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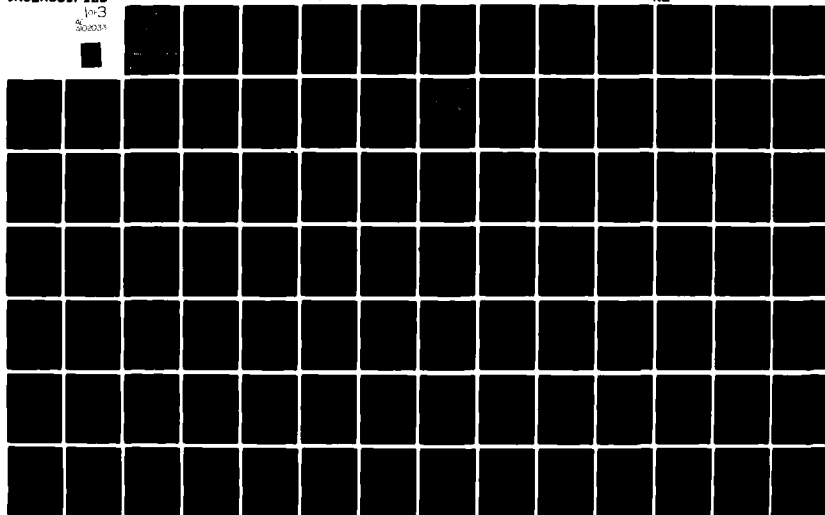
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CHATTAHOOCHEE RIVER WATER QUALITY ANALYSIS. (U)
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CHATTAHOOCHEE RIVER
WATER QUALITY ANALYSIS

Final Report to the Waterways Experiment Station
and Savannah District

by

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April 1978

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PREFACE

This document is a final report being submitted to the Corps of Engineer's Waterways Experiment Station (WES) and Savannah District Office. This report supersedes the draft report of the same title dated December 1975.

Editorial changes to the draft report include results of WES and HEC reviews and an independent review by Dr. Carl W. Chen, Tetra Tech. Other changes include deletion of chapters and appendices which documented the computer program. The program has been recently documented in the 1977 WQRRS users manual.

Chapter VI required significant change due to the development of more comprehensive computer software since 1975. The display of the temporal change of the water quality condition at a specific location is obtained from a recently developed HEC program. The remainder of the results must be considered preliminary as the programs required to manage the data for display in the format shown are presently under development and scheduled for completion by October 1978. While these results are preliminary and some change in the exact value of the results can be anticipated, no significant difference in the general conclusions should be expected.

The general methodology documented in this report is intended to define methods of obtaining or estimating the data required for aquatic ecosystem computer programs, to demonstrate the interface of rainfall-runoff quantity and quality modeling with receiving water modeling, and to demonstrate the evaluation of the impact on river water quality due to planning alternatives regarding modified treatment levels on municipal-industrial effluents and on stormwater runoff.

R.G. Willey

CHATTAHOOCHEE RIVER WATER QUALITY ANALYSIS

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I. INTRODUCTION

Background

Since December 1972, the Corps of Engineers, Savannah District, has been conducting a water resources study in metropolitan Atlanta, Georgia. The study is a joint effort of the Corps, Atlanta Regional Commission, Georgia Environmental Protection Division, and U.S. Environmental Protection Agency.

One of the objectives of the Metropolitan Atlanta Water Resources Study is to develop regional alternatives for wastewater treatment and management in the 7-county area. In conjunction with this effort, broad regional alternatives for treatment of point wastewater sources were developed, including various size, number, and location of treatment plants and various treatment levels. In addition, an evaluation was conducted of the magnitude and treatment options of non-point pollution sources, including urban runoff and combined sewer overflows.

During late 1974, the four agencies conducting the Atlanta study recognized the limitations inherent in the steady-state water quality computer models available for evaluating wastewater management strategies. A related question concerned the amount and validity of data available for water quality analysis, including the input data and cost-effectiveness of structural and non-structural management techniques.

Subsequently, during early 1975 the four agencies initiated discussions with the Corps' Waterways Experiment Station (WES) in Vicksburg, Mississippi and the Hydrologic Engineering Center (HEC) in Davis, California regarding assistance in evaluating water quality and computer modeling needs for metropolitan Atlanta.

In January 1975, the Hydrologic Engineering Center was engaged to adapt a state-of-the-art water quality computer model for one of the major rivers in Metropolitan Atlanta and to demonstrate the potential for assessing the impact of selected pollution sources on water quality in a receiving stream. The computer program, "Water Quality for River-Reservoir Systems" (WQRRS) was selected by the four study agencies and was to be adapted by HEC for the 116-mile reach of the Chattahoochee River between Buford Dam and the headwaters of West Point Reservoir. The location map shown in figure I-1 defines the boundaries of the study area.

Scope and Objectives

The general objectives for adapting the WQRRS model to the study area were to demonstrate the capability for interfacing storm water modeling results with selected pollutants from other sources and evaluating their individual impacts on the river water quality condition. The procedure and data requirements for calibrating the model were to be defined in a documented methodology that could be used by personnel of the four study agencies in continuing studies.

The developed methodology uses available data only, since neither time nor funds were authorized for data collection. The quantity and quality of sewage treated effluents were furnished by Georgia's Environmental Protection Division, but the developed methodology includes procedures for estimating quantity and quality of storm water runoff from the entire study area.

The methodology for evaluating the impact on the water quality of the Chattahoochee River due to improved treatment at the existing sewage treatment plants, and due to the collection and treatment of storm water runoff for existing conditions will be demonstrated.

Specific tasks to be accomplished by the study include the following:

1. Modify the Corps' steady flow "Water Quality for River-Reservoir Systems" (WQRRS) model (1) to include the capability for unsteady flow analysis.



Fig. I-1. Location Map for Study Area

2. Develop a preprocessor to facilitate the preparation of input data for the dynamic WQRRS model.
3. Select a representative study period for analysis. Locate and assemble the necessary meteorological, geometrical (i.e., cross sections), hydrological, and water quality data. Estimate any additional data required. The hydrological and water quality data were to include in-stream data (for calibration) as well as data for all significant loading and withdrawal points.
4. Examine the study area and discuss data requirements with local field personnel.
5. Develop local flows for ungaged tributaries and streamflow routing criteria for the Muskingum routing method.
6. Develop a procedure for estimating the quality of storm water runoff (i.e., determination of non-point source inflow.)
7. Apply the preprocessor and the water quality model to the Chattahoochee River for existing conditions. Calibrate the model using observed and estimated data. Verify the model on observed data that was not used in the calibration process.
8. Apply the model using the sewage treated effluents with improved treatment and the treated storm water runoff.
9. Compare the Chattahoochee River water quality conditions resulting from tasks 7 and 8.
10. Prepare a report documenting the basic concepts and input description for the model and the results of tasks 7-9. Provide a two-day training seminar on the basic concepts of the model, the Chattahoochee River application, and the study results.

Study Team

The study was conducted under the supervision of Mr. R. G. Willey. Major portions of the technical work were performed by Messrs. D. Huff, J. Abbott, A. Onodera, R. Carl and K. Iceman of the Hydrologic Engineering

Center. Roger Nutter prepared the figures for the report. The Hydrologic Engineering Center (HEC) is a research and training center for the Corps of Engineers. One of its main functions is the development and application of comprehensive hydrologic engineering computer programs for all Corps offices. The HEC has been participating in the development and application of the WQRRS model for about six years. This model and several similar versions were developed by Drs. Chen and Orlob. These models have been applied on more than ten major water quality studies. They have been presented for critical review at several major technical conferences and have been continuously updated as new approaches have been advanced. Mr. Willey has been involved full-time in much of this development work during the last six years.

Dr. Carl W. Chen and Mr. Don Smith of Tetra Tech were consultants to the project providing review of the system coefficients used in the model and evaluation of the resulting output. Dr. Ian King of Resource Management Associates modified the steady flow WQRRS model to perform unsteady flow analysis.

The overall management of the study was provided by Mr. Jerry Brown of the Corps' Waterways Experiment Station and William C. Porter and Larry Lyons of the Savannah District. The project was funded jointly by the Corps' Waterways Experiment Station and the Savannah District.

The required data were graciously provided by the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), Corps of Engineers' Mobile District, Corps of Engineers' Savannah District, Georgia Environmental Protection Division, (EPD), Georgia Game and Fish Department, Atlanta Water Works (AWW), and Georgia Power (GP). The same offices also provided numerous consultations with the study participants by phone and in-person which were extremely important to this project. The value of these local contacts cannot be over-emphasized.

Computer programs used in this study, other than those developed specially for this study, include Flood Hydrograph Package (HEC-1) (2), Water Surface Profiles (HEC-2) (3), Geometric Elements for Cross Section Coordinates (GEDA) (4), Urban Storm Water Runoff (STORM) (5), and several general utility programs all of which were developed at and are available from the HEC.

II. SUMMARY AND CONCLUSIONS

Summary

The Chattahoochee River study was performed for the purposes of establishing and documenting the methodology for interfacing storm water modeling results with selected pollutants from other sources and evaluating their individual impacts on the river water quality condition. The development of the Chattahoochee River data deck for use in the "Water Quality for River-Reservoir Systems" (WQRRS) computer program is the successful conclusion of establishing this methodology. This report is the conclusion of the effort to document the methodology so that local and state government agencies can easily use the model for evaluation of their own study objectives.

The computer program and the associated data deck should be quite useful in numerous anticipated applications. The model and data deck have been designed specifically to minimize the man-power requirements for studying objectives which differ from those in this project. Examples of other potential applications which would require a minimum modification include evaluating the water quality impact on the Chattahoochee River due to the following causes:

- (a) Unprecedented release schedules from Buford Dam,
- (b) Encouraging rapid growth and the associated urbanization,
- (c) Various feasible treatment levels at the sewage treatment plants or for other pollutant sources such as storm water runoff,
- (d) Modification of the network of sewage treatment plants into a well designed and operated system, and
- (e) Diversions of water into or out of the basin.

Conclusions

The methodology for interfacing a dynamic river water quality model and a watershed runoff-quality model has been developed. Now that this interface has been completed, watershed quantity-quality analysis similar

to the Chattahoochee River study can be performed with far less emphasis on model development.

The developed procedure was applied to the Chattahoochee River using data that were readily available. Stream profiles were simulated for temperature, dissolved oxygen (DO), ammonia (NH_3), nitrate (NO_3), total phosphate (PO_4), pH, total dissolved solids (TDS), and fecal coliform.

Graphs were produced which show observed and simulated results for each parameter, at specific stream locations for the 90 day study period when instream data were available for comparison. The mean error and the standard deviation of the error were tabulated.

The mean error was added to the most critical (i.e., maximum for all parameters except DO) values from the simulated results for each parameter and each river reach, and envelope curves defined as "maximum or minimum normally expected" functions were constructed. Maximum recorded data were plotted for comparison.

The "existing condition" data input was modified first for simulating treatment of storm runoff, then for improved treatment of municipal sewage. Graphs of the modified simulations were compared with the existing condition simulations and the impact of treating either storm water runoff or more advanced treatment of sewage treatment plant effluents was concluded.

Based on the analyses of simulation results, the following conclusions can be made:

1. Diurnal fluctuations of water temperature can often be as large as 7°C due to the large fluctuation of flows and waste heat input. The water temperature below the Georgia Power Plants does not cause the river water temperature to exceed the 32.2°C standard, but it can potentially cause a change in river temperature in excess of the allowable 2.78°C .
2. The DO level from Camp Creek to Franklin is a potential problem, often having DO concentrations below the 5 mg/l standard. Under normal operating procedures, the DO for approximately 3 miles below Buford dam will also be below 5 mg/l.
3. Plant nutrient concentrations are lower than the drinking water standards, however, they are higher than the level necessary to limit algal growth.

4. TDS concentrations and the pH indicate good quality stream water.
5. The coliform level often exceeds the standards for recreational uses and poses the most serious water quality problem. This coliform problem exists from Suwanee Creek to Franklin.
6. No significant impact was apparent when storm water runoff from existing conditions was treated to the ABT-5 level specified in table VI-2.
7. The upgrading of sewage treatment plants to the ABT-5 level cannot improve the water quality sufficiently to meet the state water quality standards, but it will significantly decrease the nutrient load to a downstream impoundment.
8. While approximately 9 man-months were required for the analyses described in this report, alternative objectives requiring minimum data deck modifications could now be analyzed in .5 to 1 man-months. Very few data deck modifications are necessary for most practical study objectives.
9. The cost of computation time on the Lawrence Berkeley Laboratory CDC 7600 for running the present data deck or one that is slightly modified (i.e., different study objective) would be approximately \$360.00 for the 116 miles of river of \$3.00 per mile of analysis.

III. CHATTAHOOCHEE RIVER SYSTEM

General

The Chattahoochee River watershed begins in the north-central part of Georgia. The mainstem and several of its tributaries flow into a large impoundment called Lake Sidney Lanier (Buford Dam). Below the dam the river travels southwest past Metropolitan Atlanta to the Alabama-Georgia border where it flows into the recently completed West Point impoundment. The inflow location to West Point is near Franklin, Georgia. The study area was located between Buford Dam and Franklin, as shown in figure III-1. A schematic of the study area including all withdrawal and loading points is shown in figures III-2a to III-2d.

Meteorological

The weather data required for the water quality model includes dry and wet bulb air temperature, percent of the sky that is cloud covered, wind speed and barometric pressure. These data were readily available from the Atlanta Airport, National Weather Service Station WBAN #13874. The short-wave solar and long-wave radiation data required for evaluation of water temperature conditions are calculated within the model based on the latitude and longitude of the site location.

The long-term mean monthly and 1974 precipitation patterns at Atlanta are shown in figures III-3 and III-4, respectively. As shown in figure III-3, the precipitation is fairly evenly distributed through the year with the months of August through November being the four lowest precipitation periods. While the 1974 precipitation pattern differs significantly from the mean annual pattern, as shown in figure III-4, the volume of precipitation is only one inch less. Notice the months of August and November 1974 are not included in the lowest four months as in the long-term mean pattern. However, September and October 1974 have the lowest monthly precipitation in 1974 similar to that shown in the long-term mean pattern.

