4	170	90/09/12	0802	WATER	4	26.4	5.0	61.0%	7.2	188
90/06/13	0910	WATER	6	23.2	6.6	75.9%	7.3	169	90/09/12	0802	WATER	5	26.5	4.9	59.8%	7.1	187
90/06/13	0911	WATER	7	23.2	6.5	74.7%	7.3	170	90/09/12	0803	WATER	6	26.5	4.9	59.8%	7.1	188
90/06/13	0912	WATER	8	23.2	6.5	74.7%	7.3	170	90/09/12	0803	WATER	7	26.5	4.8	58.5%	7.0	187
90/06/13	0913	WATER	9	23.2	6.4	73.6%	7.3	170	90/09/12	0804	WATER	8	26.5	4.7	57.3%	7.0	187

STORET RETRIEVAL DATE 92/10/16

PGM=RET

475265 1053

35 18 00.0 085 04 33.0 2

CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040801

TENNESSEE RIVER 490.47

/TYP/AMBNT/STREAM/SOLIDS

131TVAC

06020001025 0005.740 ON

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT HFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	0830	WATER	0.5	.83	10K								
90/04/10	0832	WATER	1				7.4	42	59	9.4	5	15	20
90/05/09	0812	WATER	0.5	1.00	20								
90/05/09	0815	WATER	1				7.4	48	65	4.0	2	25	32
90/06/13	0900	WATER	0.5	1.00	10K								
90/06/13	0902	WATER	1				7.7	41	72	5.0	4	20	25
90/07/10	0903	WATER	0.5	1.25	10K								
90/07/10	0906	WATER	1				8.0	67	91	4.0	3	15	20
90/08/14	1000	WATER	0.5	1.27	10K	D1							
90/08/14	1001	WATER	0.5		10K	D2							
90/08/14	1002	WATER	0.5		10K	D3							
90/08/14	1003	WATER	1			D1	7.8	64	85	3.0	3	3	5
90/08/14	1004	WATER	1			D2	7.7	64	85	5.0	4	3	5
90/08/14	1005	WATER	1			D3	7.8	62	89		3	3	5
90/09/12	0756	WATER	0.5	1.22	10K								
90/09/12	0758	WATER	1				7.6	69	91	3.0	4	5	7

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2+NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/05	1200	WATER	1									5
90/04/10	0832	WATER	1		1.5	3.6J	.15	.03	.32	.020	.009	
90/04/19	1200	WATER	1									10
90/05/09	0815	WATER	1		2.0	1.9	.16	.02	.28	.020	.009	
90/05/11	1200	WATER	1									4
90/05/30	1200	WATER	1									8
90/06/12	1200	WATER	1									28
90/06/13	0902	WATER	1		2.1	1.9	.16	.01K	.21	.020	.002K	
90/06/27	1200	WATER	1									10
90/07/10	0906	WATER	1		2.3	2.0	.26	.01K	.14	.030	.004	14
90/07/30	1200	WATER	1									11
90/08/13	1200	WATER	1									7
90/08/14	1000	WATER	0.5	D1								
90/08/14	1001	WATER	0.5	D2								
90/08/14	1002	WATER	0.5	D3								
90/08/14	1003	WATER	1	D1	2.0	2.1	.21	.01	.20	.020	.007	
90/08/14	1004	WATER	1	D2	2.1	2.0	.22	.01K	.20	.030	.009	
90/08/14	1005	WATER	1	D3	2.1	2.0	.22	.01K	.20	.020	.009	
90/08/28	1200	WATER	1									6
90/09/12	0758	WATER	1		2.0	1.9	.14	.06	.19	.030	.020	

PGM=RET

475266 1062

35 22 34.0 085 01 56.0 2

CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040801

TENNESSEE RIVER 496.50

06020001024 0009.790 ON

/TYPA/AMBNT/STREAM/SOLIDS

131TVAC

0000 METERS DEPTH

A-18

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/09	1126	WATER	0.5	12.8	10.0	94.3%	7.7	127	90/07/11	0838	WATER	1	26.0	4.1	50.0%	7.4	194
90/04/09	1128	WATER	1	12.6	9.9	93.4%	7.7	126	90/07/11	0841	WATER	1.5	26.0	4.1	50.0%	7.4	194
90/04/09	1130	WATER	1.5	12.6	9.8	92.5%	7.7	127	90/07/11	0842	WATER	2	26.0	4.0	48.8%	7.4	194
90/04/09	1132	WATER	2	12.5	9.8	90.7%	7.7	127	90/07/11	0842	WATER	2.5	25.9	3.9	47.6%	7.4	196
90/04/09	1134	WATER	2.5	12.5	9.7	89.8%	7.7	127	90/07/11	0843	WATER	3	25.9	3.9	47.6%	7.4	196
90/04/09	1136	WATER	3	12.4	9.7	89.8%	7.7	128	90/07/11	0843	WATER	4	25.9	3.7	45.1%	7.4	196
90/04/09	1138	WATER	4	12.4	9.7	89.8%	7.6	127	90/07/11	0844	WATER	5	25.9	3.7	45.1%	7.4	196
90/04/09	1140	WATER	5	12.4	9.6	88.9%	7.6	127	90/07/11	0845	WATER	6	25.9	3.6	43.9%	7.4	197
90/04/09	1141	WATER	6	12.3	9.6	88.9%	7.6	127	90/07/11	0846	WATER	7	25.9	3.6	43.9%	7.3	197
90/04/09	1142	WATER	7	12.3	9.6	88.9%	7.6	127	90/07/11	0847	WATER	8	25.9	3.6	43.9%	7.3	197
90/04/09	1143	WATER	8	12.3	9.6	88.9%	7.6	128	90/07/11	0848	WATER	9	25.9	3.6	43.9%	7.3	197
90/04/09	1145	WATER	9	12.3	9.6	88.9%	7.6	127	90/08/14	0827	WATER	0.5	25.8	5.7	69.5%	7.6	184
90/05/08	0906	WATER	0.5	17.5	8.2	84.3%	7.5	135	90/08/14	0830	WATER	1	25.9	5.5	67.1%	7.5	185
90/05/08	0909	WATER	1	17.4	7.9	81.4%	7.4	133	90/08/14	0833	WATER	1.5	25.9	5.5	67.1%	7.4	185
90/05/08	0912	WATER	1.5	17.2	7.8	80.4%	7.4	132	90/08/14	0833	WATER	2	25.8	5.5	67.1%	7.4	183
90/05/08	0914	WATER	2	17.2	7.6	78.4%	7.4	132	90/08/14	0834	WATER	3	25.8	5.4	65.9%	7.3	184
90/05/08	0916	WATER	2.5	17.2	7.6	78.4%	7.4	132	90/08/14	0834	WATER	4	25.8	5.4	65.9%	7.3	183
90/05/08	0918	WATER	3	17.1	7.5	77.3%	7.4	132	90/08/14	0835	WATER	5	25.8	5.4	65.9%	7.2	182
90/05/08	0920	WATER	4	17.1	7.4	76.3%	7.3	132	90/08/14	0835	WATER	6	25.8	5.3	64.6%	7.2	182
90/05/08	0922	WATER	5	17.1	7.4	76.3%	7.3	132	90/08/14	0836	WATER	7	25.8	5.3	64.6%	7.2	181
90/05/08	0924	WATER	6	17.2	7.4	76.3%	7.3	132	90/08/14	0836	WATER	8	25.8	5.3	64.6%	7.2	182
90/05/08	0927	WATER	7	17.2	7.4	76.3%	7.3	132	90/08/14	0837	WATER	9	25.8	5.3	64.6%	7.3	181
90/05/08	0930	WATER	8	17.2	7.3	75.3%	7.3	132	90/08/14	0838	WATER	9.5	25.8	5.2	63.4%	7.2	182
90/05/08	0933	WATER	9	17.2	7.3	75.3%	7.3	132	90/09/11	0830	WATER	0.5	26.5	5.1	62.2%	7.4	189
90/05/08	0940	WATER	9.5	17.2	7.2	74.2%	7.3	132	90/09/11	0832	WATER	1	26.5	5.0	61.0%	7.3	188
90/06/12	0830	WATER	0.5	23.1	7.2	82.8%	7.4	163	90/09/11	0834	WATER	1.5	26.6	4.9	60.5%	7.3	188
90/06/12	0832	WATER	1	23.1	6.9	79.3%	7.4	163	90/09/11	0835	WATER	2	26.6	4.8	59.3%	7.2	189
90/06/12	0834	WATER	1.5	23.1	6.8	78.2%	7.4	163	90/09/11	0835	WATER	3	26.6	4.8	59.3%	7.2	188
90/06/12	0835	WATER	2	23.1	6.7	77.0%	7.4	163	90/09/11	0836	WATER	4	26.6	4.8	59.3%	7.1	188
90/06/12	0836	WATER	2.5	23.1	6.6	75.9%	7.3	163	90/09/11	0836	WATER	5	26.6	4.7	58.0%	7.1	188
90/06/12	0837	WATER	3	23.1	6.6	75.9%	7.4	163	90/09/11	0837	WATER	6	26.6	4.7	58.0%	7.1	188
90/06/12	0838	WATER	4	23.1	6.6	75.9%	7.3	163	90/09/11	0838	WATER	7	26.5	4.6	56.1%	7.1	187
90/06/12	0839	WATER	5	23.1	6.5	74.7%	7.3	162	90/09/11	0839	WATER	8	26.5	4.6	56.1%	7.1	187
90/06/12	0840	WATER	6	23.1	6.4	73.6%	7.3	162	90/09/11	0840	WATER	9	26.5	4.5	54.9%	7.1	187
90/06/12	0841	WATER	7	23.1	6.3	72.4%	7.3	161									
90/06/12	0842	WATER	8	23.1	6.2	71.3%	7.3	162									
90/06/12	0844	WATER	9	23.1	6.2	71.3%	7.3	162									
90/06/12	0847	WATER	9.5	23.1	6.2	71.3%	7.3	161									
90/07/11	0835	WATER	0.5	26.0	4.2	51.2%	7.4	194									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

475266 1062

35 22 34.0 085 01 56.0 2

CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040801

TENNESSEE RIVER 496.50

/TYPA/AMBNT/STREAM/SOLIDS

131TVAC

06020001024 0009.790 ON

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI NFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/09	1126	WATER	0.5	1.00	10K								
90/04/09	1128	WATER	1				7.5	42	55	7.6	4	10	20
90/05/08	0906	WATER	0.5	.80	10								
90/05/08	0909	WATER	1				7.4	49	63	5.7	5	30	32
90/06/12	0830	WATER	0.5	1.00	10K								
90/06/12	0832	WATER	1				7.6	66	68	7.0	4	20	25
90/07/11	0835	WATER	0.5	1.75	10								
90/07/11	0838	WATER	1				7.6	77	100	4.0	3	15	20
90/08/14	0827	WATER	0.5	1.62	10K								
90/08/14	0830	WATER	1				7.7	72	79	2.0	1K	2	5
90/09/11	0830	WATER	0.5	1.27	10	D1							
90/09/11	0831	WATER	0.5		10K	D2							
90/09/11	0832	WATER	0.5		10K	D3							
90/09/11	0832	WATER	1			D1	7.4	70	91	3.0	3	2	5
90/09/11	0833	WATER	1			D2	7.6	69	87	3.0	3	3	7
90/09/11	0834	WATER	1			D3	7.5	70	83	3.0	4	5	7

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2+NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CNLRPHYL A UG/L CORRECTO
90/04/05	1200	WATER	1									4
90/04/09	1128	WATER	1		1.5	2.0J	.09	.03	.32	.020	.009	
90/04/19	1200	WATER	1									6
90/05/08	0909	WATER	1		1.8	1.9	.13	.03	.30	.030	.020	
90/05/11	1200	WATER	1									2
90/05/30	1200	WATER	1									3
90/06/12	0832	WATER	1		2.0	1.8	.15	.05	.27	.020	.010	14
90/06/27	1200	WATER	1									14
90/07/10	1200	WATER	1									14
90/07/11	0838	WATER	1		1.9	1.8	.17	.05	.29	.030	.005	
90/07/30	1200	WATER	1									3
90/08/13	1200	WATER	1									2
90/08/14	0830	WATER	1		2.0	2.0	.14	.04	.26	.030	.020	
90/08/28	1200	WATER	1									3
90/09/11	0830	WATER	0.5	D1								
90/09/11	0831	WATER	0.5	D2								
90/09/11	0832	WATER	0.5	D3								
90/09/11	0832	WATER	1	D1	2.0	1.9	.10	.08	.18	.020	.020	2
90/09/11	0833	WATER	1	D2	1.9	1.9	.15	.07	.18	.020	.020	
90/09/11	0834	WATER	1	D3	1.9	1.9	.17	.07	.18	.020	.020	

PGM=RET

STREET RETRIEVAL	DATE
475804	1071

35 26 31.0 084 56 59.0 2

CHICKAMAUGA RESERVOIR

47143 TENNESSEE

TENNESSEE RIVER BASIN

TENNESSEE RIVER 506.6

TENNESSEE
131TVAC

0000 METERS DEPTH

RHEA
040801

06020001037 0002.270 ON

/TPA/AMBNT/STREAM/SOLIDS

A-20

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDCTVY FIELD MICRONHMO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDCTVY FIELD MICRONHMO
90/04/11	1121	WATER	0.5	13.7	9.8	94.2%		127	90/07/10	1218	WATER	1	25.3	2.5	29.8%	7.3	200
90/04/11	1123	WATER	1	13.7	9.5	91.3%	7.5	127	90/07/10	1221	WATER	1.5	25.0	2.4	28.6%	7.3	200
90/04/11	1126	WATER	1.5	13.7	9.5	91.3%		128	90/07/10	1222	WATER	2	24.9	2.4	28.6%	7.3	200
90/04/11	1128	WATER	2	13.7	9.5	91.3%		128	90/07/10	1223	WATER	2.5	24.9	2.4	28.6%	7.3	201
90/04/11	1130	WATER	2.5	13.7	9.5	91.3%		128	90/07/10	1224	WATER	3	24.8	2.4	28.6%	7.2	201
90/04/11	1132	WATER	3	13.7	9.4	90.4%		128	90/07/10	1225	WATER	4	24.8	2.3	27.4%	7.2	201
90/04/11	1134	WATER	4	13.7	9.4	90.4%		129	90/07/10	1225	WATER	5	24.8	2.3	27.4%	7.3	200
90/04/11	1136	WATER	5	13.7	9.4	90.4%		129	90/07/10	1226	WATER	6	24.8	2.3	27.4%	7.2	200
90/04/11	1138	WATER	6	13.7	9.4	90.4%		130	90/07/10	1227	WATER	7	24.8	2.3	27.4%	7.2	200
90/04/11	1140	WATER	7	13.7	9.3	89.4%		131	90/07/10	1228	WATER	8	24.8	2.3	27.4%	7.2	200
90/04/11	1142	WATER	8	13.7	9.3	89.4%		132	90/07/10	1229	WATER	9	24.8	2.3	27.4%	7.2	201
90/04/11	1144	WATER	8.5	13.7	9.3	89.4%		133	90/07/10	1230	WATER	10	24.7	2.3	27.4%	7.2	200
90/05/08	1232	WATER	0.5	18.2	7.1	74.7%	7.7	131	90/08/14	1124	WATER	0.5	25.8	5.1	62.2%	7.4	182
90/05/08	1235	WATER	1	18.1	7.0	73.7%	7.5	131	90/08/14	1127	WATER	1	25.8	5.0	61.0%	7.4	183
90/05/08	1238	WATER	1.5	18.0	6.9	72.6%	7.4	131	90/08/14	1130	WATER	1.5	25.8	5.0	61.0%	7.4	183
90/05/08	1239	WATER	2	17.9	6.8	71.6%	7.3	130	90/08/14	1132	WATER	2	25.8	5.0	61.0%	7.4	183
90/05/08	1240	WATER	2.5	17.8	6.8	71.6%	7.3	132	90/08/14	1134	WATER	2.5	25.7	5.0	61.0%	7.4	184
90/05/08	1241	WATER	3	17.8	6.8	71.6%	7.3	132	90/08/14	1136	WATER	3	25.7	5.0	61.0%	7.4	184
90/05/08	1242	WATER	4	17.8	6.8	71.6%	7.3	132	90/08/14	1138	WATER	4	25.7	5.0	61.0%	7.4	184
90/05/08	1243	WATER	5	17.8	6.8	71.6%	7.3	132	90/08/14	1140	WATER	5	25.7	5.0	61.0%	7.4	185
90/05/08	1244	WATER	6	17.8	6.8	71.6%	7.3	132	90/08/14	1142	WATER	6	25.7	5.0	61.0%	7.4	185
90/05/08	1245	WATER	7	17.8	6.8	71.6%	7.3	132	90/08/14	1144	WATER	7	25.7	5.0	61.0%	7.4	185
90/05/08	1246	WATER	8	17.8	6.8	71.6%	7.3	132	90/08/14	1146	WATER	8	25.7	5.0	61.0%	7.4	185
90/05/08	1247	WATER	9	17.8	6.8	71.6%	7.2	132	90/08/14	1148	WATER	9	25.7	5.1	62.2%	7.4	184
90/05/08	1248	WATER	9.5	17.8	6.8	71.6%	7.2	132	90/08/14	1150	WATER	10	25.7	5.0	61.0%	7.4	185
90/06/12	1214	WATER	0.5	23.5	6.7	77.0%	7.6	168	90/09/11	1108	WATER	0.5	26.6	3.6	44.4%	7.4	179
90/06/12	1216	WATER	1	23.2	6.7	77.0%	7.6	170	90/09/11	1110	WATER	1	26.6	3.6	44.4%	7.3	180
90/06/12	1218	WATER	1.5	23.2	6.7	77.0%	7.6	170	90/09/11	1112	WATER	1.5	26.6	3.6	44.4%	7.3	180
90/06/12	1220	WATER	2	23.1	6.7	77.0%	7.6	171	90/09/11	1113	WATER	2	26.6	3.6	44.4%	7.3	181
90/06/12	1221	WATER	2.5	23.1	6.7	77.0%	7.6	171	90/09/11	1114	WATER	2.5	26.6	3.6	44.4%	7.3	181
90/06/12	1222	WATER	3	23.1	6.7	77.0%	7.6	171	90/09/11	1115	WATER	3	26.6	3.5	43.2%	7.3	181
90/06/12	1223	WATER	4	23.0	6.7	77.0%	7.6	172	90/09/11	1116	WATER	4	26.6	3.5	43.2%	7.3	181
90/06/12	1224	WATER	5	23.0	6.7	77.0%	7.5	172	90/09/11	1117	WATER	5	26.6	3.5	43.2%	7.3	181
90/06/12	1225	WATER	6	23.0	6.7	77.0%	7.5	172	90/09/11	1118	WATER	6	26.6	3.5	43.2%	7.3	181
90/06/12	1226	WATER	7	23.0	6.7	77.0%	7.5	172	90/09/11	1119	WATER	7	26.6	3.5	43.2%	7.3	181
90/06/12	1227	WATER	8	23.0	6.7	77.0%	7.5	172	90/09/11	1120	WATER	8	26.6	3.5	43.2%	7.3	181
90/06/12	1228	WATER	9	23.0	6.7	77.0%	7.5	172	90/09/11	1121	WATER	9	26.6	3.5	43.2%	7.3	181
90/06/12	1230	WATER	10	23.0	6.7	77.0%	7.5	172	90/09/11	1125	WATER	9.5	26.6	3.5	43.2%	7.3	181
90/07/10	1215	WATER	0.5	25.4	2.6	31.0%	7.3	200									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

475804 1071
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CHICKAMAUGA RESERVOIR

47143 TENNESSEE

RHEA

TENNESSEE RIVER BASIN

040801

TENNESSEE RIVER 506.6

/TYPA/AMBNT/STREAM/SOLIDS

131TVAC

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0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1121	WATER	0.5	1.60	10K								
90/04/11	1123	WATER	1				7.7	51	71	6.4	3	10	15
90/05/08	1232	WATER	0.5	2.10	10	D1							
90/05/08	1233	WATER	0.5		10K	D2							
90/05/08	1234	WATER	0.5		10K	D3							
90/05/08	1235	WATER	1			D1	7.3	51	61	3.0	3	25	27
90/05/08	1236	WATER	1			D2	7.5	49	67	3.5	2	20	22
90/05/08	1237	WATER	1			D3	7.6	50	59	3.5	2	20	22
90/06/12	1214	WATER	0.5	1.63	10K								
90/06/12	1216	WATER	1				7.9	64	82	6.0	4	20	25
90/07/10	1215	WATER	0.5	1.88	10K								
90/07/10	1218	WATER	1				7.6	78	99	4.0	2	15	20
90/08/14	1124	WATER	0.5	2.13	10K								
90/08/14	1127	WATER	1				7.8	73	93	2.0	1K	2	5
90/09/11	1108	WATER	0.5	2.63	10K								
90/09/11	1110	WATER	1				7.5	70	93	2.0	3	2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C MG/L	00681 D ORG C MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTO
90/04/02	1200	WATER	1									3
90/04/11	1123	WATER	1		1.5	2.1J	.08	.04	.33	.020	.010	9
90/04/23	1200	WATER	1									
90/05/08	1232	WATER	0.5	D1								
90/05/08	1233	WATER	0.5	D2								
90/05/08	1234	WATER	0.5	D3								
90/05/08	1235	WATER	1	D1	1.8	1.8	.10	.04	.29	.030	.020	
90/05/08	1236	WATER	1	D2	2.1	1.7	.07	.05	.29	.030	.020	
90/05/08	1237	WATER	1	D3	1.7	1.6	.10	.04	.28	.020	.020	
90/05/09	1200	WATER	1									1
90/05/30	1200	WATER	1									1
90/06/12	1216	WATER	1		1.9	1.9	.17	.07	.25	.020	.010	
90/06/13	1200	WATER	1									2
90/06/27	1200	WATER	1									1
90/07/10	1218	WATER	1		1.8	1.9	.20	.02	.41	.030	.010	1
90/07/30	1200	WATER	1									2
90/08/13	1200	WATER	1									2
90/08/14	1127	WATER	1		2.0	1.9	.29	.05	.28	.020	.010	2
90/08/23	1200	WATER	1									2
90/09/11	1110	WATER	1		2.1	1.8	.11	.07	.20	.020	.020	2

PGM=RET

475363 1077
35 32 16.0 084 52 51.0 2
NEAR HENRY LIGHT CHICK. RES.
47121 TENNESSEE MEIGS
TENNESSEE RIVER BASIN 040801
TENNESSEE RIVER 518.0
131TVAC HQ 06
0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

HQ 06020001039 0003.360 OFF

0000 METERS DEPTH

A-22

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICRONHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICRONHO
90/04/09	1047	WATER	0.5	13.1	10.3	97.2%	7.8	140	90/08/14	1010	WATER	2.5	25.2	5.4	64.3%	7.4	182
90/04/09	1049	WATER	1	13.1	10.2	96.2%	7.8	140	90/08/14	1011	WATER	3	25.2	5.3	63.1%	7.4	183
90/04/09	1051	WATER	1.5	13.1	10.1	95.3%	7.8	141	90/08/14	1012	WATER	4	25.2	5.3	63.1%	7.4	183
90/04/09	1052	WATER	2	13.1	10.1	95.3%	7.8	142	90/08/14	1013	WATER	5	25.2	5.3	63.1%	7.4	184
90/04/09	1053	WATER	2.5	13.1	10.1	95.3%	7.8	142	90/08/14	1014	WATER	6	25.2	5.3	63.1%	7.4	185
90/04/09	1054	WATER	3	13.1	10.1	95.3%	7.8	142	90/09/11	0951	WATER	0.5	26.3	4.0	49.1%	7.5	180
90/04/09	1056	WATER	4	13.1	10.4	98.1%	7.8	142	90/09/11	0953	WATER	1	26.4	4.0	48.9%	7.4	182
90/04/09	1058	WATER	4.7	13.1	10.1	95.3%	7.8	142	90/09/11	0956	WATER	1.5	26.4	4.0	48.7%	7.4	182
90/05/08	1104	WATER	0.5	17.3	7.4	76.3%	7.4	133	90/09/11	0957	WATER	2	26.5	4.0	48.8%	7.4	181
90/05/08	1107	WATER	1	17.3	7.2	74.2%	7.4	133	90/09/11	0959	WATER	2.5	26.5	3.9	47.6%	7.4	181
90/05/08	1110	WATER	1.5	17.3	7.2	74.2%	7.3	133	90/09/11	1001	WATER	3	26.5	3.9	47.6%	7.4	181
90/05/08	1111	WATER	2	17.3	7.2	74.2%	7.3	133	90/09/11	1003	WATER	4	26.5	3.9	47.6%	7.4	181
90/05/08	1112	WATER	2.5	17.3	7.2	74.2%	7.3	134	90/09/11	1005	WATER	5	26.5	3.9	47.6%	7.4	181
90/05/08	1113	WATER	3	17.3	7.1	73.2%	7.3	134									
90/05/08	1114	WATER	4	17.3	7.2	74.2%	7.3	133									
90/05/08	1115	WATER	5	17.3	7.2	74.2%	7.3	133									
90/05/08	1116	WATER	6	17.3	7.1	73.2%	7.4	134									
90/06/12	1034	WATER	0.5	22.5	6.8	77.3%	7.8	173									
90/06/12	1036	WATER	1	22.5	6.8	77.3%	7.8	173									
90/06/12	1038	WATER	1.5	22.5	6.8	77.3%	7.8	173									
90/06/12	1039	WATER	2	22.5	6.7	76.1%	7.8	173									
90/06/12	1040	WATER	2.5	22.5	6.7	76.1%	7.7	173									
90/06/12	1041	WATER	3	22.5	6.7	76.1%	7.7	173									
90/06/12	1042	WATER	4	22.5	6.7	76.1%	7.7	173									
90/06/12	1044	WATER	5	22.5	6.6	75.0%	7.7	174									
90/06/12	1046	WATER	5.5	22.5	6.6	75.0%	7.7	174									
90/07/10	1035	WATER	0.5	24.9	3.6	42.9%	7.3	195									
90/07/10	1038	WATER	1	24.9	3.5	41.7%	7.4	196	</								

STORET RETRIEVAL DATE 92/10/16

475363

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PGM=RET

35 32 16.0 084 52 51.0 2

NEAR HENRY LIGHT CHICK. RES.

47121 TENNESSEE MEIGS

TENNESSEE RIVER BASIN 040801

TENNESSEE RIVER 518.0

131TVAC

HQ 06020001039 0003.360 OFF

/TYP/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT WFLY MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/09	1047	WATER	0.5	1.63	10K								
90/04/09	1049	WATER	1				7.6	51	51	7.1	6	10	20
90/05/08	1104	WATER	0.5	2.00	10K		7.4	52	69	2.0	2	20	22
90/05/08	1107	WATER	1										
90/06/12	1034	WATER	0.5	1.13	10K	D1							
90/06/12	1035	WATER	0.5		10	D2							
90/06/12	1036	WATER	0.5		10K	D3							
90/06/12	1036	WATER	1			D1	7.8	66	88	8.0	8	25	28
90/06/12	1037	WATER	1			D2	7.7	64	76	9.0	8	20	22
90/06/12	1038	WATER	1			D3	7.7	68	80	9.0	8	15	20
90/07/10	1035	WATER	0.5	1.38	10K		7.6	72	81	7.0	6	7	10
90/07/10	1038	WATER	1										
90/08/14	1003	WATER	0.5		10K		7.6	72	110	8.0	7	2	5
90/08/14	1006	WATER	1				7.6	72	110	8.0	7	2	5
90/09/11	0951	WATER	0.5	1.88	10K		7.6	69	97	3.0	4	2	5
90/09/11	0953	WATER	1										

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N H MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/02	1200	WATER	1									4
90/04/09	1049	WATER	1		1.5	1.7J	.21	.01	.36	.020	.008	
90/04/23	1200	WATER	1									4
90/05/08	1107	WATER	1		1.7	1.6	.06	.06	.26	.010	.009	
90/05/09	1200	WATER	1									2
90/05/30	1200	WATER	1									14
90/06/12	1034	WATER	0.5	D1								
90/06/12	1035	WATER	0.5	D2								
90/06/12	1036	WATER	0.5	D3								
90/06/12	1036	WATER	1	D1	2.3	1.9	.31	.09	.23	.030	.006	
90/06/12	1037	WATER	1	D2	2.0	1.9	.14	.08	.23	.030	.006	
90/06/12	1038	WATER	1	D3	2.1	1.9	.19	.07	.23	.020	.006	
90/06/13	1200	WATER	1									5
90/06/27	1200	WATER	1									1
90/07/10	1038	WATER	1		1.9	1.8	.20	.01K	.32	.030	.003	2
90/07/30	1200	WATER	1									2
90/08/13	1200	WATER	1									3
90/08/14	1006	WATER	1		2.2	1.8	.19	.03	.27	.020	.010	2
90/08/23	1200	WATER	1									2
90/09/11	0953	WATER	1		2.1	1.9	.17	.05	.18	.020	.010	2

/TYPA/AMBNT/FISH/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO
90/04/09	0955	WATER	0.5	13.2	11.4	107.5%	8.1	141	90/09/11	0847	WATER	0.5	26.4	4.3	52.4%	7.5	182
90/04/09	0956	WATER	1	13.2	10.9	102.8%	8.1	141	90/09/11	0849	WATER	1	26.5	4.3	52.4%	7.5	182
90/04/09	0958	WATER	1.5	13.2	10.7	100.9%	8.1	142	90/09/11	0851	WATER	1.5	26.5	4.3	52.4%	7.5	182
90/04/09	0959	WATER	2	13.2	10.7	100.9%	8.1	142	90/09/11	0852	WATER	2	26.5	4.3	52.4%	7.4	182
90/04/09	1000	WATER	2.5	13.2	10.6	100.0%	8.1	143	90/09/11	0852	WATER	2.5	26.5	4.2	51.2%	7.5	182
90/04/09	1001	WATER	3	13.2	10.7	100.9%	8.1	144	90/09/11	0853	WATER	3	26.5	4.2	51.2%	7.4	182
90/04/09	1002	WATER	3.7	13.2	10.6	100.0%	8.1	144	90/09/11	0853	WATER	4	26.5	4.2	51.2%	7.4	182
90/05/08	0918	WATER	0.5	17.1	7.3	75.3%	7.0	136									
90/05/08	0921	WATER	1	17.1	7.3	75.3%	7.1	137									
90/05/08	0924	WATER	1.5	17.1	7.3	75.3%	7.2	136									
90/05/08	0925	WATER	2	17.1	7.3	75.3%	7.3	136									
90/05/08	0926	WATER	2.5	17.1	7.3	75.3%	7.3	136									
90/05/08	0927	WATER	3	17.1	7.3	75.3%	7.4	136									
90/05/08	0928	WATER	4	17.1	7.3	75.3%	7.4	136									
90/05/08	0929	WATER	4.4	17.1	7.3	75.3%	7.4	136									
90/06/12	0849	WATER	0.5	21.9	7.1	80.7%	7.8	177									
90/06/12	0851	WATER	1	21.9	7.1	80.7%	7.8	177									
90/06/12	0853	WATER	1.5	21.9	7.1	80.7%	7.8	177									
90/06/12	0855	WATER	2	21.9	7.1	80.7%	7.8	177									
90/06/12	0857	WATER	2.5	21.9	7.1	80.7%	7.8	177									
90/06/12	0859	WATER	3	21.9	7.1	80.7%	7.8	177									
90/06/12	0901	WATER	4	21.9	7.1	80.7%	7.8	177									
90/07/10	0922	WATER	0.5	24.2	3.4	40.0%	7.5	201									
90/07/10	0925	WATER	1	24.2	3.3	38.8%	7.5	201									
90/07/10	0928	WATER	1.5	24.2	3.2	37.6%	7.5	201									
90/07/10	0928	WATER	2	24.2	3.1	36.5%	7.5	201									
90/07/10	0928	WATER	2.5	24.3	3.2	37.6%	7.5	201									
90/07/10	0929	WATER	3	24.3	3.1	36.5%	7.5	201									
90/07/10	0929	WATER	4	24.3	3.1	36.5%	7.5	201									
90/07/10	0929	WATER	4.3	24.2	3.1	36.5%	7.4	201									
90/07/10	1435	WATER		25.7	4.1	50.0%											
90/08/13	0955	WATER		26.0	6.3	76.8%											
90/08/14	0856	WATER	0.5	24.8	5.6	66.7%	7.5	184									
90/08/14	0859	WATER	1	24.9	5.5	65.5%	7.5	184									
90/08/14	0902	WATER	1.5	24.9	5.5	65.5%	7.5	184									
90/08/14	0902	WATER	2	24.9	5.5	65.5%	7.5	184									
90/08/14	0902	WATER	2.5	24.9	5.5	65.5%	7.5	185									
90/08/14	0903	WATER	3	24.9	5.5	65.5%	7.5	185									
90/08/14	0903	WATER	4	24.9	5.5	65.5%	7.5	185									

STORET RETRIEVAL DATE 92/10/16

475364 1086

35 37 12.0 084 46 59.0 2

WATTS BAR DAM TAILRACE

47121 TENNESSEE

TENNESSEE RIVER BASIN

TENNESSEE RIVER 529.9

131TVAC

0000 METERS DEPTH

MEIGS

040801

06020001

PGM=RET

/TYP/AMBNT/FISH/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI HFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT MFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/09	0955	WATER	0.5		10K								
90/04/09	0956	WATER	1				7.6	49	50	5.9	5	10	13
90/05/08	0918	WATER	0.5	1.25	10K								
90/05/08	0921	WATER	1				7.5	52	69	3.6	3	20	22
90/06/12	0849	WATER	0.5	.88	10K	D1							
90/06/12	0850	WATER	0.5		10K	D2							
90/06/12	0851	WATER	0.5		10K	D3							
90/06/12	0851	WATER	1			D1	8.0	69	86	9.0	8	20	23
90/06/12	0852	WATER	1			D2	7.9	69	72	8.0	8	25	30
90/06/12	0853	WATER	1			D3	7.8	67	86	9.0	9	25	30
90/07/10	0922	WATER	0.5	1.13	10K								
90/07/10	0925	WATER	1				7.9	77	95	7.0	5	20	25
90/08/14	0856	WATER	0.5	.88	10K								
90/08/14	0859	WATER	1				7.8	74	97	9.0	8	5	7
90/09/11	0847	WATER	0.5	1.63	10K								
90/09/11	0849	WATER	1				7.6	74	100	3.0	3	2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-015 ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTO
90/04/02	1200	WATER	1									6
90/04/09	0956	WATER	1		1.5	2.1J	.22	.01K	.33	.020	.006	
90/04/23	1200	WATER	1									4
90/05/08	0921	WATER	1		1.6	1.6	.10	.04	.26	.030	.020	
90/05/09	1200	WATER	1									2
90/05/30	1200	WATER	1									12
90/06/12	0849	WATER	0.5	D1								
90/06/12	0850	WATER	0.5	D2								
90/06/12	0851	WATER	0.5	D3								
90/06/12	0851	WATER	1	D1	2.1	1.9	.15	.05	.25	.030	.003	
90/06/12	0852	WATER	1	D2	2.0	1.8	.23	.05	.26	.030	.003	
90/06/12	0853	WATER	1	D3	2.0	1.9	.15	.07	.25	.040	.003	
90/06/13	1200	WATER	1									8
90/06/27	1200	WATER	1									2
90/07/10	0925	WATER	1		1.7	1.7	.18	.01K	.35	.030	.006	5
90/08/13	1200	WATER	1									5
90/08/14	0859	WATER	1		2.2	1.8	.30	.04	.27	.030	.009	
90/08/23	1200	WATER	1									4
90/09/11	0849	WATER	1		2.2	1.9	.20	.02	.19	.020	.008	

PGM=RET

35 22 01.0 084 54 37.0 2
RUSSELL BRIDGE HWY 58
47121 TENNESSEE MEIGS
TENNESSEE RIVER BASIN 040501
HIWASSEE RIVER 7.4
131TVAC 06
0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