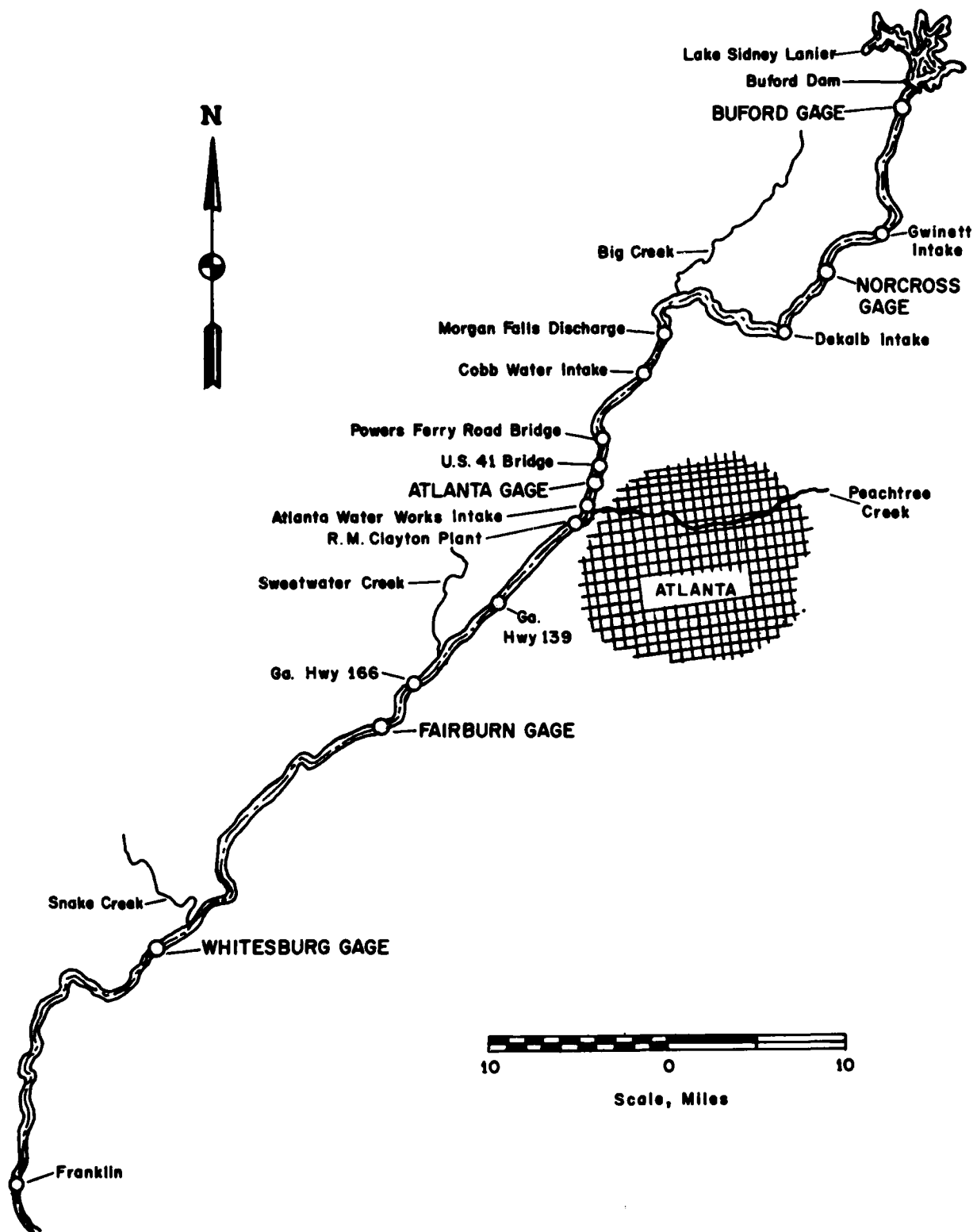


Figure III-1 CHATTAHOOCHEE RIVER FROM BUFORD DAM TO THE FRANKLIN GAGE

RIVER MILE

NAME AND
RIVER MILE

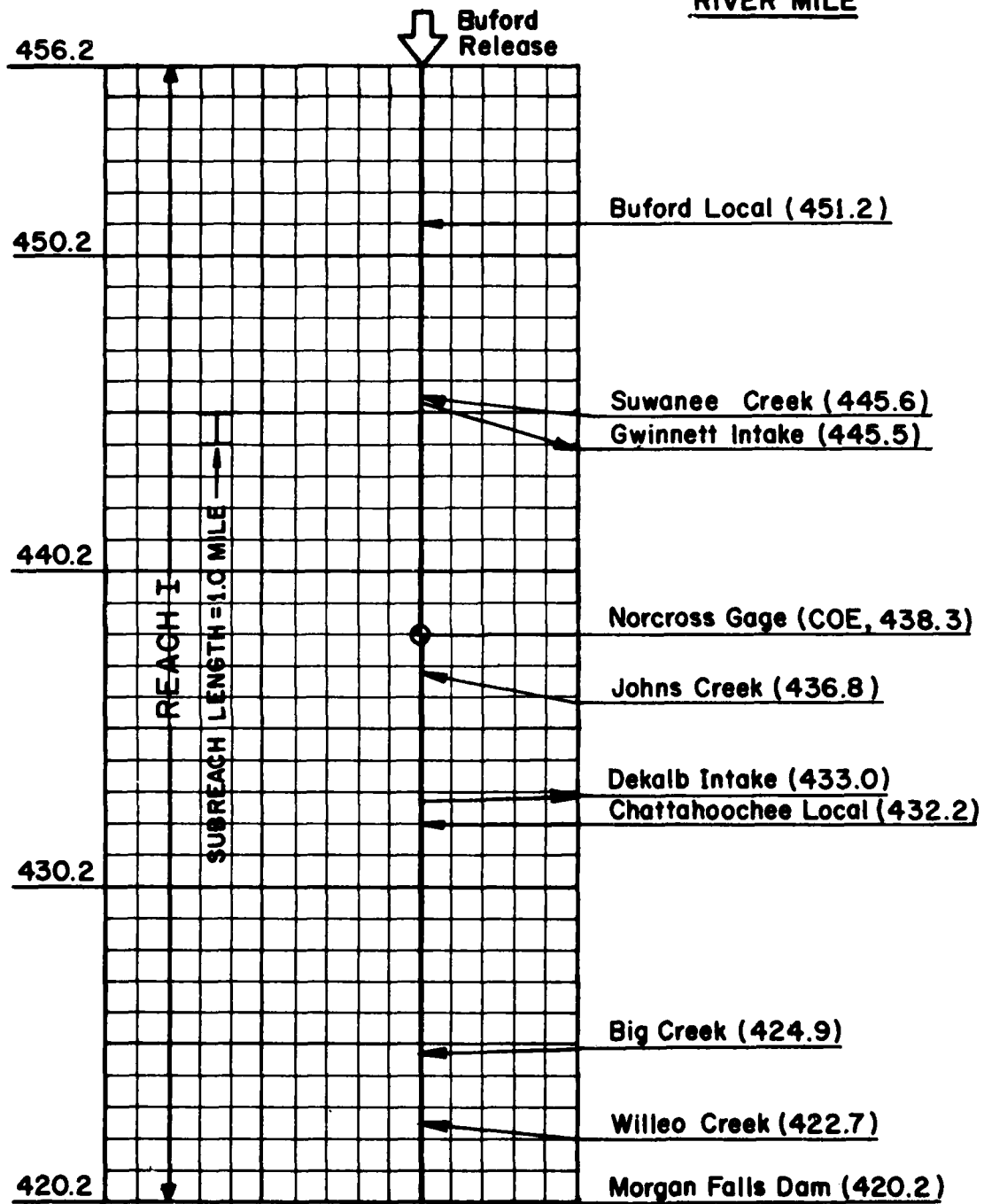
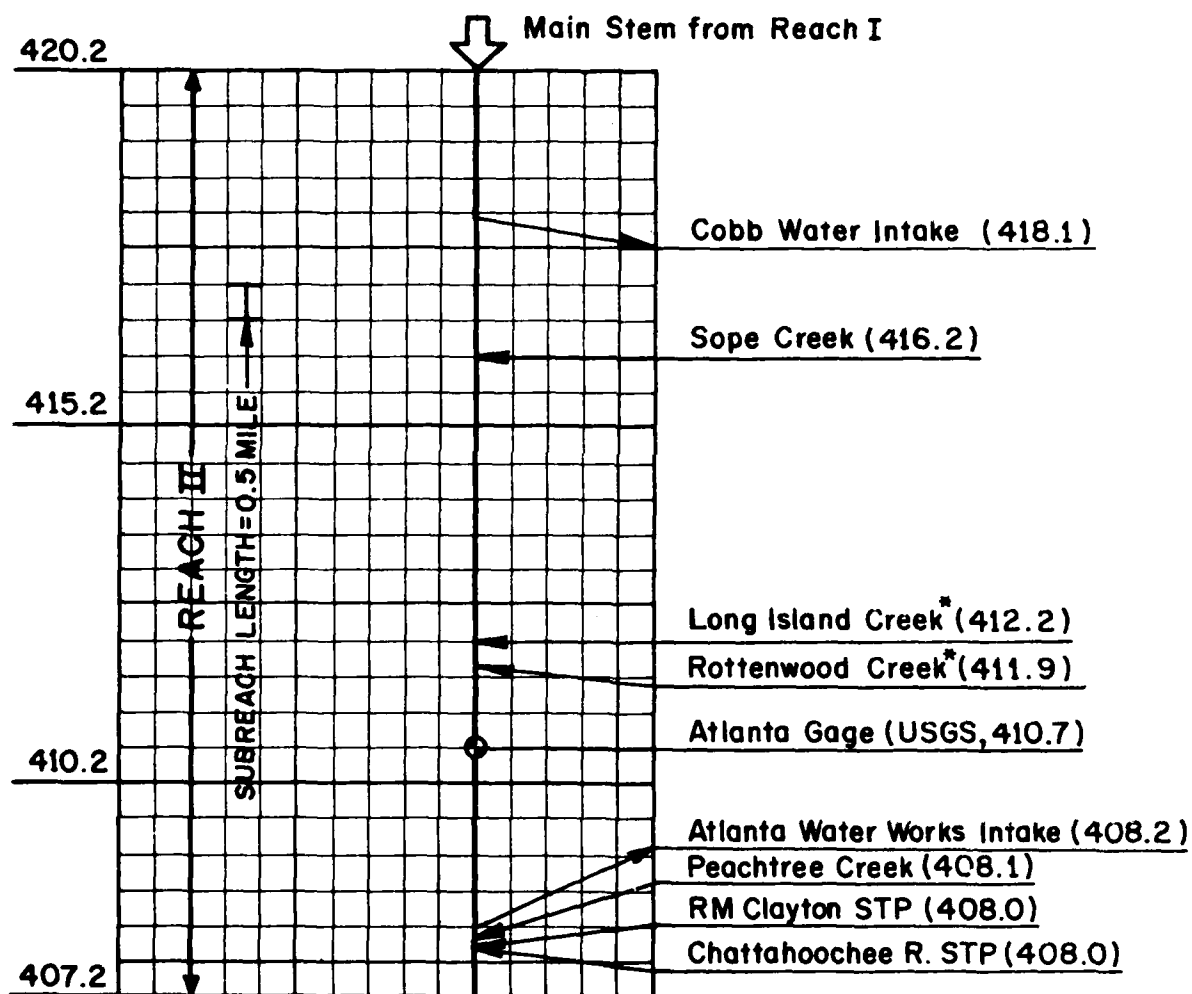
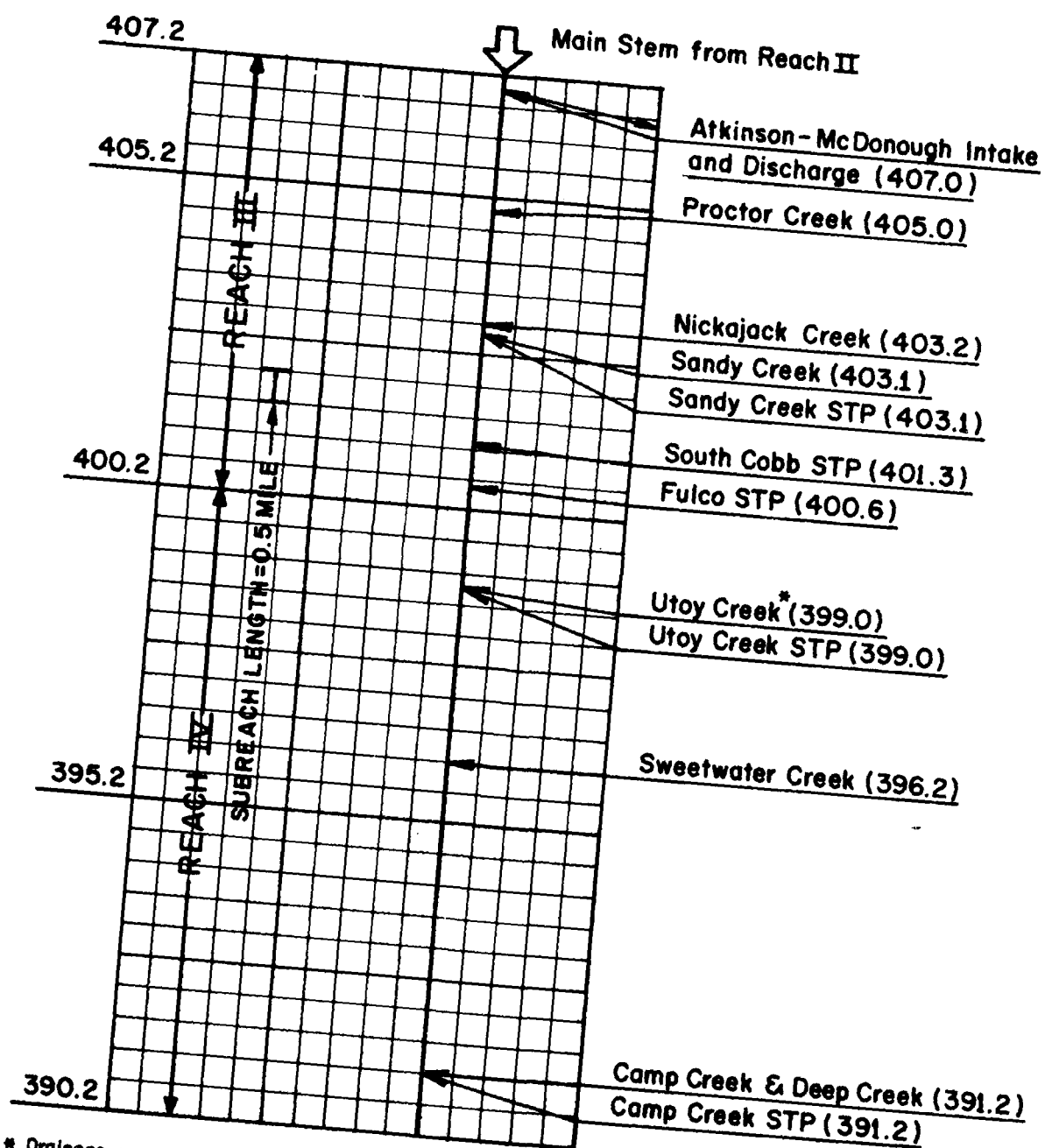


Fig. III-2a. Schematic of Chattahoochee River



* Drainage area has been increased to account for some local drainage.

Fig. III-2b. Schematic of Chattahoochee River



* Drainage area has been increased to account for some local drainage.

Fig. III-2c. Schematic of Chattahoochee River

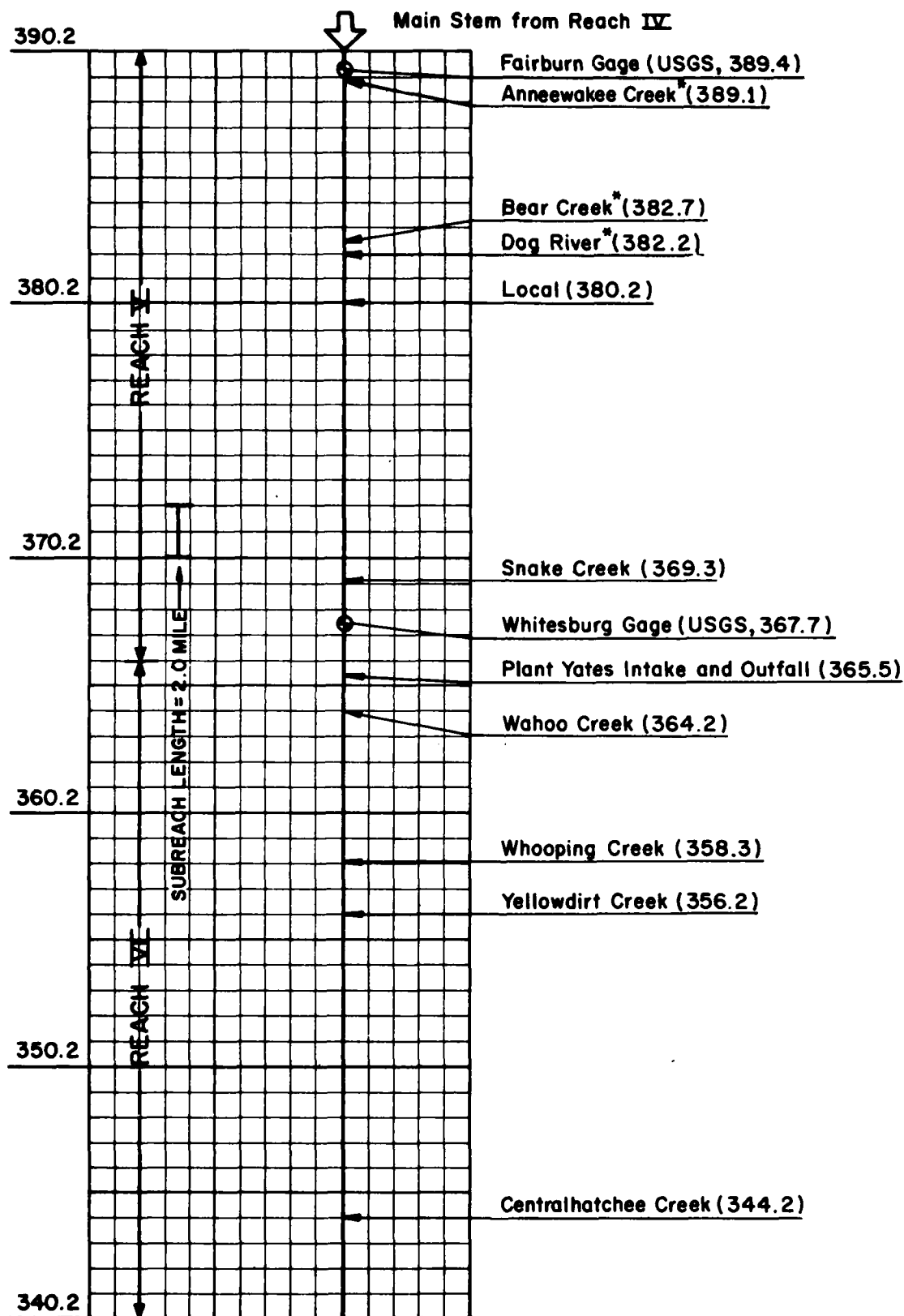


Fig. III-2d. Schematic of Chattahoochee River

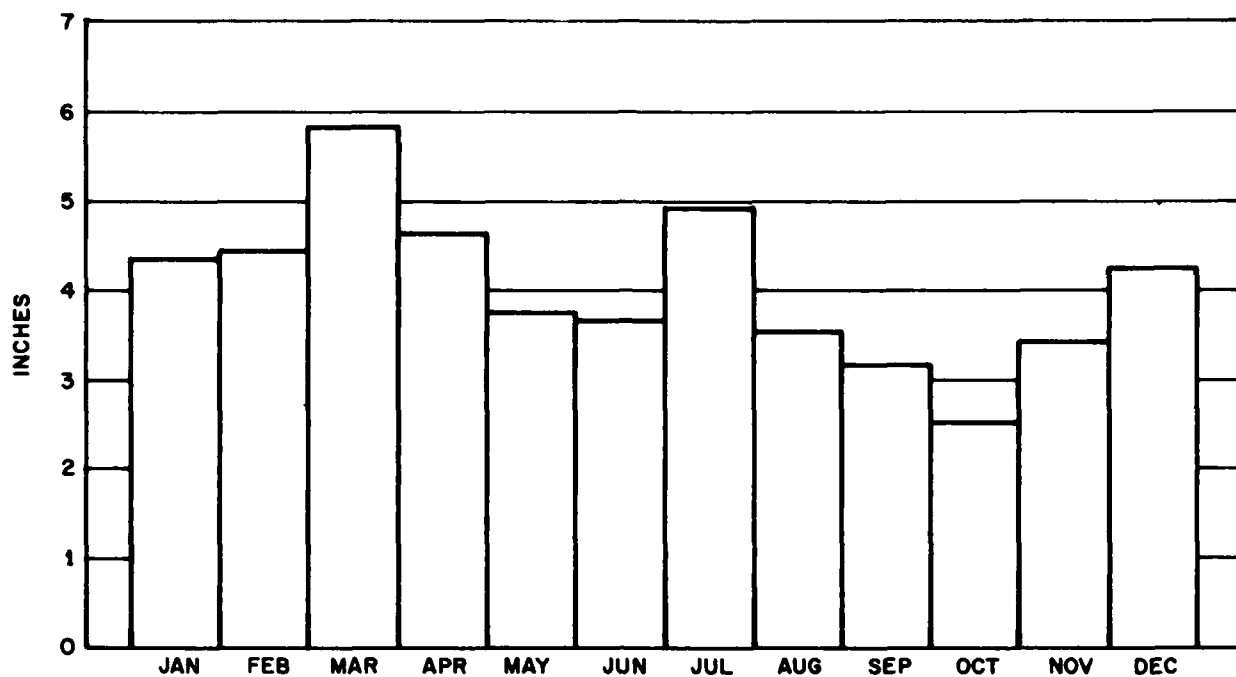


Fig. III-3. Mean Precipitation Pattern at Atlanta (1934-1974)