06020002001 0006.050 DN

0000 METERS DEPTH

A-26

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/12	0922	WATER	0.5	13.2	9.8	92.5%	7.7	156	90/07/12	1100	WATER	0.5	26.2	7.0	85.4%	7.4	165
90/04/12	0924	WATER	.	13.2	9.7	91.5%	7.7	156	90/07/12	1103	WATER	1	26.1	6.9	84.1%	7.4	164
90/04/12	0927	WATER	1.3	13.2	9.6	90.6%	7.7	155	90/07/12	1106	WATER	1.5	26.1	6.8	82.9%	7.4	163
90/04/12	0929	WATER	2	13.2	9.6	90.6%	7.7	155	90/07/12	1107	WATER	2	25.9	6.6	80.5%	7.4	162
90/04/12	0931	WATER	2.5	13.2	9.6	90.6%	7.7	154	90/07/12	1108	WATER	2.5	25.6	6.5	79.3%	7.3	158
90/04/12	0933	WATER	3	13.2	9.6	90.6%	7.7	155	90/07/12	1109	WATER	3	25.1	6.6	78.6%	7.2	149
90/04/12	0935	WATER	4	13.2	9.6	90.6%	7.7	155	90/07/12	1110	WATER	4	24.6	6.4	76.2%	7.2	143
90/04/12	0937	WATER	5	13.2	9.6	90.6%	7.7	156	90/07/12	1111	WATER	5	24.4	6.3	74.1%	7.2	143
90/04/12	0939	WATER	6	13.2	9.6	90.6%	7.7	155	90/07/12	1112	WATER	6	24.3	6.3	74.1%	7.2	140
90/04/12	0941	WATER	7	13.2	9.5	89.6%	7.6	156	90/07/12	1113	WATER	7	24.2	6.4	75.3%	7.1	140
90/04/12	0943	WATER	8	13.2	9.6	90.6%	7.6	156	90/07/12	1114	WATER	8	24.2	6.4	75.3%	7.1	137
90/04/12	0945	WATER	9	13.2	9.6	90.6%	7.6	155	90/07/12	1115	WATER	9	24.2	6.4	75.3%	7.1	137
90/04/12	0947	WATER	9.7000	13.2	9.5	89.6%	7.6	156	90/08/16	1058	WATER	0.5	26.1	8.4	102.4%	7.9	130
90/05/09	1030	WATER	0.5	18.3	8.1	85.3%	7.0	142	90/08/16	1100	WATER	1	25.4	7.9	94.0%	7.6	126
90/05/09	1033	WATER	1	18.3	8.1	85.3%	7.0	143	90/08/16	1102	WATER	1.5	25.0	7.6	90.5%	7.5	124
90/05/09	1036	WATER	1.5	18.3	8.0	84.2%	7.0	141	90/08/16	1104	WATER	2	24.3	7.4	87.1%	7.3	118
90/05/09	1037	WATER	2	18.2	8.0	84.2%	7.1	142	90/08/16	1106	WATER	2.5	23.6	7.2	84.7%	7.2	113
90/05/09	1038	WATER	2.5	18.2	8.0	84.2%	7.1	141	90/08/16	1108	WATER	3	23.2	7.0	80.5%	7.2	109
90/05/09	1039	WATER	3	18.1	8.0	84.2%	7.1	142	90/08/16	1110	WATER	4	22.7	7.2	82.8%	7.2	109
90/05/09	1040	WATER	4	18.1	8.0	84.2%	7.1	142	90/08/16	1112	WATER	5	22.6	7.2	82.8%	7.1	110
90/05/09	1041	WATER	5	18.0	8.0	84.2%	7.1	142	90/08/16	1114	WATER	6	22.5	7.3	83.0%	7.0	111
90/05/09	1042	WATER	6	18.0	8.0	84.2%	7.1	142	90/08/16	1116	WATER	7	22.5	7.3	83.0%	7.1	111
90/05/09	1043	WATER	7	17.9	8.0	84.2%	7.1	142	90/08/16	1117	WATER	8	22.5	7.3	83.0%	7.1	111
90/05/09	1044	WATER	8	17.9	7.9	83.2%	7.1	141	90/08/16	1119	WATER	9	22.5	7.3	83.0%	7.3	111
90/05/09	1045	WATER	9	17.9	7.9	83.2%	7.1	141	90/09/13	1057	WATER	0.5	25.1	6.8	81.0%	7.4	132
90/05/09	1146	WATER	9.5	17.9	7.9	83.2%	7.1	141	90/09/13	1059	WATER	1	24.8	6.7	79.8%	7.2	133
90/06/14	1106	WATER	0.5	26.4	10.3	125.6%	8.6	146	90/09/13	1101	WATER	1.5	24.7	6.8	81.0%	7.1	134
90/06/14	1108	WATER	1	25.9	10.2	124.4%	8.5	146	90/09/13	1102	WATER	2	24.6	6.8	81.0%	7.1	136
90/06/14	1111	WATER	1.5	24.6	9.3	110.7%	8.0	147	90/09/13	1103	WATER	2.5	24.4	6.8	80.0%	7.1	137
90/06/14	1112	WATER	2	22.7	8.5	97.7%	7.5	145	90/09/13	1104	WATER	3	24.3	6.7	78.8%	7.0	138
90/06/14	1113	WATER	2.5	22.2	8.1	92.0%	7.4	140	90/09/13	1105	WATER	4	23.8	6.4	75.3%	7.0	144
90/06/14	1114	WATER	3	21.7	8.0	90.9%	7.3	137	90/09/13	1106	WATER	5	23.7	6.3	74.1%	7.0	146
90/06/14	1115	WATER	4	21.0	7.9	87.8%	7.3	137	90/09/13	1107	WATER	6	23.6	6.3	74.1%	7.0	148
90/06/14	1116	WATER	5	20.7	7.9	87.8%	7.2	144	90/09/13	1107	WATER	7	23.6	6.3	74.1%	6.9	148
90/06/14	1117	WATER	6	20.4	7.7	83.7%	7.2	149	90/09/13	1108	WATER	8	23.6	6.3	74.1%	6.9	146
90/06/14	1118	WATER	7	20.3	7.7	83.7%	7.1	151	90/09/13	1109	WATER	9	23.6	6.3	74.1%	6.9	147
90/06/14	1119	WATER	8	20.3	7.6	82.6%	7.1	151									
90/06/14	1120	WATER	9	20.3	7.6	82.6%	7.1	151									
90/06/14	1122	WATER	9.5	20.2	7.5	81.5%	7.1	150									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

475366 2882
35 22 01.0 084 54 37.0 2

RUSSELL BRIDGE HWY 58

47121 TENNESSEE MEIGS
TENNESSEE RIVER BASIN 040501

HIWASSEE RIVER 7.4

131TVAC

06020002001 0006.050 ON

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/12	0922	WATER	0.5	.82	20								
90/04/12	0924	WATER	1										
90/05/09	1030	WATER	0.5	.88	50		7.4	40	63	14.0	5	20	25
90/05/09	1033	WATER	1				7.2	46	55	14.0	7	45	48
90/06/14	1106	WATER	0.5		10K								
90/06/14	1108	WATER	1				8.2	42	62	7.0	5	30	32
90/07/12	1100	WATER	0.5	.63	10K	D1							
90/07/12	1101	WATER	0.5		10K	D2							
90/07/12	1102	WATER	0.5		10	D3							
90/07/12	1103	WATER	1			D1	7.4	30	77	10.0	8	40	45
90/07/12	1104	WATER	1			D2	7.4	36	42	10.0	8	35	40
90/07/12	1105	WATER	1			D3	7.4	38	71	11.0	8	40	45
90/08/16	1058	WATER	0.5	1.12	10K								
90/08/16	1100	WATER	1				7.6	30	89	7.0	5	20	25
90/09/13	1057	WATER	0.5	.88	20								
90/09/13	1059	WATER	1				7.2	27	95	6.0	9	20	25

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2+NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CNLRPHYL A UG/L CORRECTD
90/04/03	1200	WATER	1									1
90/04/12	0924	WATER	1									
90/04/23	1200	WATER	1		2.2	2.5J	.24	.08	.24	.030	.009	8
90/05/09	1033	WATER	1		3.3	2.8	.28	.04	.18	.030	.010	4
90/05/31	1200	WATER	1									8
90/06/13	1200	WATER	1									16
90/06/14	1108	WATER	1		3.0	2.7	.33	.01K	.01K	.040	.003	10
90/06/28	1200	WATER	1									11
90/07/09	1200	WATER	1									
90/07/12	1100	WATER	0.5	D1								
90/07/12	1101	WATER	0.5	D2								
90/07/12	1102	WATER	0.5	D3								
90/07/12	1103	WATER	1	D1	3.2	2.7	.28	.01K	.12	.040	.007	
90/07/12	1104	WATER	1	D2	3.3	2.8	.32	.01K	.12	.040	.006	
90/07/12	1105	WATER	1	D3	3.3	2.8	.32	.01K	.12	.040	.007	
90/07/31	1200	WATER	1									6
90/08/14	1200	WATER	1									12
90/08/16	1100	WATER	1		3.0	2.5	.38	.01K	.04	.020	.004	13
90/08/27	1200	WATER	1									5
90/09/11	1200	WATER	1									
90/09/13	1059	WATER	1		2.9	2.6	.39	.03	.11	.030	.006	

STORET RETRIEVAL DATE 92/10/16
477245

PGM=RET

35 19 27.0 084 49 15.0 2
BELOW NORTH MOUSE CREEK

47011 TENNESSEE BRADLEY
TENNESSEE RIVER BASIN 040501

HIWASSEE RIVER 13.4

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

INDEX 1021500 007720 00920 6824
MILES 0953.80 0046.50 499.70 013.40

INDEX 1021500 007720 00920 6824
MILES 0953.80 0046.50 499.70 013.40

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/10	1101	WATER	0.5	13.2	9.9	93.4%	7.6	154
90/04/10	1103	WATER	1	13.1	9.7	91.5%	7.3	154
90/04/10	1105	WATER	1.5	13.1	9.6	90.6%	7.3	153
90/04/10	1107	WATER	2	13.1	9.6	90.6%	7.3	153
90/04/10	1109	WATER	2.5	13.1	9.5	89.6%	7.3	153
90/04/10	1111	WATER	3	13.1	9.4	88.7%	7.3	155
90/04/10	1113	WATER	4	13.1	9.8	92.5%	7.5	152
90/04/10	1115	WATER	5	13.1	9.8	92.5%	7.5	156
90/04/10	1117	WATER	6	13.1	9.8	92.5%	7.5	156
90/05/10	1049	WATER	0.5	15.8	8.7	87.0%	7.3	140
90/05/10	1052	WATER	1	15.8	8.7	87.0%	7.2	141
90/05/10	1055	WATER	1.5	15.8	8.7	87.0%	7.2	140
90/05/10	1056	WATER	2	15.8	8.7	87.0%	7.2	141
90/05/10	1057	WATER	2.5	15.8	8.7	87.0%	7.3	140
90/05/10	1058	WATER	3	15.8	8.7	87.0%	7.3	141
90/05/10	1059	WATER	4	15.8	8.7	87.0%	7.3	140
90/05/10	1100	WATER	5	15.8	8.7	87.0%	7.3	140
90/05/10	1101	WATER	6	15.8	8.7	87.0%	7.3	140
90/05/10	1102	WATER	6.5	15.8	8.7	87.0%	7.3	140
90/06/13	1049	WATER	0.5	20.1	7.9	85.9%	7.6	142
90/06/13	1051	WATER	1	21.0	7.9	87.8%	7.3	141
90/06/13	1053	WATER	1.5	20.8	8.0	88.9%	7.3	141
90/06/13	1054	WATER	2	20.8	7.9	87.8%	7.3	140
90/06/13	1055	WATER	2.5	20.7	8.0	88.9%	7.3	140
90/06/13	1056	WATER	3	20.7	7.9	87.8%	7.2	140
90/06/13	1057	WATER	4	20.7	7.9	87.8%	7.2	141
90/06/13	1058	WATER	5	20.7	7.9	87.8%	7.2	140
90/06/13	1059	WATER	6	20.7	7.9	87.8%	7.2	140
90/06/13	1100	WATER	7	20.6	7.9	87.8%	7.2	140
90/07/11	1015	WATER	0.5	23.2	7.8	89.7%	7.7	139
90/07/11	1018	WATER	1	23.1	7.7	88.5%	7.5	141
90/07/11	1021	WATER	1.5	23.1	7.8	89.7%	7.4	136
90/07/11	1022	WATER	2	23.0	7.8	89.7%	7.4	134
90/07/11	1023	WATER	2.5	23.0	7.8	89.7%	7.4	133
90/07/11	1024	WATER	3	23.0	7.8	89.7%	7.3	136
90/07/11	1025	WATER	4	22.8	7.8	89.7%	7.3	137
90/07/11	1026	WATER	5	22.8	7.8	89.7%	7.3	134
90/07/11	1027	WATER	6	22.8	7.8	89.7%	7.3	134
90/07/11	1029	WATER	7	22.8	7.8	89.7%	7.2	134

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/08/15	1002	WATER	0.5	22.5	7.6	86.4%	7.3	100
90/08/15	1005	WATER	1	22.4	7.6	86.4%	7.2	100
90/08/15	1008	WATER	1.5	22.3	7.6	86.4%	7.2	100
90/08/15	1009	WATER	2	22.3	7.6	86.4%	7.2	100
90/08/15	1009	WATER	2.5	22.2	7.6	86.4%	7.2	98
90/08/15	1010	WATER	3	22.2	7.6	86.4%	7.2	99
90/08/15	1010	WATER	4	22.1	7.6	86.4%	7.2	99
90/08/15	1011	WATER	5	22.1	7.6	86.4%	7.2	99
90/08/15	1011	WATER	6	22.1	7.6	86.4%	7.2	99
90/08/15	1012	WATER	7	22.1	7.6	86.4%	7.1	99
90/09/12	1010	WATER	0.5	23.7	7.2	84.7%	7.5	132
90/09/12	1012	WATER	1	23.6	7.2	84.7%	7.3	133
90/09/12	1014	WATER	1.5	23.6	7.2	84.7%	7.2	134
90/09/12	1014	WATER	2	23.6	7.1	83.5%	7.2	134
90/09/12	1014	WATER	2.5	23.6	7.1	83.5%	7.2	134
90/09/12	1015	WATER	3	23.6	7.1	83.5%	7.1	134
90/09/12	1015	WATER	4	23.6	7.1	83.5%	7.1	134
90/09/12	1015	WATER	5	23.6	7.1	83.5%	7.1	135
90/09/12	1016	WATER	6	23.6	7.1	83.5%	7.1	135
90/09/12	1016	WATER	7	23.6	7.1	83.5%	7.1	136

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477245

35 19 27.0 084 49 15.0 2

BELOW NORTH MOUSE CREEK

47011 TENNESSEE

BRADLEY

TENNESSEE RIVER BASIN

040501

HIWASSEE RIVER 13.4

131TVAC 900505

06020001

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDTY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	1101	WATER	0.5	1.38	40								
90/04/10	1103	WATER	1				7.4	42	63	10.0	3	25	30
90/05/10	1049	WATER	0.5	.63	10K								
90/05/10	1052	WATER	1				7.4	40	67	24.0	16	40	43
90/06/13	1049	WATER	0.5	.88	100								
90/06/13	1051	WATER	1				7.4	32	46	9.0	6	35	40
90/07/11	1015	WATER	0.5	1.13									
90/07/11	1018	WATER	1				7.3	30	110	8.0	4	35	40
90/08/15	1002	WATER	0.5	.88	10	D1							
90/08/15	1003	WATER	0.5		60	D2							
90/08/15	1004	WATER	0.5		110	D3							
90/08/15	1005	WATER	1			D1	7.2	27	83	6.0	6	25	30
90/08/15	1006	WATER	1			D2	7.3	24	87	5.0	5	25	30
90/08/15	1007	WATER	1			D3	7.2	23	73	6.0	6	25	30
90/09/12	1010	WATER	0.5	1.12	10K								
90/09/12	1012	WATER	1				7.1	24	95	5.0	6	20	25

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CNLRPHYL A UG/L CORRECTD
90/04/03	1200	WATER	1									
90/04/10	1103	WATER	1		1.7	2.2J	.10	.08	.27	.020	.009	1K
90/04/23	1200	WATER	1									2
90/05/09	1200	WATER	1									2
90/05/10	1052	WATER	1		2.4	2.1	.30	.04	.25	.070	.030	3
90/05/31	1200	WATER	1									2
90/06/13	1051	WATER	1		3.4	2.8	.12	.12	.17	.050	.020	4
90/06/28	1200	WATER	1									6
90/07/09	1200	WATER	1		3.0	2.9	.20	.04	.14	.030	.008	1
90/07/11	1018	WATER	1									2
90/07/31	1200	WATER	1									
90/08/14	1200	WATER	1									
90/08/15	1002	WATER	0.5	D1								
90/08/15	1003	WATER	0.5	D2								
90/08/15	1004	WATER	0.5	D3								
90/08/15	1005	WATER	1	D1	3.0	2.8	.20	.06	.15	.040	.010	
90/08/15	1006	WATER	1	D2	3.5	2.7	.16	.06	.15	.030	.010	
90/08/15	1007	WATER	1	D3	3.2	2.8	.16	.06	.15	.030	.010	
90/08/27	1200	WATER	1									3
90/09/11	1200	WATER	1									9
90/09/12	1012	WATER	1		2.9	2.7	.12	.12	.17	.020	.020	

STORET RETRIEVAL DATE 92/10/16
 475908 2918
 35 17 28.0 084 43 56.0 2
 0.22 MILE ABOVE OOSTANAU LA CREEK
 47011 TENNESSEE BRADLEY
 TENNESSEE RIVER BASIN 040501
 HIASSEE RIVER 20.0
 131TVAC
 0000 METERS DEPTH

PGM=RET

06020002083 0000.310 ON

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/10	0906	WATER	0.5	13.1	10.6	100.0%	7.6	82	90/08/15	0835	WATER	2.5	21.2	8.7	96.7%	7.2	53
90/04/10	0908	WATER	1	13.0	10.3	97.2%	7.5	82	90/08/15	0836	WATER	3	21.2	8.8	97.8%	7.2	53
90/04/10	0910	WATER	1.5	13.1	10.3	97.2%	7.5	82	90/08/15	0837	WATER	4	21.2	8.7	96.7%	7.2	53
90/04/10	0912	WATER	2	13.0	10.2	96.2%	7.5	82	90/08/15	0838	WATER	5	21.2	8.7	96.7%	7.2	54
90/04/10	0914	WATER	2.5	13.1	10.2	96.2%	7.4	83	90/08/15	0839	WATER	5.5	21.2	8.7	96.7%	7.3	54
90/04/10	0916	WATER	3	13.0	10.2	96.2%	7.4	83	90/09/12	0821	WATER	0.5	23.1	8.6	98.9%	7.5	66
90/04/10	0918	WATER	4	13.0	10.2	96.2%	7.4	84	90/09/12	0822	WATER	1	23.1	8.6	98.9%	7.4	66
90/04/10	0920	WATER	5	13.0	10.2	96.2%	7.4	85	90/09/12	0826	WATER	1.5	23.1	8.6	98.9%	7.4	65
90/05/10	0843	WATER	0.5	15.7	9.2	92.0%	6.7	98	90/09/12	0828	WATER	2	23.1	8.6	98.9%	7.3	65
90/05/10	0846	WATER	1	15.7	9.2	92.0%	6.8	98	90/09/12	0830	WATER	2.5	23.1	8.6	98.9%	7.3	65
90/05/10	0849	WATER	1.5	15.7	9.2	92.0%	6.9	98	90/09/12	0832	WATER	3	23.1	8.6	98.9%	7.3	66
90/05/10	0851	WATER	2	15.7	9.2	92.0%	7.0	98	90/09/12	0835	WATER	4	23.1	8.6	98.9%	7.3	66
90/05/10	0853	WATER	2.5	15.7	9.2	92.0%	7.0	98	90/09/12	0838	WATER	5	23.1	8.5	97.7%	7.3	65
90/05/10	0855	WATER	3	15.7	9.1	91.0%	7.1	98	90/09/12	0841	WATER	5.5	23.1	8.6	98.9%	7.3	66
90/05/10	0857	WATER	4	15.7	9.1	91.0%	7.1	97									
90/05/10	0859	WATER	5	15.7	9.1	91.0%	7.1	98									
90/05/10	0901	WATER	5.5	15.7	9.0	90.0%	7.1	98									
90/06/13	0845	WATER	0.5	18.1	9.5	100.0%	7.5	58									
90/06/13	0847	WATER	1	18.1	9.5	100.0%	7.4	58									
90/06/13	0849	WATER	1.5	18.1	9.5	100.0%	7.4	58									
90/06/13	0850	WATER	2	18.1	9.5	100.0%	7.3	58									
90/06/13	0851	WATER	2.5	18.1	9.5	100.0%	7.3	58									
90/06/13	0852	WATER	3	18.1	9.5	100.0%	7.3	58									
90/06/13	0853	WATER	4	18.1	9.5	100.0%	7.3	58									
90/06/13	0854	WATER	5	18.1	9.5	100.0%	7.3	58									
90/06/13	0856	WATER	5.5	18.1	9.5	100.0%	7.3	58									
90/07/11	0847	WATER	0.5	20.8	9.2	102.2%	7.9	62									
90/07/11	0850	WATER	1	20.7	9.2	102.2%	7.7	62									
90/07/11	0853	WATER	1.5	20.7	9.2	102.2%	7.6	62									
90/07/11	0854	WATER	2	20.7	9.2	102.2%	7.5	62									
90/07/11	0854	WATER	2.5	20.7	9.2	102.2%	7.4	62									
90/07/11	0855	WATER	3	20.7	9.2	102.2%	7.4	62									
90/07/11	0855	WATER	4	20.7	9.2	102.2%	7.4	62									
90/07/11	0856	WATER	5	20.7	9.2	102.2%	7.4	62									
90/07/11	0856	WATER	5.5	20.7	9.2	102.2%	7.3	61									
90/08/15	0828	WATER	0.5	21.2	8.8	97.8%	7.5	52									
90/08/15	0831	WATER	1	21.2	8.7	96.7%	7.3	53									
90/08/15	0834	WATER	1.5	21.2	8.7	96.7%	7.3	53									
90/08/15	0834	WATER	2	21.2	8.7	96.7%	7.2	53									

STORET RETRIEVAL DATE 92/10/16
 475908 2918
 35 17 28.0 084 43 56.0 2
 0.22 MILE ABOVE OOSTANAULA CREEK
 47011 TENNESSEE BRADLEY
 TENNESSEE RIVER BASIN 040501
 HIWASSEE RIVER 20.0
 131TVAC
 0000 METERS DEPTH

PGM=RET

06020002083 0000.310 ON

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MPN-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	0906	WATER	0.5	1.38	40								
90/04/10	0908	WATER	1				7.3	23	42	6.1	3	10	10
90/05/10	0843	WATER	0.5	.63	2000L								
90/05/10	0846	WATER	1				7.4	25	39	18.0	16	100	100
90/06/13	0845	WATER	0.5	1.13	200	D1							
90/06/13	0846	WATER	0.5		200	D2							
90/06/13	0847	WATER	0.5		200	D3							
90/06/13	0847	WATER	1			D1	7.3	15	46	3.0	4	10	15
90/06/13	0848	WATER	1			D2	7.2	18	50	3.0	5	15	18
90/06/13	0849	WATER	1			D3	7.1	18	40	3.0	4	15	18
90/07/11	0847	WATER	0.5	1.88	100								
90/07/11	0850	WATER	1				7.1	14	130	6.0	5	10	15
90/08/15	0828	WATER	0.5	2.38	10K								
90/08/15	0831	WATER	1				7.2	12	100	4.0	4	3	5
90/09/12	0821	WATER	0.5	2.63	10K								
90/09/12	0823	WATER	1				7.1	12	130	3.0	3	15	20

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLORPHYL A UG/L CORRECTO
90/04/03	1200	WATER	1									1
90/04/10	0908	WATER	1									1
90/04/23	1200	WATER	1		.8	1.5J	.06	.01K	.18	.009	.006	1
90/05/09	1200	WATER	1									1
90/05/10	0846	WATER	1		1.8	1.8	.29	.01	.16	.050	.020	1
90/05/31	1200	WATER	1									2
90/06/13	0845	WATER	0.5	D1								
90/06/13	0846	WATER	0.5	D2								
90/06/13	0847	WATER	0.5	D3								
90/06/13	0847	WATER	1	D1	1.3	1.2	.08	.01K	.16	.010	.003	2
90/06/13	0848	WATER	1	D2	1.1	1.1	.07	.01	.16	.008	.003	
90/06/13	0849	WATER	1	D3	1.1	1.1	.06	.01K	.16	.010	.002	
90/06/28	1200	WATER	1									1
90/07/09	1200	WATER	1									3
90/07/11	0850	WATER	1		1.2	1.1	.06	.01K	.13	.020	.005	
90/07/31	1200	WATER	1									3
90/08/14	1200	WATER	1									2
90/08/15	0831	WATER	1		1.5	1.2	.14	.01K	.15	.008	.004	
90/08/27	1200	WATER	1									2
90/09/11	1200	WATER	1									1
90/09/12	0823	WATER	1		1.3	1.2	.14	.02	.16	.010	.006	

STORET RETRIEVAL DATE 92/10/16
477228

PGM=RET

35 07 28.0 085 08 37.0 2
TRIBUTARY TO HARRISON BAY

47065 TENNESSEE HAMILTON
TENNESSEE RIVER BASIN 040802

WACONDA BAY 0.95
131TVAC 900505
0000 METERS DEPTH

06020001

/TYPA/AMBNT/STREAM/SOLIDS

A-32

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/11	1049	WATER	0.5	14.3	10.2	98.1%	8.0	130	90/09/13	0955	WATER	1.5	27.7	6.9	87.3%	7.7	178
90/04/11	1051	WATER	1	14.3	10.2	98.1%	7.9	130	90/09/13	0956	WATER	2	27.7	6.8	86.1%	7.7	178
90/04/11	1053	WATER	1.5	14.3	10.1	97.1%	7.9	130	90/09/13	0957	WATER	3	27.7	6.6	83.5%	7.7	178
90/04/11	1055	WATER	2	14.2	10.1	97.1%	7.9	127	90/09/13	0958	WATER	3.5	27.7	6.5	82.3%	7.6	178
90/04/11	1057	WATER	2.5	14.2	10.1	97.1%	7.9	127									
90/04/11	1100	WATER	3	14.2	10.0	96.2%	7.9	127									
90/05/10	0934	WATER	0.5	19.0	7.5	79.8%	7.4	136									
90/05/10	0937	WATER	1	19.0	7.4	78.7%	7.4	137									
90/05/10	0940	WATER	1.5	19.0	7.3	77.7%	7.4	136									
90/05/10	0941	WATER	2	19.0	7.2	76.6%	7.4	137									
90/05/10	0943	WATER	2.5	19.0	7.1	75.5%	7.3	137									
90/05/10	0945	WATER	3	19.0	7.0	74.5%	7.3	137									
90/05/10	0947	WATER	4	18.9	6.9	73.4%	7.3	137									
90/06/14	1040	WATER	0.5	25.6	8.6	104.9%	8.2	160									
90/06/14	1042	WATER	1	25.6	8.4	102.4%	8.2	160									
90/06/14	1044	WATER	1.5	25.4	8.5	101.2%	8.2	160									
90/06/14	1045	WATER	2	25.3	8.3	98.8%	8.1	161									
90/06/14	1046	WATER	2.5	25.3	7.6	90.5%	7.9	161									
90/06/14	1047	WATER	2.8	25.2	6.6	78.6%	7.5	161									
90/06/14	1048	WATER	3	25.2	6.4	76.2%	7.4	161									
90/06/14	1049	WATER	3.3	25.2	6.0	71.4%	7.3	161									
90/06/14	1050	WATER	3.6	25.1	5.6	66.7%	7.3	162									
90/06/14	1051	WATER	4	25.0	4.8	57.1%	7.2	163									
90/07/12	1052	WATER	0.5	28.4	4.8	60.8%	7.5	172									
90/07/12	1055	WATER	1	28.4	4.7	59.5%	7.4	173									
90/07/12	1058	WATER	1.5	28.4	4.7	59.5%	7.4	172									
90/07/12	1059	WATER	2	28.4	4.7	59.5%	7.4	172									
90/07/12	1100	WATER	2.5	28.4	4.7	59.5%	7.4	173									
90/07/12	1101	WATER	3	28.4	4.5	57.0%	7.4	174									
90/07/12	1102	WATER	3.5	28.3	4.4	55.7%	7.3	174									
90/08/16	0948	WATER	0.5	28.4	9.1	115.2%	8.6	166									
90/08/16	0950	WATER	1	28.4	9.0	113.9%	8.6	167									
90/08/16	0953	WATER	1.5	28.4	8.9	112.7%	8.6	167									
90/08/16	0954	WATER	2	28.4	8.8	111.4%	8.6	167									
90/08/16	0954	WATER	2.5	28.3	8.4	106.3%	8.4	168									
90/08/16	0955	WATER	3	28.2	6.8	86.1%	8.3	172									
90/08/16	0956	WATER	3.5	27.6	5.4	68.4%	7.4	178									
90/09/13	0951	WATER	0.5	27.6	7.2	91.1%	7.7	178									
90/09/13	0953	WATER	1	27.7	7.1	89.9%	7.7	178									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477228

35 07 28.0 085 08 37.0 2

TRIBUTARY TO HARRISON BAY

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

WACONDA BAY 0.95

131TVAC 900505

06020001

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI NFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1049	WATER	0.5	.76	10K								
90/04/11	1051	WATER	1				7.7	48	69	13.0	11	15	25
90/05/10	0934	WATER	0.5	.97	20R								
90/05/10	0937	WATER	1			D1	7.3	52	63	11.0	5	30	33
90/05/10	0938	WATER	1			D2	7.5	46	67	11.0	7	25	33
90/05/10	0939	WATER	1			D3	7.4	48	55	12.0	5	30	37
90/06/14	1040	WATER	0.5	1.50	10K								
90/06/14	1042	WATER	1				7.9	59	94	5.0	4	20	23
90/07/12	1052	WATER	0.5	.77	10K								
90/07/12	1055	WATER	1				7.7	70	95	9.0	6	15	20
90/08/16	0948	WATER	0.5	1.27	10K								
90/08/16	0950	WATER	1				8.1	63	91	4.0	3	5	7
90/09/13	0951	WATER	0.5	.82	40								
90/09/13	0953	WATER	1				7.7	70	100	5.0	8	10	15

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C MG/L	00681 D ORG C MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/04	1200	WATER	1									11
90/04/11	1051	WATER	1									
90/04/19	1200	WATER	1		1.7	1.9J	.26	.01K	.32	.020	.004	6
90/05/10	0937	WATER	1	D1	1.8	1.6	.11	.03	.23	.010	.007	
90/05/10	0938	WATER	1	D2	1.8	1.7	.13	.03	.24	.020	.006	
90/05/10	0939	WATER	1	D3	1.7	1.7	.13	.03	.23	.020	.006	
90/05/11	1200	WATER	1									16
90/05/29	1200	WATER	1									9
90/06/12	1200	WATER	1									8
90/06/14	1042	WATER	1		2.0	1.9	.17	.01	.09	.010	.003	
90/06/27	1200	WATER	1									5
90/07/10	1200	WATER	1									12
90/07/12	1055	WATER	1		2.1	2.0	.02K	.03	.11	.030	.004	
90/07/30	1200	WATER	1									14
90/08/09	1200	WATER	1									13
90/08/13	1200	WATER	1									8
90/08/16	0950	WATER	1		2.2	2.0	.28	.01K	.03	.010	.003	
90/08/28	1200	WATER	1									10
90/09/13	0953	WATER	1		2.1	2.0	.23	.03	.06	.020	.006	

PGM=RET

35 09 26.0 085 05 20.0 2

AT WOLFEVER FISHING CLUB

47065 TENNESSEE HAMILTON

TENNESSEE RIVER BASIN 040802

WOLFTEVER CREEK 4.2

131TVAC 900505

0000 METERS DEPTH

06020001

/TYPA/AMBNT/STREAM/SOLIDS

A-34

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/11	0928	WATER	0.5	14.9	10.9	106.9%	7.9	211	90/07/12	1027	WATER	5	27.7	5.7	72.2%	7.8	206
90/04/11	0930	WATER	1	14.9	10.4	102.0%	7.8	212	90/08/16	0855	WATER	0.5	28.2	8.4	106.3%	8.5	196
90/04/11	0933	WATER	1.5	14.9	10.2	100.0%	7.8	212	90/08/16	0858	WATER	1	28.2	8.3	105.1%	8.5	196
90/04/11	0934	WATER	2	14.9	10.0	98.0%	7.8	211	90/08/16	0901	WATER	1.5	28.2	8.3	105.1%	8.4	196
90/04/11	0935	WATER	2.5	14.9	10.0	98.0%	7.8	211	90/08/16	0901	WATER	2	28.2	7.8	98.7%	8.3	196
90/04/11	0937	WATER	3	14.9	9.8	96.1%	7.7	211	90/08/16	0902	WATER	2.5	27.9	6.1	77.2%	7.6	200
90/04/11	0939	WATER	4	14.9	9.6	94.1%	7.8	209	90/08/16	0902	WATER	3	27.8	5.1	64.6%	7.5	202
90/04/11	0941	WATER	4.5	14.8	8.8	86.3%	7.7	212	90/08/16	0903	WATER	4	27.3	4.8	59.3%	7.4	218
90/05/10	0847	WATER	0.5	20.3	8.3	90.2%	7.9	222	90/08/16	0903	WATER	5	25.8	4.1	50.0%	7.2	246
90/05/10	0850	WATER	1	20.3	8.2	89.1%	7.9	223	90/08/16	0904	WATER	5.5	20.5	5.3	57.6%	7.1	247
90/05/10	0853	WATER	1.5	20.2	7.8	84.8%	7.8	226	90/09/13	0925	WATER	0.5	27.4	6.9	85.2%	7.8	196
90/05/10	0854	WATER	2	20.0	7.8	84.8%	7.8	226	90/09/13	0927	WATER	1	27.4	6.7	82.7%	7.8	196
90/05/10	0856	WATER	2.5	19.8	7.9	85.9%	7.9	226	90/09/13	0929	WATER	1.5	27.5	6.6	81.5%	7.8	196
90/05/10	0858	WATER	3	19.8	7.9	85.9%	7.8	225	90/09/13	0929	WATER	2	27.5	6.6	81.5%	7.8	196
90/05/10	0901	WATER	4	19.7	7.6	82.6%	7.7	227	90/09/13	0930	WATER	3	27.5	6.5	80.2%	7.7	196
90/05/10	0905	WATER	5	19.6	7.4	80.4%	7.7	226	90/09/13	0931	WATER	4	27.4	6.0	74.1%	7.6	202
90/05/10	0910	WATER	5.5	19.0	7.7	81.9%	7.5	222	90/09/13	0932	WATER	5	26.6	5.2	64.2%	7.3	210
90/06/14	1000	WATER	0.5	27.5	10.4	128.4%	8.8	190	90/09/13	0933	WATER	5.5	23.8	5.6	65.9%	7.2	221
90/06/14	1002	WATER	1	27.4	10.3	127.2%	8.8	190									
90/06/14	1005	WATER	1.5	27.4	9.9	122.2%	8.7	190									
90/06/14	1006	WATER	1.8	27.3	9.6	118.5%	8.7	191									
90/06/14	1007	WATER	2	27.2	7.8	96.3%	8.6	193									
90/06/14	1008	WATER	2.5	26.5	7.3	89.0%	7.8	197									
90/06/14	1009	WATER	2.8	25.9	6.1	74.4%	7.5	194									
90/06/14	1010	WATER	3	25.9	5.9	72.0%	7.4	190									
90/06/14	1011	WATER	3.3	25.5	5.3	63.1%	7.3	186									
90/06/14	1012	WATER	3.6	25.3	4.1	48.8%	7.1	195									
90/06/14	1013	WATER	4	25.2	3.4	40.5%	7.1	201									
90/06/14	1014	WATER	5	24.3	2.7	31.8%	7.0	228									
90/06/14	1015	WATER	5.3	22.2	4.6	52.3%	7.1	238									
90/06/14	1016	WATER	5.5	19.6	5.6	60.9%	7.0	240									
90/07/12	1017	WATER	0.5	29.5	7.3	93.6%	8.2	187									
90/07/12	1020	WATER	1	29.5	7.2	92.3%	8.2	187									
90/07/12	1023	WATER	1.5	29.5	7.7	98.7%	8.4	183									
90/07/12	1024	WATER	2	29.5	7.6	97.4%	8.4	183									
90/07/12	1024	WATER	2.5	29.4	7.5	96.2%	8.4	182									
90/07/12	1025	WATER	3	29.4	7.0	89.7%	8.4	185									
90/07/12	1025	WATER	3.6	29.4	6.4	82.1%	8.1	188									
90/07/12	1026	WATER	4	29.1	5.1	65.4%	8.4	197									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477229

35 09 26.0 085 05 20.0 2

AT WOLFTEVER FISHING CLUB

47065 TENNESSEE HAMILTON

TENNESSEE RIVER BASIN 040802

WOLFTEVER CREEK 4.2

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI NFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	0928	WATER	0.5	.70	10								
90/04/11	0930	WATER	1				7.9	105	61	7.0	5	10	15
90/05/10	0847	WATER	0.5	.95	10K								
90/05/10	0850	WATER	1			01	7.8	110	110	6.5	4	30	35
90/05/10	0851	WATER	1			02	7.8	110	100	6.0	6	25	32
90/05/10	0852	WATER	1			03	7.8	110	110	6.4	5	30	30
90/06/14	1000	WATER	0.5	1.25	10K								
90/06/14	1002	WATER	1				8.6	82	98	5.0	3	20	23
90/07/12	1017	WATER	0.5	1.22	10K								
90/07/12	1020	WATER	1				8.1	86	100	7.0	5	15	20
90/08/16	0855	WATER	0.5	1.87	10K								
90/08/16	0858	WATER	1				8.2	83	91	2.0	1	10	15
90/09/13	0925	WATER	0.5	1.23	10K								
90/09/13	0927	WATER	1				7.8	81	99	3.0	4	2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTO
90/04/04	1200	WATER	1									8
90/04/11	0930	WATER	1		1.2	1.6J	.12	.01K	.24	.020	.006	7
90/04/19	1200	WATER	1									
90/05/10	0850	WATER	1	01	2.6	2.3	.27	.03	.03	.020	.005	
90/05/10	0851	WATER	1	02	2.6	2.3	.38	.02	.03	.030	.003	
90/05/10	0852	WATER	1	03	2.6	2.4	.34	.02	.03	.050	.005	
90/05/11	1200	WATER	1									13
90/05/29	1200	WATER	1									10
90/06/12	1200	WATER	1									9
90/06/14	1002	WATER	1		3.1	2.6	.22	.01K	.01K	.020	.002K	
90/06/15	1200	WATER	1									31
90/06/27	1200	WATER	1									4
90/07/10	1200	WATER	1									13
90/07/12	1020	WATER	1		2.5	2.4	.32	.01K	.01K	.040	.004	
90/07/30	1200	WATER	1									11
90/08/09	1200	WATER	1									10
90/08/13	1200	WATER	1									7
90/08/16	0858	WATER	1		2.5	2.3	.30	.01K	.01K	.010	.002	
90/08/28	1200	WATER	1									9
90/09/13	0927	WATER	1		2.4	2.2	.21	.01	.01K	.020	.005	

PGM=RET

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35 08 01.0 085 04 28.0 2
BELOW ROGERS BRANCH
47065 TENNESSEE HAMILTON
TENNESSEE RIVER BASIN 040802
WOLFTEVER CREEK 5.65
1311VAC 900505 0602
0000 METERS DEPTH

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06020001

/TYPA/AMBNT/STREAM/SOLIDS

A-36

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/11	1000	WATER	0.5	14.2	11.3	108.7%	8.1	231									
90/04/11	1002	WATER	1	14.2	10.1	97.1%	8.1	231	90/09/13	0915	WATER	3	26.6	5.0	61.7%	7.5	277
90/04/11	1005	WATER	1.5	14.2	10.0	96.2%	8.0	231									
90/04/11	1007	WATER	2	14.2	10.0	96.2%	8.0	231									
90/04/11	1010	WATER	2.5	14.2	10.0	96.2%	8.0	231									
90/04/11	1014	WATER	3	14.2	9.9	95.2%	8.0	231									
90/05/10	0825	WATER	0.5	18.8	9.0	95.7%	7.9	202									
90/05/10	0828	WATER	1	18.5	8.6	90.5%	7.9	200									
90/05/10	0831	WATER	1.5	17.1	8.2	84.5%	7.6	165									
90/05/10	0833	WATER	2	16.8	8.3	85.6%	7.5	170									
90/05/10	0836	WATER	2.5	16.7	8.3	85.6%	7.5	162									
90/05/10	0839	WATER	3	16.6	8.3	85.6%	7.5	168									
90/05/10	0842	WATER	3.5	16.6	8.2	84.5%	7.5	178									
90/06/14	0913	WATER	0.5	27.2	7.2	88.9%	8.1	259									
90/06/14	0915	WATER	0.8	27.2	6.3	77.8%	8.0	260									
90/06/14	0918	WATER	1	27.3	5.9	72.8%	8.0	261									
90/06/14	0920	WATER	1.3	27.2	5.0	61.7%	7.8	263									
90/06/14	0920	WATER	1.5	27.2	4.2	51.9%	7.7	264									
90/06/14	0921	WATER	1.8	26.8	1.7	21.0%	7.5	268									
90/06/14	0922	WATER	2	26.8	2.5	30.9%	7.5	268									
90/07/12	0950	WATER	0.5	29.3	6.2	79.5%	7.6	214									
90/07/12	0953	WATER	1	29.2	5.9	75.6%	7.6	214									
90/07/12	0956	WATER	1.5	29.2	6.0	76.9%	7.6	215									
90/07/12	0956	WATER	2	29.1	5.2	66.7%	7.6	218									
90/07/12	0957	WATER	2.5	27.9	4.2	53.2%	7.5	248									
90/07/12	0957	WATER	3	27.2	3.9	48.1%	7.4	262									
90/07/12	0958	WATER	3.5	26.9	3.3	40.7%	7.4	265									
90/08/16	0829	WATER	0.5	28.2	7.5	94.9%	8.0	213									
90/08/16	0832	WATER	1	28.2	7.3	92.4%	8.0	214									
90/08/16	0834	WATER	1.5	28.2	7.3	92.4%	8.0	213									
90/08/16	0834	WATER	2	28.2	7.2	91.1%	8.0	212									
90/08/16	0835	WATER	2.5	27													

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477230

35 08 01.0 085 04 28.0 2

BELOW ROGERS BRANCH

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

WOLFTEVER CREEK 5.65

131TVAC 900505

06020001

0000 METERS DEPTH

/TYP/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFH-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1000	WATER	0.5	.68	10								
90/04/11	1002	WATER	1										
90/05/10	0825	WATER	0.5	.50	10K		8.0	105	55	13.0	11	7	15
90/05/10	0828	WATER	1				7.8	91	98	17.0	14	30	38
90/06/14	0913	WATER	0.5	.50	10	D1							
90/06/14	0914	WATER	0.5		10K	D2							
90/06/14	0915	WATER	0.5		10K	D3							
90/06/14	0918	WATER	1			D1	8.0	130	82	15.0	14	35	40
90/06/14	0919	WATER	1			D2	8.0	130	78	15.0	14	45	48
90/06/14	0920	WATER	1			D3	7.8	130	130	15.0	14	30	35
90/07/12	0950	WATER	0.5	.63	10K		7.9	110	100	12.0	10	20	25
90/07/12	0953	WATER	1										
90/08/16	0829	WATER	0.5	.92	10K		8.0	84	100	6.0	6	10	15
90/08/16	0832	WATER	1										
90/09/13	0908	WATER	0.5	.73	10K		7.9	100	100	6.0	10	2	5
90/09/13	0910	WATER	1										

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T DRG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTNO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/04	1200	WATER	1									4
90/04/11	1002	WATER	1		1.4	2.3J	.15	.01	.10	.020	.003	
90/04/19	1200	WATER	1									5
90/05/10	0828	WATER	1		3.4	3.3	.35	.03	.07	.050	.005	
90/05/11	1200	WATER	1									12
90/05/29	1200	WATER	1									14
90/06/12	1200	WATER	1									14
90/06/14	0913	WATER	0.5	D1								
90/06/14	0914	WATER	0.5	D2								
90/06/14	0915	WATER	0.5	D3								
90/06/14	0918	WATER	1	D1	4.0	3.3	.62	.02	.01K	.050	.002	
90/06/14	0919	WATER	1	D2	4.2	3.3	.61	.01	.01K	.050	.002	
90/06/14	0920	WATER	1	D3	4.0	3.2	.61	.01	.01K	.050	.002	
90/06/15	1200	WATER	1									8
90/06/27	1200	WATER	1									5
90/07/10	1200	WATER	1									17
90/07/12	0953	WATER	1		2.8	2.5	.38	.01K	.01K	.040	.004	
90/07/30	1200	WATER	1									10
90/08/09	1200	WATER	1									14
90/08/13	1200	WATER	1									10
90/08/16	0832	WATER	1		2.8	2.4	.30	.01K	.01K	.010	.002	
90/08/28	1200	WATER	1									11
90/09/13	0910	WATER	1		2.8	2.4	.34	.01K	.01K	.020	.005	

STORET RETRIEVAL DATE 92/10/16
477231

PGH=RET

35 09 11.0 085 03 32.0 2

SAVANNAH BAY

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SAVANNAH CREEK 2.95

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/11	0901	WATER	0.5	13.9	10.2	98.1%	8.3	268
90/04/11	0904	WATER	1	14.0	9.6	92.3%	8.3	267
90/05/10	0800	WATER	0.5	19.1	8.3	88.3%	8.0	250
90/05/10	0803	WATER	1	19.0	7.9	84.0%	8.0	248
90/05/10	0806	WATER	1.5	18.8	7.0	74.5%	7.8	242
90/05/10	0812	WATER	2	18.4	6.7	70.5%	7.7	230
90/06/14	0945	WATER	0.5	27.6	9.1	115.2%	8.4	235
90/06/14	0947	WATER	1	27.6	8.7	110.1%	8.3	236
90/06/14	0950	WATER	1.5	27.5	8.3	102.5%	8.2	237
90/06/14	0951	WATER	1.8	27.3	7.1	87.7%	7.9	241
90/06/14	0952	WATER	2	27.0	7.0	86.4%	7.9	236
90/06/14	0953	WATER	2.5	25.4	6.4	76.2%	7.5	261
90/06/14	0954	WATER	3	23.9	5.9	69.4%	7.3	276
90/06/14	0955	WATER	3.5	23.5	5.8	66.7%	7.3	276
90/07/11	1141	WATER	0.5	29.9	7.0	92.1%	7.7	245
90/07/11	1144	WATER	1	29.9	6.4	84.2%	7.8	246
90/07/11	1147	WATER	1.3	29.2	4.7	60.3%	7.6	247
90/07/11	1147	WATER	1.5	29.3	4.9	62.8%	7.7	246
90/07/11	1147	WATER	2	29.1	4.0	51.3%	7.6	248
90/08/16	0806	WATER	0.5	28.1	7.1	89.9%	8.1	231
90/08/16	0809	WATER	1	28.1	6.4	81.0%	8.0	232
90/08/16	0812	WATER	1.5	28.1	6.3	79.7%	8.0	232
90/08/16	0813	WATER	2	27.9	3.1	39.2%	7.5	235
90/09/13	0852	WATER	0.5	27.1	6.2	76.5%	7.9	226
90/09/13	0855	WATER	1	27.2	6.0	74.1%	7.9	226
90/09/13	0858	WATER	1.5	27.2	6.0	74.1%	7.9	227
90/09/13	0858	WATER	2	27.2	6.0	74.1%	7.9	225

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477231

35 09 11.0 085 03 32.0 2

SAVANNAH BAY

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SAVANNAH CREEK 2.95

131TVAC 900505

06020001

0000 METERS DEPTH

/TYP/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MPN-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	0901	WATER	0.5	.75	470								
90/04/11	0904	WATER	1				8.1	130	63	23.0	22	15	25
90/05/10	0800	WATER	0.5	.43	10K								
90/05/10	0803	WATER	1				8.1	120	92	20.0	15	48	48
90/06/14	0945	WATER	0.5	.75	10								
90/06/14	0947	WATER	1				8.0	115	120	7.0	7	20	25
90/07/11	1141	WATER	0.5	.48	10K	D1							
90/07/11	1142	WATER	0.5		20	D2							
90/07/11	1143	WATER	0.5		10	D3							
90/07/11	1144	WATER	1			D1	7.9	120	130	23.0	22	20	25
90/07/11	1145	WATER	1			D2	8.0	120	130	21.0	21	20	25
90/07/11	1146	WATER	1			D3	7.9	120	120	21.0	21	15	20
90/08/16	0806	WATER	0.5	.46	10K								
90/08/16	0809	WATER	1				8.1	110	97	11.0	11	10	15
90/09/13	0852	WATER	0.5	.47	10K								
90/09/13	0855	WATER	1				8.1	110	97	11.0	22	5	10

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTO
90/04/04	1200	WATER	1									17
90/04/11	0904	WATER	1		2.0	2.3J	.51	.01	.05	.040	.003	
90/04/19	1200	WATER	1									11
90/05/10	0803	WATER	1		3.7	3.3	.62	.01K	.02	.030	.005	
90/05/11	1200	WATER	1									4
90/05/29	1200	WATER	1									20
90/06/12	1200	WATER	1									12
90/06/14	0947	WATER	1		3.5	2.8	.38	.01K	.01K	.050	.003	
90/06/27	1200	WATER	1									9
90/07/10	1200	WATER	1									20
90/07/11	1141	WATER	0.5	D1								
90/07/11	1142	WATER	0.5	D2								
90/07/11	1143	WATER	0.5	D3								
90/07/11	1144	WATER	1	D1	3.7	3.1	.62	.01K	.01K	.070	.003	
90/07/11	1145	WATER	1	D2	3.9	3.1	.66	.01K	.01K	.070	.003	
90/07/11	1146	WATER	1	D3	3.9	3.1	.66	.01K	.01K	.070	.003	
90/07/30	1200	WATER	1									22
90/08/09	1200	WATER	1									20
90/08/13	1200	WATER	1									13
90/08/16	0809	WATER	1		3.9	3.4	.54	.01K	.01K	.030	.002	
90/08/28	1200	WATER	1									20
90/09/13	0855	WATER	1		4.0	3.2	.52	.02	.01	.030	.005	

A-39

PGM=RET

477232

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CHESTER FROST COUNTY PARK

47065 TENNESSEE HAMILTON

TENNESSEE RIVER BASIN

DALLAS BAY 0.9

31TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICRONHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICRONHO
90/04/10	0912	WATER	0.5	15.0	12.0	117.68	8.1	134	90/07/10	1309	WATER	4.3	28.4	2.2	27.88	7.4	189
90/04/10	0914	WATER	1	15.0	11.8	115.78	8.1	134	90/07/10	1309	WATER	4.6	28.4	1.8	22.88	7.3	188
90/04/10	0917	WATER	1.5	15.0	11.6	113.78	8.1	134	90/07/10	1310	WATER	5	28.3	1.1	13.98	7.2	188
90/04/10	0919	WATER	2	15.0	11.4	111.88	8.1	134	90/07/10	1310	WATER	6	27.9	.1	1.38	7.1	193
90/04/10	0921	WATER	2.5	14.9	11.2	109.88	8.1	134	90/08/15	1015	WATER	0.5	27.9	8.8	111.48	8.6	174
90/04/10	0923	WATER	3	14.7	10.8	105.98	8.0	133	90/08/15	1018	WATER	1	27.9	8.6	108.98	8.6	175
90/04/10	0925	WATER	4	14.5	10.4	100.08	7.9	132	90/08/15	1021	WATER	1.5	27.9	8.4	106.38	8.5	175
90/04/10	0927	WATER	5	13.7	9.4	90.48	7.6	132	90/08/15	1021	WATER	2	27.9	8.3	105.18	8.5	176
90/04/10	0929	WATER	5.5	13.6	8.3	79.88	7.4	134	90/08/15	1022	WATER	2.5	27.8	8.2	103.88	8.6	175
90/05/09	1045	WATER	0.5	20.4	9.4	102.28	7.9	140	90/08/15	1022	WATER	3	27.6	3.4	43.08	7.6	178
90/05/09	1048	WATER	1	20.5	9.2	100.08	7.9	140	90/08/15	1023	WATER	4	27.0	2.5	30.98	7.1	177
90/05/09	1051	WATER	1.5	20.5	9.1	98.98	7.9	140	90/08/15	1023	WATER	4.5	26.8	1.5	18.58	7.0	177
90/05/09	1052	WATER	2	20.5	9.1	98.98	7.9	141	90/08/15	1024	WATER	5	26.8	1.1	13.68	6.9	178
90/05/09	1053	WATER	2.5	19.8	6.6	71.78	7.5	139	90/08/15	1024	WATER	6	26.6	.3	3.78	4.9	184
90/05/09	1054	WATER	3	19.7	6.6	71.78	7.3	139	90/09/12	0952	WATER	0.5	27.9	7.9	100.08	8.2	178
90/05/09	1055	WATER	4	19.3	6.1	64.98	7.2	140	90/09/12	0954	WATER	1	28.0	7.8	98.78	8.2	178
90/05/09	1057	WATER	5	19.1	6.1	64.98	7.2	139	90/09/12	0957	WATER	1.5	28.0	7.6	96.28	8.2	178
90/05/09	1100	WATER	6	19.0	6.0	63.88	7.1	139	90/09/12	0957	WATER	2	28.0	7.5	94.98	8.1	178
90/06/13	1115	WATER	0.5	26.8	9.2	113.68	8.6	157	90/09/12	0957	WATER	3	27.9	6.4	81.08	7.8	179
90/06/13	1117	WATER	1	26.8	9.2	113.68	8.6	157	90/09/12	0958	WATER	2.5	28.0	7.2	91.18	8.0	178
90/06/13	1119	WATER	1.5	26.6	9.1	112.38	8.6	157	90/09/12	0958	WATER	3.5	27.6	5.0	63.38	7.3	179
90/06/13	1120	WATER	2	26.5	9.1	111.08	8.6	156	90/09/12	0959	WATER	4	27.6	4.3	54.48	7.2	179
90/06/13	1121	WATER	2.5	26.1	9.0	109.88	8.4	158	90/09/12	0959	WATER	4.5	27.5	3.2	39.58	7.0	180
90/06/13	1122	WATER	3	25.7	8.6	104.98	8.1	160	90/09/12	1000	WATER	5	27.5	1.8	22.28	6.9	181
90/06/13	1123	WATER	3.5	25.1	7.0	83.38	7.3	161	90/09/12	1000	WATER	6	27.4	1.2	14.88	6.8	181
90/06/13	1124	WATER	4	25.2	6.7	79.88	7.5	162									
90/06/13	1125	WATER	4.5	24.7	5.5	45.58	7.2	160									
90/06/13	1126	WATER	5	24.5	5.1	60.08	7.1	158									
90/06/13	1127	WATER	5.5	24.3	3.7	43.58	7.0	160									
90/06/13	1128	WATER	6	24.0	2.0	23.58	6.9	162									
90/07/10	1300	WATER	0.5	30.5	8.7	114.58	8.5	182									
90/07/10	1303	WATER	1	30.2	8.9	117.18	8.6	181									
90/07/10	1306	WATER	1.5	29.7	8.4	110.58	8.6	181									
90/07/10	1307	WATER	2	29.6	8.1	106.68	8.5	183									
90/07/10	1307	WATER	2.5	29.5	7.3	93.68	8.5	183									
90/07/10	1308	WATER	2.8	29.2	5.5	70.58	7.8	185									
90/07/10	1308	WATER	3	29.3	5.0	64.18	7.9	186									
90/07/10	1308	WATER	3.3	28.8	3.9	50.08	7.6	188									
90/07/10	1309	WATER	4	28.6	3.2	41.08	7.5	188									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477232

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CHESTER FROST COUNTY PARK

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

DALLAS BAY 0.9

131TVAC 900505

06020001

0000 METERS DEPTH

/TYP/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFH-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	0912	WATER	0.5		10K								
90/04/10	0914	WATER	1				7.8	52	73	6.4	5	10	15
90/05/09	1045	WATER	0.5	1.75	10K		7.6	52	61	2.8	2	30	30
90/05/09	1048	WATER	1										
90/06/13	1115	WATER	0.5	1.50	10K	D1							
90/06/13	1116	WATER	0.5		10K	D2							
90/06/13	1117	WATER	0.5		10K	D3							
90/06/13	1117	WATER	1			D1	8.1	59	72	5.0	4	20	22
90/06/13	1118	WATER	1			D2	8.1	58	78	6.0	5	20	22
90/06/13	1119	WATER	1			D3	8.1	58	70	5.0	4	20	22
90/07/10	1300	WATER	0.5	1.00	10K	D1							
90/07/10	1301	WATER	0.5		10K	D2							
90/07/10	1302	WATER	0.5		10K	D3							
90/07/10	1303	WATER	1				8.6	67	99	6.0	5	10	15
90/08/15	1015	WATER	0.5	1.37	10K		8.2	67	81	4.0	3	3	5
90/08/15	1018	WATER	1										
90/09/12	0952	WATER	0.5	.97	10K		7.8	69	95	3.0	5	2	5
90/09/12	0954	WATER	1										

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG-N H MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTED
90/04/04	1200	WATER	1									10
90/04/10	0914	WATER	1		1.6	1.8J	.18	.01K	.20	.010	.004	6
90/04/19	1200	WATER	1									
90/05/09	1048	WATER	1		1.9	2.0	.18	.01K	.14	.009	.004	15
90/05/11	1200	WATER	1									9
90/05/29	1200	WATER	1									6
90/06/12	1200	WATER	1									
90/06/13	1115	WATER	0.5	D1								
90/06/13	1116	WATER	0.5	D2								
90/06/13	1117	WATER	0.5	D3								
90/06/13	1117	WATER	1	D1	2.3	2.3	.25	.01K	.01	.010	.002K	
90/06/13	1118	WATER	1	D2	2.3	2.1	.20	.01K	.02	.010	.002K	
90/06/13	1119	WATER	1	D3	2.3	2.1	.20	.01K	.02	.005	.002K	
90/06/27	1200	WATER	1									4
90/07/10	1200	WATER	1									10
90/07/10	1300	WATER	0.5	D1								
90/07/10	1301	WATER	0.5	D2								
90/07/10	1302	WATER	0.5	D3								
90/07/10	1303	WATER	1		2.5	2.2	.36	.01K	.01K	.020	.004	12
90/08/09	1200	WATER	1									13
90/08/13	1200	WATER	1									8
90/08/15	1018	WATER	1		2.3	2.1	.20	.01K	.01K	.009	.005	7
90/08/28	1200	WATER	1		2.3	2.0	.25	.01	.01K	.010	.007	
90/09/12	0954	WATER	1									

STORET RETRIEVAL DATE 92/10/16
477233

PGM=RET

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CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SODDY CREEK 1.7

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/10	1026	WATER	0.5	14.4	12.2	117.3%	7.6	94	90/06/13	1050	WATER	9.5	21.7	2.8	31.8%	6.7	143
90/04/10	1028	WATER	1	14.4	11.8	113.5%	7.6	94	90/07/10	1105	WATER	0.5	28.9	8.4	107.7%	8.5	172
90/04/10	1029	WATER	1.5	14.4	11.5	110.6%	7.6	94	90/07/10	1108	WATER	1	28.9	7.9	101.3%	8.5	173
90/04/10	1031	WATER	2	14.4	11.3	108.7%	7.6	94	90/07/10	1111	WATER	1.5	28.7	8.2	105.1%	8.5	173
90/04/10	1033	WATER	2.5	14.4	11.2	107.7%	7.6	94	90/07/10	1111	WATER	2	28.5	7.5	94.9%	8.4	176
90/04/10	1035	WATER	3	14.4	11.0	105.8%	7.5	94	90/07/10	1111	WATER	2.3	27.6	5.8	73.4%	8.0	184
90/04/10	1037	WATER	4	14.3	11.0	105.8%	7.5	94	90/07/10	1112	WATER	2.5	27.5	5.5	67.9%	8.2	185
90/04/10	1039	WATER	5	14.2	10.7	102.9%	7.5	94	90/07/10	1112	WATER	3	27.2	4.9	60.5%	7.9	186
90/04/10	1041	WATER	6	13.8	10.5	101.0%	7.4	94	90/07/10	1113	WATER	4	26.9	4.3	53.1%	7.7	188
90/04/10	1044	WATER	7	13.2	9.9	93.4%	7.3	90	90/07/10	1113	WATER	5	26.6	3.5	43.2%	7.6	188
90/04/10	1047	WATER	8	13.0	9.8	92.5%	7.2	89	90/07/10	1114	WATER	5.3	26.5	3.0	36.6%	7.4	189
90/04/10	1050	WATER	8.5	13.0	9.9	93.4%	7.3	89	90/07/10	1114	WATER	6	26.2	2.1	25.6%	7.3	187
90/05/09	0926	WATER	0.5	20.2	9.8	106.5%	8.1	112	90/07/10	1115	WATER	7	25.7	1.4	17.1%	7.2	188
90/05/09	0929	WATER	1	20.2	9.8	106.5%	8.1	112	90/07/10	1116	WATER	8	25.4	.8	9.5%	7.2	188
90/05/09	0932	WATER	1.5	20.2	9.7	105.4%	8.1	112	90/07/10	1117	WATER	9	25.0	.3	3.6%	7.1	191
90/05/09	0933	WATER	2	19.8	8.4	91.3%	7.8	112	90/07/10	1119	WATER	9.5	24.0	.2	2.4%	7.0	197
90/05/09	0934	WATER	2.5	19.3	8.1	86.2%	7.5	106	90/08/15	0902	WATER	0.5	27.3	9.4	116.1%	8.7	167
90/05/09	0935	WATER	3	18.9	6.8	72.3%	7.3	124	90/08/15	0905	WATER	1	27.3	9.2	113.6%	8.6	169
90/05/09	0936	WATER	4	18.6	6.6	70.2%	7.2	129	90/08/15	0908	WATER	1.5	27.3	9.3	114.8%	8.7	167
90/05/09	0937	WATER	5	18.4	6.7	70.5%	7.2	129	90/08/15	0908	WATER	2	27.3	9.3	114.8%	8.6	167
90/05/09	0938	WATER	6	18.3	6.6	69.5%	7.2	126	90/08/15	0909	WATER	2.5	27.1	9.0	111.1%	8.5	167
90/05/09	0939	WATER	7	18.2	6.2	65.3%	7.1	116	90/08/15	0909	WATER	3	27.0	7.2	88.9%	8.0	168
90/05/09	0940	WATER	8	17.8	6.3	66.3%	7.0	105	90/08/15	0910	WATER	3.5	26.6	6.2	76.5%	7.5	169
90/05/09	0941	WATER	9	17.2	7.2	74.2%	6.9	73	90/08/15	0910	WATER	4	26.5	5.3	64.6%	7.4	168
90/05/09	0945	WATER	10	16.8	7.2	74.2%	6.8	69	90/08/15	0911	WATER	5	26.3	4.4	53.7%	7.2	168
90/06/13	1030	WATER	0.5	26.1	9.7	118.3%	8.6	141	90/08/15	0911	WATER	6	26.2	3.4	41.5%	7.1	168
90/06/13	1032	WATER	1	26.1	9.6	117.1%	8.6	141	90/08/15	0912	WATER	6.5	26.0	2.2	26.8%	6.9	168
90/06/13	1034	WATER	1.5	26.1	9.4	114.6%	8.5	141	90/08/15	0913	WATER	7	25.9	1.7	20.7%	6.8	170
90/06/13	1035	WATER	2	25.9	9.7	118.3%	8.5	148	90/08/15	0913	WATER	8	25.7	.9	11.0%	6.7	172
90/06/13	1036	WATER	2.5	25.5	9.9	117.9%	8.5	154	90/08/15	0914	WATER	9	25.4	.3	3.6%	6.7	179
90/06/13	1037	WATER	3	24.7	8.6	102.4%	8.0	162	90/08/15	0914	WATER	10	24.4	.2	2.4%	6.7	189
90/06/13	1038	WATER	3.5	24.3	7.8	91.8%	7.7	162	90/09/12	0918	WATER	0.5	27.5	8.3	102.5%	8.3	176
90/06/13	1039	WATER	4	24.0	7.0	82.4%	7.4	162	90/09/12	0920	WATER	1	27.5	8.2	101.2%	8.3	177
90/06/13	1040	WATER	5	23.9	6.6	77.6%	7.3	162	90/09/12	0922	WATER	1.5	27.5	8.2	101.2%	8.3	177
90/06/13	1041	WATER	6	23.7	5.9	69.4%	7.2	160	90/09/12	0923	WATER	2	27.5	8.2	101.2%	8.3	177
90/06/13	1042	WATER	6.5	23.5	5.4	62.1%	7.1	157	90/09/12	0923	WATER	3	27.5	7.7	95.1%	8.0	177
90/06/13	1044	WATER	7	23.2	4.8	55.2%	7.0	156	90/09/12	0923	WATER	4	27.5	7.6	93.8%	7.9	176
90/06/13	1046	WATER	8	22.8	4.0	46.0%	6.9	144	90/09/12	0924	WATER	4.5	27.2	5.2	64.2%	7.2	179
90/06/13	1048	WATER	9	22.1	3.4	38.6%	6.8	140	90/09/12	0924	WATER	5	27.2	4.3	53.1%	7.0	180

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477233

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CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SODDY CREEK 1.7

131TVAC 900505

06020001

0000 METERS DEPTH

/TYP/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTIV FIELD MICROMHO	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/09/12	0925	WATER	6	27.3	3.8	46.9%	6.9	180										
90/09/12	0925	WATER	6.5	26.9	2.9	35.8%	6.8	180										
90/09/12	0926	WATER	7	26.9	2.3	28.4%	6.7	180										
90/09/12	0927	WATER	7.5	26.8	.7	8.6%	6.6	180										
90/09/12	0927	WATER	8	26.8	.4	4.9%	6.6	180										
90/09/12	0928	WATER	9	26.5	.2	2.4%	6.5	182										
90/09/12	0929	WATER	9.5	25.9	.2	2.4%	6.5	186										
90/04/10	1026	WATER	0.5	1.20														
90/04/10	1028	WATER	1															
90/05/09	0926	WATER	0.5	1.65														
90/05/09	0929	WATER	1															
90/06/13	1030	WATER	0.5	2.00														
90/06/13	1032	WATER	1															
90/07/10	1105	WATER	0.5	2.00														
90/07/10	1106	WATER	0.5															
90/07/10	1107	WATER	0.5															
90/07/10	1108	WATER	1															
90/07/10	1109	WATER	1															
90/07/10	1110	WATER	1															
90/08/15	0902	WATER	0.5	1.73														
90/08/15	0905	WATER	1															
90/09/12	0918	WATER	0.5	1.95														
90/09/12	0920	WATER	1															
90/04/05	1200	WATER	1															
90/04/10	1028	WATER	1															
90/04/19	1200	WATER	1															
90/05/09	0929	WATER	1															
90/05/11	1200	WATER	1															
90/05/29	1200	WATER	1															
90/06/12	1200	WATER	1															
90/06/13	1032	WATER	1															
90/06/27	1200	WATER	1															
90/07/10	1105	WATER	0.5															
90/07/10	1106	WATER	0.5															
90/07/10	1107	WATER	0.5															
90/07/10	1108	WATER	1															
90/07/10	1109	WATER	1															
90/07/10	1110	WATER	1															
90/07/11	1200	WATER	1															
90/07/30	1200	WATER	1															
90/08/06	1200	WATER	1															
90/08/13	1200	WATER	1															
90/08/15	0905	WATER	1															
90/08/28	1200	WATER	1															
90/09/12	0920	WATER	1															

A-43

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477234

35 17 20.0 085 08 40.0 2

CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SODDY CREEK 4.0

131TVAC 900505

06020001

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/10	1002	WATER	0.5	14.0	11.5	110.6%	7.5	87	90/09/12	0855	WATER	0.5	27.4	7.0	86.4%	7.7	175
90/04/10	1004	WATER	1	14.0	11.1	106.7%	7.4	87	90/09/12	0857	WATER	1	27.5	6.9	85.2%	7.7	175
90/04/10	1007	WATER	1.5	14.0	10.9	104.5%	7.4	87	90/09/12	0859	WATER	1.5	27.5	6.9	85.2%	7.7	175
90/04/10	1010	WATER	2	13.9	10.7	102.5%	7.4	87	90/09/12	0859	WATER	2	27.5	6.8	84.0%	7.6	175
90/04/10	1015	WATER	2.5	13.9	10.6	101.9%	7.3	87	90/09/12	0900	WATER	2.5	27.4	4.8	59.3%	7.2	176
90/04/10	1020	WATER	3	13.9	10.5	101.0%	7.3	87	90/09/12	0901	WATER	3	27.4	2.4	29.6%	7.0	177
90/05/09	0902	WATER	0.5	20.3	8.8	95.7%	7.5	91	90/09/12	0902	WATER	3.5	27.2	1.5	18.5%	6.8	179
90/05/09	0905	WATER	1	20.4	8.7	94.6%	7.5	90	90/09/12	0903	WATER	4	27.2	1.1	13.6%	6.8	179
90/05/09	0908	WATER	1.5	20.4	8.6	93.5%	7.5	90									
90/05/09	0909	WATER	2	20.3	8.4	91.3%	7.4	92									
90/05/09	0911	WATER	2.5	19.7	8.4	91.3%	7.4	87									
90/05/09	0913	WATER	3	19.4	8.0	85.1%	7.3	85									
90/05/09	0915	WATER	4	18.7	7.7	81.9%	7.2	77									
90/05/09	0917	WATER	4.5	17.9	7.9	83.2%	7.0	68									
90/06/13	1010	WATER	0.5	26.3	9.1	111.0%	8.3	125									
90/06/13	1012	WATER	1	26.3	9.0	109.8%	8.3	124									
90/06/13	1014	WATER	1.5	26.3	8.8	107.3%	8.3	124									
90/06/13	1015	WATER	2	26.3	8.7	106.1%	8.2	124									
90/06/13	1016	WATER	2.5	26.2	8.6	104.9%	8.2	124									
90/06/13	1017	WATER	3	25.2	9.2	109.5%	7.8	138									
90/06/13	1018	WATER	3.5	24.1	7.7	90.6%	7.1	139									
90/06/13	1019	WATER	4	24.1	5.6	65.9%	7.0	136									
90/07/10	1029	WATER	0.5	29.1	7.4	94.9%	8.2	166									
90/07/10	1032	WATER	1	29.1	7.1	91.0%	8.2	166									
90/07/10	1035	WATER	1.5	29.0	6.8	87.2%	8.2	166									
90/07/10	1036	WATER	2	28.9	6.5	83.3%	8.1	168									
90/07/10	1037	WATER	2.3	28.4	4.9	62.0%	7.8	172									
90/07/10	1038	WATER	2.5	27.7	4.5	57.0%	7.9	174									
90/07/10	1039	WATER	2.8	27.1	3.1	38.3%	7.5	176									
90/07/10	1040	WATER	3	27.0	2.6	32.1%	7.4	177									
90/07/10	1041	WATER	4	26.7	1.6	19.8%	7.3	177									
90/08/15	0842	WATER	0.5	27.5	5.8	108.6%	8.5	170									
90/08/15	0845	WATER	1	27.5	8.7	107.4%	8.5	170									
90/08/15	0848	WATER	1.5	27.5	8.3	102.5%	8.4	170									
90/08/15	0848	WATER	2	27.4	7.1	87.7%	8.0	171									
90/08/15	0848	WATER	2.5	26.7	3.6	44.4%	7.2	172									
90/08/15	0849	WATER	3	26.6	2.2	27.2%	7.1	173									
90/08/15	0850	WATER	3.5	26.3	.9	11.0%	6.9	176									
90/08/15	0850	WATER	4	26.3	.6	7.3%	6.9	178									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477234