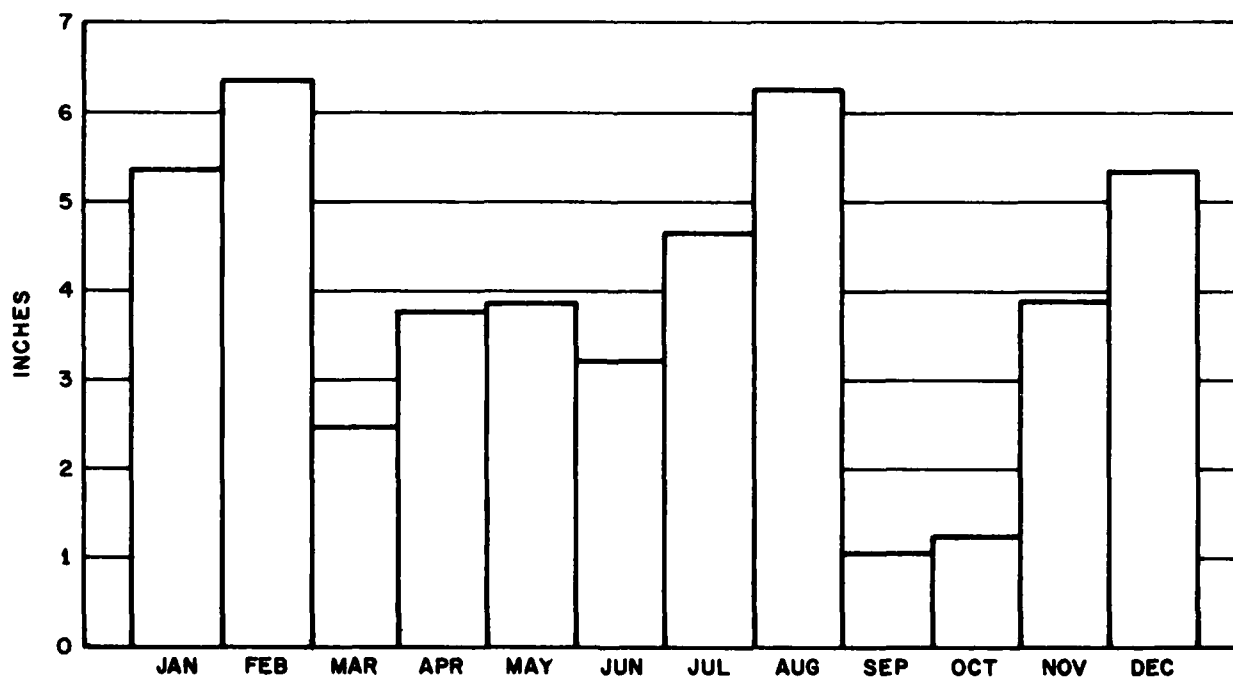


Fig. III-4. 1974 Precipitation at Atlanta

Geometrical

The river channel geometry was well documented with field surveys conducted by the Corps' Mobile District Office. The Corps' survey was performed for a Flood Plain Information Report (6) for the Chattahoochee river channel between Buford Dam and Whitesburg. The U.S. Geological Survey (USGS) has cross sections at Whitesburg and Franklin in the downstream end of the study area.

The numbering of river miles for this study starts with mile 0 being located at the mouth of the Apalachicola River, see figure I-1. The confluence of the Chattahoochee and Flint Rivers is river mile 107.6. The river miles associated with Franklin and Buford Dam (i.e., the study boundaries) are 340.2 and 456.2, respectively.

Hydrological

The Corps' Mobile District Office has excellent records of hourly streamflow data defining their total discharge from Buford Dam into the Chattahoochee River channel. They also maintain a continuous stage recorder at Norcross, 15 miles downstream from Buford. The USGS has streamgaging stations located at Paces Ferry Road (Atlanta), Fairburn and Whitesburg. Table III-1 shows the name, location and source of flow data for all inflows and withdrawals. The sources of in-stream flow data are shown in table III-2.

Water Quality

The concentrations of various pollutants and water quality parameters were available for several tributaries, and thermal power plant and municipal sewage treatment plant discharges. The name, location and source of these data are shown in table III-1. Water quality data were available for a greater number of locations than those having flow quantity data but, in general, samples were obtained at irregular intervals (i.e., approximately once or twice per month).

TABLE III-1
LOADING AND WITHDRAWAL DATA INVENTORY

<u>Tributary or Withdrawal</u>	<u>River Mile</u>	<u>Data Sources</u>	
		<u>Quantity</u>	<u>Quality</u>
<u>Reach I</u>	456.2-420.2		
Buford discharge	456.2	Mobile	Mobile/AMU
Buford Local	451.2		
Suwanee Creek	445.6		AMU
Gwinnett intake	445.5	Gwinnett Co.	
Johns Creek	436.9		
Dekalb intake	433.0	Dekalb Co.	
Chattahoochee local	432.2		
Big Creek	424.0	USGS	AMU
Willeo Creek	422.7		
<u>Reach II</u>	420.2-407.2		
Cobb intake	418.1	Cobb Co.	
Sope Creek	416.2		AMU
Long Island Cr.	412.2		AMU
Potterwood Cr.	411.9		AMU
Atlanta intake	408.2	AMU	
Beachtree Cr.	408.1	USGS	AMU, USGS
Clayton STP	408.0	EPD	EPD
Chattahoochee 2. STP (Cobb Co.)	408.0	EPD	EPD

TABLE III-1 (cont'd)
LOADING AND WITHDRAWAL DATA INVENTORY

<u>Tributary or Withdrawal</u>	<u>River Mile</u>	<u>Data Sources</u>	
		<u>Quantity</u>	<u>Quality</u>
<u>Reach III</u>	407.2-400.2		
Atkinson-McDonough Intake and Discharge	407.0	GP	GP
Proctor Creek	405.0		
Nickajack Creek	403.2		
Sandy Creek	403.1		
Sandy Creek STP	403.1	EPD	EPD
So. Cobb STP	401.3	EPD	EPD
Fulco STP	400.6	EPD	EPD
 <u>Reach IV</u>	 400.2-390.2		
Utoy Creek	399.0		
Utoy Creek STP	399.0	EPD	EPD
Sweetwater Creek	396.2	USGS	USGS
Camp Creek	391.2		
Camp Creek STP	391.2	EPD	EPD
 <u>Reach V</u>	 390.2-366.2		
Anneewakee Creek	389.1		
Bear Creek	382.7		
Dog River	382.2		USGS/AWW
Local	380.2		
Snake Creek	369.3	USGS	

TABLE III-1 (cont'd)
LOADING AND WITHDRAWAL DATA INVENTORY

<u>Tributary or Withdrawal</u>	<u>River Mile</u>	<u>Data Sources</u>	
		<u>Quantity</u>	<u>Quality</u>
<u>Reach VI</u>	366.2-340.2		
Yates intake and discharge	365.5	GP	GP
Wahoo Creek	364.2		
Whooping Creek	358.3		
Yellowdirt Creek	356.2		
Centralhatchee Creek	344.2		

Sources: AWW - Atlanta Water Works: Grab Samples of Temperature, DO, BOD, HN3, NO3-N, PO4, TDS, pH, alkalinity, coliform and others.

EPD - NPDES permits for STP: Mostly BOD, some temperature, DO, NO3-N, pH and others and discharge.

GP - Georgia Power: Thermal plant operating specs, capacity, heat rejection, flow for units. These data were obtained by GP contract with Dr. John Edinger [7].

USGS- Geologic Survey: Grab samples of temperature, DO, BOD, NH3-N, total N, total P, pH, alkalinity, coliform and others. Hourly discharge for study period.

Mobile - Corps' Mobile District: Turbine Q and monitor of Temperature, DO, pH and others.

Gwinnett Co. - Intake withdrawal, mean monthly Q.

Dekalb Co. - Intake withdrawal, mean monthly Q.

Cobb Co. - Intake withdrawal, mean monthly Q.

TABLE III-2. IN-STREAM DATA INVENTORY

<u>Location</u>	<u>River Mile</u>	<u>Data Sources</u>	
		<u>Quantity</u>	<u>Quality</u>
<u>Reach I</u>	456.2-420.2		
Below Buford	455.2		GP
Buford Gage	453.4	USGS	
Suwanee Creek	445.6		AWW
Gwinnett Intake	445.5		AWW/EPD
Norcross Gage (State Hwy. 141)	438.3	Mobile	GP
Dekalb Intake	433.0		AWW/EPD
Big Creek (State Hwy. 19)	424.9		AWW/GP
Morgan Falls	420.2	GP (stage)	GP/AWW
<u>Reach II</u>	420.2-407.2		
Cobb Intake (Johnson Ferry Rd.)	418.1		GP/AWW/EPD
Powers Ferry Rd. (Akers Mill Road)	413.8		AWW/GP
U.S. Highway 41	411.1		AWW/GP
Atlanta Gage (Paces Ferry)	410.7	USGS	GP/AWW/EPD
Atlanta Water Works Intake	408.2		AWW/EPD
State Highway 3 (Marietta Blvd.)	408.0		GP

TABLE III-2. IN-STREAM DATA INVENTORY (cont'd)

<u>Location</u>	<u>River Mile</u>	<u>Data Sources</u>	
		<u>Quantity</u>	<u>Quality</u>
<u>Reach III</u>	407.2-400.2		
Atkinson-McDonough Plant	407.0		GP
State Highway 280	406.1		GP
U.S. Highway 285	405.1		EPD
State Highway 139 (Gordon Road)	402.0		EPD/GP
<u>Reach IV</u>	400.2-390.2		
State Highway 166	393.1		EPD/GP
<u>Reach V</u>	390.2-366.2		
Fairburn Gage (State Highway 92)	389.4	USGS	EPD/GP
Capps Ferry Road	378.8		EPD/GP
Whitesburg (State Highway 16 & U.S. Highway 27A)	367.7	USGS	EPD/GP
<u>Reach VI</u>	366.2-340.2		
Plant Yates	365.5		GP
Franklin (U.S. Highway 27)	343.5		EPD/GP

Sources: USGS - Geological Survey, Q and grab samples of temp, DO, BOD, NH3-N, total N, total P, pH, alkalinity, coliform and others.
 EPD - State Environmental Protection Division, Q and grab samples of temp and DO regularly, and BOD, NH3, etc., irregularly.
 GP - Georgia Power, temp and DO. These data were obtained by GP contract with Dr. John Edinger [7].
 AWW - Atlanta Water Works, grab samples of temp, BOD, DO, NH3, NO3-N, PO4, TDS, pH, alkalinity, coliform and others.
 Mobile - Corps' Mobile District, continuous stage.

In addition to having background level water quality data available for several tributaries, an HEC computer program, STORM, (5) was used to evaluate the water quality concentrations due to storm runoff for all the tributaries shown in table III-1. The results from STORM include concentrations for biochemical oxygen demand (BOD), total inorganic nitrogen, total phosphate, and suspended solids.

In-stream water quality data were also available for the Chattahoochee River at several gage sites from several sources as shown in table III-2. This data is important to the study for purposes of calibrating the model to existing conditions in contrast to the required input data from tributaries, sewage treatment plants and withdrawals.

IV. MODEL FORMULATION

General

A comprehensive ecological simulation model for aquatic environments (ECO model) was developed for the Office of Water Resources Research by Drs. Chen and Orlob in December 1972 (8). That same year the Corps' Hydrologic Engineering Center (HEC) contracted with Dr. Orlob's firm, Water Resources Engineers, to combine their reservoir and river ecologic simulation models into one water resource system model. This new model is capable of analyzing up to 18 different physical, chemical and biological water quality parameters in any river or reservoir or any river-reservoir system. A preprocessor was developed by the HEC for simplifying the preparation of input data. This package of programs is called the "Water Quality for River-Reservoir Systems" (WQRRS) model (1).

The original river routines analyze dynamic water quality conditions but were developed to handle only steady-state hydraulic conditions (i.e., no channel routing). In September 1974, the HEC contracted with Resource Management Associates to add streamflow routing capability to the WQRRS model (9). The model is being developed to include the capability for routing streamflows using either the St. Venant equations, Kinematic Wave, Muskingum, or Modified Puls routing methods. The model can also be used in a steady flow mode with either backwater analysis or a stage-flow relationship specified by input data.

Structure*

The WQRRS model is a modular set of mathematical computer programs developed specifically for the dynamic solution of water quality analysis of river and reservoir systems. The programs making up the total package are designed to interface data and results through magnetic tape, disk files, or punched cards. Three separate but integrable modules exist within the WQRRS model. The stream analysis programs consist

*Portions of this material were excerpted from reference 9.

of a dynamic flow routing module, a dynamic stream water quality module, and a preprocessor program for each module. The reservoir analysis programs include the reservoir water quality module and a preprocessor program.

The system analysis procedure for river basin water quality modeling can be performed with the reservoir results being used as input to the stream module or vice versa. Each module is also fully capable of running in a stand alone mode.

Many of the same subroutine names, variable names, common blocks and computer logic are used throughout the three modules to help the user feel more comfortable when working with the various modules. Figures IV-1, IV-2 and IV-3 show the computational sequence of the reservoir and stream modules. An important feature to note for each of the three modules contained in the system is that the input data for every program is collected, prepared, synchronized and integrated into the correct sequence and format for the respective module via a preprocessor. Since the WQRRS model is described in detail in reference 1, the model will not be described further in this report.