35 17 20.0 085 08 40.0 2

CHICKAMAUGA RESERVOIR

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SODDY CREEK 4.0

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFN-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	1002	WATER	0.5	1.33	10K								
90/04/10	1004	WATER	1										
90/05/09	0902	WATER	0.5	2.00	10K		7.2	23	55	4.8	2	10	20
90/05/09	0905	WATER	1				7.2	26	67	1.4	1K	20	20
90/06/13	1010	WATER	0.5	2.00	10								
90/06/13	1012	WATER	1				7.9	41	66	2.0	2	20	22
90/07/10	1029	WATER	0.5	1.25	10	D1							
90/07/10	1030	WATER	0.5		10K	D2							
90/07/10	1031	WATER	0.5		10	D3							
90/07/10	1032	WATER	1			D1	7.7	62	95	4.0	2	10	15
90/07/10	1033	WATER	1			D2	7.9	67	81	3.0	2	10	15
90/07/10	1034	WATER	1			D3	7.8	61	100	4.0	3	10	15
90/08/15	0842	WATER	0.5	1.77	10K								
90/08/15	0845	WATER	1				8.0	65	100	4.0	2	5	7
90/09/12	0855	WATER	0.5	1.72	10K								
90/09/12	0857	WATER	1				7.7	68	95	2.0	2	10	15

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/05	1200	WATER	1									2
90/04/10	1004	WATER	1									
90/04/19	1200	WATER	1		.8	7.1J	.04	.01K	.16	.007	.002K	2
90/05/09	0905	WATER	1		1.2	1.2	.08	.01K	.09	.004	.002	2
90/05/11	1200	WATER	1									2
90/05/29	1200	WATER	1									3
90/06/12	1200	WATER	1									2
90/06/13	1012	WATER	1		1.8	1.6	.20	.01K	.03	.006	.002K	3
90/06/27	1200	WATER	1									
90/07/10	1029	WATER	0.5	D1								
90/07/10	1030	WATER	0.5	D2								
90/07/10	1031	WATER	0.5	D3								
90/07/10	1032	WATER	1	D1	2.5	2.2	.20	.01K	.01K	.010	.002K	6
90/07/10	1033	WATER	1	D2	2.5	2.2	.26	.01K	.01K	.010	.002K	
90/07/10	1034	WATER	1	D3	2.6	2.2	.26	.01K	.01K	.010	.002K	
90/07/30	1200	WATER	1									5
90/08/06	1200	WATER	1									8
90/08/13	1200	WATER	1									7
90/08/15	0845	WATER	1		2.4	2.2	.18	.01K	.01K	.007	.004	
90/08/28	1200	WATER	1									3
90/09/12	0857	WATER	1		2.2	2.0	.15	.03	.02	.006	.004	

STORET RETRIEVAL DATE 92/10/16

PGM=RET

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TRIBUTARY TO TENNESSEE RIVER 489.70

47065 TENNESSEE HAMILTON

TENNESSEE RIVER BASIN 040802

POSSUM CREEK 2.0

131TVAC 900505

06020001

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/10	1136	WATER	0.5	14.4	11.5	110.68	7.6	109	90/07/10	0948	WATER	4	26.2	3.5	42.78	7.5	188
90/04/10	1138	WATER	1	14.4	11.3	108.78	7.6	109	90/07/10	0949	WATER	4.6	26.0	2.7	32.98	7.4	188
90/04/10	1140	WATER	1.5	14.4	11.1	106.78	7.6	109	90/07/10	0950	WATER	5	25.8	2.2	26.88	7.3	189
90/04/10	1142	WATER	2	14.4	10.9	104.88	7.6	108	90/07/10	0951	WATER	5.6	25.6	1.8	22.08	7.2	190
90/04/10	1144	WATER	2.5	14.4	10.8	103.88	7.6	108	90/07/10	0952	WATER	6	25.3	1.0	11.98	7.1	194
90/04/10	1146	WATER	3	14.4	10.7	102.98	7.6	108	90/07/10	0954	WATER	6.5	24.7	.4	4.88	7.1	200
90/04/10	1148	WATER	4	13.6	9.9	95.28	7.5	108	90/08/15	0755	WATER	0.5	27.3	9.7	119.88	8.8	166
90/04/10	1150	WATER	5	13.4	10.0	94.38	7.4	108	90/08/15	0758	WATER	1	27.4	9.4	116.18	8.8	166
90/04/10	1152	WATER	5.5	13.3	9.8	92.58	7.4	109	90/08/15	0801	WATER	1.5	27.4	9.2	113.68	8.7	166
90/05/09	1135	WATER	0.5	19.9	9.0	97.88	7.6	119	90/08/15	0802	WATER	2	27.4	9.1	112.38	8.7	166
90/05/09	1138	WATER	1	19.9	8.9	96.78	7.6	119	90/08/15	0802	WATER	2.5	26.8	7.1	87.78	8.1	169
90/05/09	1141	WATER	1.5	19.9	8.9	96.78	7.6	120	90/08/15	0803	WATER	3	26.5	6.3	76.88	7.6	168
90/05/09	1142	WATER	2	19.9	8.9	96.78	7.6	120	90/08/15	0803	WATER	3.5	26.1	4.7	57.38	7.2	168
90/05/09	1143	WATER	2.5	19.9	8.9	96.78	7.6	121	90/08/15	0804	WATER	4	25.9	3.8	46.38	7.1	168
90/05/09	1144	WATER	3	19.8	8.8	95.78	7.6	121	90/08/15	0804	WATER	4.5	25.8	3.1	37.88	7.0	169
90/05/09	1146	WATER	3.5	19.2	7.5	79.88	7.3	124	90/08/15	0805	WATER	5	25.7	1.6	19.58	6.9	169
90/05/09	1148	WATER	4	19.0	6.3	67.08	7.3	129	90/08/15	0805	WATER	5.5	25.5	.5	6.08	6.8	171
90/05/09	1150	WATER	5	18.3	6.2	65.38	7.2	133	90/08/15	0807	WATER	6	25.3	.4	4.88	6.8	174
90/05/09	1152	WATER	5.5	18.1	5.2	54.78	7.0	132	90/08/15	0809	WATER	6.5	25.0	.4	4.88	6.8	180
90/05/09	1154	WATER	6	18.1	4.0	42.18	7.1	131	90/09/12	0820	WATER	0.5	27.6	8.1	102.58	8.5	172
90/06/13	0925	WATER	0.5	26.0	8.7	106.18	7.9	135	90/09/12	0822	WATER	1	27.7	8.0	101.38	8.2	172
90/06/13	0927	WATER	1	25.0	8.6	104.98	7.9	135	90/09/12	0824	WATER	1.5	27.7	7.9	100.08	8.2	173
90/06/13	0929	WATER	1.5	26.0	8.5	103.78	7.9	134	90/09/12	0825	WATER	2	27.7	7.8	98.78	8.1	173
90/06/13	0930	WATER	2	26.0	8.5	103.78	7.8	135	90/09/12	0825	WATER	2.5	27.6	7.6	96.28	7.9	173
90/06/13	0931	WATER	2.5	25.2	8.5	101.28	7.7	146	90/09/12	0826	WATER	3	27.6	6.2	78.58	7.6	174
90/06/13	0932	WATER	3	24.5	8.2	96.58	7.6	152	90/09/12	0826	WATER	3.5	27.4	5.7	70.48	7.3	175
90/06/13	0933	WATER	3.5	23.9	6.8	80.08	7.4	159	90/09/12	0827	WATER	4	27.2	3.1	38.38	6.9	178
90/06/13	0934	WATER	4	23.2	5.4	62.18	7.1	156	90/09/12	0827	WATER	4.5	26.9	.3	3.78	6.7	180
90/06/13	0935	WATER	5	22.9	5.1	58.68	7.0	151	90/09/12	0828	WATER	5	26.8	.2	2.58	6.6	181
90/06/13	0936	WATER	5.5	22.6	4.1	47.18	6.9	152	90/09/12	0829	WATER	6	26.3	.2	2.48	6.7	186
90/06/13	0937	WATER	6	22.5	3.7	42.08	6.9	153									
90/07/10	0936	WATER	0.5	28.8	8.7	111.58	8.4	168									
90/07/10	0939	WATER	1	28.9	8.7	111.58	8.5	167									
90/07/10	0942	WATER	1.5	28.9	8.8	112.88	8.5	168									
90/07/10	0943	WATER	2	28.9	8.8	112.88	8.5	167									
90/07/10	0944	WATER	2.5	28.8	8.8	112.88	8.5	169									
90/07/10	0945	WATER	3	27.9	8.0	101.38	8.3	180									
90/07/10	0946	WATER	3.5	27.2	6.3	77.88	7.9	184									
90/07/10	0947	WATER	3.6	26.6	4.3	53.18	7.7	188									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477235

35 18 25.0 085 05 24.0 2

TRIBUTARY TO TENNESSEE RIVER 489.70

47065 TENNESSEE HAMILTON

TENNESSEE RIVER BASIN 040802

POSSUM CREEK 2.0

131TVAC 900505

06020001

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	1136	WATER	0.5	1.15	10K								
90/04/10	1138	WATER	1				7.5	32	61	4.0	1	7	7
90/05/09	1135	WATER	0.5	1.80	10								
90/05/09	1138	WATER	1				7.4	17	57	2.4	1K	20	20
90/06/13	0925	WATER	0.5	2.00	10K								
90/06/13	0927	WATER	1				7.8	44	70	2.0	2	15	17
90/07/10	0936	WATER	0.5	2.00	10K								
90/07/10	0939	WATER	1				8.1	63	91	2.0	1K	10	15
90/08/15	0755	WATER	0.5	2.13	10K	D1							
90/08/15	0756	WATER	0.5		10K	D2							
90/08/15	0757	WATER	0.5		10K	D3							
90/08/15	0758	WATER	1			D1	5.3	64	95	2.0	1	10	15
90/08/15	0759	WATER	1			D2	8.3	67	83	2.0	2	5	7
90/08/15	0800	WATER	1			D3	8.2	65	83		1	10	15
90/09/12	0820	WATER	0.5	1.77	10K								
90/09/12	0822	WATER	1				7.8	67	99	1.0	1K	5	7

INDEX 1021500 007720 00920 6610
MILES 0953.80 0046.50 489.70 002.00

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C MG/L	00681 D ORG C MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPNYL A UG/L CORRECTD
90/04/05	1200	WATER	1									4
90/04/10	1138	WATER	1		.8	1.1J	.04	.01K	.22	.005	.004	5
90/04/19	1200	WATER	1									4
90/05/09	1138	WATER	1		1.4	1.4	.08	.01K	.12	.007	.004	2
90/05/11	1200	WATER	1									4
90/05/30	1200	WATER	1									2
90/06/12	1200	WATER	1									4
90/06/13	0927	WATER	1		1.7	1.5	.10	.01K	.05	.003	.002K	3
90/06/27	1200	WATER	1									5
90/07/10	0939	WATER	1		2.3	2.0	.20	.01K	.01K	.008	.003	9
90/07/30	1200	WATER	1									9
90/08/06	1200	WATER	1									6
90/08/13	1200	WATER	1									
90/08/15	0755	WATER	0.5	D1								
90/08/15	0756	WATER	0.5	D2								
90/08/15	0757	WATER	0.5	D3								
90/08/15	0758	WATER	1	D1	2.2	2.0	.14	.01K	.01K	.006	.005	
90/08/15	0759	WATER	1	D2	2.2	2.0	.14	.01K	.01K	.008	.005	
90/08/15	0800	WATER	1	D3	2.2	2.0	.18	.01K	.01K	.006	.005	
90/08/28	1200	WATER	1									3
90/09/12	0822	WATER	1		2.2	2.0	.15	.01K	.01	.007	.004	

A-47

STORET RETRIEVAL DATE 92/10/16
 477236
 35 22 01.0 085 04 16.0 2
 TRIBUTARY TO TENNESSEE RIVER 494.90
 47065 TENNESSEE HAMILTON
 TENNESSEE RIVER BASIN 040802
 SALE CREEK 1.3
 131TVAC 900505 06020001
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

A-48

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/09	1057	WATER	0.5	13.5	10.4	98.1%	7.8	102	90/07/11	0942	WATER	2.3	27.1	5.9	72.8%	7.9	187
90/04/09	1058	WATER	1	13.3	10.3	97.2%	7.8	101	90/07/11	0943	WATER	2.5	27.2	5.4	66.7%	8.1	187
90/04/09	1100	WATER	1.5	13.2	10.3	97.2%	7.8	102	90/07/11	0943	WATER	3	27.5	4.7	58.0%	7.4	188
90/04/09	1101	WATER	2	13.2	10.3	97.2%	7.8	102	90/07/11	0944	WATER	3.3	26.5	4.0	48.8%	7.4	189
90/04/09	1102	WATER	2.5	13.0	10.3	97.2%	7.8	101	90/07/11	0945	WATER	3.6	26.3	3.2	39.0%	7.4	189
90/04/09	1104	WATER	3	12.8	10.3	97.2%	7.8	100	90/07/11	0945	WATER	4	26.2	3.1	37.8%	7.6	189
90/04/09	1106	WATER	4	12.5	10.2	94.4%	7.7	100	90/07/11	0946	WATER	4.3	26.1	2.7	32.9%	7.3	189
90/04/09	1108	WATER	5	12.4	9.9	91.7%	7.6	98	90/07/11	0947	WATER	5	26.0	2.2	26.8%	7.2	191
90/04/09	1110	WATER	6	12.3	9.9	91.7%	7.6	95	90/07/11	0948	WATER	6	25.6	1.6	19.5%	7.5	188
90/04/09	1112	WATER	7	12.1	9.6	88.9%	7.5	95	90/07/11	0949	WATER	7	25.0	2.0	23.8%	7.4	184
90/04/09	1114	WATER	8	11.7	9.4	87.0%	7.5	98	90/07/11	0951	WATER	8	24.5	2.3	27.1%	7.3	185
90/05/08	1046	WATER	0.5	19.4	8.9	94.7%	7.5	113	90/08/14	0929	WATER	0.5	27.3	9.1	112.3%	8.8	165
90/05/08	1049	WATER	1	19.2	8.6	91.5%	7.5	112	90/08/14	0932	WATER	1	27.3	9.1	112.3%	8.8	165
90/05/08	1052	WATER	1.5	19.0	8.2	87.2%	7.4	113	90/08/14	0935	WATER	1.5	27.3	9.1	112.3%	8.8	164
90/05/08	1054	WATER	2	18.9	7.9	84.0%	7.4	114	90/08/14	0936	WATER	2	27.3	8.9	109.9%	8.7	165
90/05/08	1056	WATER	2.5	18.5	6.9	72.6%	7.2	112	90/08/14	0936	WATER	2.5	26.5	6.5	79.3%	7.6	167
90/05/08	1058	WATER	3	18.1	6.4	67.4%	7.1	119	90/08/14	0937	WATER	3	26.4	4.9	59.8%	7.4	168
90/05/08	1100	WATER	4	17.8	6.5	68.4%	7.1	92	90/08/14	0937	WATER	3.5	25.8	3.5	42.7%	7.1	167
90/05/08	1102	WATER	5	17.3	7.1	73.2%	7.0	77	90/08/14	0938	WATER	4	25.8	3.2	39.0%	7.0	168
90/05/08	1104	WATER	6	16.5	7.5	75.0%	6.9	67	90/08/14	0938	WATER	4.5	25.7	2.7	32.9%	6.9	168
90/05/08	1106	WATER	7	15.9	7.8	78.0%	6.9	63	90/08/14	0939	WATER	5	25.7	1.3	15.9%	6.8	168
90/05/08	1108	WATER	8	15.7	7.8	78.0%	6.9	63	90/08/14	0939	WATER	6	25.4	2.3	27.4%	6.8	170
90/05/08	1110	WATER	8.5	15.7	7.8	78.0%	6.8	63	90/08/14	0940	WATER	6.5	24.8	3.7	44.0%	6.9	170
90/06/12	0950	WATER	0.5	25.4	9.8	116.7%	8.6	142	90/08/14	0940	WATER	7	24.8	4.1	48.8%	6.9	170
90/06/12	0952	WATER	1	25.4	9.7	115.5%	8.6	143	90/08/14	0941	WATER	7.5	24.3	3.9	45.9%	6.9	171
90/06/12	0954	WATER	1.5	25.4	9.7	115.5%	8.5	143	90/08/14	0941	WATER	8	23.6	2.4	28.2%	6.8	171
90/06/12	0955	WATER	2	25.2	9.0	107.1%	8.3	145	90/08/14	0942	WATER	8.5	22.7	.9	10.3%	6.7	181
90/06/12	0956	WATER	2.5	24.9	8.9	106.0%	8.1	153	90/09/11	0938	WATER	0.5	27.1	7.3	90.1%	8.0	176
90/06/12	0957	WATER	3	24.1	7.4	87.1%	7.6	158	90/09/11	0940	WATER	1	27.1	7.1	87.7%	7.9	177
90/06/12	0958	WATER	4	23.7	6.6	77.6%	7.4	157	90/09/11	0942	WATER	1.5	27.1	7.0	86.4%	7.9	177
90/06/12	0959	WATER	5	23.4	5.9	67.8%	7.2	153	90/09/11	0943	WATER	2	27.2	7.0	86.4%	7.9	177
90/06/12	1000	WATER	6	22.6	5.6	64.4%	7.1	139	90/09/11	0943	WATER	3	27.2	6.9	85.2%	7.8	177
90/06/12	1001	WATER	7	21.9	4.9	55.7%	6.9	129	90/09/11	0944	WATER	3.5	27.1	6.3	77.8%	7.4	177
90/06/12	1002	WATER	7.5	20.7	4.5	50.0%	6.8	124	90/09/11	0944	WATER	4	27.1	2.9	35.8%	7.2	179
90/06/12	1003	WATER	8	20.2	4.2	45.7%	6.8	128	90/09/11	0945	WATER	4.5	26.7	1.8	22.2%	6.8	182
90/07/11	0936	WATER	0.5	27.9	8.9	112.7%	8.2	177	90/09/11	0946	WATER	5	26.7	1.3	16.0%	6.8	182
90/07/11	0939	WATER	1	28.0	8.8	111.4%	8.4	177	90/09/11	0947	WATER	6	26.5	1.0	12.2%	6.8	181
90/07/11	0942	WATER	1.5	27.9	8.7	110.1%	8.5	178	90/09/11	0948	WATER	7	26.0	1.9	23.2%	6.8	178
90/07/11	0942	WATER	2	27.7	7.3	92.4%	8.3	184	90/09/11	0950	WATER	8	25.3	1.4	18.7%	6.7	181

STORET RETRIEVAL DATE 92/10/16
 477236
 35 22 01.0 085 04 16.0 2
 TRIBUTARY TO TENNESSEE RIVER 494.90
 47065 TENNESSEE HAMILTON
 TENNESSEE RIVER BASIN 040802
 SALE CREEK 1.3
 131TVAC 900505 06020001
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MPN-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLY MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/09	1057	WATER	0.5	1.42	10K								
90/04/09	1058	WATER	1										
90/05/08	1046	WATER	0.5	1.50	10K		7.6	39	59	4.0	3	10	10
90/05/08	1049	WATER	1										
90/06/12	0950	WATER	0.5	2.00	10K		7.3	41	53	4.0	3	25	28
90/06/12	0952	WATER	1										
90/07/11	0936	WATER	0.5	1.85	10K		8.6	58	72	2.0	2	20	22
90/07/11	0939	WATER	1										
90/08/14	0929	WATER	0.5	1.67	10K		8.2	67	120	3.0	3	15	20
90/08/14	0932	WATER	1										
90/09/11	0938	WATER	0.5	1.47	10K	D1	8.5	62	87	1.0	1K	1K	1K
90/09/11	0939	WATER	0.5		10K	D2							
90/09/11	0940	WATER	0.5		10K	D3							
90/09/11	0940	WATER	1			D1	7.7	67	97	2.0	3	5	7
90/09/11	0941	WATER	1			D2	7.9	68	91	2.0	5	5	7
90/09/11	0942	WATER	1			D3	7.8	67	93	2.0		2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C MG/L	00681 D ORG C MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLAPHYL A UG/L CORRECTD
90/04/05	1200	WATER	1									4
90/04/09	1058	WATER	1		1.0	1.2J	.10	.01K	.32	.006	.003	
90/04/19	1200	WATER	1									4
90/05/08	1049	WATER	1		1.7	1.6	.11	.01K	.17	.009	.006	
90/05/11	1200	WATER	1									5
90/05/30	1200	WATER	1									5
90/06/12	0952	WATER	1		2.1	1.9	.20	.01K	.06	.008	.003	
90/06/27	1200	WATER	1									2
90/07/11	0939	WATER	1		2.4	2.0	.22	.01K	.04	.020	.003	10
90/07/30	1200	WATER	1									7
90/08/13	1200	WATER	1									8
90/08/14	0932	WATER	1		2.3	2.2	.18	.01K	.01K	.010	.004	
90/08/28	1200	WATER	1									5
90/09/11	0938	WATER	0.5	D1								
90/09/11	0939	WATER	0.5	D2								
90/09/11	0940	WATER	0.5	D3								
90/09/11	0940	WATER	1	D1	2.1	1.9	.16	.02	.04	.010	.006	
90/09/11	0941	WATER	1	D2	2.2	1.9	.24	.02	.05	.010	.006	
90/09/11	0942	WATER	1	D3	2.2	2.0	.21	.01	.05	.010	.006	

PGM=RET

477237

35 22 17.0 085 04 51.0 2

NEAR PRICE POINT

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SALE CREEK 2.0

06020001

/TYPA/AMBNT/STREAM/SOLIDS

131TVAC 900505

0000 METERS DEPTH

A-50

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/09	1000	WATER	0.5	12.8	10.0	94.3%	7.7	96	90/07/11	0917	WATER	2.5	27.0	3.6	44.4%	7.3	178
90/04/09	1002	WATER	1	12.9	10.0	94.3%	7.7	96	90/07/11	0918	WATER	3	26.8	3.4	42.0%	7.3	180
90/04/09	1005	WATER	1.5	12.9	9.9	93.4%	7.6	95	90/07/11	0918	WATER	3.3	26.4	2.3	28.0%	7.2	180
90/04/09	1007	WATER	2	12.5	10.1	93.5%	7.6	94	90/07/11	0919	WATER	4	25.9	1.5	18.3%	7.1	178
90/04/09	1009	WATER	2.5	12.4	10.2	94.4%	7.6	94	90/07/11	0920	WATER	5	25.4	2.2	26.2%	7.1	174
90/04/09	1015	WATER	3	12.3	10.2	94.4%	7.6	93	90/07/11	0921	WATER	6	24.7	2.3	27.4%	7.1	174
90/04/09	1020	WATER	4	12.1	10.2	94.4%	7.6	94	90/07/11	0922	WATER	6.5	23.6	1.6	18.8%	7.0	179
90/04/09	1025	WATER	5	12.0	10.2	94.4%	7.6	93	90/08/14	0904	WATER	0.5	27.4	8.9	109.9%	8.7	165
90/04/09	1032	WATER	5.5	11.9	10.2	94.4%	7.6	93	90/08/14	0907	WATER	1	27.3	8.8	108.6%	8.7	166
90/05/08	1001	WATER	0.5	19.0	8.3	88.3%	7.3	90	90/08/14	0910	WATER	1.5	27.3	8.5	104.9%	8.6	166
90/05/08	1004	WATER	1	19.0	8.2	87.2%	7.3	90	90/08/14	0910	WATER	2	27.2	7.0	86.4%	8.3	167
90/05/08	1007	WATER	1.5	18.9	8.1	86.2%	7.3	89	90/08/14	0911	WATER	2.5	26.5	4.7	57.3%	7.3	169
90/05/08	1008	WATER	2	18.6	8.2	87.2%	7.3	86	90/08/14	0911	WATER	3	26.4	3.6	43.9%	7.2	168
90/05/08	1009	WATER	2.5	17.9	8.2	86.3%	7.2	81	90/08/14	0912	WATER	4	25.8	4.2	51.2%	7.1	166
90/05/08	1010	WATER	3	17.5	8.2	84.5%	7.2	77	90/08/14	0913	WATER	5	25.3	4.6	54.8%	7.1	164
90/05/08	1013	WATER	3.5	17.1	7.8	80.4%	7.0	73	90/08/14	0914	WATER	5.5	24.5	4.6	54.1%	7.0	164
90/05/08	1016	WATER	4	16.3	7.8	78.0%	7.0	68	90/08/14	0915	WATER	6	23.7	3.2	37.6%	6.8	165
90/05/08	1019	WATER	5	15.4	8.3	81.4%	7.0	64	90/08/14	0916	WATER	7	23.3	3.1	35.6%	6.8	168
90/05/08	1023	WATER	6	14.6	8.6	84.3%	7.0	61	90/09/11	0905	WATER	0.5	27.1	6.0	74.1%	7.6	168
90/05/08	1027	WATER	7	14.5	8.7	83.7%	6.9	60	90/09/11	0907	WATER	1	27.1	5.9	72.8%	7.5	168
90/06/12	0910	WATER	0.5	25.5	9.4	111.9%	8.1	114	90/09/11	0909	WATER	1.5	27.1	5.7	70.4%	7.4	168
90/06/12	0912	WATER	1	25.5	9.2	109.5%	8.1	114	90/09/11	0910	WATER	2	27.1	5.6	69.1%	7.4	169
90/06/12	0914	WATER	1.5	25.5	8.8	104.8%	8.1	113	90/09/11	0911	WATER	3	27.0	5.4	66.7%	7.3	169
90/06/12	0915	WATER	2	25.5	8.7	103.6%	8.0	113	90/09/11	0912	WATER	4	26.8	4.4	54.3%	7.2	170
90/06/12	0916	WATER	2.5	25.0	8.7	103.6%	7.8	126	90/09/11	0913	WATER	4.5	26.7	3.7	45.7%	6.9	172
90/06/12	0917	WATER	3	24.2	8.3	97.6%	7.4	129	90/09/11	0914	WATER	5	26.7	3.1	38.3%	6.9	172
90/06/12	0918	WATER	3.5	23.6	7.8	91.8%	7.2	130	90/09/11	0916	WATER	5.5	26.7	2.6	32.1%	6.8	174
90/06/12	0919	WATER	4	23.4	6.9	79.3%	7.2	129	90/09/11	0918	WATER	6	25.9	1.9	23.2%	6.7	177
90/06/12	0920	WATER	4.5	23.0	6.2	71.3%	7.0	121	90/09/11	0920	WATER	6.5	25.5	1.6	19.0%	6.7	179
90/06/12	0921	WATER	5	22.3	6.0	68.2%	6.9	118									
90/06/12	0922	WATER	5.5	21.1	5.4	60.0%	6.8	125									
90/06/12	0923	WATER	6	21.0	4.9	54.4%	6.8	125									
90/06/12	0924	WATER	6.5	20.1	4.8	52.2%	6.8	130									
90/07/11	0909	WATER	0.5	28.1	8.1	102.5%	8.1	167									
90/07/11	0912	WATER	1	28.0	7.9	100.0%	8.1	167									
90/07/11	0915	WATER	1.5	27.9	7.7	97.5%	8.2	167									
90/07/11	0916	WATER	1.8	27.7	6.5	82.3%	7.8	167									
90/07/11	0916	WATER	2	27.7	5.4	68.4%	7.9	170									
90/07/11	0917	WATER	2.3	27.4	4.1	50.6%	7.4	175									

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477237

35 22 17.0 085 04 51.0 2

NEAR PRICE POINT

47065 TENNESSEE

HAMILTON

TENNESSEE RIVER BASIN

040802

SALE CREEK 2.0

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/09	1000	WATER	0.5	1.12	10K								
90/04/09	1002	WATER	1				7.3	34	53	5.2	4	5	15
90/05/08	1001	WATER	0.5	1.50	10K								
90/05/08	1004	WATER	1				7.3	31	51	4.4	3	25	25
90/06/12	0910	WATER	0.5	1.50	10K								
90/06/12	0912	WATER	1				7.9	44	78	3.0	3	25	25
90/07/11	0909	WATER	0.5	1.50	10K								
90/07/11	0912	WATER	1				8.0	65	110	3.0	3	20	25
90/08/14	0904	WATER	0.5	1.82	10K								
90/08/14	0907	WATER	1				8.3	68	95	1.0	1K	2	5
90/09/11	0905	WATER	0.5	1.42	10K	D1							
90/09/11	0906	WATER	0.5		10K	D2							
90/09/11	0907	WATER	1			D1	7.6	80	93	2.0	2	2	5
90/09/11	0908	WATER	1			D2	7.5	67	99	2.0	2	2	5
90/09/11	0909	WATER	1			D3	7.5	68	95	2.0	2	2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/05	1200	WATER	1									3
90/04/09	1002	WATER	1		.9	1.7J	.11	.01	.30	.006	.003	3
90/04/19	1200	WATER	1									3
90/05/08	1004	WATER	1		1.6	1.5	.14	.04	.15	.009	.006	2
90/05/11	1200	WATER	1									5
90/05/30	1200	WATER	1									3
90/06/12	0912	WATER	1		2.1	1.8	.16	.02	.02	.008	.003	2
90/06/27	1200	WATER	1									7
90/07/10	1200	WATER	1									6
90/07/11	0912	WATER	1		2.5	2.1	.24	.01K	.01	.020	.002K	10
90/07/30	1200	WATER	1									7
90/08/06	1200	WATER	1									4
90/08/13	1200	WATER	1									
90/08/14	0907	WATER	1		2.4	2.2	.20	.01K	.01K	.008	.004	
90/08/28	1200	WATER	1									
90/09/11	0905	WATER	0.5	D1								
90/09/11	0906	WATER	0.5	D2								
90/09/11	0907	WATER	1	D1	2.5	2.2	.20	.04	.02	.008	.002	
90/09/11	0908	WATER	1	D2	2.5	2.2	.22	.04	.02	.008	.003	
90/09/11	0909	WATER	1	D3	2.4	2.3	.17	.05	.02	.009	.003	

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO
90/04/11	1004	WATER	0.5	14.1	11.1	106.78		130	90/07/12	0938	WATER	3	25.4	3.4	40.58	7.4	186
90/04/11	1006	WATER	1	14.1	10.9	104.88	7.4	130	90/07/12	0939	WATER	3.5	25.4	3.2	38.18	7.3	186
90/04/11	1009	WATER	1.5	14.2	10.9	104.88		131	90/07/12	0940	WATER	4	25.2	3.1	36.98	7.3	186
90/04/11	1011	WATER	2	14.2	10.9	104.88		131	90/07/12	0941	WATER	5	24.3	2.4	28.28	7.2	187
90/04/11	1013	WATER	2.5	14.2	10.9	104.88		130	90/07/12	0941	WATER	5.5	21.7	2.8	31.88	7.2	191
90/04/11	1015	WATER	3	14.2	10.9	104.88		132	90/07/12	0942	WATER	5.8	21.5	3.1	34.48	7.2	192
90/04/11	1017	WATER	4	14.2	10.7	102.98		132	90/08/16	0903	WATER	0.5	26.2	8.1	98.88	8.2	175
90/04/11	1019	WATER	5	14.0	9.9	95.28		132	90/08/16	0906	WATER	1	26.3	8.0	97.68	8.2	175
90/04/11	1021	WATER	5.5	14.0	9.9	95.28		134	90/08/16	0909	WATER	1.5	26.3	8.0	97.68	8.1	174
90/05/09	0855	WATER	0.5	18.6	9.2	97.98	7.4	119	90/08/16	0911	WATER	1.7	26.2	6.5	79.38	8.1	178
90/05/09	0858	WATER	1	18.6	9.0	95.78	7.5	119	90/08/16	0913	WATER	2	26.0	5.2	63.48	7.6	180
90/05/09	0901	WATER	1.5	18.7	8.6	91.58	7.5	122	90/08/16	0915	WATER	2.5	26.0	5.3	64.68	7.5	180
90/05/09	0902	WATER	2	18.3	7.9	83.28	7.5	124	90/08/16	0917	WATER	3	25.8	5.0	61.08	7.5	182
90/05/09	0903	WATER	2.5	18.1	7.8	82.18	7.5	123	90/08/16	0919	WATER	4	25.7	4.6	56.18	7.4	182
90/05/09	0904	WATER	3	17.8	7.6	80.08	7.5	117	90/08/16	0921	WATER	4.4	25.6	4.4	53.78	7.3	183
90/05/09	0905	WATER	4	17.3	7.8	80.48	7.5	103	90/08/16	0923	WATER	5	24.5	2.9	34.18	7.3	186
90/05/09	0905	WATER	4.1	16.9	7.9	81.48	7.4	101	90/08/16	0924	WATER	5.1	23.6	3.1	36.58	7.2	190
90/05/09	0906	WATER	5	15.7	8.2	82.08	7.5	100	90/08/16	0926	WATER	6	21.5	3.1	34.48	7.3	195
90/05/09	0908	WATER	6	15.3	8.2	80.48	7.4	100	90/09/13	0859	WATER	0.5	26.7	5.7	70.48	7.7	188
90/05/09	0909	WATER	6.5	15.2	8.2	80.48	7.3	101	90/09/13	0901	WATER	1	26.8	5.6	69.18	7.6	189
90/06/14	0922	WATER	0.5	25.2	10.2	121.48	8.5	154	90/09/13	0903	WATER	1.5	26.8	5.6	69.18	7.6	188
90/06/14	0924	WATER	1	25.0	8.5	101.28	8.4	156	90/09/13	0903	WATER	2	26.8	5.5	67.98	7.6	188
90/06/14	0927	WATER	1.2	23.9	8.2	96.58	8.1	158	90/09/13	0904	WATER	2.5	24.8	5.5	67.98	7.6	188
90/06/14	0928	WATER	1.5	23.6	6.4	75.38	7.8	163	90/09/13	0904	WATER	3	24.8				

STORET RETRIEVAL DATE 92/10/16

PGM=RET

475909 3251

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TRIB. TO TRM 504.4

47143 TENNESSEE

RHEA

TENNESSEE RIVER BASIN

040802

RICHLAND CREEK 0.5

/TYPA/AMBNT/STREAM/SOLIDS

131TVAC

06020001048 0000.580 ON

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1004	WATER	0.5	1.10	10								
90/04/11	1006	WATER	1				7.8	56	77	8.0	5	10	15
90/05/09	0855	WATER	0.5	1.38	20	D1							
90/05/09	0856	WATER	0.5		10	D2							
90/05/09	0857	WATER	0.5		10	D3							
90/05/09	0858	WATER	1			D1	7.5	48	61	2.6	1K	20	32
90/05/09	0859	WATER	1			D2	7.5	48	65	2.7	2	25	26
90/05/09	0900	WATER	1			D3	7.4	47	59	2.8	2	25	28
90/06/14	0922	WATER	0.5	1.63	10K								
90/06/14	0924	WATER	1				8.1	69	86	3.0	3	20	23
90/07/12	0930	WATER	0.5	1.13	10K								
90/07/12	0933	WATER	1				8.0	70	99	5.0	3	10	15
90/08/16	0903	WATER	0.5	1.68	20								
90/08/16	0906	WATER	1				8.0	70	93	4.0	3	10	15
90/09/13	0859	WATER	0.5	1.38	50								
90/09/13	0901	WATER	1				7.7	74	100	3.0	5	2	5

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLORPHYL A UG/L CORRECTO
90/04/02	1200	WATER	1									3
90/04/11	1006	WATER	1									
90/04/23	1200	WATER	1		1.1	1.5J	.24	.01K	.27	.020	.004	6
90/05/09	0855	WATER	0.5	D1								
90/05/09	0856	WATER	0.5	D2								
90/05/09	0857	WATER	0.5	D3								
90/05/09	0858	WATER	1	D1	1.8	1.7	.14	.01K	.21	.009	.002	12
90/05/09	0859	WATER	1	D2	1.9	1.7	.16	.01K	.21	.009	.004	
90/05/09	0900	WATER	1	D3	1.8	1.7	.20	.01K	.21	.020	.004	
90/05/30	1200	WATER	1									19
90/06/13	1200	WATER	1									9
90/06/14	0924	WATER	1		2.4	2.1	.42	.02	.06	.030	.002	5
90/06/27	1200	WATER	1									12
90/07/10	1200	WATER	1									
90/07/12	0933	WATER	1		2.3	2.0	.38	.01K	.10	.040	.007	
90/07/30	1200	WATER	1									12
90/08/02	1200	WATER	1									8
90/08/13	1200	WATER	1									13
90/08/16	0906	WATER	1		2.5	2.1	.32	.01K	.11	.020	.002K	11
90/08/23	1200	WATER	1									14
90/09/11	1200	WATER	1									
90/09/13	0901	WATER	1		2.3	2.0	.23	.03	.11	.020	.006	

PGM=RET

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CHICKAMAUGA RESERVOIR AT DAYTON
47143 TENNESSEE RHEA
TENNESSEE RIVER BASIN 040802
RICHLAND CREEK 2.8
131TVAC 900505 06
0000 METERS DEPTH

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/TYPA/AMBNT/STREAM/SOLIDS

A-54

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO	DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO
90/04/11	0920	WATER	0.5	13.2	9.6	90.6%		103	90/09/13	0839	WATER	2.5	26.3	4.6	56.1%	7.6	233
90/04/11	0922	WATER	1	13.3	9.6	90.6%	7.5	105									
90/04/11	0930	WATER	1.5	13.4	9.4	88.7%		105									
90/04/11	0940	WATER	1.7	13.4	9.7	91.5%		105									
90/05/09	0833	WATER	0.5	18.6	9.3	98.9%	7.6	91									
90/05/09	0836	WATER	1	18.5	9.2	96.8%	7.6	91									
90/05/09	0839	WATER	1.2	18.0	8.9	93.7%	7.5	89									
90/05/09	0840	WATER	1.5	17.2	9.3	95.9%	7.7	88									
90/05/09	0841	WATER	2	15.2	9.4	92.2%	7.7	71									
90/05/09	0842	WATER	2.5	15.0	9.4	92.2%	7.7	66									
90/05/09	0843	WATER	3	14.9	9.3	91.2%	7.7	67									
90/06/14	0831	WATER	0.5	26.0	10.2	124.4%	8.5	146									
90/06/14	0833	WATER	1	26.1	10.0	122.0%	8.5	148									
90/06/14	0836	WATER	1.2	24.8	8.3	98.8%	7.8	161									
90/06/14	0838	WATER	1.5	24.4	8.4	98.8%	7.7	165									
90/06/14	0840	WATER	1.7	23.8	7.0	82.4%	7.4	174									
90/06/14	0842	WATER	2	23.7	6.5	76.5%	7.4	180									
90/06/14	0845	WATER	2.2	22.5	5.4	61.4%	7.3	199									
90/06/14	0850	WATER	2.5	22.4	4.9	55.7%	7.3	214									
90/06/14	0855	WATER	2.8	21.8	4.4	50.0%	7.3	232									
90/07/12	0900	WATER	0.5	26.8	6.3	77.8%	7.7	220									
90/07/12	0903	WATER	1	26.9	6.2	76.5%	7.7	221									
90/07/12	0906	WATER	1.2	26.7	3.0	37.0%	7.4	219									
90/07/12	0907	WATER	1.5	26.7	3.1	38.3%	7.6	220									
90/07/12	0909	WATER	1.7	26.3	1.9	23.2%	7.1	214									
90/07/12	0912	WATER	2	26.1	.9	11.0%	7.1	210									
90/07/12	0915	WATER	2.5	25.8	.2	2.4%	7.1	212									
90/08/16	0838	WATER	0.5	27.0	8.2	101.2%	8.3	164									
90/08/16	0840	WATER	1	27.0	8.2	101.2%	8.4	164									
90/08/16	0842	WATER	1.2	26.8	7.0	86.4%	7.9	168									
90/08/16	0843	WATER	1.5	26.6	5.2	64.2%	7.7	171									
90/08/16	0844	WATER	2	25.2	4.5	53.6%	7.4	199									
90/08/16	0845	WATER	2.2	24.7	4.2	50.0%	7.4	215									
90/08/16	0847	WATER	2.5	24.4	3.5	41.2%	7.4	228									
90/09/13	0826	WATER	0.5	27.0	7.0	86.4%	8.0	211									
90/09/13	0828	WATER	1	27.1	7.0	86.4%	8.0	210									
90/09/13	0830	WATER	1.5	27.1	7.0	86.4%	8.0	210									
90/09/13	0832	WATER	1.7	26.8	6.7	82.7%	7.7	215									
90/09/13	0835	WATER	2	26.8	4.7	58.0%	7.7	223									

STORET RETRIEVAL DATE 92/10/16
477238

PGM=RET

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CHICKAMAUGA RESERVOIR AT DAYTON
47143 TENNESSEE RHEA
TENNESSEE RIVER BASIN 040802
RICHLAND CREEK 2.8
131TVAC 900505
0000 METERS DEPTH

06020001

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MPH-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	0920	WATER	0.5	1.10	60								
90/04/11	0922	WATER	1				7.7	40	59	9.0	6	10	15
90/05/09	0833	WATER	0.5	1.38	10K								
90/05/09	0836	WATER	1				7.3	33	43	2.0	3	25	32
90/06/14	0831	WATER	0.5	1.13	10K	D1							
90/06/14	0832	WATER	0.5		10	D2							
90/06/14	0833	WATER	0.5		10K	D3							
90/06/14	0833	WATER	1			D1	7.9	68	88	4.0	5	25	28
90/06/14	0834	WATER	1			D2	7.9	68	78	4.0	3	20	22
90/06/14	0835	WATER	1			D3	7.9	69	84	4.0	5	20	22
90/07/12	0900	WATER	0.5	.88	10								
90/07/12	0903	WATER	1				8.0	90	100	7.0	5	15	20
90/08/16	0838	WATER	0.5	.88	40								
90/08/16	0840	WATER	1				8.0	70	99	7.0	7	10	15
90/09/13	0826	WATER	0.5	1.12	50								
90/09/13	0828	WATER	1				7.9	90	120	4.0	5	5	7

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/02	1200	WATER	1									1
90/04/11	0922	WATER	1		1.0	1.4J	.13	.01	.26	.010	.004	
90/04/23	1200	WATER	1									9
90/05/09	0836	WATER	1		1.6	1.5	.12	.01K	.24	.010	.002	4
90/05/30	1200	WATER	1									19
90/06/13	1200	WATER	1									15
90/06/14	0831	WATER	0.5	D1								
90/06/14	0832	WATER	0.5	D2								
90/06/14	0833	WATER	0.5	D3								
90/06/14	0833	WATER	1	D1	2.7	2.2	.28	.01K	.01K	.030	.002K	
90/06/14	0834	WATER	1	D2	2.7	2.3	.34	.01K	.01K	.030	.002K	
90/06/14	0835	WATER	1	D3	2.7	2.3	.34	.01K	.01K	.040	.002K	
90/06/27	1200	WATER	1									9
90/07/10	1200	WATER	1									18
90/07/12	0903	WATER	1		2.7	2.1	.26	.01K	.01K	.060	.007	
90/08/02	1200	WATER	1									15
90/08/13	1200	WATER	1									11
90/08/16	0840	WATER	1		2.8	2.2	.38	.01K	.01K	.020	.002K	
90/08/23	1200	WATER	1									12
90/09/11	1200	WATER	1									19
90/09/13	0828	WATER	1		2.7	2.5	.38	.01K	.01K	.020	.005	

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477239

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TRIBUTARY TO TENNESSEE RIVER 504.90

47143 TENNESSEE RHEA

TENNESSEE RIVER BASIN 040802

MUD CREEK 1.3

131TVAC 900505

06020001

/TYP/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/11	1033	WATER	0.5	14.5	9.5	91.3%		153
90/04/11	1035	WATER	1	14.5	9.2	88.5%	7.4	154
90/04/11	1038	WATER	1.5	14.5	9.1	87.5%		153
90/04/11	1040	WATER	2	14.5	9.3	89.4%		154
90/05/08	1308	WATER	0.5	20.8	8.4	93.3%	7.8	157
90/05/08	1311	WATER	1	20.8	8.1	90.0%	7.8	158
90/05/08	1314	WATER	1.2	20.6	5.6	62.2%	7.6	160
90/05/08	1316	WATER	1.5	19.8	5.9	64.1%	7.6	160
90/05/08	1318	WATER	2	19.6	5.3	57.6%	7.5	159
90/05/08	1320	WATER	2.5	19.5	7.0	74.5%	7.5	152
90/05/08	1323	WATER	3	19.0	6.1	64.9%	7.4	148
90/06/12	1130	WATER	0.5	26.2	8.2	100.0%	8.3	177
90/06/12	1132	WATER	1	25.7	8.2	100.0%	8.4	176
90/06/12	1135	WATER	1.5	25.6	8.2	100.0%	8.4	176
90/06/12	1139	WATER	2	25.5	7.3	86.9%	8.2	177
90/06/12	1143	WATER	2.2	25.4	6.1	72.6%	7.9	179
90/06/12	1147	WATER	2.5	24.8	3.4	40.5%	7.6	180
90/07/10	1125	WATER	0.5	28.9	7.6	97.4%	8.6	181
90/07/10	1128	WATER	1	29.0	7.4	94.9%	8.6	182
90/07/10	1131	WATER	1.5	28.9	7.1	91.0%	8.5	182
90/07/10	1132	WATER	1.7	28.6	3.9	50.0%	7.7	185
90/07/10	1133	WATER	2	28.4	2.8	35.4%	7.7	186
90/07/10	1134	WATER	2.2	27.8	.6	7.6%	7.2	187
90/07/10	1135	WATER	2.5	28.1	.1	1.3%	7.2	192
90/07/10	1136	WATER	3	26.9	.1	1.2%	7.1	191
90/08/14	1051	WATER	0.5	28.2	8.2	103.8%	8.5	161
90/08/14	1054	WATER	1	28.0	7.9	100.0%	8.5	162
90/08/14	1057	WATER	1.3	27.8	7.7	97.5%	8.4	163
90/08/14	1059	WATER	1.5	27.6	5.4	68.4%	8.0	166
90/08/14	1101	WATER	2	27.0	2.9	35.8%	7.5	168
90/08/14	1103	WATER	2.2	26.7	1.7	21.0%	7.2	169
90/08/14	1105	WATER	2.5	26.6	1.1	13.6%	7.2	170
90/09/11	1045	WATER	0.5	27.5	4.7	58.0%	7.6	172
90/09/11	1047	WATER	1	27.5	4.5	55.6%	7.6	172
90/09/11	1049	WATER	1.5	27.4	4.3	53.1%	7.5	172
90/09/11	1049	WATER	2	27.4	4.3	53.1%	7.5	172
90/09/11	1050	WATER	2.5	27.3	4.2	51.9%	7.5	173

STORET RETRIEVAL DATE 92/10/16
 477239
 35 28 26.0 084 57 21.0 2
 TRIBUTARY TO TENNESSEE RIVER 504.90
 47143 TENNESSEE RHEA
 TENNESSEE RIVER BASIN 040802
 MUD CREEK 1.3
 131TVAC 900505 06020001
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/11	1033	WATER	0.5	.60	30								
90/04/11	1035	WATER	1				7.8	69	79	21.0	20	10	25
90/05/08	1308	WATER	0.5	.80	20	D1							
90/05/08	1309	WATER	0.5		10	D2							
90/05/08	1310	WATER	0.5		10K	D3							
90/05/08	1311	WATER	1			D1	7.8	67	78	9.0	7	25	33
90/05/08	1312	WATER	1			D2	7.9	70	67	8.5	7	25	33
90/05/08	1313	WATER	1			D3	7.8	71	53	8.0	7	30	33
90/06/12	1130	WATER	0.5	.63	10								
90/06/12	1132	WATER	1				8.3	77	74	12.0	8	30	33
90/07/10	1125	WATER	0.5	.88	10K								
90/07/10	1128	WATER	1				8.1	62	95	9.0	8	15	20
90/08/14	1051	WATER	0.5	1.13	10K								
90/08/14	1054	WATER	1				8.2	74	85	6.0	6	5	7
90/09/11	1045	WATER	0.5	.63	10K								
90/09/11	1047	WATER	1				7.6	71	93	6.0	10	5	7

DATE FROM TO	TIME OF DAY	MEDIUM	SNK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/02	1200	WATER	1									6
90/04/11	1035	WATER	1		2.2	2.3J	.40	.02	.31	.030	.003	11
90/04/23	1200	WATER	1									
90/05/08	1308	WATER	0.5	D1								
90/05/08	1309	WATER	0.5	D2								
90/05/08	1310	WATER	0.5	D3								
90/05/08	1311	WATER	1	D1	2.7	2.4	.32	.04	.11	.010	.005	
90/05/08	1312	WATER	1	D2	2.8	2.4	.33	.03	.12	.010	.007	
90/05/08	1313	WATER	1	D3	2.9	2.5	.32	.04	.11	.010	.006	
90/05/09	1200	WATER	1									12
90/05/30	1200	WATER	1									14
90/06/12	1132	WATER	1		3.1	2.7	.38	.04	.05	.020	.003	
90/06/13	1200	WATER	1									11
90/06/27	1200	WATER	1									4
90/07/10	1128	WATER	1		2.9	2.5	.44	.01K	.01K	.050	.004	19
90/07/30	1200	WATER	1									17
90/08/02	1200	WATER	1									17
90/08/13	1200	WATER	1									15
90/08/14	1054	WATER	1		3.1	2.6	.20	.01K	.01K	.020	.006	
90/08/23	1200	WATER	1									14
90/09/11	1047	WATER	1		2.8	2.4	.47	.08	.01K	.020	.007	

A-57

STORET RETRIEVAL DATE 92/10/16
477240

PGM=RET

35 29 57.0 084 50 39.0 2
TRIBUTARY TO TENNESSEE RIVER 514.60

47121 TENNESSEE MEIGS
TENNESSEE RIVER BASIN 040802

GOODFIELD CREEK 0.9

131TVAC 900505

06020001

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/09	1237	WATER	0.5	13.7	10.0	96.2%	7.7	212
90/04/09	1240	WATER	1	13.7	9.8	94.2%	7.7	212
90/05/08	1130	WATER	0.5	18.3	9.7	102.1%	7.9	195
90/05/08	1133	WATER	1	17.9	9.4	98.9%	7.9	196
90/05/08	1136	WATER	1.5	17.5	9.1	93.8%	7.9	200
90/06/12	1312	WATER	0.5	26.0	9.5	115.9%	8.4	204
90/06/12	1315	WATER	0.7	24.0	10.0	117.6%	8.4	205
90/06/12	1320	WATER	1	24.1	8.3	97.6%	8.0	210
90/06/12	1325	WATER	1.2	23.6	8.2	96.5%	7.9	213
90/06/12	1330	WATER	1.5	21.7	7.7	87.5%	7.8	225
90/07/10	1300	WATER	0.5	28.8	9.0	115.4%	8.7	208
90/07/10	1303	WATER	0.7	28.1	8.6	108.9%	8.6	210
90/07/10	1305	WATER	1	27.8	8.0	101.3%	8.4	212
90/07/10	1308	WATER	1.3	26.6	6.7	82.7%	8.1	218
90/08/14	1218	WATER	0.5	27.5	9.3	114.8%	8.5	190
90/08/14	1220	WATER	0.7	27.2	9.0	111.1%	8.4	191
90/08/14	1222	WATER	1	27.1	7.1	87.7%	8.0	193
90/08/14	1225	WATER	1.3	25.8	6.2	75.6%	7.7	203
90/08/14	1227	WATER	1.5	24.8	6.7	79.8%	7.8	213
90/09/11	1200	WATER	0.5	26.1	7.8	95.1%	8.0	193
90/09/11	1202	WATER	0.7	26.0	7.4	90.2%	8.0	193
90/09/11	1205	WATER	1	25.8	6.6	80.5%	7.8	193
90/09/11	1207	WATER	1.3	25.0	5.6	66.7%	7.6	207

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477240

35 29 57.0 084 50 39.0 2

TRIBUTARY TO TENNESSEE RIVER 514.60

47121 TENNESSEE MEIGS

TENNESSEE RIVER BASIN 040802

GOODFIELD CREEK 0.9

131TVAC 900505

06020001

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/09	1237	WATER	0.5	.38	20								
90/04/09	1240	WATER	1				8.0	107	61	14.0	14	5	15
90/05/08	1130	WATER	0.5	1.00	10K	01							
90/05/08	1131	WATER	0.5		10K	02							
90/05/08	1132	WATER	0.5		20	03							
90/05/08	1133	WATER	1			01	7.9	98	90	5.8	4	35	38
90/05/08	1134	WATER	1			02	7.8	89	94	5.5	5	25	33
90/05/08	1135	WATER	1			03	8.0	96	130	5.6	5	25	33
90/06/12	1312	WATER	0.5	.63	10K								
90/06/12	1320	WATER	1				8.4	93	110	11.0	10	30	33
90/07/10	1300	WATER	0.5	.63	10K								
90/07/10	1305	WATER	1				7.9	100	87	18.0	16	20	25
90/08/14	1218	WATER	0.5	1.13	10K								
90/08/14	1222	WATER	1				8.5	67	87	9.0	8	10	15
90/09/11	1200	WATER	0.5	.63	50								
90/09/11	1205	WATER	1				7.9	68	87	7.0	12	5	10

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLORPHYL A UG/L CORRECTO
90/04/02	1200	WATER	1									2
90/04/09	1240	WATER	1		1.1	1.8J	.10	.02	.13	.020	.004	7
90/04/23	1200	WATER	1									
90/05/08	1130	WATER	0.5	01								
90/05/08	1131	WATER	0.5	02								
90/05/08	1132	WATER	0.5	03								
90/05/08	1133	WATER	1	01	2.4	2.1	.20	.01K	.07	.010	.009	
90/05/08	1134	WATER	1	02	2.4	2.2	.19	.01	.06	.010	.009	
90/05/08	1135	WATER	1	03	2.4	2.2	.22	.01K	.07	.010	.009	
90/05/09	1200	WATER	1									13
90/05/30	1200	WATER	1									15
90/06/12	1320	WATER	1		2.8	2.3	.39	.01	.01K	.030	.005	
90/06/13	1200	WATER	1									12
90/06/27	1200	WATER	1									6
90/07/10	1305	WATER	1		2.3	1.8	.38	.01K	.04	.060	.006	12
90/07/30	1200	WATER	1									11
90/08/02	1200	WATER	1									13
90/08/13	1200	WATER	1									16
90/08/14	1222	WATER	1		3.0	2.3	.36	.01K	.01K	.030	.006	
90/08/23	1200	WATER	1									17
90/09/11	1205	WATER	1		2.7	2.3	.38	.01K	.01K	.030	.006	23

STORET RETRIEVAL DATE 92/10/16
 477241
 35 21 08.0 084 55 58.0 2
 TRIBUTARY TO HIWASSEE RIVER 6.50
 47121 TENNESSEE MEIGS
 HIWASSEE RIVER BASIN 040502
 GUNSTOCKER CREEK 0.85
 131TVAC 900505
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICROMHO
90/04/12	0854	WATER	0.5	12.8	10.2	96.2%	8.2	163
90/04/12	0855	WATER	1	12.8	10.0	94.3%	8.3	162
90/05/09	1012	WATER	0.5	18.9	8.1	86.2%	7.1	174
90/05/09	1015	WATER	1	18.9	7.8	83.0%	7.2	173
90/05/09	1018	WATER	1.2	18.9	7.2	76.6%	7.3	174
90/05/09	1019	WATER	1.5	18.7	6.0	63.8%	7.2	183
90/06/14	1037	WATER	0.5	25.0	8.4	100.0%	7.8	147
90/06/14	1039	WATER	1	24.7	7.7	91.7%	7.7	147
90/06/14	1042	WATER	1.2	24.5	7.3	85.9%	7.4	146
90/06/14	1044	WATER	1.5	24.5	4.2	49.4%	7.4	144
90/07/12	1035	WATER	0.5	27.2	5.4	66.7%	7.5	170
90/07/12	1038	WATER	1	27.1	4.9	60.5%	7.4	170
90/07/12	1041	WATER	1.5	26.9	2.5	30.9%	7.1	172
90/08/16	1035	WATER	0.5	27.4	7.1	87.7%	8.0	129
90/08/16	1037	WATER	1	27.3	6.5	80.2%	8.0	129
90/08/16	1040	WATER	1.1	25.4	4.7	56.0%	6.9	126
90/08/16	1043	WATER	1.4	24.9	4.4	52.4%	7.0	127
90/09/13	1036	WATER	0.5	26.1	6.5	79.3%	7.5	133
90/09/13	1038	WATER	1	26.1	5.8	70.7%	7.4	133
90/09/13	1040	WATER	1.3	25.6	3.9	47.6%	7.0	134
90/09/13	1043	WATER	1.5	25.6	3.4	41.5%	7.1	133

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477241

35 21 08.0 084 55 58.0 2

TRIBUTARY TO HIWASSEE RIVER 6.50

47121 TENNESSEE MEIGS

HIWASSEE RIVER BASIN 040502

GUNSTOCKER CREEK 0.85

131TVAC 900505

06020002

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/12	0854	WATER	0.5	.60	60								
90/04/12	0855	WATER	1				7.8	56	75	31.0	40	10	30
90/05/09	1012	WATER	0.5	.88	10								
90/05/09	1015	WATER	1				7.5	49	57	11.0	8	45	47
90/06/14	1037	WATER	0.5	1.13	10K								
90/06/14	1039	WATER	1				7.7	45	80	6.0	4	30	33
90/07/12	1035	WATER	0.5	.38	10K	01							
90/07/12	1036	WATER	0.5		10K	02							
90/07/12	1037	WATER	0.5		30	03							
90/07/12	1038	WATER	1			01	7.4	47	79	19.0	15	25	30
90/07/12	1039	WATER	1			02	7.5	48	87	17.0	15	25	30
90/07/12	1040	WATER	1			03	7.5	46	73	19.0	16	30	35
90/08/16	1035	WATER	0.5	.88	10K								
90/08/16	1037	WATER	1				7.7	34	100	7.0	7	20	25
90/09/13	1036	WATER	0.5	.88	10K								
90/09/13	1038	WATER	1				7.3	31	110	6.0	9	5	7

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLORPHYL A UG/L CORRECTD
90/04/03	1200	WATER	1									13
90/04/12	0855	WATER	1		2.1	2.9J	.30	.02	.09	.040	.006	
90/04/23	1200	WATER	1									19
90/05/09	1015	WATER	1		3.2	2.9	.34	.01K	.08	.060	.006	15
90/05/31	1200	WATER	1									14
90/06/13	1200	WATER	1									13
90/06/14	1039	WATER	1		3.1	2.6	.34	.01K	.01	.040	.003	
90/06/28	1200	WATER	1									23
90/07/09	1200	WATER	1									30
90/07/12	1035	WATER	0.5	01								
90/07/12	1036	WATER	0.5	02								
90/07/12	1037	WATER	0.5	03								
90/07/12	1038	WATER	1	01	3.2	2.7	.36	.01K	.01K	.070	.007	
90/07/12	1039	WATER	1	02	3.3	2.8	.52	.01K	.01K	.060	.007	
90/07/12	1040	WATER	1	03	3.2	2.7	.54	.01K	.01K	.060	.007	
90/07/31	1200	WATER	1									21
90/08/03	1200	WATER	1									17
90/08/14	1200	WATER	1									16
90/08/16	1037	WATER	1		2.8	2.3	.38	.01K	.01K	.020	.002	
90/08/27	1200	WATER	1									30
90/09/13	1038	WATER	1		2.9	2.4	.44	.02	.01	.020	.006	

STORET RETRIEVAL DATE 92/10/16

477242

35 22 30.0 084 54 17.0 2

NEAR HWY 58 BOAT DOCK

47121 TENNESSEE

MEIGS

HIWASSEE RIVER BASIN

040502

AGENCY CREEK 0.65

131TVAC 900505

06020002

0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/12	1235	WATER	0.5	14.0	10.8	103.8%	7.9	157
90/04/12	1237	WATER	1	14.0	10.4	100.0%	8.0	158
90/04/12	1240	WATER	1.5	13.9	10.3	99.0%	8.0	157
90/04/12	1242	WATER	2	13.8	10.2	98.1%	8.0	157
90/04/12	1244	WATER	2.6	13.8	10.1	97.1%	8.0	156
90/05/09	1050	WATER	0.5	19.8	8.9	96.7%	7.2	168
90/05/09	1053	WATER	1	19.9	8.9	96.7%	7.3	168
90/05/09	1056	WATER	1.5	19.8	8.7	94.6%	7.3	168
90/05/09	1057	WATER	1.9	19.2	6.6	70.2%	7.1	163
90/05/09	1058	WATER	2	19.4	8.3	88.3%	7.3	166
90/05/09	1059	WATER	2.5	18.7	5.0	53.2%	7.2	167
90/05/09	1101	WATER	2.7	18.4	3.7	38.9%	7.0	168
90/06/14	1133	WATER	0.5	26.2	10.2	124.4%	8.5	149
90/06/14	1135	WATER	1	26.2	9.8	119.5%	8.6	149
90/06/14	1138	WATER	1.5	25.8	9.0	109.8%	8.4	148
90/06/14	1140	WATER	1.7	24.2	7.6	89.4%	7.7	142
90/06/14	1142	WATER	2	24.0	6.2	72.9%	7.7	137
90/06/14	1144	WATER	2.2	22.6	4.3	49.4%	7.0	135
90/06/14	1146	WATER	2.5	22.5	3.8	43.2%	7.1	133
90/06/14	1148	WATER	2.7	22.2	2.3	26.1%	6.8	135
90/06/14	1150	WATER	3	21.9	1.1	12.5%	6.8	138
90/07/12	1125	WATER	0.5	27.2	7.2	88.9%	7.8	168
90/07/12	1128	WATER	1	27.2	7.1	87.7%	7.8	168
90/07/12	1131	WATER	1.5	27.1	7.0	86.4%	7.8	167
90/07/12	1131	WATER	2	27.0	6.9	85.2%	7.7	167
90/07/12	1131	WATER	2.5	26.8	6.7	82.7%	7.5	168
90/07/12	1131	WATER	2.8	26.5	4.5	54.9%	7.3	168
90/08/16	1135	WATER	0.5	26.6	9.2	113.6%	8.5	134
90/08/16	1138	WATER	0.7	26.2	9.3	113.4%	8.5	136
90/08/16	1139	WATER	1	26.4	7.5	91.5%	8.6	136
90/08/16	1142	WATER	1.2	25.3	7.0	83.3%	7.3	134
90/08/16	1143	WATER	1.5	25.3	6.1	72.6%	7.5	135
90/08/16	1144	WATER	1.7	24.7	6.2	73.8%	7.1	134
90/08/16	1145	WATER	2	24.4	4.8	56.5%	7.2	135
90/08/16	1146	WATER	2.2	23.9	4.5	52.9%	6.9	132
90/08/16	1146	WATER	2.5	23.9	3.2	37.6%	7.0	131
90/08/16	1147	WATER	2.7	23.3	1.9	21.8%	6.8	127
90/08/16	1148	WATER	3	23.4	1.1	12.6%	6.8	127
90/09/13	1115	WATER	0.5	25.8	7.5	91.5%	7.5	134

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477242

35 22 30.0 084 54 17.0 2

NEAR HWY 58 BOAT DOCK

47121 TENNESSEE

MEIGS

HIWASSEE RIVER BASIN

040502

AGENCY CREEK 0.65

131TVAC 900505

06020002

0000 METERS DEPTH

/TYP/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/09/13	1117	WATER	1	25.8	7.4	90.2%	7.5	133
90/09/13	1119	WATER	1.2	25.3	6.9	82.1%	7.1	131
90/09/13	1121	WATER	1.5	25.3	5.7	67.9%	7.2	130
90/09/13	1123	WATER	2	24.9	5.0	59.5%	7.0	130
90/09/13	1124	WATER	2.2	24.7	3.3	39.3%	6.7	132
90/09/13	1125	WATER	2.5	24.7	3.6	42.9%	6.8	131
90/09/13	1127	WATER	2.7	24.5	1.4	16.5%	6.6	135
90/09/13	1130	WATER	3	24.5	.5	5.6%	6.6	137

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/12	1235	WATER	0.5	.70	20								
90/04/12	1237	WATER	1				7.7	55	79	13.0	11	10	30
90/05/09	1050	WATER	0.5	.88	10								
90/05/09	1053	WATER	1				7.6	58	63	8.6	7	40	40
90/06/14	1133	WATER	0.5	1.13	10K								
90/06/14	1135	WATER	1				8.1	44	62	5.0	4	30	32
90/07/12	1125	WATER	0.5	.88	10K	D1							
90/07/12	1126	WATER	0.5		10K	D2							
90/07/12	1127	WATER	0.5		10	D3							
90/07/12	1128	WATER	1			D1	7.6	44	63	8.0	6	35	40
90/07/12	1129	WATER	1			D2	7.6	43	67	9.0	7	30	35
90/07/12	1130	WATER	1			D3	7.6	46	83	9.0	7	30	35
90/08/16	1135	WATER	0.5	1.12	10K								
90/08/16	1139	WATER	1				7.9	30	93	7.0	5	20	25
90/09/13	1115	WATER	0.5	1.12	10								
90/09/13	1117	WATER	1				7.4	32	100	4.0	6	10	15

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C MG/L	00681 D ORG C MG/L	00605 ORG N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTO
90/04/03	1200	WATER	1									9
90/04/12	1237	WATER	1		1.9	2.1J	.32	.01K	.19	.020	.006	
90/04/23	1200	WATER	1									10
90/05/09	1053	WATER	1		3.3	2.8	.40	.02	.06	.040	.006	15
90/05/31	1200	WATER	1									35
90/06/13	1200	WATER	1									12
90/06/14	1135	WATER	1		2.9	2.6	.32	.01K	.01K	.030	.004	
90/06/28	1200	WATER	1									27
90/07/09	1200	WATER	1									26
90/07/12	1125	WATER	0.5	D1								
90/07/12	1126	WATER	0.5	D2								
90/07/12	1127	WATER	0.5	D3								
90/07/12	1128	WATER	1	D1	3.1	2.8	.44	.01K	.03	.040	.006	
90/07/12	1129	WATER	1	D2	3.1	2.7	.47	.01K	.02	.050	.006	
90/07/12	1130	WATER	1	D3	3.2	2.7	.38	.01K	.02	.040	.006	
90/07/31	1200	WATER	1									29
90/08/03	1200	WATER	1									48
90/08/14	1200	WATER	1									10
90/08/16	1139	WATER	1		2.9	2.4	.32	.01K	.01K	.030	.002	
90/08/27	1200	WATER	1									48
90/09/11	1200	WATER	1									19
90/09/13	1117	WATER	1		2.7	2.6	.48	.01K	.04	.020	.006	

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477243

35 19 21.0 084 50 56.0 2

TRIBUTARY TO CHANNEL 0.6 AT LEDFORD ISLAND

47011 TENNESSEE

BRADLEY

HIWASSEE RIVER BASIN

040502

CANDIES CREEK 1.5

131TVAC 900505

06020002

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/12	1030	WATER	0.5	12.2	9.2	85.2%	7.9	204
90/04/12	1032	WATER	1	12.2	9.1	84.3%	7.9	204
90/04/12	1035	WATER	1.5	12.2	9.1	84.3%	7.9	205
90/04/12	1037	WATER	2	12.2	9.0	83.3%	7.9	205
90/04/12	1039	WATER	2.5	12.1	9.0	83.3%	7.9	205
90/05/10	1126	WATER	0.5	17.0	7.5	77.3%	7.2	139
90/05/10	1129	WATER	1	16.8	7.4	76.3%	7.2	141
90/05/10	1132	WATER	1.5	16.6	7.4	76.3%	7.2	141
90/05/10	1133	WATER	2	16.6	7.4	76.3%	7.2	142
90/05/10	1134	WATER	2.5	16.4	7.4	74.0%	7.2	145
90/05/10	1135	WATER	3	16.4	7.4	74.0%	7.2	148
90/06/13	1142	WATER	0.5	25.2	9.7	115.5%	8.2	182
90/06/13	1144	WATER	1	25.1	9.1	108.3%	8.2	174
90/06/13	1146	WATER	1.2	24.4	8.7	102.4%	7.9	171
90/06/13	1148	WATER	1.5	23.2	4.4	50.6%	7.4	204
90/06/13	1150	WATER	2	22.5	3.3	37.5%	7.4	244
90/06/13	1155	WATER	2.5	22.3	3.0	34.1%	7.3	235
90/06/13	1200	WATER	3	21.9	2.9	33.0%	7.4	185
90/07/11	1050	WATER	0.5	27.5	7.1	87.7%	7.8	218
90/07/11	1053	WATER	0.7	27.3	6.7	82.7%	7.6	215
90/07/11	1054	WATER	1	26.6	5.9	72.8%	7.6	202
90/07/11	1057	WATER	1.2	25.6	1.6	19.5%	7.3	228
90/07/11	1058	WATER	1.5	24.9	1.5	17.9%	7.4	281
90/07/11	1100	WATER	2	24.8	1.4	16.7%	7.3	282
90/07/11	1102	WATER	2.5	24.5	.6	7.1%	7.3	286
90/07/11	1105	WATER	2.8	24.4	.1	1.2%	7.3	290
90/08/15	1034	WATER	0.5	26.3	7.0	85.4%	7.7	191
90/08/15	1037	WATER	0.7	26.5	7.1	86.6%	7.9	165
90/08/15	1038	WATER	1	26.0	5.7	69.5%	7.7	197
90/08/15	1041	WATER	1.2	24.0	4.6	54.1%	7.4	246
90/08/15	1042	WATER	1.5	24.1	4.2	49.4%	7.5	250
90/08/15	1043	WATER	2	23.6	3.4	40.0%	7.4	253
90/08/15	1044	WATER	2.5	23.3	2.9	33.3%	7.4	254
90/09/12	1055	WATER	0.5	25.9	5.2	63.4%	7.5	163
90/09/12	1057	WATER	0.7	24.9	3.9	46.4%	7.3	168
90/09/12	1059	WATER	1	24.5	3.6	42.4%	7.3	215
90/09/12	1102	WATER	1.5	24.1	3.7	43.5%	7.3	267
90/09/12	1105	WATER	2	23.7	3.4	40.0%	7.3	270
90/09/12	1108	WATER	2.5	23.7	3.4	40.0%	7.3	270

STORET RETRIEVAL DATE 92/10/16
477243

PGM=RET

35 19 21.0 084 50 56.0 2
TRIBUTARY TO CHANNEL 0.6 AT LEDFORD ISLAND
47011 TENNESSEE BRADLEY
HIWASSEE RIVER BASIN 040502
CANDIES CREEK 1.5
131TVAC 900505 06020002
0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFH-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/12	1030	WATER	0.5	.40	2000L								
90/04/12	1032	WATER	1				8.0	100		27.0	16	10	20
90/05/10	1126	WATER	0.5	.13	2000L								
90/05/10	1129	WATER	1				7.5	52	67	63.0	52	200	230
90/06/13	1142	WATER	0.5	.88	10K								
90/06/13	1144	WATER	1				8.0	69	76	9.0	8	30	35
90/07/11	1050	WATER	0.5	.63	1K								
90/07/11	1054	WATER	1				7.7	84	120	18.0	14	25	30
90/08/15	1034	WATER	0.5	.63	100K	D1							
90/08/15	1035	WATER	0.5		100	D2							
90/08/15	1038	WATER	1			D1	7.9	50	73	11.0	11	10	15
90/08/15	1039	WATER	1			D2	7.9	60	91	14.0	14	10	15
90/08/15	1040	WATER	1			D3	7.9	60	83	14.0	14	20	25
90/09/12	1055	WATER	0.5	.63	100								
90/09/12	1059	WATER	1				7.2	50	97	11.0	17	20	25