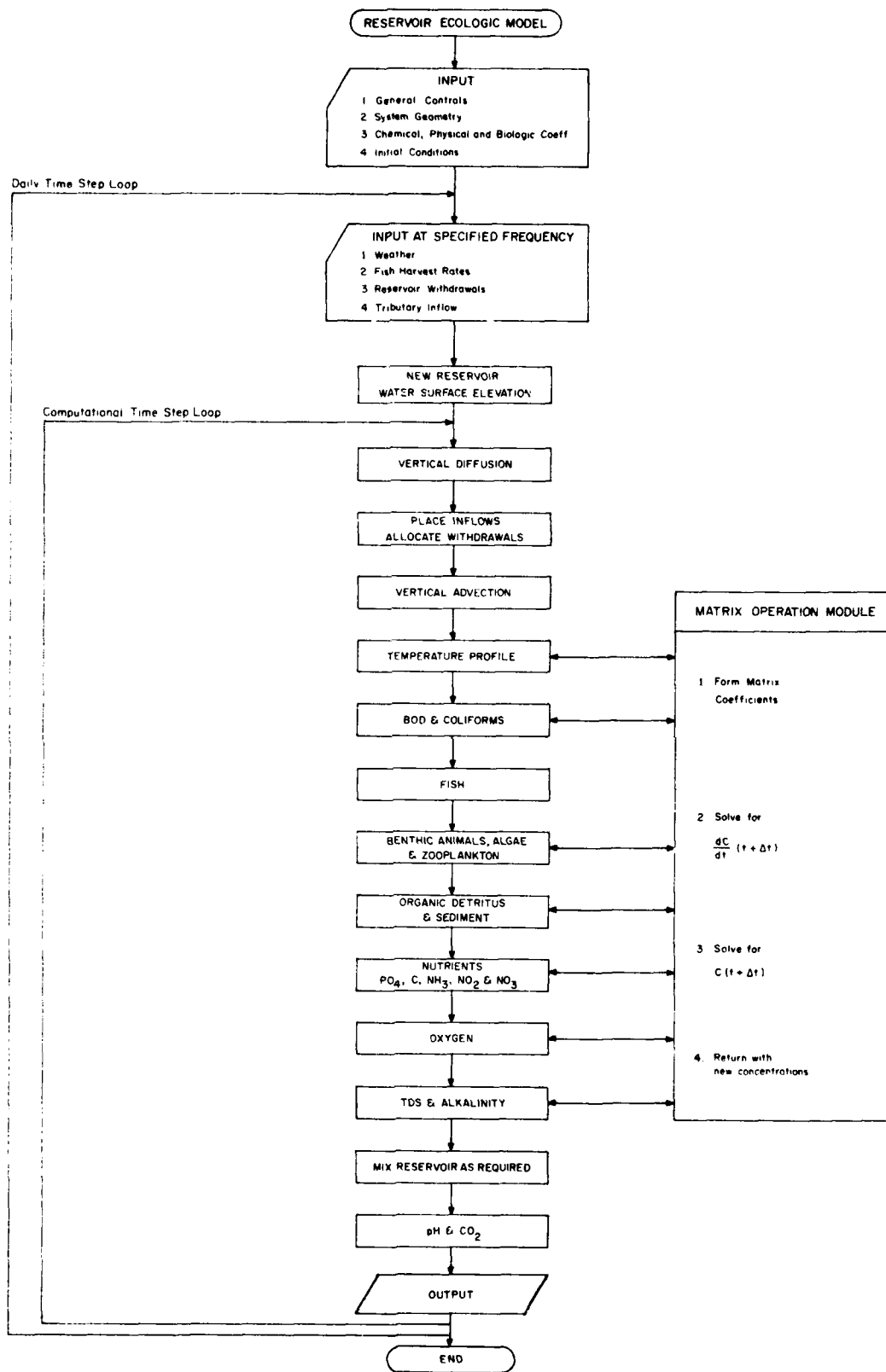


Figure IV-1 COMPUTATIONAL SEQUENCE - RESERVOIR SECTION

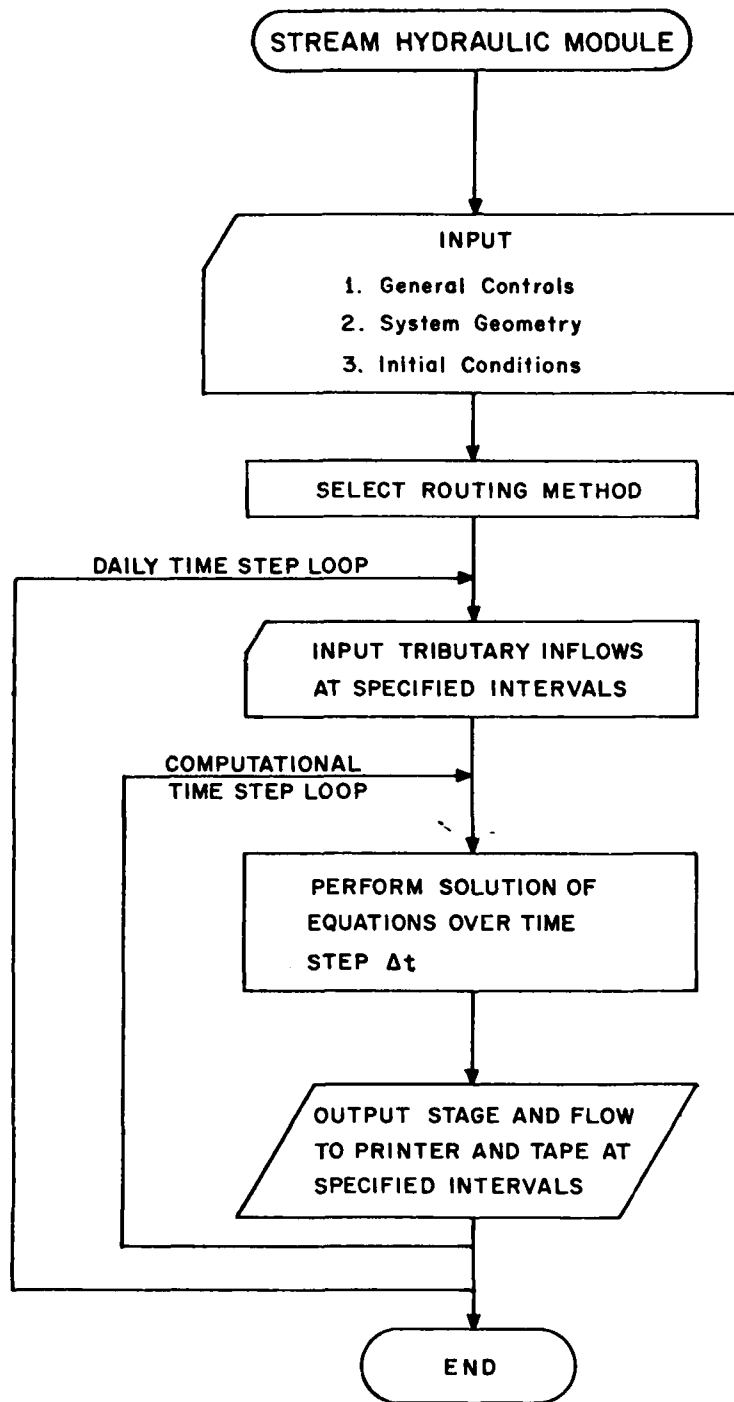


Figure IV -2 COMPUTATION SEQUENCE - STREAM HYDRAULIC MODULE

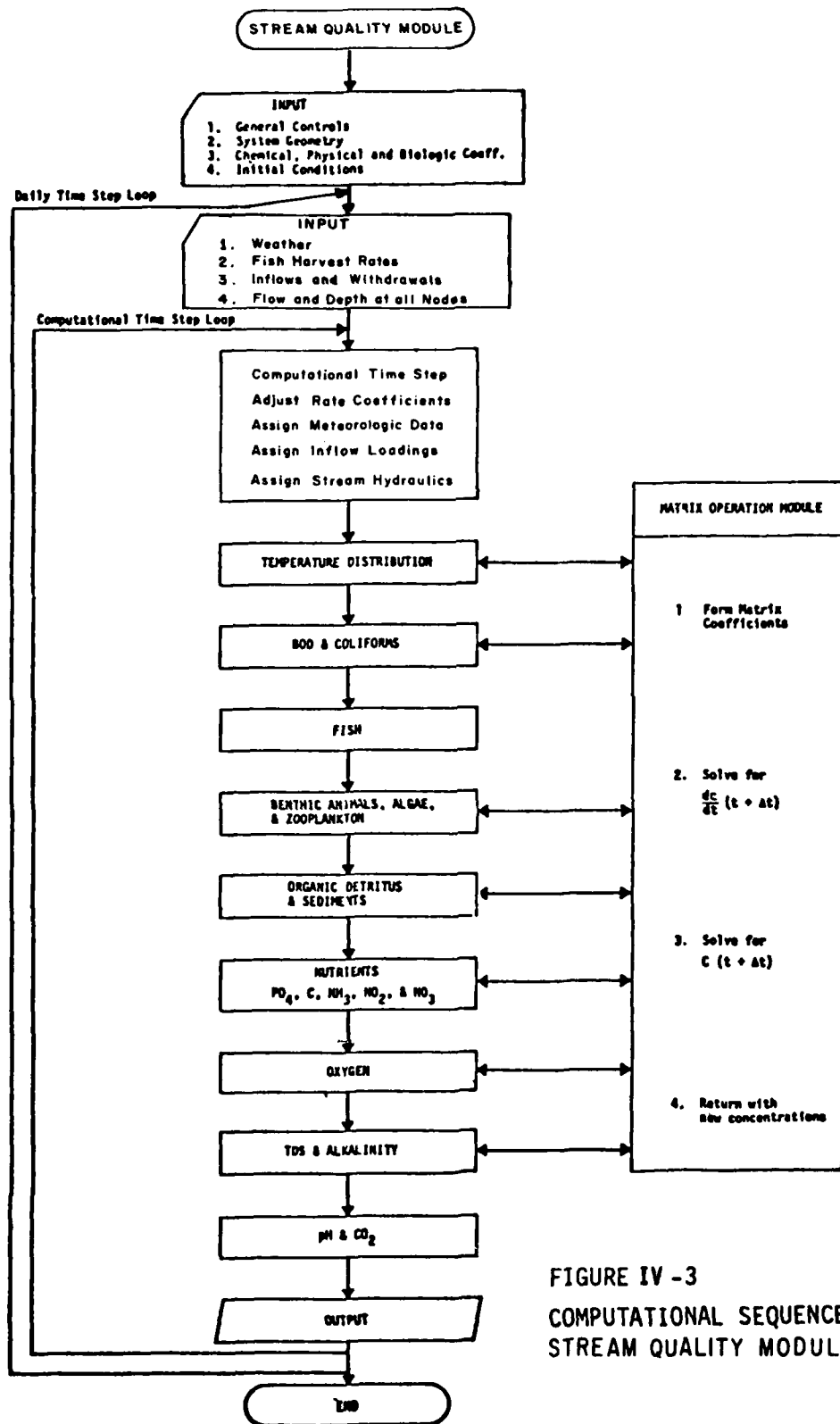


FIGURE IV -3
COMPUTATIONAL SEQUENCE—
STREAM QUALITY MODULE

V. APPLICATION TO CHATTAHOOCHEE RIVER

General

Previous chapters in the report have attempted to familiarize the reader with the physical system of the Chattahoochee River, the general availability of required input data and the historical development and formulation of the dynamic WQRRS model.

The purposes of this chapter are to document the specific methodology applied to the study of this river including unique manipulations of the model and the required input data. It is intended to provide a skeleton procedure to be used on future studies with a similar objective but it is anticipated that changes in the procedure may be required for unique characteristics or objectives of another study.

System Simulation

The WQRRS model has the capability to evaluate water quality conditions in any aerobic river-reservoir system which can be adequately represented by a one dimensional model. This particular study only uses the river routines of the model but interest has been expressed in the eventual additional analysis of either West Point, Buford, or both impoundments. Since these reservoirs have anaerobic hypolimnions, the reservoir routines need expansion to include capability for analysis of anaerobic reservoir conditions. This expansion is being initiated.

Figure V-1 shows the entire river-reservoir system including Lake Sidney Lanier (Buford Dam), West Point Reservoir and a major tributary system as an example for discussion purposes. To demonstrate the steps involved in a general river-reservoir system analysis the following tasks can be outlined:

- (1) Simulate Lake Sidney Lanier using the WQRRS reservoir routines and evaluate the quantity and quality of release from Buford Dam.
- (2) Simulate the Chattahoochee River from Buford Dam to the Peachtree Creek confluence using the dynamic WQRRS river routines. Input to this

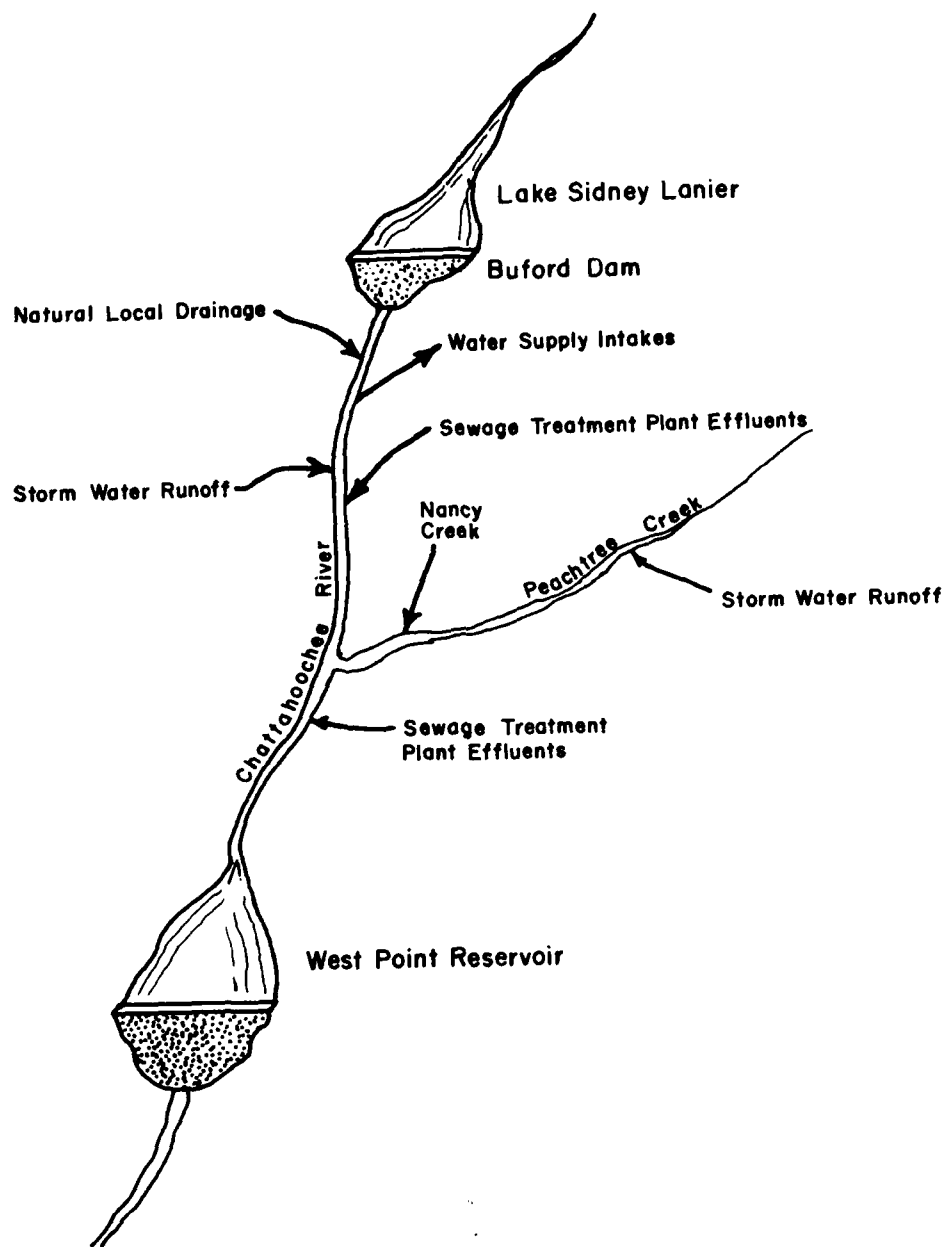


Fig. V-1 Typical River-Reservoir System

simulation includes Buford Dam releases, water supply intake quantities, natural local drainage, storm water runoff, and sewage treatment plant effluents.

(3) Simulate the Peachtree Creek system using the WQRRS river routines. Inputs to this simulation are similar to inputs described in task 2.

(4) The mass balance analyses required at the Chattahoochee-Peachtree confluence are computed automatically as the input loading conditions are specified for the Chattahoochee River analysis.

(5) Simulate from the Chattahoochee-Peachtree confluence to the headwater of West Point using the WQRRS river routines. Inputs to this simulation can include any of the previously described inputs in task 2.

(6) Simulate West Point Reservoir using the WQRRS reservoir routine and the resultant inflow from task 5.

The present study, unlike the preceding example, does not include analysis of either Lake Sidney Lanier or West Point Reservoir or of any tributary systems. It uses known or estimated inputs at Buford Dam and for all tributaries, gaged or ungaged.

Data Sources

The WQRRS model requires data on meteorology, inflow quantity and quality, and stream geometry and hydraulics. The task of locating the required input data can be awesome and involve a considerable portion of the entire time allocated for the study. This task can be greatly simplified by beginning with a review of the USGS's Catalog of Information on Water Data and the associated maps (10). While this step can prove to be invaluable in locating most of the sources of available input data for quantity and quality of flow the use of this publication does not eliminate the need to search for additional data. It is often found that the information in this report is not entirely correct and up-to-date. The local sources of data required for this specific analysis have been tabulated in appendix A.

Study Period

The selection of the study period usually follows the task of understanding the local study area and making contacts with sources of local data. Three significant items were learned from the local data source contacts: (1) during the period 29 July to 21 December 1974 the EPD collected in-stream water quality data every 2 days, (2) during July 1974 the R.M. Clayton sewage treatment plant was completed and put on-line, and (3) on 28 October 1974 Buford releases were increased significantly over normal conditions to transfer water to the newly completed West Point impoundment. Because the study objectives required comparison with existing conditions and because good verification data at regular intervals was needed, the study period between 1 August and 27 October 1974 was selected for the existing condition test period.

Meteorological

A magnetic tape of weather data for the Atlanta Airport Weather Station was ordered from the Weather Service office in Asheville, North Carolina. The request included the station name, period of interest, magnetic tape format and tape specification (i.e., density, parity, number of tracks, etc.). An example of this request is included in appendix B.

The tape was ordered for the period from January 1965 through December 1974 because there is a fix cost for up to 10 years of data at one station. Having ordered the last 10 years of records allows for potential future studies of other periods of record.

The tape format ordered is called "Card Deck 144" (CD-144). This format includes all the required weather parameters and is one of the least expensive methods of transferring the data from the Weather Service. The cost associated with either of these formats is usually \$70 per 10 station-years. A manual describing the tape format for CD-144 is included in appendix B.

This cost estimate only applies to orders for data that have already been processed. If a recent month is requested, the cost is usually \$25 per station-month.

The HEC has a utility program which transfers the weather data from the CD-144 format to the format required by the WQRRS model. This utility program makes the weather data preparation the easiest and least expensive of all tasks to perform.

The input weather data update interval used for this analysis was every three hours every day. This is the shortest update interval available. It provides for dynamic variations in meteorological conditions during each day of the study period.

The "Local Climatological Data" is shown in appendix B.

Geometrical

The Mobile District of the Corps of Engineers used the HEC-2, Water Surface Profiles, computer program (3) for analysis of the backwater profile in the Chattahoochee River from Buford Dam to Whitesburg for their flood plain information study (6). Several years ago, the District obtained, by field survey, the input cross section data required by HEC-2 and coded the data for use in the model.

At HEC's request, the District sent punched cards containing data on several hundred cross sections including numerous bridge sections. The cross section data was in HEC-2 format (i.e., tables of station-elevation coordinate pairs defining each section). The sections described by the data were located at irregular intervals along the channel (generally at transitions and controls). Instead of using cross section data, the WQRRS model requires tables of geometric and hydraulic elements.