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/03	1200	WATER	1									1
90/04/12	1032	WATER	1		2.3	2.6J	.32	.02	.16	.030	.006	7
90/04/23	1200	WATER	1									
90/05/10	1129	WATER	1		5.1	5.0	.54	.04	.23	.080	.040	16
90/05/31	1200	WATER	1									13
90/06/13	1144	WATER	1		2.9	2.5	.28	.01K	.01K	.030	.002	41
90/06/28	1200	WATER	1									21
90/07/09	1200	WATER	1									
90/07/11	1054	WATER	1		2.9	2.5	.38	.01K	.01K	.050	.006	7
90/07/31	1200	WATER	1									13
90/08/03	1200	WATER	1									20
90/08/14	1200	WATER	1									
90/08/15	1034	WATER	0.5	01								
90/08/15	1035	WATER	0.5	02								
90/08/15	1038	WATER	1	01	2.8	2.6	.34	.01K	.01K	.030	.005	
90/08/15	1039	WATER	1	02	2.8	2.5	.42	.01K	.01K	.040	.006	
90/08/15	1040	WATER	1	03	2.9	2.5	.38	.01K	.01K	.040	.006	
90/08/27	1200	WATER	1									22
90/09/12	1059	WATER	1		2.7	2.3	.37	.01	.03	.020	.010	

STORET RETRIEVAL DATE 92/10/16
 477244
 35 20 46.0 084 49 26.0 2
 TRIBUTARY TO HIWASSEE RIVER 12.00
 47121 TENNESSEE MEIGS
 HIWASSEE RIVER BASIN 040502
 ROGERS CREEK 1.5
 131TVAC 900505 06020002
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CNDUCTVY FIELD MICRONHO
90/04/10	1337	WATER	0.5	14.9	10.3	101.0%	8.1	152
90/04/10	1338	WATER	1	14.9	10.3	101.0%	8.1	153
90/05/10	1215	WATER	0.5	18.3	8.1	85.3%	7.5	170
90/05/10	1218	WATER	1	18.3	8.1	85.3%	7.5	170
90/05/10	1221	WATER	1.5	18.2	8.0	84.2%	7.5	170
90/05/10	1222	WATER	2	18.1	7.6	80.0%	7.4	169
90/06/13	1226	WATER	0.5	24.8	9.7	115.5%	8.2	146
90/06/13	1228	WATER	1	24.7	9.5	114.3%	8.3	146
90/06/13	1230	WATER	1.5	24.3	8.3	103.5%	8.1	146
90/06/13	1232	WATER	1.7	24.4	8.5	100.0%	8.1	146
90/06/13	1234	WATER	2	22.2	5.2	59.1%	7.5	150
90/07/11	1120	WATER	0.5	27.1	8.4	103.7%	7.8	173
90/07/11	1123	WATER	0.7	26.8	7.7	95.1%	7.6	173
90/07/11	1124	WATER	1	26.8	7.2	88.9%	7.8	172
90/07/11	1127	WATER	1.3	25.6	4.8	58.5%	7.2	172
90/07/11	1127	WATER	1.5	25.3	4.4	52.4%	7.1	173
90/07/11	1127	WATER	1.8	24.9	1.7	20.2%	6.9	176
90/08/15	1110	WATER	0.5	25.9	9.3	113.4%	8.3	131
90/08/15	1113	WATER	0.7	26.0	8.7	106.1%	8.3	132
90/08/15	1114	WATER	1	25.1	7.6	90.5%	7.4	134
90/08/15	1118	WATER	1.2	24.1	5.9	69.4%	7.0	133
90/08/15	1123	WATER	1.5	23.8	5.2	61.2%	7.1	132
90/09/12	1130	WATER	0.5	26.2	9.0	109.8%	8.2	137
90/09/12	1132	WATER	1	25.0	5.1	60.7%	7.0	132
90/09/12	1135	WATER	1.2	24.7	3.8	45.2%	6.8	132
90/09/12	1139	WATER	1.5	24.5	3.6	42.4%	6.9	130

STORET RETRIEVAL DATE 92/10/16
 477244
 35 20 46.0 084 49 26.0 2
 TRIBUTARY TO HIWASSEE RIVER 12.00
 47121 TENNESSEE MEIGS
 HIWASSEE RIVER BASIN 040502
 ROGERS CREEK 1.5
 131TVAC 900505 06020002
 0000 METERS DEPTH

PGM=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MPN-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CAC03 MG/L	00900 TOT HARD CAC03 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	1337	WATER	0.5	.63	10K								
90/04/10	1338	WATER	1				7.9	44	55	18.0	17	10	25
90/05/10	1215	WATER	0.5	.88	550								
90/05/10	1218	WATER	1				7.5	56	74	15.0	9	35	48
90/06/13	1226	WATER	0.5	.88	10K								
90/06/13	1228	WATER	1				7.8	43	58	7.0	6	35	38
90/07/11	1120	WATER	0.5	.88	1K								
90/07/11	1124	WATER	1				7.7	50	110	9.0	7	25	30
90/08/15	1110	WATER	0.5	.88	100K	D1							
90/08/15	1111	WATER	0.5		100K	D2							
90/08/15	1112	WATER	0.5		100K	D3							
90/08/15	1114	WATER	1			D1	7.8	30	77	4.0	4	20	25
90/08/15	1115	WATER	1			D2	7.8	36	81	6.0	5	25	30
90/08/15	1116	WATER	1			D3	7.8	30	91	7.0	6	25	30
90/09/12	1130	WATER	0.5	1.12	10K								
90/09/12	1132	WATER	1				7.5	25	100	4.0	5	15	20

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/03	1200	WATER	1									2
90/04/10	1338	WATER	1		1.7	2.4J	.26		.08	.030	.006	8
90/04/23	1200	WATER	1									13
90/05/09	1200	WATER	1									
90/05/10	1218	WATER	1		2.6	2.4	.26	.02	.09	.070	.008	14
90/05/31	1200	WATER	1									16
90/06/13	1228	WATER	1		3.0	2.6	.14	.01K	.02	.030	.004	34
90/06/28	1200	WATER	1									21
90/07/09	1200	WATER	1									
90/07/11	1124	WATER	1		3.0	2.7	.36	.01K	.01K	.040	.005	23
90/07/31	1200	WATER	1									48
90/08/03	1200	WATER	1									13
90/08/14	1200	WATER	1									
90/08/15	1110	WATER	0.5	D1								
90/08/15	1111	WATER	0.5	D2								
90/08/15	1112	WATER	0.5	D3								
90/08/15	1114	WATER	1	D1	3.2	2.9	.34	.01K	.01K	.030	.004	
90/08/15	1115	WATER	1	D2	3.4	2.9	.36	.01K	.01K	.030	.005	
90/08/15	1116	WATER	1	D3	3.3	2.9	.50	.01K	.02	.040	.004	
90/08/27	1200	WATER	1									26
90/09/12	1132	WATER	1		2.8	2.5	.33	.01	.01K	.040	.007	

STORET RETRIEVAL DATE 92/10/16
 477246
 35 19 44.0 084 47 52.0 2
 TRIBUTARY TO HIWASSEE RIVER 14.50
 47107 TENNESSEE MCMINN
 HIWASSEE RIVER BASIN 040502
 NORTH MOUSE CREEK 0.5
 131TVAC 900505 06020002
 0000 METERS DEPTH

PGH=RET

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICRONHO
90/04/10	1033	WATER	0.5	13.5	9.4	88.7%	8.0	247
90/04/10	1036	WATER	1	13.5	9.3	87.7%	8.0	247
90/04/10	1039	WATER	1.5	13.5	9.5	89.6%	8.0	247
90/05/10	1025	WATER	0.5	16.1	7.8	78.0%	7.2	201
90/05/10	1028	WATER	1	16.0	7.8	78.0%	7.3	200
90/05/10	1031	WATER	1.5	16.0	7.8	78.0%	7.3	201
90/05/10	1032	WATER	2	16.0	7.8	78.0%	7.3	205
90/06/13	1014	WATER	0.5	23.7	7.3	85.9%	7.9	245
90/06/13	1016	WATER	0.7	23.2	8.3	95.4%	7.7	246
90/06/13	1018	WATER	1	21.2	4.5	50.0%	7.5	237
90/06/13	1020	WATER	1.5	20.6	5.8	64.4%	7.5	253
90/06/13	1024	WATER	2	20.3	5.3	57.6%	7.5	262
90/06/13	1028	WATER	2.5	20.3	5.3	57.6%	7.5	264
90/06/13	1033	WATER	2.8	20.2	5.2	56.5%	7.5	265
90/07/11	0950	WATER	0.5	26.5	8.6	104.9%	8.1	262
90/07/11	0953	WATER	0.7	25.5	7.2	85.7%	7.8	263
90/07/11	0956	WATER	1	25.8	4.3	52.4%	8.0	268
90/07/11	0959	WATER	1.5	24.0	4.2	49.4%	7.7	281
90/07/11	1002	WATER	2	23.6	3.5	41.2%	7.6	284
90/07/11	1007	WATER	2.5	23.5	4.1	47.1%	7.6	283
90/08/15	0924	WATER	0.5	25.3	10.5	125.0%	8.7	226
90/08/15	0927	WATER	0.7	25.2	10.7	127.4%	8.7	222
90/08/15	0928	WATER	1	24.0	7.2	84.7%	7.9	220
90/08/15	0931	WATER	1.2	23.5	6.6	75.9%	7.7	261
90/08/15	0932	WATER	1.5	23.1	5.4	62.1%	7.8	285
90/08/15	0933	WATER	2	22.7	4.8	55.2%	7.7	292
90/08/15	0935	WATER	2.5	22.3	4.3	48.9%	7.7	296
90/09/12	0930	WATER	0.5	24.9	9.6	114.3%	8.3	274
90/09/12	0932	WATER	0.7	24.9	7.1	84.0%	8.3	274
90/09/12	0934	WATER	1	24.1	4.7	55.3%	7.6	187
90/09/12	0937	WATER	1.5	23.3	3.7	42.5%	7.5	287
90/09/12	0941	WATER	2	23.3	3.7	42.5%	7.6	286
90/09/12	0949	WATER	2.5	23.1	3.5	40.2%	7.5	289

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477246

35 19 44.0 084 47 52.0 2

TRIBUTARY TO HIWASSEE RIVER 14.50

47107 TENNESSEE

MCMINN

HIWASSEE RIVER BASIN

040502

NORTH MOUSE CREEK 0.5

131TVAC 900505

06020002

0000 METERS DEPTH

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MFM-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/10	1033	WATER	0.5	.63	30								
90/04/10	1036	WATER	1				8.0	127	130	15.0	13	15	20
90/05/10	1025	WATER	0.5	.13	10K								
90/05/10	1028	WATER	1				7.5	86	80	49.0	42	150	220
90/06/13	1014	WATER	0.5	.63	10K								
90/06/13	1018	WATER	1				8.1	115	140	12.0	12	35	37
90/07/11	0950	WATER	0.5	.88	30								
90/07/11	0956	WATER	1				8.0	140	140	13.0	10	20	25
90/08/15	0924	WATER	0.5	.63	10K								
90/08/15	0928	WATER	1				8.2	100	120	6.0	7	20	25
90/09/12	0930	WATER	0.5	.63	10	D1							
90/09/12	0931	WATER	0.5		10K	D2							
90/09/12	0932	WATER	0.5		10	D3							
90/09/12	0934	WATER	1			D1	8.3	150	130	7.0	9	10	15
90/09/12	0935	WATER	1			D2	8.2	150	100	6.0	8	5	10
90/09/12	0936	WATER	1			D3	8.0	160	140	6.0	8	5	10

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C MG/L	00681 D ORG C MG/L	00605 ORG N MG/L	00610 NH3+NH4-N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPHYL A UG/L CORRECTD
90/04/03	1200	WATER	1									1
90/04/10	1036	WATER	1		1.0	1.5J	.17	.01	.66	.020	.007	1
90/04/23	1200	WATER	1									5
90/05/09	1200	WATER	1									2
90/05/10	1028	WATER	1		3.9	3.7	.57	.05	.63	.110	.050	18
90/05/31	1200	WATER	1									7
90/06/13	1018	WATER	1		3.0	2.5	.34	.01K	.46	.040	.003	13
90/06/28	1200	WATER	1									11
90/07/09	1200	WATER	1									14
90/07/11	0956	WATER	1		2.2	1.9	.44	.01K	.17	.050	.006	16
90/07/31	1200	WATER	1									19
90/08/03	1200	WATER	1									15
90/08/14	1200	WATER	1									
90/08/15	0928	WATER	1		3.3	2.7	.48	.01K	.07	.030	.004	
90/08/27	1200	WATER	1									
90/09/11	1200	WATER	1									
90/09/12	0930	WATER	0.5	D1								
90/09/12	0931	WATER	0.5	D2								
90/09/12	0932	WATER	0.5	D3								
90/09/12	0934	WATER	1	D1	2.8	2.3	.34	.02	.05	.030	.009	
90/09/12	0935	WATER	1	D2	2.7	2.2	.33	.01	.05	.030	.009	
90/09/12	0936	WATER	1	D3	2.7	2.3	.35	.01	.05	.030	.008	

STORET RETRIEVAL DATE 92/10/16
477247

PGM=RET

35 18 23.0 084 48 00.0 2
TRIBUTARY TO HIWASSEE RIVER 15.50
47011 TENNESSEE BRADLEY
HIWASSEE RIVER BASIN 040502
SOUTH MOUSE CREEK 1.1
131TVAC 900505
0000 METERS DEPTH

06020002

/TYPA/AMBNT/STREAM/SOLIDS

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (M)	00010 WATER TEMP CENT	00300 DO MG/L	00301 DO SATUR PERCENT	00400 PH SU	00094 CONDUCTVY FIELD MICROMHO
90/04/12	1130	WATER	0.5	12.3	8.9	82.4%	7.9	252
90/04/12	1132	WATER	1	11.9	8.6	79.6%	7.9	251
90/05/10	0957	WATER	0.5	16.7	7.4	76.3%	7.2	156
90/05/10	1000	WATER	1	16.7	7.3	75.3%	7.2	156
90/05/10	1003	WATER	1.5	16.7	7.4	76.3%	7.2	156
90/06/13	0929	WATER	0.5	23.3	9.4	108.0%	8.2	236
90/06/13	0932	WATER	0.7	23.3	8.0	92.0%	8.0	249
90/06/13	0937	WATER	1	22.0	7.3	83.0%	7.8	189
90/06/13	0948	WATER	1.4	21.4	4.5	50.0%	7.7	187
90/07/11	0920	WATER	0.5	25.9	5.2	63.4%	7.9	234
90/07/11	0923	WATER	1	26.1	4.4	53.7%	7.6	236
90/07/11	0926	WATER	1.3	25.9	3.2	39.0%	7.2	240
90/07/11	0931	WATER	1.5	25.6	1.6	19.5%	7.4	228
90/08/15	0900	WATER	0.5	25.7	8.3	101.2%	8.2	250
90/08/15	0903	WATER	0.7	25.5	7.0	83.3%	7.8	261
90/08/15	0906	WATER	1	25.9	5.5	67.1%	7.8	292
90/09/12	0902	WATER	0.5	25.0	7.2	85.7%	7.7	260
90/09/12	0904	WATER	0.7	25.1	6.0	71.4%	7.7	244
90/09/12	0905	WATER	1	24.6	4.8	57.1%	7.6	233
90/09/12	0907	WATER	1.3	23.8	3.4	40.0%	7.4	223
90/09/12	0910	WATER	1.5	23.9	3.1	36.5%	7.4	225

STORET RETRIEVAL DATE 92/10/16

PGM=RET

477247

35 18 23.0 084 48 00.0 2

TRIBUTARY TO HIWASSEE RIVER 15.50

47011 TENNESSEE BRADLEY

HIWASSEE RIVER BASIN 040502

SOUTH MOUSE CREEK 1.1

131TVAC 900505

06020002

/TYPA/AMBNT/STREAM/SOLIDS

0000 METERS DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	00078 TRANSP SECCHI METERS	31616 FEC COLI MPN-FCBR /100ML	84002 CODE GENERAL REMARKS	00403 PH LAB SU	00410 T ALK CACO3 MG/L	00900 TOT HARD CACO3 MG/L	82079 TURBIDITY LAB NTU	00530 RESIDUE TOT NFLT MG/L	00080 COLOR PT-CO UNITS	00081 AP COLOR PT-CO UNITS
90/04/12	1130	WATER	0.5	.50									
90/04/12	1132	WATER	1										
90/05/10	0957	WATER	0.5	.13	2000L		8.0	113	120	25.0	16	10	15
90/05/10	1000	WATER	1				7.3	58	74	88.0	87	250	280
90/06/13	0929	WATER	0.5	.38	10K		8.1	110	110	28.0	35	35	40
90/06/13	0937	WATER	1										
90/07/11	0920	WATER	0.5	.38	1K		7.4	70	130	43.0	43	25	30
90/07/11	0923	WATER	1										
90/08/15	0900	WATER	0.5	.38	500		8.2	120	110	17.0	19	20	25
90/08/15	0906	WATER	1										
90/09/12	0902	WATER	0.5	.38	10K	01							
90/09/12	0903	WATER	0.5		200	02							
90/09/12	0904	WATER	0.5		10K	03							
90/09/12	0905	WATER	1			01	7.8	130	130	25.0	33	15	20
90/09/12	0906	WATER	1			02	7.7	120	120	24.0	33	15	20
90/09/12	0907	WATER	1			03	7.8	110	140	28.0	37	20	25

DATE FROM TO	TIME OF DAY	MEDIUM	SHK OR DEPTH (M)	84002 CODE GENERAL REMARKS	00680 T ORG C C MG/L	00681 D ORG C C MG/L	00605 ORG N N MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2+NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P	00671 PHOS-DIS ORTHO MG/L P	32211 CHLRPNYL A UG/L CORRECTD
90/04/03	1200	WATER	1									5
90/04/12	1132	WATER	1									5
90/04/23	1200	WATER	1		2.7	3.0J	.53	.03	.68	.040	.010	3
90/05/09	1200	WATER	1									3
90/05/10	1000	WATER	1		5.2	4.9	.76	.04	.27	.160J	.050	21
90/05/31	1200	WATER	1									49
90/06/13	0937	WATER	1		3.3	2.9	.64	.01	.05	.090	.002	17
90/06/28	1200	WATER	1									41
90/07/09	1200	WATER	1									34
90/07/11	0923	WATER	1		3.5	3.4	1.70	.01K	.03	.270	.040	54
90/07/31	1200	WATER	1									24
90/08/03	1200	WATER	1									49
90/08/14	1200	WATER	1									14
90/08/15	0906	WATER	1		3.7	2.9	.74	.01K	.06	.080	.008	49
90/08/27	1200	WATER	1									14
90/09/11	1200	WATER	1									
90/09/12	0902	WATER	0.5	D1								
90/09/12	0903	WATER	0.5	D2								
90/09/12	0904	WATER	0.5	D3								
90/09/12	0905	WATER	1	D1	4.1	3.4	.59	.01	.18	.070	.020	
90/09/12	0906	WATER	1	D2	4.0	3.5	.58	.02	.20	.080	.020	
90/09/12	0907	WATER	1	D3	4.3	3.6	.59	.01	.22	.080	.020	

APPENDIX B
PHYSICAL/CHEMICAL CHARACTERISTICS OF SEDIMENT

Chickamauga Embayment Study WY 1990 - Sediment
Metals and Solids

Station	YY	MM	DD	Metals, mg/kg (dry weight)											
				ALUMINUM	CADMIUM	CALCIUM	CHROMIUM	COPPER	IRON	LEAD	MANGANESE	MANGANESE	MERCURY	NICKEL	ZINC
TENN RIVER STATIONS															
475358 (472.3)	90	5	30	31000	0.1 K	2600	24	67	52000	75	2900	5200	0.79	32	340
475302 (478.19)	90	5	25	48000	0.1 K	6900	31	55	49000	61	3800	4000	0.51	37	390
475265 (490.47)	90	5	25	37000	0.1 K	2500	25	50	44000	53	3400	5000	0.33	30	260
475266 (496.50)	90	6	22	38000	0.1 K	2500	23	51	42000	51	3500	3600	0.36	26	290
475804 (506.6)	90	5	22	28000	0.1 K	2800	11	21	35000	37	4100	4400	0.18	20	130
475363 (518.0)	90	6	22	44000	0.1 K	2400	25	29	42000	29	3900	1400	0.10 K	29	83
HIWASSEE RIVER STATIONS															
475366 (7.4)	90	5	24	33000	0.1 K	1900	29	69	36000	62	3000	1300	0.57	30	750
477245 (13.4)	90	6	22	33000	0.1 K	970	18	43	38000	36	2700	1200	0.10 K	19	280
475908 (20.0)	90	6	22	37000	0.1 K	710	21	61	39000	49	2800	580	0.10 K	22	520
EMBAYMENT STATIONS															
477228 (Waconda Bay 0.95)	90	5	30	37000	0.1 K	1400	41	46	40000	180	1700	810	0.75	24	230
477229 (Wolftever Cr 4.2)	90	5	25	34000	0.1 K	2400	21	23	32000	55	2600	780	0.10 K	19	110
477230 (Wolftever Cr 5.65)	90	5	25	27000	0.1 K	2300	20	21	27000	34	2100	660	0.10 K	18	80
477231 (Savannah Cr 2.95)	90	5	25	15000	0.1 K	7800	10	19	28000	36	1500	1200	0.10 K	13	44
477232 (Dallas Bay 0.9)	90	5	25	54000	0.1 K	2700	18	8	42000	61	2500	490	0.30	19	71
477233 (Soddy Cr 1.7)	90	5	25	28000	0.1 K	1400	19	23	36000	33	2400	530	0.10 K	41	130
477234 (Soddy Cr 4.0)	90	6	22	36000	0.1 K	1100	24	28	36000	35	2300	390	0.10 K	39	120
477235 (Possum Cr 2.0)	90	5	25	41000	0.1 K	1400	26	27	42000	46	2600	720	0.27	77	270
477236 (Sale Cr 1.3)	90	5	24	32000	0.1 K	1200	22	18	32000	40	2000	520	0.23	29	130
477237 (Sale Cr 2.0)	90	5	24	24000	0.1 K	2000	18	11	27000	32	1700	880	0.10 K	38	110
475909 (Richland Cr 0.5)	90	5	22	26000	0.1 K	3000	67	25	30000	46	2500	850	0.17	22	160
477238 (Richland Cr 2.8)	90	6	22	18000	0.1 K	2500	12	20	19000	35	1500	480	0.10 K	15	70
477239 (Mud Cr 1.3)	90	5	22	59000	0.1 K	3100	31	18	38000	43	4700	1500	0.11	22	98

Chickamauga Embayment Study WY 1990 - Sediment
Metals and Solids

Station	YY MM DD	Metals, mg/kg (dry weight)											
		ALUMINUM	CADMIUM	COPPER	CHROMIUM	COBALT	IRON	LEAD	MANGANESE	MANGANESE	MERCURY	NICKEL	ZINC
EMBAYMENT STATIONS (continued)													
477240 (Goodfield Cr 0.9)	90 5 22	28000	0.1 K	2900	26	34	19000	31	4100	1200	0.10 K	25	200
477241 (Gunstocker Cr 0.85)	90 5 24	37000	0.1 K	1700	28	14	31000	44	2700	1600	0.23	24	45
477242 (Agency Cr 0.65)	90 5 24	36000	0.1 K	2500	23	33	36000	53	2600	960	0.82	23	410
477243 (Candies Cr 1.5)	90 5 23	39000	0.1 K	1800	27	7	28000	23	3600	1500	0.10 K	21	68
477244 (Rogers Cr 1.5)	90 5 23	19000	0.1 K	1600	5	21	24000	31	2100	790	0.41	11	300
477246 (N. Mouse Cr 0.5)	90 5 23	22000	0.1 K	3000	20	19	30000	51	2000	1600	0.12	21	110
477247 (S. Mouse Cr 1.1)	90 5 23	36000	0.1 K	5000	22	18	28000	33	3300	1300	0.10 K	21	180
	Maximum	59000	0.1 K	7800	67	69	52000	180	4700	5200	0.82	77	750
	Minimum	15000	0.1 K	710	5	7	19000	23	1500	390	0.10 K	11	44
	Average	33690	0.1 K	2554	24	30	34552	48	2779	1567	0.26	26	206

Chickamauga Embayment Study WY 1990 - Sediment
Metals and Solids

Station	YY MM DD	Solids, %	Total Tot Vol.	Size fraction, %		
<hr/>						
TENN RIVER STATIONS						
475358 (472.3)	90 5 30	37.3	8.2	97	99.3	99.6
475302 (478.19)	90 5 25	46	7.7	73.7	78.5	83.5
475265 (490.47)	90 5 25	45.1	7.2	91.2	98.4	99.9
475266 (496.50)	90 6 22	53.9	6.2	69.5	85.2	98.5
475804 (506.6)	90 5 22	61.1	5.2	59.3	74.8	99.4
475363 (518.0)	90 6 22	65.9	5.8	81.3	87.1	99.6
<hr/>						
HIMASSEE RIVER STATIONS						
475366 (7.4)	90 5 24	58.6	8.4	70.7	88.4	99.8
477245 (13.4)	90 6 22	70.3	4.7	57	66.2	98
475908 (20.0)	90 6 22	61.4	6.1	67.7	76.3	98.3
<hr/>						
EMBAYMENT STATIONS						
477228 (Wacanda Bay 0.95)	90 5 30	41.9	7.3	99.1	99.5	99.7
477229 (Wolfever Cr 4.2)	90 5 25	45.8	6.9	97.6	99.5	99.9
477230 (Wolfever Cr 5.65)	90 5 25	52.6	5.6	88.2	95	99.9
477231 (Savannah Cr 2.95)	90 5 25	50.2	5.6	93.9	97.2	99.5
477232 (Dallas Bay 0.9)	90 5 25	34.3	7	99.1	99.5	99.7
477233 (Soddy Cr 1.7)	90 5 25	42.5	9	97.1	98.8	99.6
477234 (Soddy Cr 4.0)	90 6 22	43.2	8.6	94.6	98.6	99.7
477235 (Possum Cr 2.0)	90 5 25	42.7	7.8	99.1	99.6	100
477236 (Sale Cr 1.3)	90 5 24	47.3	6.2	89.2	94	99.8
477237 (Sale Cr 2.0)	90 5 24	48	11.9	92.1	95	99.5
475909 (Richland Cr 0.5)	90 5 22	32.3	10.1	96.4	98.3	99.9
477238 (Richland Cr 2.8)	90 6 22	52.6	9.4	50.2	63.3	90.8
477239 (Mud Cr 1.3)	90 5 22	49.9	7.1	99.5	99.7	100
477240 (Goodfield Cr 0.9)	90 5 22	72.4	4.2	76.9	90	96.3
477241 (Gunstocker Cr 0.85)	90 5 24	57.1	6.6	95.4	99.2	99.9
477242 (Agency Cr 0.65)	90 5 24	48.4	7.4	99.6	99.9	100
477243 (Candles Cr 1.5)	90 5 23	75.9	3.9	75.6	93.2	99.2
477244 (Rogers Cr 1.5)	90 5 23	52.7	5.5	94.1	98.5	99.8
477246 (N. Mouse Cr 0.5)	90 5 23	55.8	8.2	86.1	91.5	99.5
477247 (S. Mouse Cr 1.1)	90 5 23	73.6	3.6	92.6	97.4	99.8
Maximum	75.9	11.9	99.6	99.9	99.9	100
Minimum	32.3	3.6	50.2	63.3	83.5	86.7
Average	52.4	6.9	85.6	91.8	98.6	99.4

Chickamauga Embayment Study WY 1990 - Sediment
Organochlorine Pesticides and PCB's (ug/kg)

Station	YY MM DD	A L D R I N	Benzene Hexachloride (BHC)				C H L O R D A N E	D I E L D R I N	DDT's			Endosulfan			E N D R I N	
			A L P H A	B E T A	G A M M A	D E L T A			P,P D D T	P,P D D D	P,P D D E	A L P H A	B E T A	S U L F A T E		
TENN RIVER STATIONS																
475358 (472.3)	90 5 30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
475302 (478.19)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
475265 (490.47)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
475266 (496.50)	90 6 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	23	10 K	10 K	10 K	10 K	10 K
475804 (506.6)	90 5 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
475363 (518.0)	90 6 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
HIWASSEE RIVER STATIONS																
475366 (7.4)	90 5 24	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477245 (13.4)	90 6 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
475908 (20.0)	90 6 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
EMBAYMENT STATIONS																
477228 (Waconda Bay 0.95)	90 5 30	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477229 (Wolftever Cr 4.2)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477230 (Wolftever Cr 5.65)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477231 (Savannah Cr 2.95)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477232 (Dallas Bay 0.9)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477233 (Soddy Cr 1.7)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477234 (Soddy Cr 4.0)	90 6 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477235 (Possum Cr 2.0)	90 5 25	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477236 (Sale Cr 1.3)	90 5 24	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477237 (Sale Cr 2.0)	90 5 24	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
475909 (Richland Cr 0.5)	90 5 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	26	10 K	10 K	10 K	10 K	10 K	10 K
477238 (Richland Cr 2.8)	90 6 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477239 (Mud Cr 1.3)	90 5 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477240 (Goodfield Cr 0.9)	90 5 22	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477241 (Gunstocker Cr 0.85)	90 5 24	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477242 (Agency Cr 0.65)	90 5 24	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477243 (Candies Cr 1.5)	90 5 23	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477244 (Rogers Cr 1.5)	90 5 23	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477246 (N. Mouse Cr 0.5)	90 5 23	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K
477247 (S. Mouse Cr 1.1)	90 5 23	10 K	10 K	10 K	10 K	10 K	10 K	10 K	10 K	12	10 K	10 K	10 K	10 K	10 K	10 K

Chickamauga Embayment Study WY 1990 - Sediment
Organochlorine Pesticides and PCB's (ug/kg)

Station	YY MM DD	E N D E	A L C H L O R	H E P O X A I C D H E L O R	T O X A P E N E	Polychlorinated Biphenyls (PCB's)										T O X A L
						1	1	1	1	1	1	1	1	1	1	
						2	2	2	2	2	2	0	0	0	0	
						2	3	4	4	5	6	1	1	1	1	
						1	2	2	8	4	0	6	6	6	6	
TENN RIVER STATIONS																
475358 (472.3)	90 5 30	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475302 (478.19)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475265 (490.47)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475266 (496.50)	90 6 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475804 (506.6)	90 5 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475363 (518.0)	90 6 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
HIWASSEE RIVER STATIONS																
475366 (7.4)	90 5 24	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477245 (13.4)	90 6 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475908 (20.0)	90 6 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
EMBAYMENT STATIONS																
477228 (Waconda Bay 0.95)	90 5 30	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477229 (Wolftever Cr 4.2)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477230 (Wolftever Cr 5.65)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477231 (Savannah Cr 2.95)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477232 (Dallas Bay 0.9)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477233 (Soddy Cr 1.7)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477234 (Soddy Cr 4.0)	90 6 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477235 (Possum Cr 2.0)	90 5 25	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477236 (Sale Cr 1.3)	90 5 24	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477237 (Sale Cr 2.0)	90 5 24	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
475909 (Richland Cr 0.5)	90 5 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477238 (Richland Cr 2.8)	90 6 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477239 (Mud Cr 1.3)	90 5 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477240 (Goodfield Cr 0.9)	90 5 22	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477241 (Gunstocker Cr 0.85)	90 5 24	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477242 (Agency Cr 0.65)	90 5 24	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477243 (Candies Cr 1.5)	90 5 23	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477244 (Rogers Cr 1.5)	90 5 23	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477246 (N. Mouse Cr 0.5)	90 5 23	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	
477247 (S. Mouse Cr 1.1)	90 5 23	10 K	10 K	10 K	500 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	100 K	

APPENDIX C
CHICKAMAUGA EMBAYMENTS BATHYMETRY/MORPHOMETRY

WACONDA BAY

WOLF CREEK EMBAYMENT & SAVANNAH BAY

DALLAS BAY

SODDY CREEK EMBAYMENT

POSSUM CREEK EMBAYMENT

SALE CREEK EMBAYMENT

RICHLAND CREEK EMBAYMENT

MUD CREEK EMBAYMENT

GOODFIELD CREEK EMBAYMENT

GUNSTOCKER CREEK EMBAYMENT

AGENCY CREEK EMBAYMENT

CANDIES CREEK EMBAYMENT

ROGERS CREEK EMBAYMENT

A map of the study area showing the coastline of the Gulf of Mexico. The map includes a scale bar from 0.0 to 2.0 miles and a north arrow. The study site is marked with a dot and labeled '089'.