The cross section data were transformed to the required WQRRS input data by a modified version of the GEDA, Geometrical Elements for Cross Section Coordinates, computer program (4), which is capable of developing tables of hydraulic properties at intervals of interest using the HEC-2 formatted cross section data. The GEDA modifications used for this project consisted of logic to obtain the best "representative" hydraulic properties based on weighting the hydraulic properties of the input sections by distances between those sections. HEC-2 bridge sections were first removed from the input deck be-

cause they were considered unrepresentative of the stream geometry.

Cross section data downstream of Whitesburg were non-existent except for a section at Franklin. The Whitesburg and Franklin sections were input to GEDA and "representative" sections were interpolated for developing the hydraulic properties of each subreach.

The weighting computation for the "representative" sections can be demonstrated best by use of an example. Figure V-2 shows an example segment of the Chattahoochee River including locations of measured cross section data, 1-mile subreach lengths and example calculation zones for the purposes of discussion.

The calculation zone at mile 3 requires computations quite typical of the majority of the subreaches between Buford Dam and Whitesburg. In this zone, the upstream end (i.e., point a) has a measured cross section exactly at the zone boundary but at the downstream end (i.e., point d) a section is interpolated based on the two closest cross sections (i.e., point c and e) weighted according to their distance from the boundary.

The next step is to calculate the hydraulic properties at a section at mile 3 by the following equation:

$$\begin{aligned} X_3 = & 1/2(\text{distance a-b}) X_a + (1/2(\text{distance a-b}) \\ & + 1/2(\text{distance b-c})) X_b + (1/2(\text{distance b-c}) \\ & + 1/2(\text{distance c-d})) X_c + 1/2(\text{distance c-d}) X_d \end{aligned} \quad \text{V-1}$$

where: X_i = cross section properties at point i.

The WQRRS model will interpolate between this section at mile 3 and a similarly calculated section at mile 4 for the hydraulic properties for each subreach or at each node.

The calculation zone for mile 0 differs from that at mile 3 because only cross sections in the downstream direction are relevant to the calculation. Calculations for a section at mile 7 are obviously similarly affected.

The calculation zone for mile 6 is similar to the actual reach from Whitesburg to Franklin. When the only available (known or interpolated) cross sections in a computation zone are located at the boundaries, the

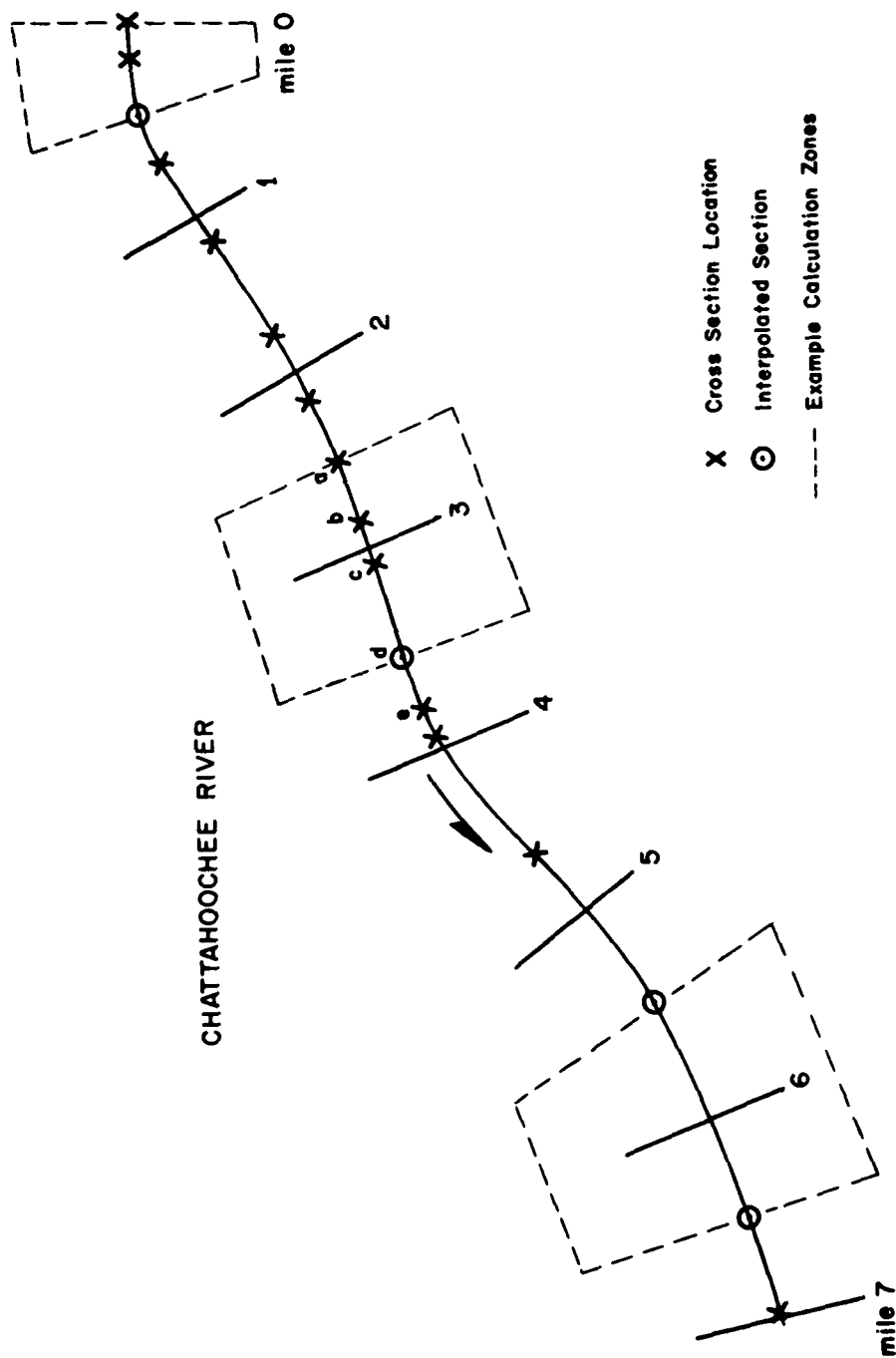


Fig. V-2. Example Cross Section Manipulation

weighting computation (i.e., equation V-1) is not necessary and the nodal sections are obtained by linear interpolation.

The development of the necessary geometrical data for the WQRRS model was a minor task requiring approximately 1 man-week once the GEDA program modifications were completed. The short amount of time required to prepare this input data was due to the modified GEDA program and the Mobile District supplying the Chattahoochee River cross sections.

Hydrology and Hydraulics

Development of the hydrologic input data was a major task. As shown in table III-1, many of the major tributaries along the Chattahoochee River are ungaged. These flows had to be estimated as well as flows from all local drainage.

Analysis of the hydrology began by obtaining the study period flow records at Atlanta, Fairburn and Whitesburg, the stage records and rating curve for Norcross, the discharge records at Buford Dam, and the power generation and operating head records at Morgan Falls.

The Norcross stages were converted to flow using the Corps' stage-discharge rating curve. Morgan Falls discharge through the turbines can be estimated from the records on power generation with the following equation:

$$Q = P / (CeHt)$$

V-2

where

Q = turbine discharge in cfs

P = power generated in kilowatt hours

C = conversion constant = .08464

e = plant efficiency = .72

H = effective head = pool elevation - tailwater elevation -
estimated head loss of four feet

t = computation interval = 1 hour

To determine the flow for the ungaged tributaries, a flow balance was made by subtracting all flows of gaged tributaries and the next most upstream gaged station in the mainstem from that of a downstream mainstem gage. The following equation is used to proportion the unbalanced flow to each ungaged tributary in accordance with the relative magnitude of its drainage area.

$$V_i = V_T(DA_i/DA_T) \quad V-3$$

where

V_i = Volume of flow for ungaged tributary i

V_T = Volume unaccounted for by gaged data

DA_i = Drainage area of the ungaged tributary i

DA_T = Drainage area unaccounted for between 2 mainstem gaging stations.

After calculating V_i for each ungaged tributary between 2 mainstem gages, any remaining volume was defined as local drainage.

For a dynamic flow routing, an inflow hydrograph is needed in lieu of the volume of flow. The study developed pattern hydrographs either from a nearby gaged tributary or by combining hydrographs from several gaged tributaries. These patterns were then used to index the shape of the hydrographs developed for the nearby ungaged tributaries. Five pattern hydrographs were developed using the USGS streamflow records for four stations as shown in table V-1.

TABLE V-1. PATTERN HYDROGRAPH DEVELOPMENT

<u>Pattern</u>	<u>USGS Station #</u>	<u>USGS Station Name</u>	<u>Weighting Factor</u>
A	5700	Big Cr. nr. Alpharetta	1.0
B	6300	Peachtree Cr. at Atlanta	1.0
C	6300	Peachtree Cr. at Atlanta	.33
	7000	Sweetwater Cr. nr. Austell	.66
D	7000	Sweetwater Cr. nr. Austell	.33
	7500	Snake Cr. nr. Whitesburg	.66
E	7500	Snake Cr. nr. Whitesburg	1.0

Table V-1 also shows the weight applied to each station's hydrograph ordinates to calculate the pattern ordinates. The volume from each ungaged tributary or local drainage was then distributed in time according to the adopted pattern hydrograph listed in table V-2.

TABLE V-2. PATTERN HYDROGRAPH APPLICATION

<u>Tributary</u>	<u>Pattern Used</u>
Buford Local	A
Suwanee Cr.	A
Johns Cr.	A
Chattahoochee Local	A
Willeo Creek	A
Sope Creek	B
Long Island Cr.	B
Rottenwood Cr.	B
Proctor Cr.	C
Nickajack Cr.	C
Sandy Cr.	C
Utoy Cr.	C
Camp Cr.	C
Anneewakee Cr.	D
Bear Cr.	D
Dog Cr.	D
Local	D
Wahoo Cr.	E
Whooping Cr.	E
Yellowdirt Cr.	E
Centralhatchee Cr.	E

Once the ungaged tributaries and local drainage flow rates had been estimated, HEC-1, Flood Hydrograph Package, computer program (2) was applied to develop optimized streamflow routing criteria (i.e., K and x) for the Muskingum method. The optimized values were developed to force

reproduction of a hydrograph at a downstream gage with a known upstream inflow and known or estimated tributary and local inflows.

The optimized values of K and x between gages still had to be interpolated to route between each water quality control point (i.e., every inflow or withdrawal). The optimized x value (i.e., attenuation) was held constant between each pair of mainstem stream gages and the optimized K (i.e., travel time in hours) value was interpolated based on length of for instantaneous translation over a short channel length, then an x of .5 must be used to avoid any attenuation of the peak. The derived routing criteria is shown in table V-3.

The development of the hydrology and hydraulics for this project required approximately 2.5 man-months of effort. This task should be considered to be one of the most important and time consuming tasks during the study.

Water Quality

General

The initial water quality profile for each reach of the Chattahoochee River was assumed to have the same magnitude for each parameter (except algae) as the 1 August inflow at the upstream end of the reach (e.g., reach I profile was obtained from 1 August Buford discharge quality). This commonly used assumption is quite satisfactory for this study since the initial conditions established in this manner are associated with water which is transported out of the study area in six days or less.

The algae profile was based on observed chlorophyll A data collected by Water Resources Engineers (11). The WRE data between Buford Dam and Franklin are shown in figure V-3.

The only initial profile parameters which cannot be identified by the 1 August inflow concentration are the fish, sediment and benthic animals since these parameters are not transported in the inflow.

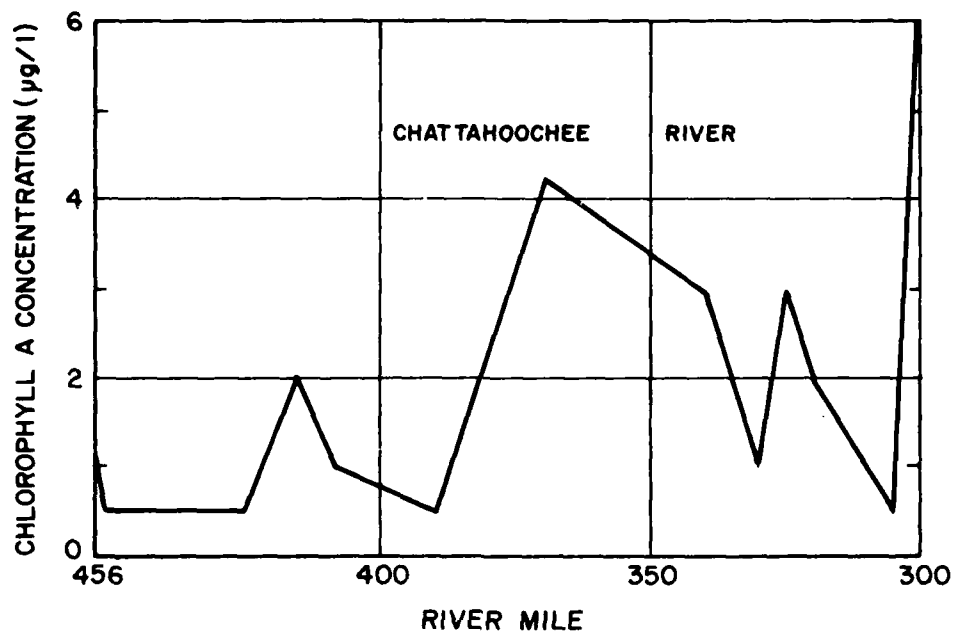


Fig. V-3. Observed Chlorophyll A Stream Profile

TABLE V-3
ROUTING COEFFICIENTS

REACH I

<u>From River Mile</u>	<u>To River Mile</u>	<u>Incremental Miles</u>	<u>No. of Steps</u>	<u>K (hrs)</u>	<u>x —</u>
456.2	451.2	5.0	2	.94	.01
451.2	445.6	5.6	2	1.00	.01
445.6	445.5	.1	1	0	.50
445.5	438.3	7.2	2	1.50	.01
438.3	436.8	1.5	1	0	.50
436.8	433.0	3.8	2	.93	.01
433.0	432.2	.8	1	0	.50
432.2	424.9	7.3	2	1.40	.01
424.9	422.7	2.2	1	.80	.01
422.7	420.2	2.5	1	.90	.01

REACH II

<u>From River Mile</u>	<u>To River Mile</u>	<u>Incremental Miles</u>	<u>No. of Steps</u>	<u>K (hrs)</u>	<u>x —</u>
420.2	418.1	2.1	1	.5	.04
418.1	416.2	1.9	1	.5	.04
416.2	412.2	4.0	2	.5	.04
412.2	411.9	.3	1	0	.50
411.9	410.7	1.2	1	.5	.04
410.7	408.2	2.5	1	1.2	.05
408.2	408.1	.1	1	0	.50
408.1	408.0	.1	1	0	.50
408.0	407.2	.8	1	0	.50

TABLE V-3 (cont'd)
ROUTING COEFFICIENTS

REACH III

<u>From River Mile</u>	<u>To River Mile</u>	<u>Incremental Miles</u>	<u>No. of Steps</u>	<u>K (hrs)</u>	<u>x —</u>
407.2	407.0	.2	1	0	.50
407.0	405.0	2.0	1	1.30	.05
405.0	403.2	1.8	1	.83	.05
403.2	403.1	.1	1	0	.50
403.1	401.3	1.8	1	1.10	.05
401.3	400.6	.7	1	0	.50
400.6	400.2	.4	1	0	.50

REACH IV

<u>From River Mile</u>	<u>To River Mile</u>	<u>Incremental Miles</u>	<u>No. of Steps</u>	<u>K (hrs)</u>	<u>x —</u>
400.2	399.0	1.2	1	.70	.05
399.0	396.2	2.8	1	1.20	.05
396.2	391.2	5.0	2	1.10	.05
391.2	390.2	1.0	1	.78	.05

TABLE V-3 (cont'd)
ROUTING COEFFICIENTS

REACH V

<u>From River Mile</u>	<u>To River Mile</u>	<u>Incremental Miles</u>	<u>No. of Steps</u>	<u>K (hrs)</u>	<u>x</u> —
390.2	389.4	.8	1	0	.50
389.4	389.1	.3	1	0	.50
389.1	382.7	6.4	3	.91	.07
382.7	383.2	.5	1	0	.50
382.2	380.2	2.0	1	1.00	.07
380.2	369.3	10.9	5	.89	.07
369.3	367.7	1.6	1	.65	.07
367.7	366.2	1.5	1	.73	.07

REACH VI

<u>From River Mile</u>	<u>To River Mile</u>	<u>Incremental Miles</u>	<u>No. of Steps</u>	<u>K (hrs)</u>	<u>x</u> —
366.2	365.5	.7	1	0	.50
365.5	364.2	1.3	1	.69	.07
364.2	358.3	5.9	3	.80	.07
358.3	356.2	2.1	1	.85	.07
356.2	344.2	12.0	6	.81	.07
344.2	340.2	4.0	2	.81	.07

Due to the lack of overall data on fish, benthic animals, zooplankton, and algae, the lack of expected changes in their concentrations during a short period of computation, and the concern of many biologists of the ability to accurately predict changes in concentrations of these biota, it was decided that for the purposes of this study their concentrations would be held constant. To estimate their respective concentrations, a field inspection trip was made. Based on the observations in the field and consultation with field biologists, a set of parameter estimates were made. A report by Dr. Carl W. Chen establishing these values is shown in appendix C.

It was estimated that the sediment for reaches I and II should be 10 gm/sq. meter between Buford Dam and Morgan Falls backwater and 150-200 gm/sq. meter in Morgan Falls impoundment. Sediment in reaches III-VI should be 20 gm/sq. meter.

The benthic animals should range between 200-1000 mg/sq. meter for all reaches. The fish standing crop should be about 1.41 kg/km for cold water fish, .06 kg/km for warm water fish and .08 kg/km for benthos feeder fish above the location of the first sewage treatment plant outfall. Below the input of sewage treated effluents the cold, warm, and benthos feeder fish biomass should be .03, .28 and .28 kg/km respectively.

Input requirements for the fish harvest, the algae and zooplankton concentration in tributaries and several biological system coefficients were not needed in this study.

Base Flow

The water quality data for each load point have been tabulated in appendix D. These data are average values for the study period based on measurements at irregular intervals by agencies documented in table III-1. They were used as input to the model to described a base loading condition. The temperature of the baseflow for ungaged tributaries was assumed to be equal to the mean daily air temperature minus 3°F. This assumption is based on the graphical relationship shown in figure V-4.

LEGEND:

- Average daily air temperature
- ▲ Grab sample trib temps from AWW data for:
Suwanee Cr., Big Creek, Marsh Cr., Sope Cr.,
Rottenwood Cr., Peachtree Cr.

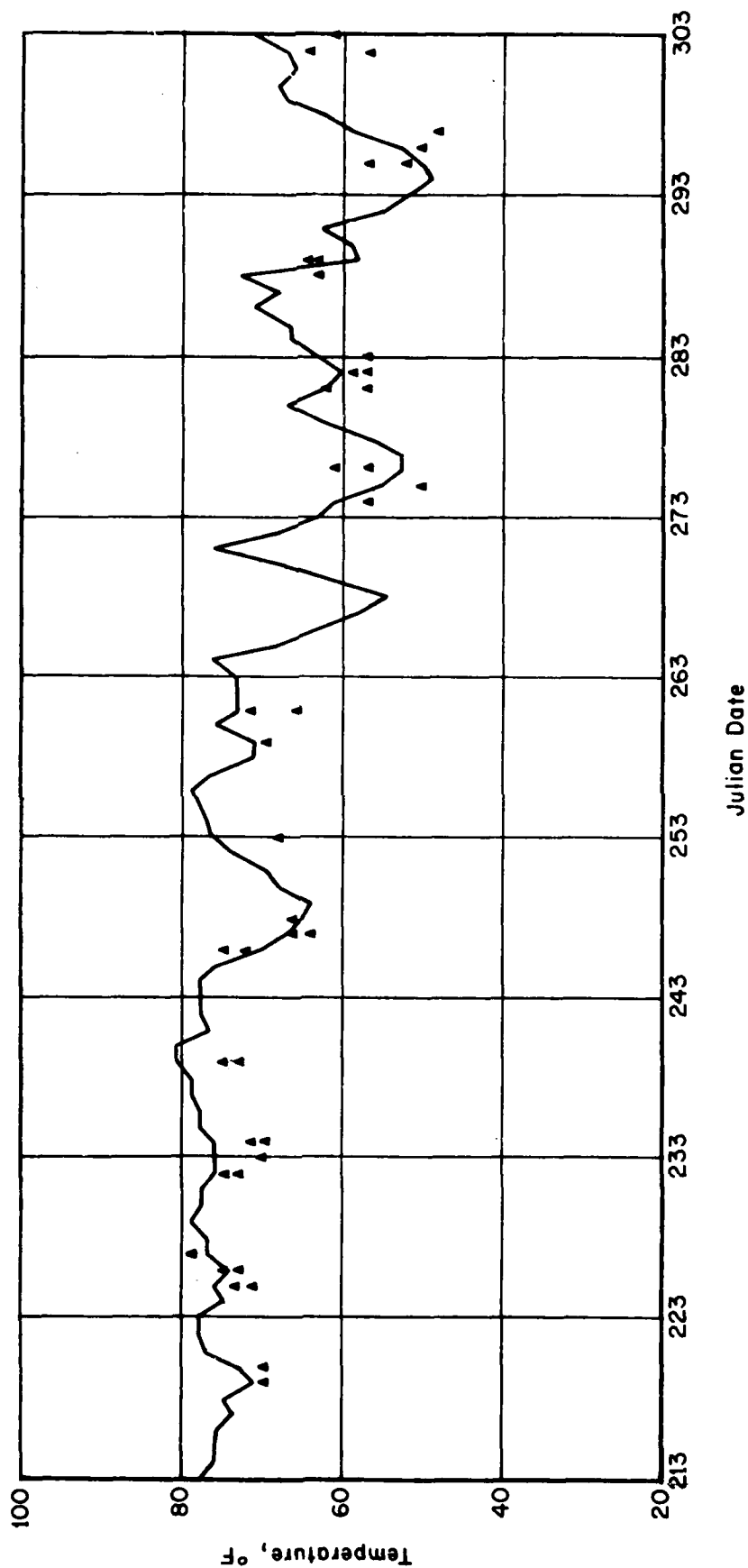


Figure V-4. AIR - WATER TEMPERATURE RELATIONSHIP

Storm

The base flow quality for tributaries was modified to include the quality of storm water runoff by using analytical results from the computer program, Urban Storm Water Runoff, STORM (5).*

The output from STORM included concentrations of suspended solids (SS), biochemical oxygen demand (BOD), total inorganic nitrogen (N) and total phosphate (PO4) for direct runoff events (i.e., not including base flow). The output for BOD and PO4 were multiplied by direct runoff and then used as mass emissions (i.e., loads or flow times concentration) for combining directly with the base flow mass emissions to calculate concentrations for the total discharge.

The actual percentage of N that is NH_3 in urban runoff samples collected at various sites in the United States is shown in table V-4 to have a range from 19 percent to 62 percent. Because of this wide range and the variability of the NH_3/N ratio from one storm to the next, a value to 50 percent or .5 was used to adjust the STORM output for N to obtain concentrations for ammonia-nitrogen (NH_3) and nitrate-nitrogen (NO_3).

The STORM output for SS was multiplied by 30 to obtain fecal coliform during storm events. Similarly SS was multiplied by .25 to obtain detritus (volatile solids). Both of these factors were selected based on the average value of the data shown in table V-4.

The temperature of storm water runoff was assumed to equal the hourly air temperature during the storm.

The direct runoff concentrations for NH_3 , NO_3 , fecal coliform, detritus and the water temperature were then mixed with the base flow concentrations using the mass balance concepts explained for the BOD and PO4 calculations.

* Details involving the calibration of STORM and analysis of storm runoff from the study area are contained in appendix E.

TABLE V-4. URBAN STORM RUNOFF*

<u>Location</u>	<u>Dates</u>	<u>NH₃/N</u>	<u>Coliform/SS</u>	<u>VS/SS</u>
Cincinnati, OH	1962-63	.60	52	.25
Castro Valley, CA	11/11/71 4/5/72	.19-.62	-	-
Oakland, CA	-	-	19	.27
Coshocton, OH	-	-	27	-
Lawrence, KY	-	-	-	.25
Atlanta, GA	1974			
Montreal Rd.		.19	51	-
Plantation Ln.		.51	7	-
Drew Valley		.26	15	-
Parkside Circle		.54	16	-

Legend:

NH ₃	= ammonia-nitrogen in mg/l.
N	= total dissolved inorganic nitrogen in mg/l.
Coliform	= fecal coliform in colonies/100 ml.
SS	= suspended solids in mg/l.
VS	= volatile solids in mg/l.

* Calculated from references 12 and 13.

All other parameters used in the WQRRS model were assumed equal to their respective base flow concentrations.

Withdrawals

The average monthly demand for municipal and industrial water supply, according to data sources shown in table III-1, is shown in appendix D. It is always assumed that the stream is laterally well mixed and that the water withdrawn contains the same dissolved constituents as the river water.

Sewage treatment Plants (STP)

Sewage treatment plant discharge and quality data for those plants having outfalls located directly on the Chattahoochee River were obtained from the EPA/EPD permit program. The average monthly values are shown in appendix D.

All the STP's shown in figure III-2 discharge directly into the Chattahoochee River. A summary of the plant's characteristics are shown in table V-5. Those STP's discharging into the tributaries were considered to be tributary flow and no separation was attempted.

Combined Sewer Overflows (CSO)

No attempt was made to specifically distinguish CSO's. Their contribution during dry weather is considered in the STP discharge analysis and the extra contribution to the river during storm periods was analyzed using STORM. Since quality data for the CSO's was not available at the loading point to the Chattahoochee River and analysis of tributaries to the mainstem was beyond the scope of this study, this superposition procedure was the best remaining approach.

Biochemical Oxygen Demand (BOD)

The BOD data from all sources were corrected from a total five-day BOD to a dissolved carbonaceous 5-day BOD required by the model by the following equation:

TABLE V -5. SEWAGE TREATMENT PLANT CHARACTERISTICS

Plant	Mean Discharge mgd	cfs	# of bypass points	# of over- flow points	Type of collect- or system	Ind. waste treated (mgd)	Type of Treatment	Other
RM Clayton Plant (R.M. 408.0)	47.6	74	2	5	BSC	0	Screening/communiton, sedi- mentation, activated sludge, clarification, and chlorination	Combined sewage may bypass chlorination. 120 mgd capacity. New plant on-line by 8-1-74.
Cobb County Chattahoochee River Plant (R.M. 408.0)	7.7 7.9 6.4	12 12 10	0	1	SAN	0.03	Screening/communiton, activated sludge, clarification, and chlorination	10 mgd capacity
Sandy Creek (R.M. 403.1)	2.2	3					Apparent screening/communiton and sedimentation	
South Cobb Plant (R.M. 401.3)	7.6 7.1 6.3	12 11 10	0	1	SAN	0.05	Screening/communiton, activated sludge, clarification, and chlorination	8 mgd capacity
Fulco (R.M. 400.6)	1.1	2					Screening/communiton and sedimentation	
Utoy Creek (R.M. 399.0)	7.3	11	0	0		1.00	Screening/communiton, sedi- mentation, activated sludge, clarification, and chlorination	30 mgd capacity
Camp Creek (R.M. 391.2)	6.0	9	1	0	SAN	0.18	Screening/communiton, sedi- mentation, activated sludge, clarification, and chlorination	15 mgd capacity. New plant on-line by 8-1-74.

Notes: (1) Type of collection system: BSC = both sanitary and combined
SAN = sanitary only.

(2) Significant quantities of flow bypassed the R.M. Clayton treatment plant during the period of study.

$$CBOD5 = TBOD5 - (NH3) O2NH3 (1-e^{-KNH3(5)}) - (NO2) O2NO2 (1-e^{-KNO2(5)}) - (DET) O2DET (1-e^{-KDET(5)})$$

V-4

where

CBOD5 = 5-day dissolved carbonaceous BOD in mg/l

TBOD5 = total dissolved and suspended 5-day BOD in mg/l

NH3 = ammonia-nitrogen in mg/l

O2NH3 = stoichiometric equivalence between DO and NO2

KNH3 = decay rate of ammonia at 20°C

NO2 = nitrite-nitrogen in mg/l

O2NO2 = stoichiometric equivalence between DO and NO2

KNO2 = decay rate of nitrite at 20°C

DET = detritus (volatile solids) in mg/l

O2DET = stoichiometric equivalence between DO and detritus

KDET = decay rate of detritus (volatile solids) at 20°C.

This correction is made automatically in the preprocessor so that the user can input the normally available total dissolved 5-day BOD, TBOD5.

Recommended Data Collection Improvements

Many important concepts and ideas were generated during the one year duration of this study. Many of these ideas were used in the model development, some were used in establishing suitable input data where lack of recorded data was apparent, and others are to be documented in this section as to how the study could have been improved if things could have been different.

First on any modeler's list of improvements needed is the necessity of having more and better quality input data. Many examples exist, in the data available for this study, where two or more agencies have collected data on the same day and have recorded widely varying values. While it is physically possible for this to happen, one might question the common occu-

rence of this data variability. A recommendation for minimizing the doubt of the acceptability of this data variability is to insure the data users of the laboratory's quality control and the qualifications of the field sampling teams by establishment of a sensitive rating system. If these ratings could be recorded on the data sheets, the data users could apply appropriate weightings to the recorded data before using the data for analysis. Under the present system, all the data are given the same weight regardless of the laboratory or field personnel involved in the sampling and analysis.

More data are always recommended but proactical limits must be found to balance the incremental increase in modeling analysis accuracy against the increased cost of collecting more data. An economic balance is obviously beyond the scope of this study but practical suggestions can be made regarding the lack of needed data. Collection of the following data is recommended in order of priority:

1. Storm runoff quality data collected at several (i.e., 3 to 5) sites during two or three storm events,
2. Better quality control and maintenance control on the data collected at Buford Dam,
3. Discharge data always measured or estimated whenever an agency collects water quality data,
4. Much better monitoring of effluents from the sewage treatment plants, particularly from the R.M. Clayton plant, including records on the quantity and quality of flows bypassing the treatment system,
5. Measured discharge at Morgan Falls,
6. Monitoring effluents for at least temperature and DO at all industrial outfalls, particularly the Atkinson-McDonough and the Yates power plants,
7. Recording the time of observation on all data sheets, and
8. Major expansion of the collection of biotic data.

Until better data are collected in the field during several storm runoff events, as suggested in recommendation 1, any dynamic (i.e., short interval) modeling effort will have significant problems reproducing observed data during the after storm periods because the time variability of runoff quality as well as the total loads can only be grossly estimated.

Recommendation 2 was suggested because of the experience in this study where the Buford monitor was found to be non-functional during 84 days out of the 92 day study period. The quality control at this point in the system is so important because it is the headwater (i.e., boundary condition) inflow and the largest inflow to the system (aside from the Atkinson-McDonough inflow which has been first withdrawn from the system and then used for cooling water only).

Examination of the loading and withdrawal data inventory (table III-1) shows that several of the tributaries are monitored regularly for water quality but no estimate is available for discharge. Without this quantity-quality coordination, as suggested in recommendation 3, the stream loadings can only be grossly estimated. If the collection points are sufficiently important to sample quality data on those tributaries, the U.S. Geological Survey or other agencies should seriously consider collecting discharge data at the same points.

Another significant input data problem experienced during the study prompted recommendation 4. The Chattahoochee River (Cobb Co.) and South Cobb sewage treatment plants had daily records on discharge, BOD, pH, chlorine and suspended solids but the R.M. Clayton, Sandy Creek, Fulco, Utoy Creek and Camp Creek plants had only yearly averages, minimums and coliform, DO, NH_3 , PO_4 , and temperature are also needed and at least weekly records should be maintained. The R.M. Clayton plant records were furnished by the State with a note suggesting that substantial amounts of unmonitored influents bypassed the system during the period of study. Some estimate is needed of the quality and quantity of all influents bypassing any treatment plants.

Recommendation 5 is important because the velocities in the Morgan Falls impoundment have to be so grossly estimated that calculated discharges are almost useless. The accuracy of the cross sections in Morgan Falls impoundment are sufficiently questionable, due to continually occurring sedimentation, that the velocities in any section are not reliable. This study used estimated discharges based on recorded power generated, recorded head and an estimated efficiency rating.

Effluent records from industrial outfalls are generally not readily available. While they are not always extremely important to an accounting of masses in the system because their discharge is usually small, any discharge of pollutants of greatly different concentrations than the receiving water concentration offers potentially significant errors in a mass accounting. Examples of the importance of recommendation 6 are the effluents from Georgia Power's Atkinson-McDonough and Yates power plants.

These recommendations are made in an effort to improve the data situation on the Chattahoochee so that further modeling efforts may more closely simulate the existing condition and so that the evaluation of the impacts of proposed alternative plans of development for the basin can be more realistic. They are not intended and it is hoped they will not be considered by anyone to be a criticism of the data collection efforts presently in progress. The data provided for this study were of better quality and more voluminous than the data this modeler has ever found available on previous studies.

The time of sample collection must be recorded, as suggested in recommendation 7, so that true error can be determined in modeling studies.

Recommendation 8 is extremely important to future modeling efforts. Besides suggesting major expansion of the collection of biotic data, the present data collection program needs critical review by an interdisciplinary team of biologists and water quality modelers.

VI. MODEL RESULTS

Analysis of Existing Conditions

General

The analysis of existing conditions with the use of a mathematical model is usually done for the purpose of (1) calibration of the model for use as a predictive tool, with existing conditions, (2) allowing the modeler to develop some degree of confidence in the model as a predictive tool, and (3) preparing to perform a predictive analysis on physical conditions that are somewhat different than the existing conditions (e.g., channel alignment project).

The distinction between calibration and verification of a mathematical model requires definition for this specific study since these words are often used interchangeably. The term calibration refers to adjusting model coefficients which can only be defined by site specific characteristics. The term verification refers to using a calibrated model to predict a condition somewhat different than the condition on which it was calibrated and then to check the predicted results against observed field data.

The error in reproduction of observed data, using a water quality model, can be caused by several phenomena besides modeling inadequacies. The error can be caused by (1) sampling data in a stream section that is not fully mixed in either the vertical or lateral dimensions, (2) laboratory error in analysis (i.e., inadequate quality control), (3) field sampling problems with preservation of the sample to insure minimum change in the sample between the field and the laboratory, and (4) the lack of observed input data for loadings and tributaries. This last point is a major cause of problems in most studies.