SOUTH MOUSE CREEK EMBAYMENT

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
WACONDA BAY (UPSTREAM OF HARRISON POINT)	660	0	0	0	0
	661	0	0	1	0
	662	1	0	1	1
	663	2	2	2	3
	664	4	4	2	5
	665	7	10	5	8
	666	12	19	7	14
	667	20	35	12	24
	668	33	62	19	39
	669	43	100	28	63
	670	51	147	36	95
	671	59	202	43	135
	672	65	264	50	182
	673	71	332	57	235
	674	76	405	64	296
	675	81	484	72	365
	676	85	567	81	441
	677	89	654	89	526
	678	93	745	96	619
	679	98	840	104	719
	680	104	941	111	826
	681	111	1049	118	941
	682	121	1165	128	1064
	683	134	1292	144	1200
	684	141	1430		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
WOLFEVER CREEK - SAVANNAH BAY	655	0	0	3	0
	656	14	7	4	4
	657	23	25	6	9
	658	41	57	9	17
	659	60	108	12	27
	660	79	177	17	42
	661	92	263	22	61
	662	110	364	30	87
	663	126	482	36	120
	664	150	620	43	160
	665	171	780	52	207
	666	187	960	63	265
	667	214	1160	76	334
	668	232	1383	91	417
	669	257	1627	105	516
	670	274	1893	118	627
	671	301	2180	132	752
	672	321	2492	148	893
	673	343	2824	164	1049
	674	365	3178	185	1223
	675	386	3553	209	1420
	676	406	3949	237	1643
	677	421	4363	271	1897
	678	437	4792	303	2183
	679	456	5238	332	2501
	680	471	5701	363	2849
	681	479	6177	399	3230
	682	486	6659	441	3650
	683	501	7152	550	4145
	684	515	7661		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
WOLFTEVER CREEK	655	0	0	3	0
+ SAVANNAH BAY	656	14	7	4	4
	657	23	26	6	9
	658	42	58	9	17
	659	61	110	12	27
	660	81	181	17	42
	661	100	271	22	61
	662	121	382	30	87
	663	143	514	36	120
	664	172	671	43	160
	665	200	857	53	208
	666	223	1069	65	267
	667	258	1309	79	338
	668	285	1581	96	426
	669	320	1883	113	531
	670	350	2218	132	654
	671	390	2588	153	796
	672	423	2995	174	959
	673	461	3437	196	1144
	674	501	3918	223	1354
	675	541	4439	255	1593
	676	581	5000	313	1877
	677	621	5601	421	2245
	678	663	6243	494	2702
	679	710	6929	557	3228
	680	754	7661	618	3815
	681	799	8438	684	4466
	682	841	9258	763	5190
	683	898	10127	946	6045
	684	955	11054		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
SAVANNAH BAY	655	0	0	0	0
(UPSTREAM OF	656	0	0	0	0
MOUTH)	657	0	0	0	0
	658	1	1	0	0
	659	1	2	0	0
	660	2	3	0	0
	661	8	8	0	0
	662	11	18	0	0
	663	17	32	0	0
	664	22	51	0	0
	665	29	77	1	1
	666	36	109	2	2
	667	44	149	3	4
	668	53	198	5	9
	669	63	256	8	15
	670	76	325	14	26
	671	89	408	20	43
	672	102	503	26	66
	673	118	613	32	95
	674	136	740	38	131
	675	155	886	46	173
	676	175	1051	77	234
	677	200	1238	151	348
	678	226	1451	191	519
	679	254	1691	225	726
	680	283	1960	255	966
	681	320	2261	286	1237
	682	355	2599	322	1541
	683	397	2975	397	1900
	684	440	3393		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
DALLAS BAY	645	0	0	2	0
	646	3	2	3	3
	647	7	7	5	6
	648	13	17	7	12
	649	18	32	9	20
	650	24	53	11	29
	651	30	80	13	41
	652	39	115	16	55
	653	47	158	18	72
	654	58	210	21	92
	655	66	272	25	115
	656	78	344	32	144
	657	89	428	43	182
	658	101	523	60	233
	659	118	632	74	301
	660	132	757	86	380
	661	150	898	97	472
	662	168	1057	107	574
	663	190	1236	119	687
	664	213	1438	133	813
	665	236	1662	148	953
	666	260	1910	163	1108
	667	283	2182	179	1280
	668	313	2480	199	1469
	669	321	2797	216	1676
	670	376	3145	239	1904
	671	401	3534	259	2153
	672	435	3952	281	2423
	673	467	4403	301	2714
	674	501	4887	322	3025
	675	540	5407	350	3361
	676	573	5964	386	3729
	677	603	6552	428	4137
	678	635	7171	461	4581
	679	663	7820	493	5059
	680	693	8498	526	5568
	681	716	9202	565	6114
	682	738	9929	618	6705
	683	760	10678	827	7427
	684	790	11453		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
SODDY CREEK	645	7	15	10	37
	646	10	23	12	48
	647	14	35	14	61
	648	18	51	16	76
	649	22	71	20	94
	650	27	96	23	115
	651	34	126	28	141
	652	41	164	32	171
	653	51	210	38	206
	654	62	266	46	248
	655	76	335	53	298
	656	90	418	61	355
	657	107	517	68	419
	658	121	631	76	490
	659	139	761	85	571
	660	158	909	95	660
	661	180	1078	104	759
	662	203	1270	113	868
	663	228	1485	122	985
	664	251	1725	131	1112
	665	275	1988	141	1248
	666	300	2275	151	1395
	667	324	2587	163	1552
	668	350	2924	176	1721
	669	373	3286	191	1905
	670	399	3672	211	2106
	671	421	4082	234	2329
	672	447	4516	257	2574
	673	471	4975	279	2841
	674	498	5459	304	3133
	675	522	5969	330	3450
	676	549	6505	357	3793
	677	572	7065	386	4165
	678	599	7651	416	4566
	679	622	8261	446	4996
	680	651	8898	479	5459
	681	677	9562	517	5957
	682	705	10253	568	6499
	683	732	10971	684	7125
	684	762	11718		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	1924		1990	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
POSSUM CREEK	645	0	0	0	0
	646	2	1	0	0
	647	4	4	0	0
	648	6	9	0	0
	649	9	17	0	0
	650	12	27	0	0
	651	16	41	0	0
	652	20	59	0	1
	653	27	83	1	1
	654	32	112	2	3
	655	40	148	4	6
	656	50	193	5	10
	657	62	249	8	17
	658	80	320	10	25
	659	101	411	13	37
	660	123	523	18	53
	661	145	657	25	75
	662	167	813	33	104
	663	188	990	42	141
	664	210	1189	52	189
	665	232	1410	63	246
	666	253	1653	74	314
	667	275	1917	85	394
	668	297	2203	96	484
	669	318	2510	108	585
	670	338	2838	120	699
	671	358	3186	131	824
	672	379	3555	143	961
	673	397	3943	155	1110
	674	413	4348	170	1272
	675	429	4769	186	1450
	676	448	5207	207	1646
	677	463	5663	243	1871
	678	479	6134	270	2128
	679	493	6620	299	2412
	680	507	7120	328	2726
	681	521	7634	364	3072
	682	540	8164	405	3456
	683	563	8716	529	3923
	684	600	9297		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	1924		1990	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
SALE CREEK	645	0	0	0	0
	646	4	2	0	0
	647	9	9	0	0
	648	12	19	0	0
	649	18	34	0	0
	650	20	53	0	0
	651	22	74	1	1
	652	26	98	2	2
	653	29	126	3	4
	654	32	156	4	8
	655	35	190	5	12
	656	37	226	7	18
	657	39	264	8	26
	658	41	304	10	35
	659	51	350	13	47
	660	63	407	17	62
	661	75	476	21	80
	662	98	562	26	104
	663	125	674	34	134
	664	160	816	47	174
	665	192	992	63	229
	666	223	1200	80	300
	667	260	1441	98	389
	668	297	1720	113	494
	669	330	2033	126	614
	670	373	2385	141	748
	671	402	2772	158	897
	672	440	3193	174	1063
	673	479	3653	193	1246
	674	516	4150	216	1451
	675	553	4685	240	1679
	676	587	5255	269	1934
	677	623	5860	325	2231
	678	662	6502	365	2576
	679	700	7183	400	2958
	680	740	7903	435	3376
	681	777	8662	478	3832
	682	817	9459	531	4337
	683	851	10293	661	4932
	684	891	11164		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
RICHLAND CREEK	660	0	0	1	0
	661	1	1	2	1
	662	7	5	2	4
	663	11	14	3	6
	664	19	29	4	10
	665	26	51	5	15
	666	32	80	7	21
	667	40	116	9	29
	668	48	160	11	39
	669	57	213	14	52
	670	66	274	18	67
	671	78	346	22	88
	672	95	433	30	114
	673	112	536	41	149
	674	134	659	52	195
	675	160	806	65	253
	676	193	983	81	326
	677	219	1189	103	419
	678	238	1417	123	532
	679	251	1662	142	664
	680	266	1920	162	816
	681	279	2193	185	990
	682	291	2478	218	1192
	683	310	2778	319	1460
	684	331	3099		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
MUD CREEK	660	0	0	0	0
	661	1	1	0	0
	662	2	2	0	0
	663	3	5	0	0
	664	4	8	0	0
	665	8	14	0	0
	666	11	24	0	0
	667	20	39	0	0
	668	30	64	2	1
	669	42	100	6	5
	670	56	149	10	13
	671	68	211	14	25
	672	80	285	20	43
	673	97	374	30	68
	674	110	477	43	105
	675	128	596	56	154
	676	149	735	80	222
	677	177	898	110	316
	678	205	1089	134	438
	679	237	1310	157	584
	680	266	1561	180	753
	681	303	1846	206	946
	682	341	2168	243	1171
	683	383	2530	397	1491
	684	430	2936		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
GOODFIELD CREEK	665	0	0	0	0
	666	8	4	0	0
	667	15	16	0	0
	668	21	34	0	0
	669	29	59	0	0
	670	37	92	0	0
	671	43	132	1	0
	672	51	179	2	2
	673	59	234	3	4
	674	67	297	5	8
	675	75	368	10	15
	676	82	446	25	32
	677	90	532	52	71
	678	99	627	70	132
	679	108	730	83	209
	680	117	843	96	298
	681	123	963	109	401
	682	131	1090	123	517
	683	139	1225	144	650
	684	150	1369		
GUNSTOCKER CREEK	665	0	0	0	0
	666	7	4	0	0
	667	13	14	0	0
	668	21	31	1	1
	669	31	57	5	3
	670	41	93	22	17
	671	51	139	35	45
	672	62	195	48	87
	673	75	264	57	140
	674	89	346	70	204
	675	103	442	87	282
	676	120	553	109	380
	677	140	683	139	504
	678	161	834	161	654
	679	187	1008	184	826
	680	218	1210	207	1021
	681	251	1445	231	1240
	682	294	1717	261	1486
	683	345	2037	355	1794
	684	387	2403		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
AGENCY CREEK	660	0	0	0	0
	661	2	1	0	0
	662	3	4	0	0
	663	5	8	0	0
	664	8	14	0	0
	665	11	24	0	0
	666	15	37	0	0
	667	20	54	1	1
	668	26	77	6	5
	669	32	106	10	13
	670	41	143	15	25
	671	49	188	20	42
	672	58	241	26	65
	673	68	304	34	95
	674	79	378	48	137
	675	91	463	65	193
	676	104	560	85	268
	677	118	671	111	366
	678	134	797	132	488
	679	153	941	151	629
	680	177	1106	170	789
	681	204	1296	191	970
	682	247	1522	216	1173
	683	296	1793	300	1431
	684	319	2101		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
CANDIES CREEK	660	0	0	0	0
	661	1	1	0	0
	662	2	2	0	0
	663	3	5	0	0
	664	4	8	0	0
	665	5	13	0	0
	666	6	18	0	0
	667	12	27	0	0
	668	19	43	0	0
	669	27	66	0	0
	670	42	100	0	0
	671	52	147	1	1
	672	70	208	4	3
	673	93	290	10	10
	674	122	397	25	28
	675	169	543	54	67
	676	242	748	108	148
	677	335	1037	207	305
	678	423	1416	255	536
	679	485	1870	293	810
	680	546	2385	330	1121
	681	590	2953	371	1472
	682	630	3563	424	1869
	683	671	4214	562	2362
	684	720	4909		

CHICKAMAUGA RESERVOIR EMBAYMENTS
IMPOUNDMENT AREAS AND VOLUMES (1924 vs 1990)

EMBAYMENT	ELEVATION (FEET-MSL)	-----1924-----		-----1990-----	
		SURF. AREA (ACRES)	VOLUME (AC-FT)	SURF. AREA (ACRES)	VOLUME (AC-FT)
ROGERS CREEK	665	0	0	0	0
	666	1	1	0	0
	667	2	2	0	0
	668	4	5	0	0
	669	8	11	0	0
	670	18	24	0	0
	671	47	57	0	0
	672	75	118	0	0
	673	104	207	2	1
	674	131	325	34	19
	675	160	470	73	73
	676	185	643	110	164
	677	211	841	168	303
	678	238	1065	204	489
	679	262	1315	236	709
	680	288	1590	264	959
	681	325	1897	294	1238
	682	378	2248	329	1550
	683	479	2677	449	1939
	684	532	3182		
NORTH MOUSE CREEK	670	0	0	0	0
	671	1	1	0	0
	672	3	3	0	0
	673	6	7	0	0
	674	10	15	1	1
	675	15	28	5	3
	676	23	47	15	13
	677	33	75	28	35
	678	46	114	37	68
	679	62	168	45	109
	680	83	241	53	158
	681	105	335	61	216
	682	140	457	70	281
	683	170	612	164	398
	684	201	798		
SOUTH MOUSE CREEK	675	0	0	4	0
	676	4	2	10	7
	677	11	10	25	24
	678	22	26	35	54
	679	35	55	43	93
	680	52	98	51	140
	681	79	164	59	195
	682	108	257	68	258
	683	136	379	119	351
	684	166	530		

APPENDIX D
LAND USE ALLOCATIONS AND ATTENUATION FACTORS

LAND USE ALLOCATIONS AND ATTENUATION FACTORS

WACONDA BAY WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.8	
Land Use Allocations				
Cropland (ha)			0	0
Pasture (ha)		5 ^a	167	191
		19		
Forest (ha)		28	261	289
Urban (ha)		25	235	260
SepTank(#user-yr)	221			221
Comments				
^a TVA Tract 24 (10.4 ac)				
WOLFTEVER CREEK (+Savannah Bay) WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.9	
Land Use Allocations				
Cropland (ha)		38	1996	2034
Pasture (ha)		135	7074	7209
Forest (ha)		121 ^a	12740	13228
		119 ^b		
		248		
Urban (ha)		43	2266	2309
SepTank(#user-yr)	842			842
Pt Source (mgd)	0.064 ^c			0.064
Comments				
^a Harrison Bay State Park (300+/- ac)				
^b TVA Tracts 26 (230 ac) & 27 (63 ac)				
^c Grindstone Estates Mobile Home Park (0.0638 mgd)				

WOLFTEVER CREEK (-Savannah Bay) WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.9	
Land Use Allocations				
Cropland (ha)		8	679	687
Pasture (ha)		27	2407	2434
Forest (ha)		121 ^a	8793	9135
		119 ^b		
		102		
Urban (ha)		22	1967	1989
SepTank(#user-yr)	387			387
Pt Source (mgd)	0.064 ^c			0.064
Comments				
^a Harrison Bay State Park (300+/- ac)				
^b TVA Tracts 26 (230 ac) & 27 (63 ac)				
^c Grindstone Estates Mobile Home Park (0.0638 mgd)				
SAVANNAH BAY WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.89	
Land Use Allocations				
Cropland (ha)		39	1308	1347
Pasture (ha)		238	4537	4775
Forest (ha)		19	4074	4093
Urban (ha)		9	311	320
SepTank(#user-yr)	455			455

DALLAS BAY WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.84	
Land Use Allocations				
Cropland (ha)		10	120	130
Pasture (ha)		37	422	459
Forest (ha)		91 ^a	1118	1337
		108		
		20 ^b		
Urban (ha)		41	462	503
SepTank(#user-yr)	242			242
Comments				
^a Chester Frost Co Park (225 ac)				
^b TVA Tract 32 (50.3 ac)				
SODDY CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.9	
Land Use Allocations				
Cropland (ha)		27 ^a	402	435
		6		
Pasture (ha)		21	1520	1541
Forest (ha)		57 ^a	13518	13826
		66 ^b		
		185		
Urban (ha)		80 ^c	819	911
		12		
SepTank(#user-yr)	226			226
Comments				
^a Tenn-WL Mgmt Area (67 ac-crops & 142 ac-woods)				
^b TVA Tracts 42 (96 ac) & 44 (66.3 ac)				
^c Soddy-Daisy (200 ac+/-)				

POSSUM CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.89	
Land Use Allocations				
Cropland (ha)		9	240	249
Pasture (ha)		32	850	882
Forest (ha)		54 ^a	6575	6875
		246		
Urban (ha)		22	602	624
SepTank(#user-yr)	216			216
Comments				
^a TVA Tracts 47 (56.5 ac) & 48 (76 ac)				
SALE CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.91	
Land Use Allocations				
Cropland (ha)		36 ^a	1437	1476
		3		
Pasture (ha)		12	5221	5233
Forest (ha)		109 ^a	21015	21219
		46 ^b		
		49		
Urban (ha)		4	1620	1624
SepTank(#user-yr)	126			126
Pt Source (mgd)	0.016 ^c			0.016
Comments				
^a Tenn-WL Mgmt Area (90 ac-crops & 269 ac-woods)				
^b TVA Tracts 59 (58.9 ac) & 61 (55.5 ac)				
^c Laurelbrook Sanitarium & School (0.016 mgd)				

RICHLAND CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.89	
Land Use Allocations				
Cropland (ha)		15 ^a	2517	2567
		35		
Pasture (ha)		53	3806	3859
Forest (ha)		177	12796	12973
Urban (ha)		180 ^b	1562	1766
		24		
SepTank(#user-yr)	187			187
Pt Source (mgd)	0.024 ^c			0.024
Comments				
^a TVA Tract 111 (36.6 ac)				
^b Dayton (450 ac +/-)				
^c Rhea Co. High School (0.045 mgd)				
MUD CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.84	
Land Use Allocations				
Cropland (ha)		65	445	510
Pasture (ha)		27 ^a	642	766
		97		
Forest (ha)		58	398	456
Urban (ha)		30	205	235
SepTank(#user-yr)	74			74
Comments				
^a TVA Tract 118 (67.2 ac)				

GUNSTOCKER CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.87	
Land Use Allocations				
Cropland (ha)		61 ^a	987	1062
		14		
Pasture (ha)		24	1785	1809
Forest (ha)		59 ^a	2080	2168
		29		
Urban (ha)		1	88	89
SepTank(#user-yr)	87			87
Comments				
^a Tenn-WL Waterfowl Refuge (150 ac-crops and 146 ac-woods)				
AGENCY CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.87	
Land Use Allocations				
Cropland (ha)		8 ^a	660	689
		21		
Pasture (ha)		36	1138	1174
Forest (ha)		42 ^a	2784	2928
		12 ^b		
		90		
Urban (ha)		9	286	295
SepTank(#user-yr)	134			134
Comments				
^a Tenn-WL Mgmt Area (20 ac-crops and 104 ac-woods)				
^b TVA Tract 77 (29.8 ac)				

GOODFIELD CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.85	
Land Use Allocations				
Cropland (ha)		11 ^a	826	849
		12		
Pasture (ha)		21	1425	1446
Forest (ha)		10 ^a	3701	3766
		55		
Urban (ha)		5	307	312
SepTank(#user-yr)	21			21
Comments				
^a Tenn-WL Mgmt Area (52 ac-crop/bottomland forest)				
CANDIES CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.92	
Land Use Allocations				
Cropland (ha)		81 ^a	412	503
		10		
Pasture (ha)		110	11974	12084
Forest (ha)		80 ^a	15141	15361
		140		
Urban (ha)			587	587
SepTank(#user-yr)	124			124
Pt Source (mgd)	0.038 ^b			0.057
	0.01 ^c			
	0.005 ^d			
	0.004 ^e			
Comments				
^a Tenn-WL Mgmt Area (200 ac-crops & 198 ac-woods)				
^b Holiday Inn I-75, Cleveland (0.05mgd)				
^c Bachman Mem. Children's Home (0.01 mgd)				
^d Blue Spring Elem. School (0.01 mgd)				
^e Hopewell Elem. School (0.0075 mgd)				

ROGERS CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.9	
Land Use Allocations				
Cropland (ha)		56 ^a	524	586
		6		
Pasture (ha)		32	3048	3080
Forest (ha)		59 ^a	10258	10424
		107		
Urban (ha)		1	71	72
SepTank(#user-yr)	50			50
Comments				
^a Tenn-WL Mgmt Area(138 ac-crop and 146 ac-woods)				
NORTH MOUSE CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.92	
Land Use Allocations				
Cropland (ha)		3	449	452
Pasture (ha)		41 ^a	10727	10837
		69		
Forest (ha)		74 ^a	10942	11087
		71		
Urban (ha)		12	1799	1811
SepTank(#user-yr)	0			0
Pt Source (mgd)	0.009 ^b			0.387
	0.011 ^c			
	0.35 ^d			
	0.017 ^e			
Comments				
^a TVA Tract 90 (101 ac-pasture and 183 ac-bottomwoods)				
^b E.K.Baker Elem. School (0.017mgd)				
^c Riceville Elem. School (0.02 mgd)				
^d Niota STP (0.35 mgd, tertiary trmt				
^e Holiday Inn I-75, Mt. Verd Rd (0.023 mgd)				

SOUTH MOUSE CREEK WATERSHED				
	Zone 1	Zone 2	Zone 3	Totals
Attenuation Factor	0.0	0.25	0.9	
Land Use Allocations				
Cropland (ha)		5	386	391
Pasture (ha)		27	2025	2052
Forest (ha)		30 ^a	3849	3930
		51		
Urban (ha)		48	3649	3697
SepTank(#user-yr)	0			0
Pt Source (mgd)	0.02 ^b			0.02
Comments				
^a Tenn-WL Mgmt Area (75 ac-woods)				
^b Postlight Mobile Home Manor (0.02 mgd)				

- Notes:
1. All point source and septic tank wastewater discharges are assumed to be directly into the waterway/embayment, Zone 1 with an attenuation factor of 0.0.
 2. All land immediately adjacent to embayments (~150 meters) are included in Zone 2 with an attenuation factor of 0.25.
 3. All remaining land is included in Zone 3 with an attenuation factor (AF) computed using:

$$\ln(\text{SDR}) = 1.01 - 0.34 \ln(D)$$
where SDR is Sediment Delivery Ratio, D is one-half the distance in meters of the main stem stream of the watershed, and AF (Attenuation Factor) = $1 - \text{SDR}$.
 4. Point source wastewater discharges for schools were adjusted based on seasonal/weekly use as follows: $(9 \text{ months}/12 \text{ months}) * (5 \text{ days}/7 \text{ days}) = 54\%$ of WWTP design capacity. Likewise, for motels, an occupancy rate of 75% was applied to the WWTP design capacity.

APPENDIX E
PESTICIDE USAGE AND APPLICATION RATES

CHICKAMAUGA EMBAYMENTS - ESTIMATED PESTICIDE APPLICATION RATES - 1982-84
(pounds of Active Ingredient/year in watershed - lbs AI/year)

Pesticide Name	Waconda Bay	Wolftever Bay (+Savannah Bay)	Savannah Bay	Wolftever Bay (-Savannah Bay)	Dallas Bay	Soddy Creek	Possum Creek	Sale Creek	Richland Creek
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
2,4-D	2	48	28	20	8	58	37	182	127
Acifluorfen	0	6	4	2	1	10	5	31	29
Alachlor	8	185	112	73	31	291	167	999	931
Atrazine	11	282	149	133	41	402	257	1627	1493
Bensulide	0	0	0	0	0	0	0	0	0
Captafol	0	0	0	0	0	1	3	39	48
Carbaryl	1	21	11	10	3	51	111	1163	1385
Carbofuran	4	106	58	48	16	117	80	439	379
Chlorothalonil	0	0	0	0	0	2	8	93	113
Cyanazine	0	8	4	4	1	12	8	49	45
Diazinon	1	13	7	6	2	16	10	61	54
Dinoseb	0	10	6	4	2	16	9	51	47
Disulfoton	0	0	0	0	0	0	0	1	1
Ethoprop	0	1	0	0	0	0	0	3	4
Fluometuron	0	0	0	0	0	0	0	0	0
Malathion	0	0	0	0	0	1	3	36	44
Methamidophos	0	0	0	0	0	2	5	54	66
Methyl Parathion	0	8	5	3	1	12	7	38	33
Metiram	0	0	0	0	0	0	0	0	0
Metolachlor	2	44	26	19	7	67	40	243	225
Parathion	0	3	2	1	0	2	2	6	4
PCNB	0	0	0	0	0	0	0	0	0
Phorate	0	0	0	0	0	0	0	1	1
Propanil	0	0	0	0	0	0	0	0	0
Thiobencarb	0	0	0	0	0	0	0	0	0
Trifluralin	3	65	41	23	11	106	59	346	328
Vernolate	0	0	0	0	0	0	0	0	0
Total Pesticides	32	801	455	346	125	1165	813	5462	5359

(Gianessi, 1987)

CHICKAMAUGA EMBAYMENTS - ESTIMATED PESTICIDE APPLICATION RATES - 1982-84
(pounds of Active Ingredient/year in watershed - lbs AI/year)

Pesticide Name -----	Mud Creek -----	Goodfield Creek -----	Gunstocker Creek -----	Agency Creek -----	Candies Creek -----	Rogers Creek -----	N. Mouse Creek -----	S. Mouse Creek -----	Total Pesticides -----
2,4-D	13	31	22	23	170	152	108	167	1004
Acifluorfen	4	5	3	4	9	13	9	9	53
Alachlor	116	156	95	117	497	604	426	486	2917
Atrazine	180	212	145	160	1455	1557	1098	1441	8645
Bensulide	0	0	0	0	0	0	0	0	0
Captafol	6	0	0	0	0	1	0	0	0
Carbaryl	184	20	12	15	97	118	83	96	577
Carbofuran	46	124	70	93	472	661	466	466	2797
Chlorothalonil	15	0	0	0	0	1	1	0	0
Cyanazine	5	6	4	5	44	45	32	43	260
Diazinon	7	13	8	10	62	76	54	61	365
Dinoseb	6	9	5	6	15	21	15	14	85
Disulfoton	0	3	1	2	2	9	7	2	10
Ethoprop	1	13	5	10	7	38	27	7	41
Fluometuron	0	0	0	0	0	0	0	0	0
Malathion	6	2	1	2	2	7	5	2	12
Methamidophos	9	0	0	0	2	7	5	2	14
Methyl Parathion	4	6	4	4	13	17	12	12	73
Metiram	0	0	0	0	0	0	0	0	0
Metolachlor	28	35	23	27	160	202	143	157	944
Parathion	0	2	1	1	10	14	10	10	59
PCNB	0	0	0	0	0	0	0	0	0
Phorate	0	0	0	0	0	2	1	0	0
Propanil	0	0	0	0	0	0	0	0	0
Thiobencarb	0	0	0	0	0	0	0	0	0
Trifluralin	42	57	33	43	98	137	97	94	564
Vernolate	0	0	0	0	0	0	0	0	0
Total Pesticides	671	695	430	523	3114	3682	2598	3070	

(Gianessi, 1987)

APPENDIX F
ALGAL DATA

ALGAL DATA
CHICKAMAUGA EMBAYMENT STUDY (APRIL-SEPTEMBER 1990)

+-----ALGAL ENUMERATION (CELLS/LITER)-----+							+-----PERCENT DISTRIBUTION-----+					
DATE	CHLOROPHYTA (GREENS)	CHRYSTOPHYTA (DIATOMS)	CYANOPHYTA (BLUE-GREENS)	CRYPTOPHYTA	EUGLENOPHYTA	PYRRHOPHYTA	TOTALS	% CHLORO	% CHRYSO	% CYANO	% CRYPTO	% OTHER
TENNESSEE RIVER MILE 472.3												
900404	183438	1661133	2109537	366876	30573	0	4351557	4.2	38.2	48.5	8.4	0.7
900419	886617	2415267	1100628	886617	163056	81528	5533713	16.0	43.6	19.9	16.0	4.4
900509	2517177	1722279	2078964	723561	81528	20382	7143891	35.2	24.1	29.1	10.1	1.4
900529	1396167	1803807	5462376	305730	10191	20382	8998653	15.5	20.0	60.7	3.4	0.3
900612	1508268	1630560	4402512	40764	0	10191	7592295	19.9	21.5	58.0	0.5	0.1
900627	2996154	1701897	8183373	173247	71337	0	13126008	22.8	13.0	62.3	1.3	0.5
900710	3882771	1824189	11189718	591078	163056	20382	17671194	22.0	10.3	63.3	3.3	1.0
900730	2822907	1029291	6858543	397449	30573	0	11138763	25.3	9.2	61.6	3.6	0.3
900813	3882771	1487886	23266053	1681515	40764	0	30358989	12.8	4.9	76.6	5.5	0.1
900828	3638187	1508268	20769258	2272593	163056	81528	28432890	12.8	5.3	73.0	8.0	0.9
TENNESSEE RIVER MILE 478.2												
900404	591078	2517177	1059864	346494	30573	0	4545186	13.0	55.4	23.3	7.6	0.7
900419	1019100	1854762	1355403	356685	122292	0	4708242	21.6	39.4	28.8	7.6	2.6
900509	1650942	1416549	1803807	407640	40764	0	5319702	31.0	26.6	33.9	7.7	0.8
900529	1579605	2231829	2639469	468786	0	10191	6929880	22.8	32.2	38.1	6.8	0.1
900612	2221638	2292975	8040699	81528	50955	0	12687795	17.5	18.1	63.4	0.6	0.4
900627	3882771	1793616	11403729	356685	40764	0	17477565	22.2	10.3	65.2	2.0	0.2
900710	4626714	2354121	5075118	540123	91719	40764	12728559	36.3	18.5	39.9	4.2	1.0
900730	3862389	1559223	16876296	1202538	142674	30573	23673693	16.3	6.6	71.3	5.1	0.7
900813	3485322	2058582	18231699	1375785	81528	10191	25243107	13.8	8.2	72.2	5.5	0.4
900828	4871298	1650942	15694140	1926099	81528	30573	24254580	20.1	6.8	64.7	7.9	0.5
TENNESSEE RIVER MILE 490.5												
900405	774516	1538841	1253493	224202	20382	0	3811434	20.3	40.4	32.9	5.9	0.5
900419	1212729	2272593	1701897	499359	132483	10191	5829252	20.8	39.0	29.2	8.6	2.4
900509	1080246	1569414	1915908	214011	40764	0	4820343	22.4	32.6	39.7	4.4	0.8
900530	2252211	2863671	3587232	631842	30573	214011	9579540	23.5	29.9	37.4	6.6	2.6
900612	3413985	1875144	10812651	387258	112101	20382	16621521	20.5	11.3	65.1	2.3	0.8
900627	3638187	1926099	15714522	1039482	30573	0	22348863	16.3	8.6	70.3	4.7	0.1
900710	3098064	1182156	9477630	336303	10191	10191	14114535	21.9	8.4	67.1	2.4	0.1
900730	3892962	968145	10262337	621651	30573	30573	15806241	24.6	6.1	64.9	3.9	0.4
900813	2038200	387258	6838161	397449	50955	10191	9722214	21.0	4.0	70.3	4.1	0.6
900828	3118446	1019100	13717086	703179	50955	20382	18629148	16.7	5.5	73.6	3.8	0.4

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DATE	CHLOROPHYTA (GREENS)	CHRYSOPHYTA (DIATOMS)	CYANOPHYTA (BLUE-GREENS)	CRYPTOPHYTA	EUGLENOPHYTA	PYRRHOPHYTA	TOTALS	% CHLORO	% CHRYSO	% CYANO	% CRYPTO	% OTHER

TENNESSEE RIVER MILE 496.5												
900405	560505	1864953	591078	244584	30573	0	3291693	17.0	56.7	18.0	7.4	0.9
900419	825471	2496795	1763043	458595	234393	30573	5808870	14.2	43.0	30.4	7.9	4.6
900509	764325	764325	2680233	489168	20382	0	4718433	16.2	16.2	56.8	10.4	0.4
900530	387258	438213	764325	183438	10191	0	1783425	21.7	24.6	42.9	10.3	0.6
900612	2639469	2017818	9477630	315921	81528	30573	14562939	18.1	13.9	65.1	2.2	0.8
900627	3617805	3067491	12657222	1161774	30573	20382	20555247	17.6	14.9	61.6	5.7	0.2
900710	3342648	2201256	5319702	682797	122292	81528	11750223	28.4	18.7	45.3	5.8	1.7
900730	1599987	346494	5737533	122292	10191	10191	7826688	20.4	4.4	73.3	1.6	0.3
900813	1783425	448404	6450903	163056	10191	10191	8866170	20.1	5.1	72.8	1.8	0.2
900828	1579605	540123	9936225	163056	30573	10191	12259773	12.9	4.4	81.0	1.3	0.3
900911	1141392	570696	4484040	142674	0	0	6338802	18.0	9.0	70.7	2.3	0.0
TENNESSEE RIVER MILE 506.6												
900423	631842	2568132	1416549	183438	81528	30573	4912062	12.9	52.3	28.8	3.7	2.3
900509	397449	285348	173247	214011	0	0	1070055	37.1	26.7	16.2	20.0	0.0
900530	407640	214011	550314	234393	0	0	1406358	29.0	15.2	39.1	16.7	0.0
900613	1019100	896808	6134982	142674	0	0	8193564	12.4	10.9	74.9	1.7	0.0
900627	764325	346494	1335021	0	0	10191	2456031	31.1	14.1	54.4	0.0	0.4
900710	1222920	438213	1426740	50955	0	10191	3149019	38.8	13.9	45.3	1.6	0.3
900730	642033	275157	4728624	20382	0	10191	5676387	11.3	4.8	83.3	0.4	0.2
900813	642033	509550	2323548	71337	0	0	3546468	18.1	14.4	65.5	2.0	0.0
900828	815280	295539	4840725	40764	0	0	5992308	13.6	4.9	80.8	0.7	0.0
900911	489168	193629	1559223	10191	0	0	2252211	21.7	8.6	69.2	0.5	0.0
TENNESSEE RIVER MILE 518.0												
900423	840840	1299480	2976064	830648	71344	20384	6038760	13.9	21.5	49.3	13.8	1.5
900509	275157	458595	101910	163056	10191	0	1008909	27.3	45.5	10.1	16.2	1.0
900530	886617	1365594	3087873	275157	30573	30573	5676387	15.6	24.1	54.4	4.8	1.1
900613	2068773	1141392	11689077	254775	20382	10191	15184590	13.6	7.5	77.0	1.7	0.2
900627	866235	478977	968145	71337	0	0	2384694	36.3	20.1	40.6	3.0	0.0
900710	1090437	540123	3770670	50955	0	0	5452185	20.0	9.9	69.2	0.9	0.0
900730	1212729	743943	5666196	50955	0	10191	7684014	15.8	9.7	73.7	0.7	0.1
900813	1661133	1019100	7001217	40764	10191	10191	9742596	17.1	10.5	71.9	0.4	0.2
900828	1304448	458595	10771887	30573	10191	0	12575694	10.4	3.6	85.7	0.2	0.1
900911	570696	305730	4820343	10191	10191	0	5717151	10.0	5.3	84.3	0.2	0.2

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DATE	CHLOROPHYTA (GREENS)	CHRYSTOPHYTA (DIATOMS)	CYANOPHYTA (BLUE-GREENS)	CRYPTOPHYTA	EUGLENOPHYTA	PYRRHOPHYTA	TOTALS	% CHLORO	% CHRYSO	% CYANO	% CRYPTO	% OTHER
TENNESSEE RIVER MILE 529.9												
900423	275184	800072	983528	178360	5096	10192	2252432	12.2	35.5	43.7	7.9	0.7
900509	305730	377067	815280	264966	20382	10191	1793616	17.0	21.0	45.5	14.8	1.7
900530	1630560	2588514	6909498	356685	61146	10191	11556594	14.1	22.4	59.8	3.1	0.6
900613	2364312	1803807	5136264	509550	91719	10191	9915843	23.8	18.2	51.8	5.1	1.0
900627	203820	489168	621651	40764	0	10191	1365594	14.9	35.8	45.5	3.0	0.7
900710	1222920	723561	1763043	71337	0	30573	3811434	32.1	19.0	46.3	1.9	0.8
900730	2150301	957954	9080181	81528	61146	20382	12351492	17.4	7.8	73.5	0.7	0.7
900813	2180874	1406358	10822842	163056	61146	40764	14675040	14.9	9.6	73.8	1.1	0.7
900828	2486604	1080246	23092806	203820	101910	10191	26975577	9.2	4.0	85.6	0.8	0.4
HIWASSEE RIVER MILE 7.4												
900403	540123	499359	540123	264966	0	0	1844571	29.3	27.1	29.3	14.4	0.0
900429	963144	1375920	1391208	820456	163072	50960	4764760	20.2	28.9	29.2	17.2	4.5
900509	988527	1212729	2017818	428022	61146	20382	4728624	20.9	25.6	42.7	9.1	1.7
900531	3964299	2792334	4687860	183438	30573	30573	11689077	33.9	23.9	40.1	1.6	0.5
900613	4759197	2425458	17569284	917190	91719	0	25762848	18.5	9.4	68.2	3.6	0.4
900628	3740097	1630560	11923470	224202	10191	0	17528520	21.3	9.3	68.0	1.3	0.1
900709	2761761	1192347	7184655	428022	71337	10191	11648313	23.7	10.2	61.7	3.7	0.7
900731	2670042	1610178	15225354	397449	30573	10191	19943787	13.4	8.1	76.3	2.0	0.2
900814	1273875	366876	5645814	122292	20382	0	7429239	17.1	4.9	76.0	1.6	0.3
900827	2578323	1161774	10496730	540123	40764	10191	14827905	17.4	7.8	70.8	3.6	0.3
900911	1141392	611460	3454749	244584	20382	10191	5482758	20.8	11.2	63.0	4.5	0.6
HIWASSEE RIVER MILE 13.4												
900403	417831	478977	529932	142674	10191	0	1579605	26.5	30.3	33.5	9.0	0.6
900423	346494	305730	570696	723561	40764	0	1987245	17.4	15.4	28.7	36.4	2.1
900509	611460	468786	886617	591078	50955	0	2608896	23.4	18.0	34.0	22.7	2.0
900531	377067	163056	448404	50955	30573	0	1070055	35.2	15.2	41.9	4.8	2.9
900613	998718	1222920	2252211	285348	10191	0	4769388	20.9	25.6	47.2	6.0	0.2
900628	1070055	560505	112101	112101	50955	0	1905717	56.1	29.4	5.9	5.9	2.7
900709	1885335	519741	621651	112101	30573	0	3169401	59.5	16.4	19.6	3.5	1.0
900731	428022	489168	499359	71337	0	10191	1498077	28.6	32.7	33.3	4.8	0.7
900814	489168	173247	529932	10191	10191	0	1212729	40.3	14.3	43.7	0.8	0.8
900827	1161774	550314	937572	193629	0	0	2843289	40.9	19.4	33.0	6.8	0.0
900911	529932	428022	743943	183438	30573	0	1915908	27.7	22.3	38.8	9.6	1.6