Careful examination of some of the observed field data shows that one or more of these causes of error probably contributed to reproduction problems. On several occasions, field samples were collected by different agencies on the same day but the reported results from the laboratory analysis are significantly different. This situation is not unusual

in modeling efforts but should be mentioned prior to any discussion of the modeling calibration effort.

Model Calibration

On the Chattahoochee River study, the calibration was completed using observed field data from reach I for the first 15 days of August 1974. The results of the 15 days of simulated data were compared against the observed data from 7-8 August and 13-15 August. The only coefficient adjustments required to calibrate the model consisted of increasing the ammonia and nitrite decay coefficients in order to better reproduce the ammonia and nitrate observed data. The coefficients used for this study are shown in Appendix F.

Originally the fecal coliform input data used at each tributary or load point was a 3-month average value. During the calibration simulation an attempt was made to improve the coliform reproduction by using mean monthly fecal coliform as input. The resulting simulation was a slight improvement over the previous simulations and the mean monthly input interval for fecal coliform data was adopted.

Model Verification

Following completion of the model calibration on reach I using the two sampling periods in the first 15 days of August, the model was used to simulate the remainder of the study period on reach I and the entire study period on reaches II through VI. Comparisons were then made between calculated and observed data but without applying any further adjustment to the coefficients.

Results

The model simulations resulted in output every 2 hours at every node (i.e., every mile in reach I, every .5 mile in reaches II-IV, and every 2 miles in reaches V-VI) for each water quality parameter. A magnetic tape was produced during the simulation runs for use by a post-processor program which is presently undergoing developmental work.

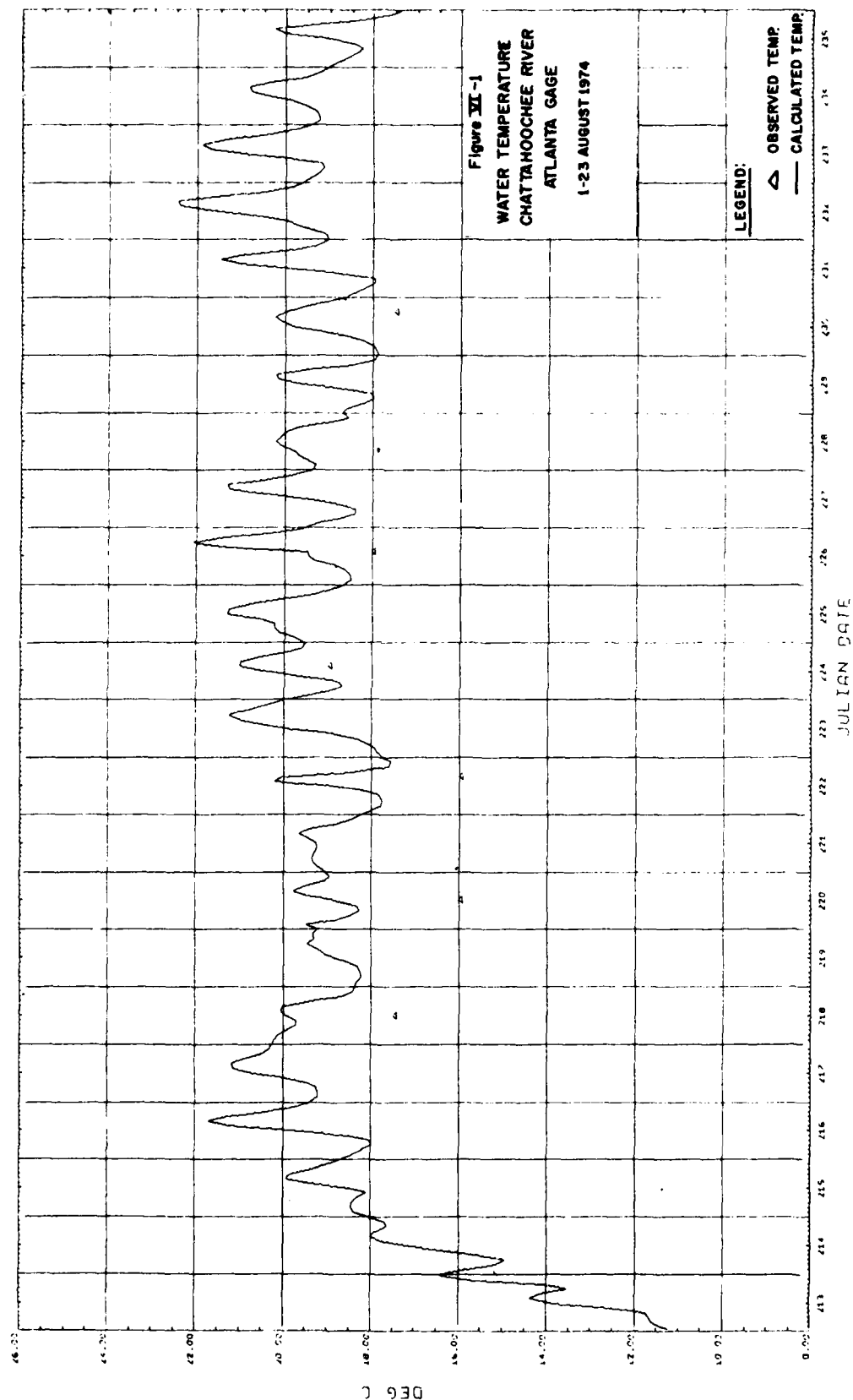
The post-processor program produced graphical output for 8 parameters (i.e., temperature, DO, NH_3 , NO_3 , PO_4 , pH, TDS, and fecal coliform) showing the calculated and observed values. Samples of the graphs are shown in figures VI-1 through VI-8. These sample graphs depict the computer simulated results at the Atlanta USGS streamflow gage (i.e., river mile 410.7).

These graphs were examined for each parameter at each sampling location. The individual observed errors (i.e., the difference between the observed data and the calculated curve) were recorded and the mean error ($\bar{X}$) and standard deviation of the errors were calculated for each parameter. These calculated statistics are shown in table VI-1.

The maximum computed value for each date and for each parameter was obtained from the graphs. Combining the maximum computed value during the 3 months and the mean error for the associated point and parameter, envelope or maximum curves were constructed for all parameters listed above except DO.

It is important to clarify that these envelope curves are developed by studying only the 3 months of August through October 1974. Obviously, higher concentrations can occur due to causes which were not represented during this study period. Examples of causes that might generate worse conditions include (1) climatic and seasonal conditions not represented during this study period; (2) operational failure of one or more treatment plants, (3) lower releases from Buford Dam and Morgan Falls than were experienced during this study, and (4) higher concentrations of storm water pollutants or tributary loads than were experienced during this study. With these qualifying remarks in mind, the envelope curves can be thought as "maximum normally expected" water quality stream profiles.

"Minimum normally expected" stream profiles were constructed in a similar manner to the method used for the maximum curves. Minimum curves were developed for temperature, DO, and pH. The stream profiles for the maximum and minimum curves are shown in figures VI-9 through VI-16.



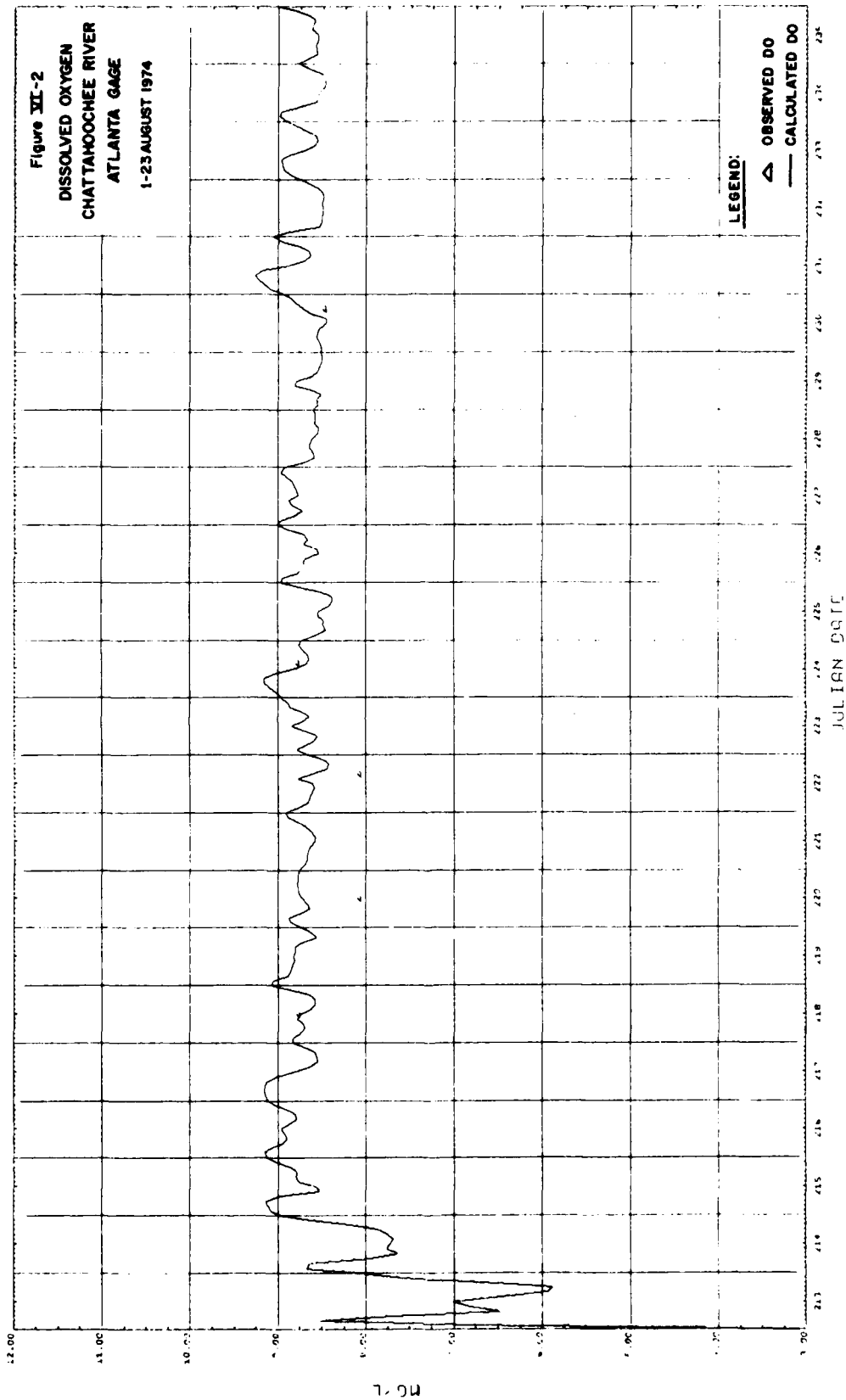
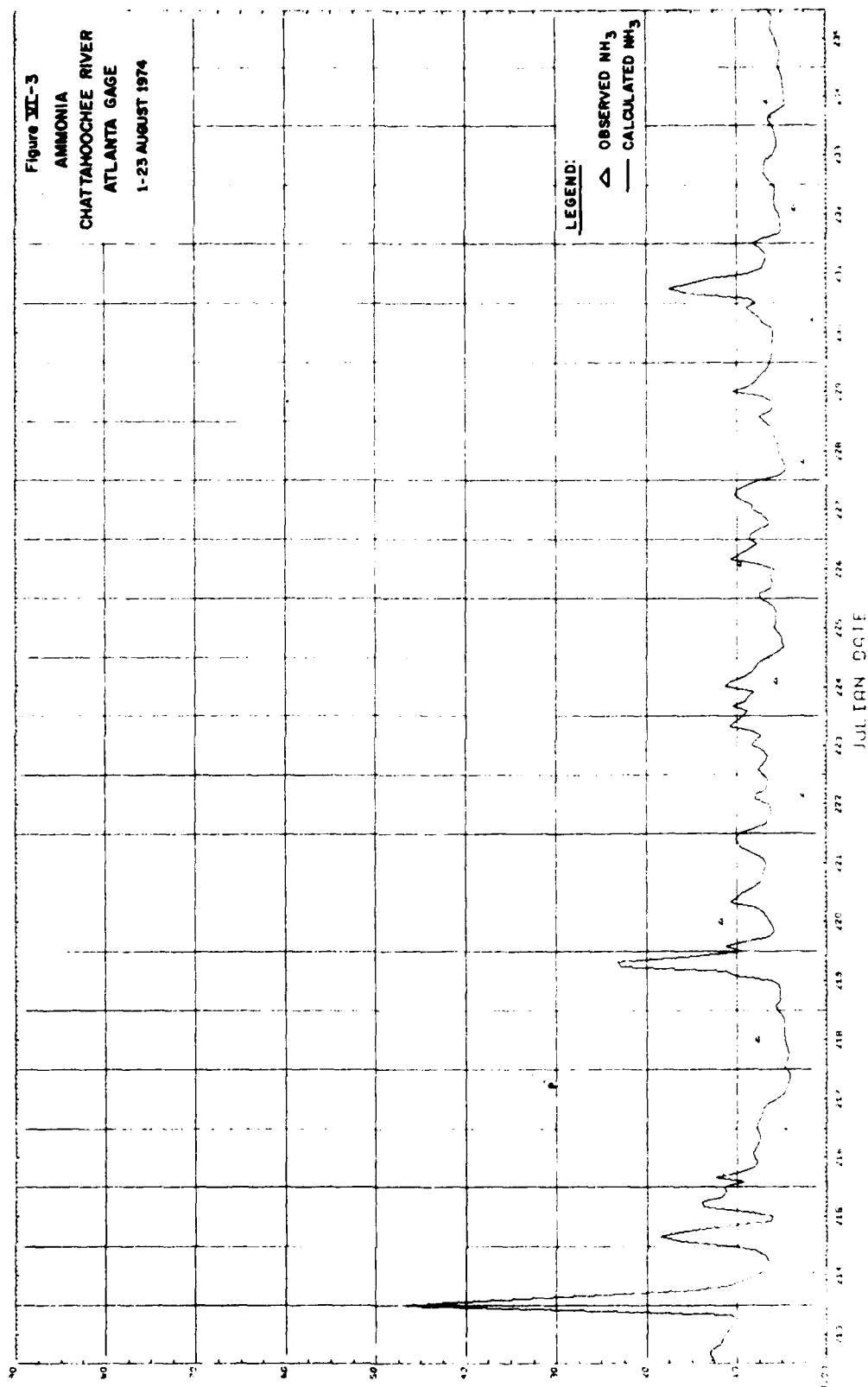
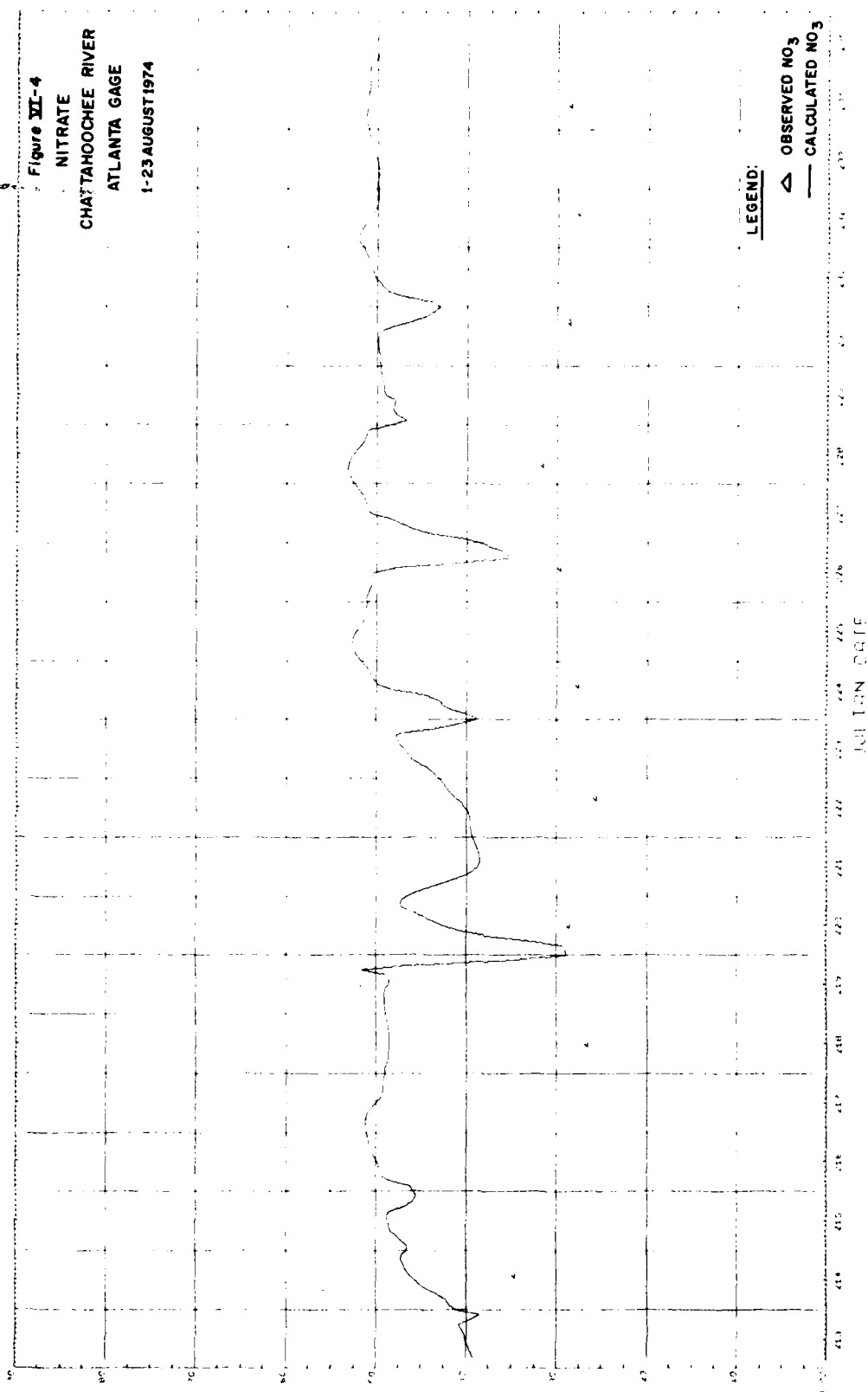