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HIWASSEE RIVER MILE 20.0												
900423	351624	107016	616616	453544	25480	5096	1559376	22.5	6.9	39.5	29.1	2.0
900509	642033	264966	101910	224202	20382	0	1253493	51.2	21.1	8.1	17.9	1.6
900531	20382	20382	0	0	0	0	40764	50.0	50.0	0.0	0.0	0.0
900613	356685	438213	2028009	173247	10191	0	3006345	11.9	14.6	67.5	5.8	0.3
900628	101910	183438	509550	10191	0	0	805089	12.7	22.8	63.3	1.3	0.0
900709	672606	142674	0	30573	0	0	845853	79.5	16.9	0.0	3.6	0.0
900731	754134	570696	550314	101910	0	0	1977054	38.1	28.9	27.8	5.2	0.0
900814	1110819	906999	978336	224202	10191	20382	3250929	34.2	27.9	30.1	6.9	0.9
900827	1987245	387258	3740097	40764	20382	0	6175746	32.2	6.3	60.6	0.7	0.3
900911	397449	387258	560505	91719	0	0	1436931	27.7	27.0	39.0	6.4	0.0
WACONDA BAY MILE 0.95												
900404	774516	4422894	1936290	356685	50955	0	7541340	10.3	58.6	25.7	4.7	0.7
900419	1172080	2155608	7644000	1253616	173264	30576	12429144	9.4	17.3	61.5	10.1	1.6
900509	876426	2333739	1834380	407640	377067	30573	5859825	15.0	39.8	31.3	7.0	7.0
900529	2058582	4300602	6940071	163056	50955	10191	13523457	15.2	31.8	51.3	1.2	0.5
900612	2700615	2527368	11006280	81528	30573	30573	16376937	16.5	15.4	67.2	0.5	0.4
900627	5156646	1763043	25671129	203820	173247	40764	33008649	15.6	5.3	77.8	0.6	0.6
900710	3393603	2058582	12259773	193629	71337	0	17976924	18.9	11.5	68.2	1.1	0.4
900730	3872580	1987245	17385846	519741	91719	30573	23887704	16.2	8.3	72.8	2.2	0.5
900813	4127355	1436931	35107995	703179	295539	40764	41711763	9.9	3.4	84.2	1.7	0.8
900828	5757915	1691706	37513071	183438	142674	183438	45472242	12.7	3.7	82.5	0.4	0.7
WOLFTEVER CREEK MILE 4.2												
900404	805089	1100628	2150301	346494	40764	0	4443276	18.1	24.8	48.4	7.8	0.9
900419	1019100	2965581	3648378	428022	101910	20382	8183373	12.5	36.2	44.6	5.2	1.5
900509	4473849	4178310	12738750	295539	112101	101910	21900459	20.4	19.1	58.2	1.3	1.0
900529	2741379	1854762	8499294	244584	50955	81528	13472502	20.3	13.8	63.1	1.8	1.0
900612	3862389	1355403	13829187	101910	50955	132483	19332327	20.0	7.0	71.5	0.5	0.9
900627	4657287	2303166	14185872	142674	112101	81528	21482628	21.7	10.7	66.0	0.7	0.9
900710	6124791	3801243	15734904	315921	366876	91719	26435454	23.2	14.4	59.5	1.2	1.7
900730	3597423	2812716	34415007	387258	142674	50955	41406033	8.7	6.8	83.1	0.9	0.5
900813	5819061	1640751	54216120	40764	244584	81528	62042808	9.4	2.6	87.4	0.1	0.5
900828	4718433	2670042	67046589	203820	112101	61146	74812131	6.3	3.6	89.6	0.3	0.2

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WOLFTEVER CREEK MILE 5.65												
900404	794898	866235	1202538	315921	91719	10191	3281502	24.2	26.4	36.6	9.6	3.1
900419	1304448	1620369	2405076	346494	132483	20382	5829252	22.4	27.8	41.3	5.9	2.6
900509	2670042	1722279	5992308	448404	71337	10191	10914561	24.5	15.8	54.9	4.1	0.7
900529	4117164	3026727	46195803	152865	122292	61146	53675997	7.7	5.6	86.1	0.3	0.3
900612	6185937	2364312	27648183	30573	122292	40764	36392061	17.0	6.5	76.0	0.1	0.4
900627	2415267	1650942	15001152	183438	122292	10191	19383282	12.5	8.5	77.4	0.9	0.7
900710	5166837	3689142	20911932	264966	122292	71337	30226506	17.1	12.2	69.2	0.9	0.6
900730	4912062	2792334	49721889	407640	91719	30573	57956217	8.5	4.8	85.8	0.7	0.2
900813	8754069	3199974	53380458	825471	264966	101910	66526848	13.2	4.8	80.2	1.2	0.6
900828	6532431	3189783	90200541	631842	112101	0	100666698	6.5	3.2	89.6	0.6	0.1
SAVANNAH BAY MILE 2.95												
900404	1824189	2170683	1834380	1671324	81528	20382	7602486	24.0	28.6	24.1	22.0	1.3
900419	2211447	2405076	22624020	224202	601269	0	28066014	7.9	8.6	80.6	0.8	2.1
900509	8203755	6858543	19739967	315921	0	50955	35169141	23.3	19.5	56.1	0.9	0.1
900529	5197410	8540058	34629018	417831	163056	61146	49008519	10.6	17.4	70.7	0.9	0.5
900612	3607614	3281502	17080116	112101	71337	30573	24183243	14.9	13.6	70.6	0.5	0.4
900627	4229265	6226701	23683884	346494	91719	101910	34679973	12.2	18.0	68.3	1.0	0.6
900710	3719715	8122227	9498012	275157	91719	61146	21767976	17.1	37.3	43.6	1.3	0.7
900730	6950262	6705678	50934618	366876	142674	50955	65151063	10.7	10.3	78.2	0.6	0.3
900813	3719715	6471285	39490125	407640	142674	71337	50302776	7.4	12.9	78.5	0.8	0.4
900828	7724778	7143891	96162276	387258	101910	50955	111571068	6.9	6.4	86.2	0.3	0.1
DALLAS BAY MILE 0.9												
900404	1182156	3444558	6247083	183438	71337	10191	11138763	10.6	30.9	56.1	1.6	0.7
900419	1681515	2191065	9528585	876426	142674	40764	14461029	11.6	15.2	65.9	6.1	1.3
900509	2068773	1997436	825471	968145	152865	0	6012690	34.4	33.2	13.7	16.1	2.5
900529	1620369	2252211	6124791	112101	20382	0	10129854	16.0	22.2	60.5	1.1	0.2
900612	2242020	2619087	26802330	152865	40764	50955	31908021	7.0	8.2	84.0	0.5	0.3
900627	4005063	2700615	13615176	224202	10191	10191	20565438	19.5	13.1	66.2	1.1	0.1
900710	3434367	2751570	5411421	356685	91719	40764	12086526	28.4	22.8	44.8	3.0	1.1
900730	4157928	6522240	22562874	529932	112101	20382	33905457	12.3	19.2	66.5	1.6	0.4
900813	5238174	4147737	41110494	478977	40764	30573	51046719	10.3	8.1	80.5	0.9	0.1
900828	3342648	1243302	23887704	0	40764	397449	28911867	11.6	4.3	82.6	0.0	1.5

ALGAL DATA
CHICKAMAUGA EMBAYMENT STUDY (APRIL-SEPTEMBER 1990)

+-----ALGAL ENUMERATION (CELLS/LITER)-----+							+-----PERCENT DISTRIBUTION-----+					
DATE	CHLOROPHYTA (GREENS)	CHRYSTOPHYTA (DIATOMS)	CYANOPHYTA (BLUE-GREENS)	CRYPTOPHYTA	EUGLENOPHYTA	PYRRHOPHYTA	TOTALS	% CHLORO	% CHRYSO	% CYANO	% CRYPTO	% OTHER
SODDY CREEK MILE 1.7												
900405	519741	998718	631842	112101	0	0	2262402	23.0	44.1	27.9	5.0	0.0
900419	978336	1569414	2955390	529932	193629	0	6226701	15.7	25.2	47.5	8.5	3.1
900509	1121010	438213	947763	723561	30573	0	3261120	34.4	13.4	29.1	22.2	0.9
900529	2201256	1182156	4137546	183438	0	20382	7724778	28.5	15.3	53.6	2.4	0.3
900612	2364312	1406358	15612612	295539	0	30573	19709394	12.0	7.1	79.2	1.5	0.2
900627	2659851	1039482	8122227	214011	0	10191	12045762	22.1	8.6	67.4	1.8	0.1
900710	4025445	2374503	8061081	173247	61146	30573	14725995	27.3	16.1	54.7	1.2	0.6
900730	3556659	4382130	14776950	305730	40764	10191	23072424	15.4	19.0	64.0	1.3	0.2
900813	3291693	4392321	15031725	315921	81528	40764	23153952	14.2	19.0	64.9	1.4	0.5
900828	2109537	2068773	11097999	285348	40764	0	15602421	13.5	13.3	71.1	1.8	0.3
SODDY CREEK MILE 4.0												
900405	336303	1008909	478977	91719	0	0	1915908	17.6	52.7	25.0	4.8	0.0
900419	453544	840840	499408	259896	61152	15288	2130128	21.3	39.5	23.4	12.2	3.6
900509	1141392	346494	805089	234393	0	0	2527368	45.2	13.7	31.9	9.3	0.0
900529	2445840	631842	1314639	234393	0	20382	4647096	52.6	13.6	28.3	5.0	0.4
900612	1915908	662415	10292910	214011	0	20382	13105626	14.6	5.1	78.5	1.6	0.2
900627	2985963	1610178	12035571	112101	40764	61146	16845723	17.7	9.6	71.4	0.7	0.6
900710	3515895	3689142	10924752	122292	40764	20382	18313227	19.2	20.1	59.7	0.7	0.3
900730	2109537	3424176	8499294	61146	0	20382	14114535	14.9	24.3	60.2	0.4	0.1
900813	4117164	7276374	17375655	529932	183438	50955	29533518	13.9	24.6	58.8	1.8	0.8
900828	3699333	2303166	16550184	163056	20382	0	22736121	16.3	10.1	72.8	0.7	0.1
POSSUM CREEK MILE 2.0												
900405	326112	1110819	692988	142674	20382	0	2292975	14.2	48.4	30.2	6.2	0.9
900419	754134	2109537	1304448	417831	20382	20382	4626714	16.3	45.6	28.2	9.0	0.9
900509	1457313	794898	397449	377067	10191	10191	3047109	47.8	26.1	13.0	12.4	0.7
900530	1732470	1059864	2557941	81528	10191	0	5441994	31.8	19.5	47.0	1.5	0.2
900612	1712088	1192347	10170618	0	20382	0	13095435	13.1	9.1	77.7	0.0	0.2
900627	1518459	733752	4657287	40764	40764	0	6991026	21.7	10.5	66.6	0.6	0.6
900710	1987245	1161774	5340084	81528	20382	0	8591013	23.1	13.5	62.2	0.9	0.2
900730	2894244	4178310	12973143	244584	10191	0	20300472	14.3	20.6	63.9	1.2	0.1
900813	2873862	3903153	9630495	71337	40764	20382	16539993	17.4	23.6	58.2	0.4	0.4
900828	2649660	876426	13737468	40764	20382	0	17324700	15.3	5.1	79.3	0.2	0.1

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CHICKAMAUGA EMBAYMENT STUDY (APRIL-SEPTEMBER 1990)

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SALE CREEK MILE 1.3												
900405	468786	1905717	417831	173247	50955	10191	3026727	15.5	63.0	13.8	5.7	2.0
900419	1039482	1742661	1661133	428022	61146	10191	4942635	21.0	35.3	33.6	8.7	1.4
900509	1895526	3281502	2017818	743943	30573	0	7969362	23.8	41.2	25.3	9.3	0.4
900530	1620369	2099346	7388475	203820	50955	10191	11373156	14.2	18.5	65.0	1.8	0.5
900612	2527368	1080246	15327264	30573	0	10191	18975642	13.3	5.7	80.8	0.2	0.1
900627	2160492	1202538	7317138	193629	20382	10191	10904370	19.8	11.0	67.1	1.8	0.3
900710	3862389	2323548	13421547	152865	50955	30573	19841877	19.5	11.7	67.6	0.8	0.4
900730	3729906	2201256	12178245	183438	50955	0	18343800	20.3	12.0	66.4	1.0	0.3
900813	3954108	2150301	19424046	234393	224202	20382	26007432	15.2	8.3	74.7	0.9	0.9
900828	3281502	1436931	26190870	214011	61146	10191	31194651	10.5	4.6	84.0	0.7	0.2
900911	3770670	1946481	30603573	540123	264966	81528	37207341	10.1	5.2	82.3	1.5	0.9
SALE CREEK MILE 2.0												
900405	326112	1508268	275157	203820	30573	10191	2354121	13.9	64.1	11.7	8.7	1.7
900419	947763	1467504	580887	601269	30573	10191	3638187	26.1	40.3	16.0	16.5	1.1
900509	1070055	1895526	866235	264966	30573	20382	4147737	25.8	45.7	20.9	6.4	1.2
900530	1599987	1100628	4657287	101910	20382	0	7480194	21.4	14.7	62.3	1.4	0.3
900612	2425458	886617	18068643	50955	0	0	21431673	11.3	4.1	84.3	0.2	0.0
900627	1019100	652224	3668760	50955	0	0	5391039	18.9	12.1	68.1	0.9	0.0
900710	3424176	2843289	13115817	132483	101910	10191	19627866	17.4	14.5	66.8	0.7	0.6
900730	3077682	2527368	15592230	203820	91719	10191	21503010	14.3	11.8	72.5	0.9	0.5
900813	3301884	2119728	19260990	336303	163056	40764	25222725	13.1	8.4	76.4	1.3	0.8
900828	2629278	743943	20667348	193629	71337	10191	24315726	10.8	3.1	85.0	0.8	0.3
900911	2843289	1763043	26486409	71337	40764	101910	31306752	9.1	5.6	84.6	0.2	0.5
RICHLAND CREEK MILE 0.5												
900423	2119728	2415267	2017818	448404	61146	50955	7113318	29.8	34.0	28.4	6.3	1.6
900509	2680233	2802525	5350275	1243302	20382	10191	12106908	22.1	23.1	44.2	10.3	0.3
900530	1905717	1844571	5706960	815280	61146	30573	10364247	18.4	17.8	55.1	7.9	0.9
900613	2843289	1661133	22868604	407640	50955	20382	27852003	10.2	6.0	82.1	1.5	0.3
900627	7551531	2547750	16580757	275157	91719	61146	27108060	27.9	9.4	61.2	1.0	0.6
900710	4687860	1508268	12861042	468786	30573	20382	19576911	23.9	7.7	65.7	2.4	0.3
900730	5992308	1182156	27311880	101910	10191	0	34598445	17.3	3.4	78.9	0.3	0.0
900813	6236892	1987245	47245476	407640	234393	61146	56172792	11.1	3.5	84.1	0.7	0.5
900828	5727342	1731054	110450058	1243302	264966	20382	119437104	4.8	1.4	92.5	1.0	0.2
900911	3607614	1885335	44004738	305730	183438	0	49986855	7.2	3.8	88.0	0.6	0.4

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RICHLAND CREEK MILE 2.8												
900423	1701897	4076400	1722279	570696	30573	20382	8122227	21.0	50.2	21.2	7.0	0.6
900509	5615241	1151583	560505	336303	30573	0	7694205	73.0	15.0	7.3	4.4	0.4
900530	4881489	1813998	11790987	468786	40764	0	18996024	25.7	9.5	62.1	2.5	0.2
900613	5217792	2833098	63703941	81528	81528	20382	71938269	7.3	3.9	88.6	0.1	0.1
900627	6563004	2486604	18527238	285348	112101	122292	28096587	23.4	8.9	65.9	1.0	0.8
900710	4810152	2078964	4891680	173247	315921	50955	12320919	39.0	16.9	39.7	1.4	3.0
900730	6654723	1110819	28096587	122292	81528	0	36065949	18.5	3.1	77.9	0.3	0.2
900813	6216510	1671324	74557356	407640	152865	152865	83158560	7.5	2.0	89.7	0.5	0.4
900828	5584668	2048391	107087028	366876	142674	20382	115250019	4.8	1.8	92.9	0.3	0.1
900911	4382130	1885335	55805916	611460	346494	71337	63102672	6.9	3.0	88.4	1.0	0.7
MUD CREEK MILE 1.3												
900403	183438	356685	0	61146	0	10191	611460	30.0	58.3	0.0	10.0	1.7
900423	2384694	2568132	6094218	662415	326112	50955	12086526	19.7	21.2	50.4	5.5	3.1
900509	3047109	3597423	20463528	377067	71337	30573	27587037	11.0	13.0	74.2	1.4	0.4
900530	3271311	2048391	15531084	448404	50955	20382	21370527	15.3	9.6	72.7	2.1	0.3
900613	5340084	1579605	99994092	50955	71337	101910	107137983	5.0	1.5	93.3	0.0	0.2
900627	3954108	1019100	17263554	203820	163056	30573	22634211	17.5	4.5	76.3	0.9	0.9
900710	4565568	2710806	11729841	377067	438213	40764	19862259	23.0	13.6	59.1	1.9	2.4
900730	5034354	1243302	41660808	529932	101910	40764	48611070	10.4	2.6	85.7	1.1	0.3
900813	4433085	1559223	71734449	550314	366876	91719	78735666	5.6	2.0	91.1	0.7	0.6
900828	3750288	998718	57416094	366876	173247	10191	62715414	6.0	1.6	91.6	0.6	0.3
900911	3485322	1406358	46868409	478977	346494	20382	52605942	6.6	2.7	89.1	0.9	0.7
GOODFIELD CREEK MILE 0.9												
900423	1538841	3189783	2150301	856044	152865	40764	7928598	19.4	40.2	27.1	10.8	2.4
900509	2242020	1070055	2710806	448404	142674	0	6613959	33.9	16.2	41.0	6.8	2.2
900530	4371939	1457313	12025380	285348	30573	40764	18211317	24.0	8.0	66.0	1.6	0.4
900613	6328611	2476413	47398341	275157	20382	10191	56509095	11.2	4.4	83.9	0.5	0.1
900627	4331175	1355403	11057235	91719	61146	10191	16906869	25.6	8.0	65.4	0.5	0.4
900710	3291693	1396167	11709459	101910	50955	0	16550184	19.9	8.4	70.8	0.6	0.3
900730	5645814	1284066	9905652	336303	264966	20382	17457183	32.3	7.4	56.7	1.9	1.6
900813	5482758	2435649	26730993	825471	468786	40764	35984421	15.2	6.8	74.3	2.3	1.4
900828	6552813	2394885	45278613	580887	132483	10191	54949872	11.9	4.4	82.4	1.1	0.3
900911	5452185	1528650	56763870	876426	397449	30573	65049153	8.4	2.3	87.3	1.3	0.7

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GUNSTOCKER CREEK MILE 0.85												
900403	1233111	3587232	1528650	856044	183438	10191	7398666	16.7	48.5	20.7	11.6	2.6
900423	1966863	3444558	3597423	601269	499359	0	10109472	19.5	34.1	35.6	5.9	4.9
900509	3801243	6736251	10996089	468786	81528	20382	22104279	17.2	30.5	49.7	2.1	0.5
900531	5309511	3862389	10659786	264966	112101	61146	20269899	26.2	19.1	52.6	1.3	0.9
900613	2894248	1712088	13717086	234393	40764	10191	18608770	15.6	9.2	73.7	1.3	0.3
900628	1324830	1171965	3933726	285348	91719	20382	6827970	19.4	17.2	57.6	4.2	1.6
900709	3128637	1457313	8183373	315921	295539	30573	13411356	23.3	10.9	61.0	2.4	2.4
900731	4677669	2028009	13696704	550314	214011	10191	21176898	22.1	9.6	64.7	2.6	1.1
900814	3383412	1385976	18588384	856044	132483	40764	24387063	13.9	5.7	76.2	3.5	0.7
900827	6083645	2017818	28096587	1630560	214011	61146	38083767	15.9	5.3	73.8	4.3	0.7
900911	2945199	1589796	99005565	377067	163056	0	104080683	2.8	1.5	95.1	0.4	0.2
AGENCY CREEK MILE 0.65												
900403	876426	1294257	988527	468786	81528	0	3709524	23.6	34.9	26.6	12.6	2.2
900423	2303166	2160492	12596076	784707	285348	40764	18170553	12.7	11.9	69.3	4.3	1.8
900509	3994872	4300602	11505639	692988	101910	20382	20616393	19.4	20.9	55.8	3.4	0.6
900531	2068773	1671324	6216510	692988	163056	10191	10822842	19.1	15.4	57.4	6.4	1.6
900613	5217792	1498077	19862259	264966	122292	20382	26985768	19.3	5.6	73.6	1.0	0.5
900628	2058582	1467504	7796115	152865	193629	91719	11760414	17.5	12.5	66.3	1.3	2.4
900709	2945199	1151583	8631777	631842	356685	81528	13798614	21.3	8.3	62.6	4.6	3.2
900731	3393603	856044	13431738	550314	142674	40764	18415137	18.4	4.6	72.9	3.0	1.0
900814	3566850	866235	20035506	784707	112101	20382	25385781	14.1	3.4	78.9	3.1	0.5
900827	5217792	1905717	41660808	1885335	560505	13248	51243405	10.2	3.7	81.3	3.7	1.1
900911	1773234	682797	16264836	264966	50955	10191	19046979	9.3	3.6	85.4	1.4	0.3
CANDIES CREEK MILE 1.5												
900403	305730	509550	896808	203820	0	10191	1926099	15.9	26.5	46.6	10.6	0.5
900423	1778504	1640912	3755752	1039584	239512	61152	8515416	20.9	19.3	44.1	12.2	3.5
900509	3383412	1620369	4973208	489168	10191	30573	10506921	32.2	15.4	47.3	4.7	0.4
900531	5564286	4259838	11097999	112101	81528	0	21115752	26.4	20.2	52.6	0.5	0.4
900613	2384694	1284066	22960323	234393	10191	10191	26883858	8.9	4.8	85.4	0.9	0.1
900628	2517177	1284066	21839313	438213	224202	20382	26323353	9.6	4.9	83.0	1.7	0.9
900709	2619087	1436931	7867452	489168	315921	112101	12840660	20.4	11.2	61.3	3.8	3.3
900731	2007627	845853	3424176	377067	71337	0	6726060	29.8	12.6	50.9	5.6	1.1
900814	3393603	1406358	9813933	234393	142674	20382	15011343	22.6	9.4	65.4	1.6	1.1
900827	2170683	1824189	12687795	703179	163056	20382	17569284	12.4	10.4	72.2	4.0	1.0
900911	3852198	2670042	17864823	529932	163056	0	25080051	15.4	10.6	71.2	2.1	0.7

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ROGERS CREEK MILE 1.5												
900403	631842	784707	1273875	448404	10191	0	3149019	20.1	24.9	40.5	14.2	0.3
900423	2323548	2038200	6053454	1314639	61146	71337	11862324	19.6	17.2	51.0	11.1	1.1
900509	2690424	6726060	3566850	356685	50955	30573	13421547	20.0	50.1	26.6	2.7	0.6
900531	3464940	4086591	5961735	377067	112101	122292	14124726	24.5	28.9	42.2	2.7	1.7
900613	4677669	2731188	13686513	214011	183438	20382	21513201	21.7	12.7	63.6	1.0	0.9
900628	2140110	1070055	5299320	540123	91719	20382	9161709	23.4	11.7	57.8	5.9	1.2
900709	3403794	1508268	11199909	478977	244584	40764	16876296	20.2	8.9	66.4	2.8	1.7
900731	4494231	1447122	6583386	601269	81528	30573	13238109	33.9	10.9	49.7	4.5	0.8
900814	3413985	1019100	15317073	1110819	529932	71337	21462246	15.9	4.7	71.4	5.2	2.8
900827	4331175	1681515	17793486	1447122	214011	20382	25487691	17.0	6.6	69.8	5.7	0.9
900911	3454749	1487886	37197150	387258	122292	20382	42669717	8.1	3.5	87.2	0.9	0.3
NORTH MOUSE CREEK MILE 0.5												
900403	234393	529932	1151583	224202	0	10191	2150301	10.9	24.6	53.6	10.4	0.5
900423	224202	397449	1620369	366876	0	0	2608896	8.6	15.2	62.1	14.1	0.0
900509	1579605	611460	285348	489168	50955	0	3016536	52.4	20.3	9.5	16.2	1.7
900531	489168	183438	50955	91719	0	10191	825471	59.3	22.2	6.2	11.1	1.2
900613	4963017	3291693	12952761	326112	20382	0	21553965	23.0	15.3	60.1	1.5	0.1
900628	1650942	978336	326112	336303	91719	20382	3403794	48.5	28.7	9.6	9.9	3.3
900709	1742661	1039482	458595	101910	30573	0	3373221	51.7	30.8	13.6	3.0	0.9
900731	2292975	1487886	2099346	519741	30573	0	6430521	35.7	23.1	32.6	8.1	0.5
900814	1844571	560505	1212729	448404	20382	10191	4096782	45.0	13.7	29.6	10.9	0.7
900827	2731188	1345212	6399948	672606	183438	0	11332392	24.1	11.9	56.5	5.9	1.6
900911	2109537	947763	7011408	183438	71337	0	10323483	20.4	9.2	67.9	1.8	0.7
SOUTH MOUSE CREEK MILE 1.1												
900403	366876	1406358	1406358	407640	0	0	3587232	10.2	39.2	39.2	11.4	0.0
900423	1457313	3271203	4208883	1039482	142674	40764	10160319	14.3	32.2	41.4	10.2	1.8
900509	1559223	1141392	2425458	214027	30573	10191	5380864	29.0	21.2	45.1	4.0	0.8
900531	1854762	6512049	631842	1151583	40764	0	10191000	18.2	63.9	6.2	11.3	0.4
900613	4963017	7806306	7225419	122292	315921	20382	20453337	24.3	38.2	35.3	0.6	1.6
900628	1956672	3128637	91719	387258	61146	0	5625432	34.8	55.6	1.6	6.9	1.1
900709	3332457	3485322	2822907	377067	468786	61146	10547685	31.6	33.0	26.8	3.6	5.0
900731	4820343	3189783	12045762	326112	417831	10191	20810022	23.2	15.3	57.9	1.6	2.1
900814	4963017	4871298	2812716	917190	183438	0	13747659	36.1	35.4	20.5	6.7	1.3
900827	4912062	4830534	5136264	733752	142674	20382	15775668	31.1	30.6	32.6	4.7	1.0
900911	2833098	3189783	4096782	61146	10191	0	10191000	27.8	31.3	40.2	0.6	0.1

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

TRM 472.3

TRM 478.19

TRM 490.47

TRM 496.5

TRM 506.6

TRM 518.0

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

TRM 529.9

WACONDA BAY 0.95

DALLAS BAY 0.9

HRM 7.4

HRM 13.4

HRM 20.0

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

WOLFTEVER CREEK 4.2

WOLFTEVER CREEK 5.65

SAVANNAH BAY 2.95

POSSUM CREEK 2.0

SODDY CREEK 1.7

SODDY CREEK 4.0

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

SALE CREEK 1.3

SALE CREEK 2.0

RICHLAND CREEK 0.5

RICHLAND CREEK 2.8

MUD CREEK 1.3

GOODFIELD CREEK 0.9

ALGAL POPULATIONS 1990 (APRIL-SEPTEMBER)
CHICKAMAUGA EMBAYMENT STUDY

GUNSTOCKER CREEK 0.85

AGENCY CREEK 0.65

CANDIES CREEK 1.5

ROGERS CREEK 1.5

SOUTH MOUSE CREEK 1.1

NORTH MOUSE CREEK 0.5

APPENDIX G
EMBAYMENT RATING SCHEME SUMMARY

EMBAYMENT RATING SCHEME SUMMARY
Chickamauga Embayment Study, 1990

Introduction

The evaluation criteria used in the Chickamauga Embayment Study of 1990 to assess the ecological condition of the embayments were based on five aquatic health indicators - Carlson's Trophic State Index, dissolved oxygen concentrations, concentrations of metals in sediment, benthic community diversity, and a fish health assessment. At sampling locations in each embayment, each of these five aquatic health indicators were rated as "good", "fair", or "poor".

A tabulation of the ecological ratings determined for each of the embayments is given in Table G-1. Table G-2 is an example of the rating scheme summary determination for Sale Creek. The following discussion provides further details.

Aquatic Health Indicators

Carlson's Trophic State Index (Average) - This index, (as given in table 6 in the report), was used to assess eutrophication of each embayment. Mesotrophic embayments were rated "good" and eutrophic embayments were rated "fair". (There were no embayments which were oligotrophic, which would have been rated "fair", or hypereutrophic, which would have been rated "poor".)

Dissolved Oxygen (DO) - Isopleths of DO concentrations were plotted versus depth and time at each sampling location for a six month (April-September) period, (as shown in figures 4a-4e in the report). For each sampling location, the DO rating is based on an estimate of the percent of the time and the depth that the concentration of DO was less than 2.0 mg/l. If the percent of the [time x depth] was less than 5%, DO was rated "good". If the percent of the [time x depth] was greater than 5% but less than 10%, DO was rated "fair". If the percent of the [time x depth] was greater than 10% the DO was rated "poor".

In addition, in consideration of state DO water quality criteria for fish and aquatic life, if the measured DO at the 1.5 meter depth at a sampling location was less than 5.0 mg/l on more than one occasion, the DO rating was decreased from "good" to "fair" or from "fair" to "poor", as appropriate.

Sediment Quality - "good", "fair", and "poor" ratings for sediment quality were assigned based on measured concentrations of seven heavy metals in sediment (i.e. Cd, Cr, Cu, Pb, Hg, Ni, and Zn). For each metal, concentrations in each embayment were compared with a "standard". (In this application, the "standard" for each metal was the average concentration of all the locations

sampled in Chickamauga reservoir in 1990, as shown in Appendix B.) Embayments with no heavy metal concentrations that exceeded the standards were rated "good"; embayments which had one to three heavy metals that exceeded the standards were rated "fair"; and embayments which four or more heavy metals which exceeded the standards were rated "poor".

Benthic Community - Based on results of cluster analysis, (as shown in table 20 and figures 37 and 38 in the report), we rated the biotic integrity or quality of aquatic environment at each site. The biotic integrity of Cluster "1" sites was "very poor". Cluster "2" sites, which included most of the Tennessee River and lower Hiwassee River main-channel sites were considered to be "good". Benthic fauna of embayments were generally in poorer condition than Cluster "2" main-channel sites. Health of Cluster "3" and "4" embayments were considered "fair" while Cluster "5" sites were classified as "poor".

Fish Health Assessment Index - A fish health, autopsy-based assessment was employed, using a survey procedure originally developed by Goede in 1990. This metric was modified by TVA to better reflect Tennessee Valley reservoir conditions by incorporating largemouth bass as the indicator fish species because of their ease of capture and because of their position on the food chain as a top predator. Fish in each embayment of Chickamauga reservoir were collected by electrofishing and immediately examined for a variety of external and internal conditions/abnormalities (e.g. blood chemistry, eyes, skin, gills, fins, opercles, pseudobranchs, thymus, mesenteric fat, spleen, hindgut, kidney, bile, liver, parasites, and sex). Results were tabulated and totaled such that the numerical value of the Fish Health Assessment Index (FHAI) is inversely related to the health of the fish. Results ranged from 44 to 98 for Chickamauga embayments, (as shown in table 23 in the report). FHAI values less than 50 were rated as "good"; between 50 and 60 as "fair"; and greater than 60 as "poor".

Note! The ratings given these five ecological health indicators are those of the authors. The authors recognize the difficulty in trying to evaluate the aquatic health of a complex reservoir system based solely on indicators which are measured at only a small number of locations. The authors recognize there may be other better indicators, and anticipate that as understanding increases, indicators and their evaluations will change. The authors solicit comments and criticisms of their choice of aquatic health indicators, their methods of rating each of the indicators, and their overall evaluations of the embayments.

Table G-1

Chickamauga Embayment Study
Embayment Rating Scheme Summary

<u>Embayment</u>	<u>Mile</u>	<u>TSI</u>	<u>Dissolved Oxygen</u>	<u>Sediment</u>	<u>Benthics</u>	<u>Fish</u>
Waconda Bay	0.95	fair (53)	good (0%)	poor (Cr,Cu,Pb,Hg,Zn)	-	poor (98)
	2.0	-	-	-	fair (cluster 4)	-
Wolftever Cr	4.1	-	-	-	fair (cluster 3)	-
	4.2	fair (53)	good (0%)	fair (Pb)	-	good (47)
	5.4	-	-	-	poor (cluster 5)	-
	5.65	fair (57)	good (0%)	good (none)	-	-
Savannah Bay	1.5	-	-	-	poor (cluster 5)	-
	2.95	fair (61)	good (0%)	good (none)	-	good (47)
Dallas Bay	0.9	good (49)	poor (18%)	fair (Pb,Hg)	-	poor (78)
	1.5	-	-	-	fair (cluster 3)	-
Soddy Creek	1.7	good (45)	poor (20%)	fair (Ni)	fair (cluster 3)	poor (75)
	4.0	good (42)	poor (16%)	fair (Ni)	good (cluster 2)	-
Possum Creek	2.0	good (42)	poor (16%)	poor (Cr,Hg,Ni,Zn)	fair (cluster 3)	fair (60)
Sale Creek	1.3	good (45)	poor (12%)	fair (Ni)	fair (cluster 3)	-
	2.0	good (45)	good (4%)	fair (Ni)	fair (cluster 4)	fair (55)
Richland Creek	0.5	fair (52)	good (0%)	fair (Cr)	poor (cluster 5)	good (47)
	2.8	fair (53)	fair (9%)	good (none)	-	-
	2.9	-	-	-	poor (cluster 5)	-
Mud Creek	1.3	fair (56)	poor (17%)	fair (Cr)	fair (cluster 4)	good (47)
Goodfield Creek	0.9	fair (57)	good (0%)	fair (Cr,Cu)	-	good (44)
	1.0	-	-	-	poor (cluster 5)	-
Gunstocker Creek	0.85	fair (60)	fair (<5ppm @ 5ft)	fair (Cr)	-	fair (55)
	1.0	-	-	-	poor (cluster 5)	-
Agency Creek	0.5	-	-	-	poor (cluster 5)	-
	0.65	fair (58)	poor (17%)	poor (Cu,Pb,Hg,Zn)	-	poor (65)
Candies Creek	1.3	-	-	-	good (cluster 2)	-
	1.5	fair (61)	poor (15%)	fair (Cr)	fair (cluster 4)	poor (81)

Table G-1(continued)

**Chickamauga Embayment Study
Embayment Rating Scheme Summary**

<u>Embayment</u>	<u>Mile</u>	<u>TSI</u>	<u>Dissolved Oxygen</u>	<u>Sediment</u>	<u>Benthics</u>	<u>Fish</u>
Rogers Creek	1.5	fair (59)	fair (5%)	fair (Hg,Zn)	poor (cluster 5)	poor (71)
North Mouse Creek	0.5	fair (59)	fair (<5ppm @ 5ft)	fair (Pb)	poor (cluster 5)	poor (99)
South Mouse Creek	1.1	fair (69)	fair (<5ppm @ 5ft)	good (none)	fair (cluster 4)	poor (64)

Embayment Summary:

- * TSI - mesotrophic (40-50) = good; eutrophic (>50) = fair.
- * Dissolved Oxygen - <5% = good; 5%-10% = fair; >10% = poor.
- * Sediment - no metals exceeding standard = good; 1-3 metals exceeding standard = fair; four or more metals exceeding standard = poor.
- * Benthics - cluster 2 = good; clusters 3 and 4 = fair; cluster 5 = poor.
- * Fish health - <50 = good; 50-60 = fair; >60 = poor.

Table G-2

Computational Method For Evaluation of Reservoir Health

Sale Creek Embayment - 1990

Aquatic Health Indicator	Observations			Ratings		
	Sale Creek Mile 1.3	Sale Creek Mile 2.0		Sale Creek Mile 1.3	Sale Creek Mile 2.0	
Dissolved Oxygen: % of [time x depth] <2 mg/l less than 5mg/l at 1.5 meter	12 no	4 no	NA NA	poor	good	NA
Carlson's Trophic State Index: Average	mesotrophic	mesotrophic	NA	good	good	NA
Sediment Quality (Cd, Cr, Cu, Pb, Ni, Hg, and Zn): Number of metals greater than standard	1 of 7 (Ni=41 ppm)	1 of 7 (Ni=39 ppm)	NA	fair	fair	NA
Benthic Community:	Cluster 3	Cluster 4	NA	fair	fair	NA
Fish Health Assessment Index: FHA1 score	No sample	55	NA	NA	fair	NA

Embayment Evaluation Key:
 Poor (red)
 Fair (yellow)
 Good (green)