Figure XI-3
AMMONIA
CHATTahoochee RIVER
ATLANTA GAGE
1-23 AUGUST 1974



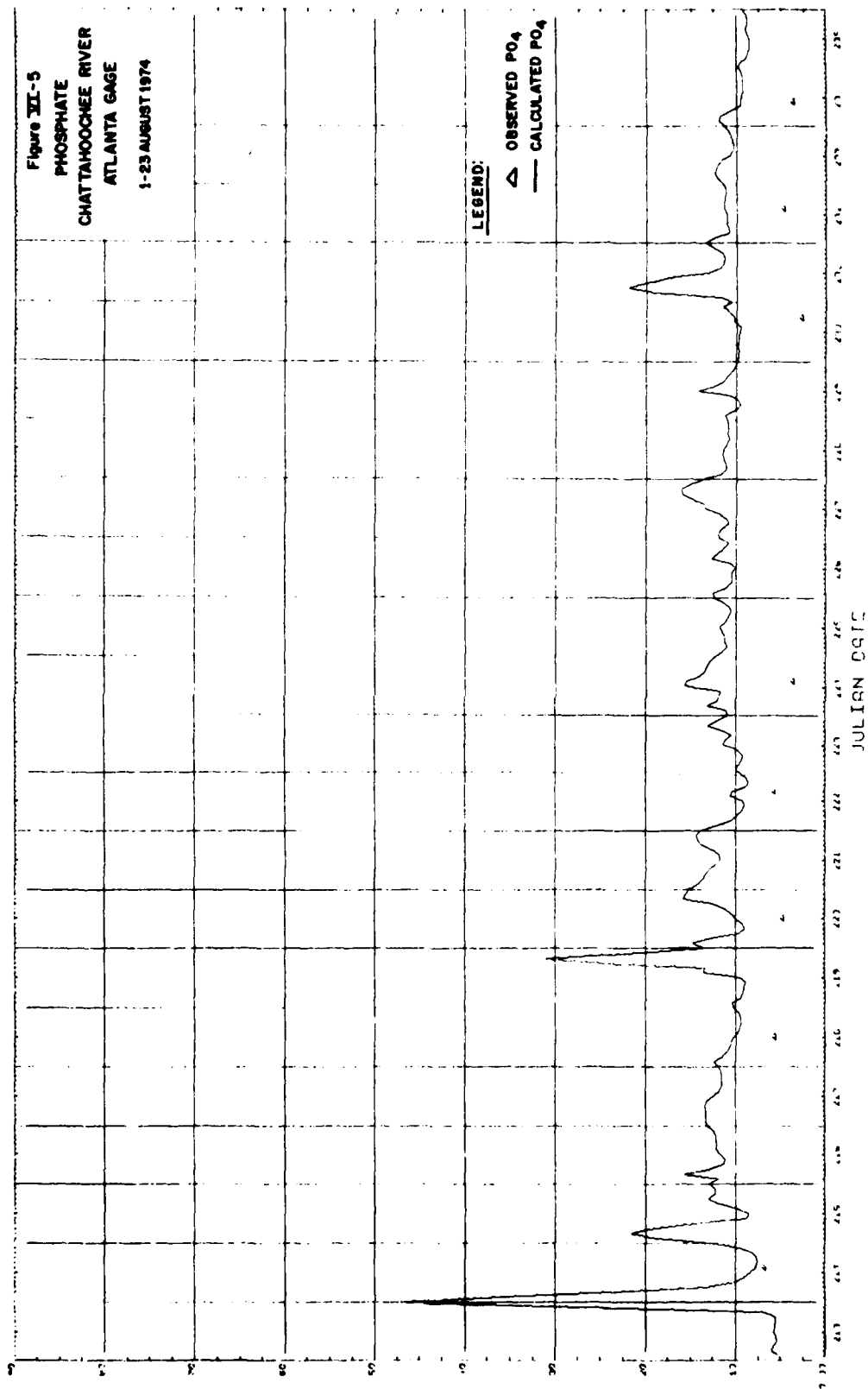
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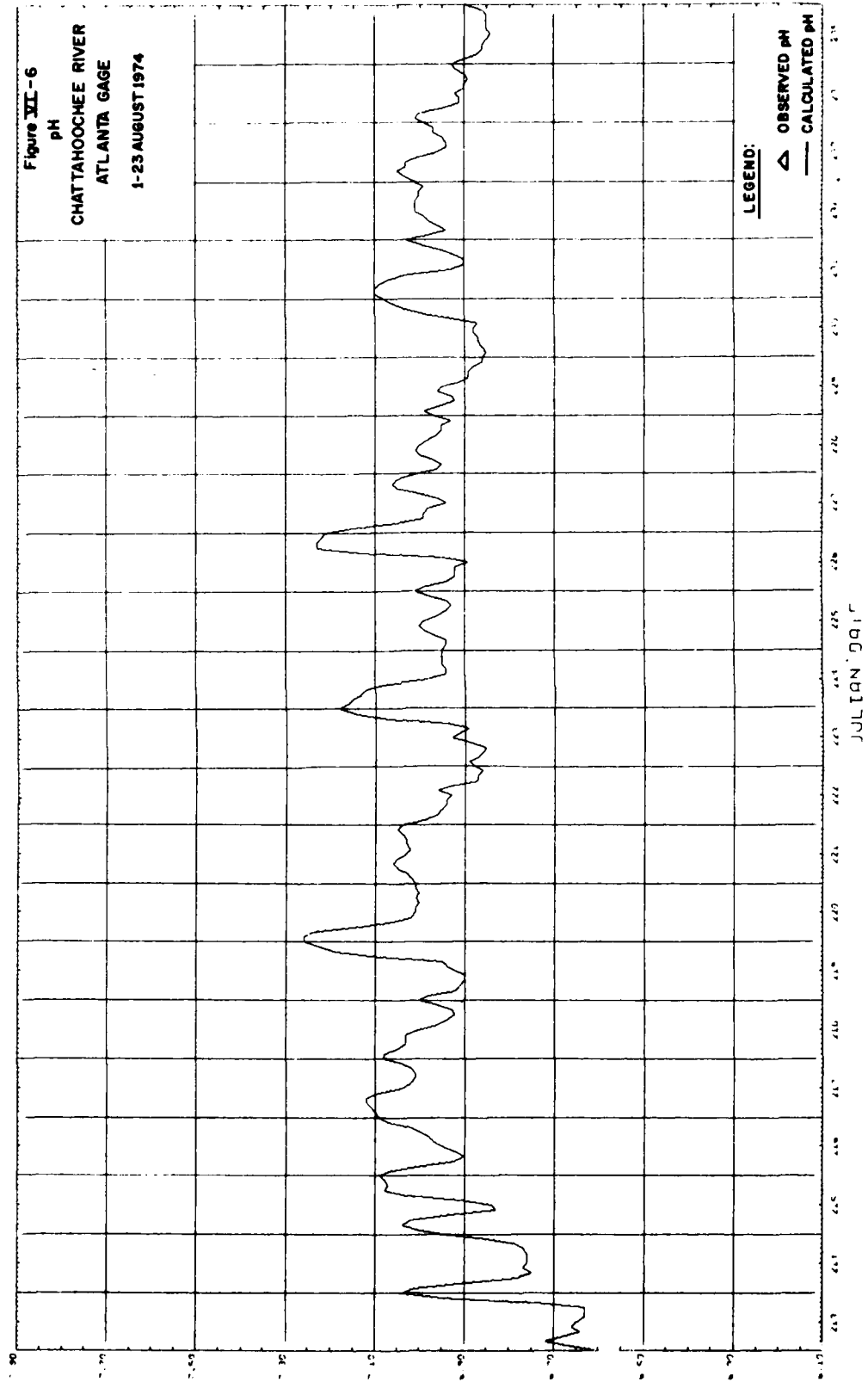
Figure VI-4
NITRATE
CHATTAHOOCHEE RIVER
ATLANTA GAGE
1-23 AUGUST 1974



7-54

Figure XI-5
 PHOSPHATE
 CHATTAHOOCHEE RIVER
 ATLANTA GAGE
 1-23 AUGUST 1974





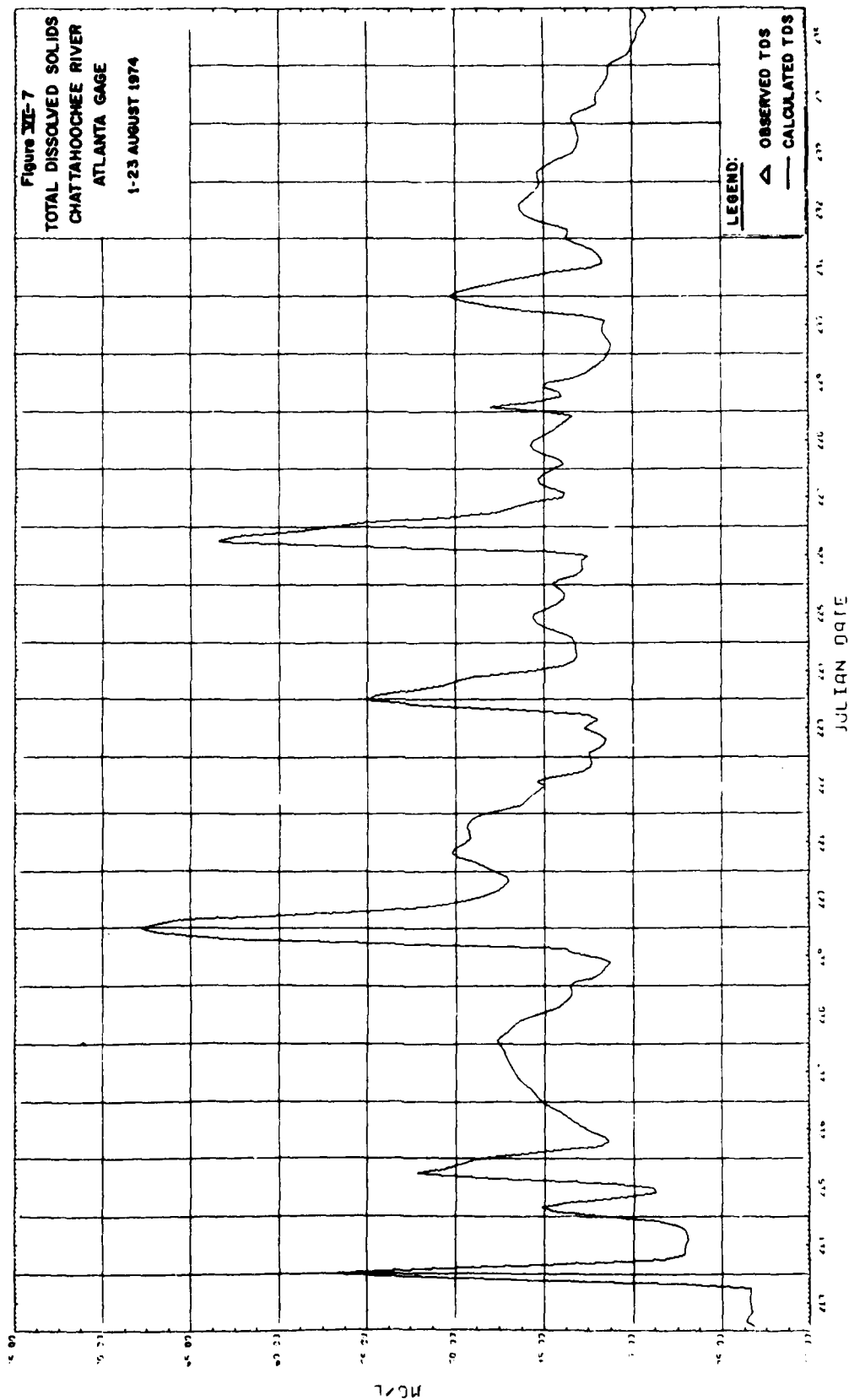


Figure XI - 8
LOG COLIFORM
CHATTahoochee RIVER
ATLANTA GAGE
1-23 AUGUST 1974

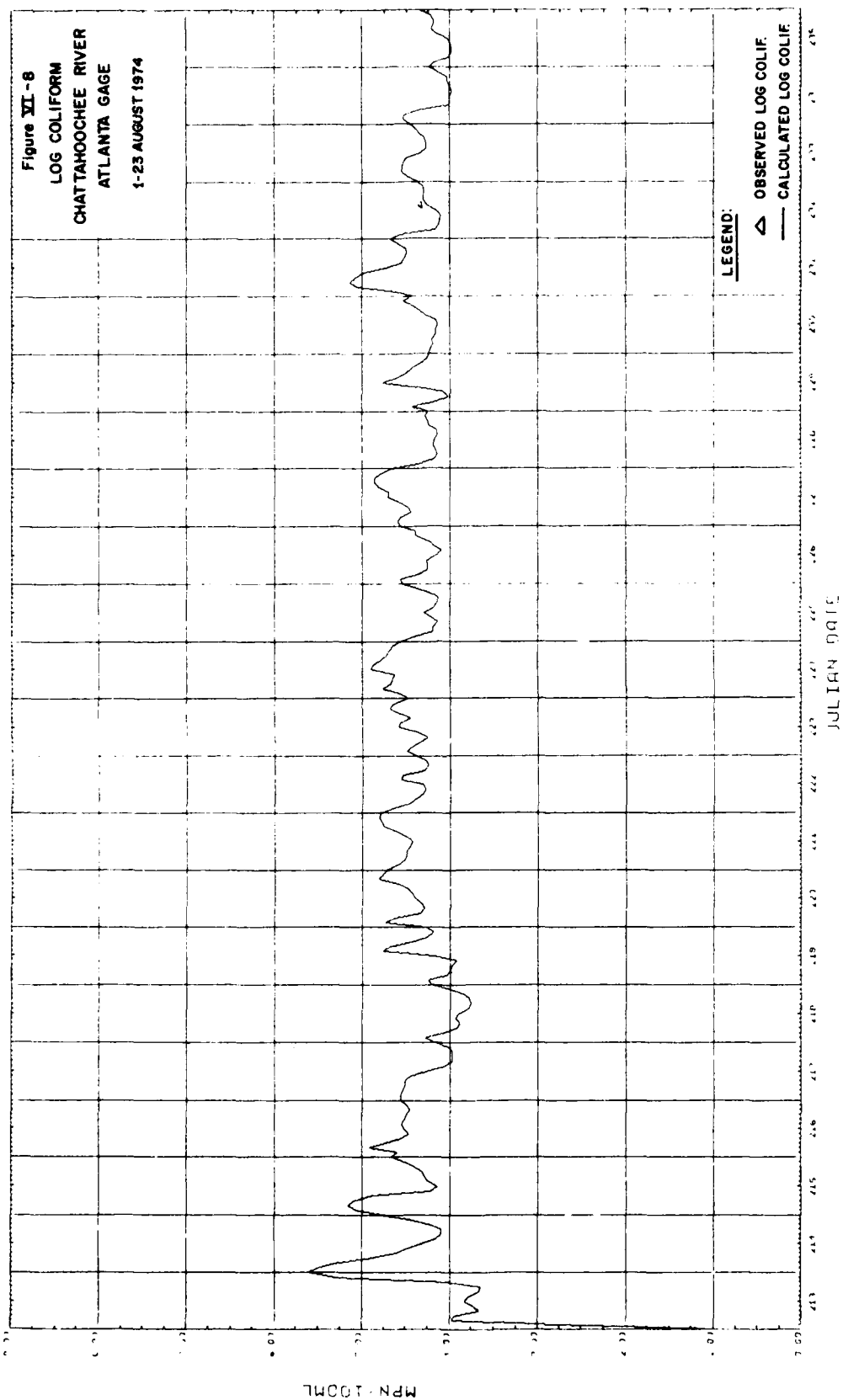


TABLE VI-1
ERROR OF REPRODUCTION STATISTICS

<u>Parameter</u>	<u>Error Statistic</u>	<u>End of Reach</u>					
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Temperature (°C)	Mean	-.5	-.1	-.1	-.2	-.6	-.9
	S	1.3	1.8	.7	1.3	1.5	1.4
DO (mg/l)	Mean	-.1	.6	1.1	1.6	3.4	1.8
	S	.2	.4	.8	.8	.6	.6
NH3 (mg/l as N)	Mean	.04	-.04			-.33	
	S	.16	.10			.31	
NO3 (mg/l as N)	Mean	-.01	.13			.72	
	S	.39	.23			.47	
PO4 (mg/l as P)	Mean	-.01	.05			.15	
	S	.08	.11			.31	
pH	Mean	.0	-.2				
	S	.1	.5				
TDS (mg/l)	Mean	1.8	-2.1				
	S	18.8	12.1				
Log Fecal Coliform (colonies/ 100 ml)	Mean	0	-.2				
	S	.5	.6				

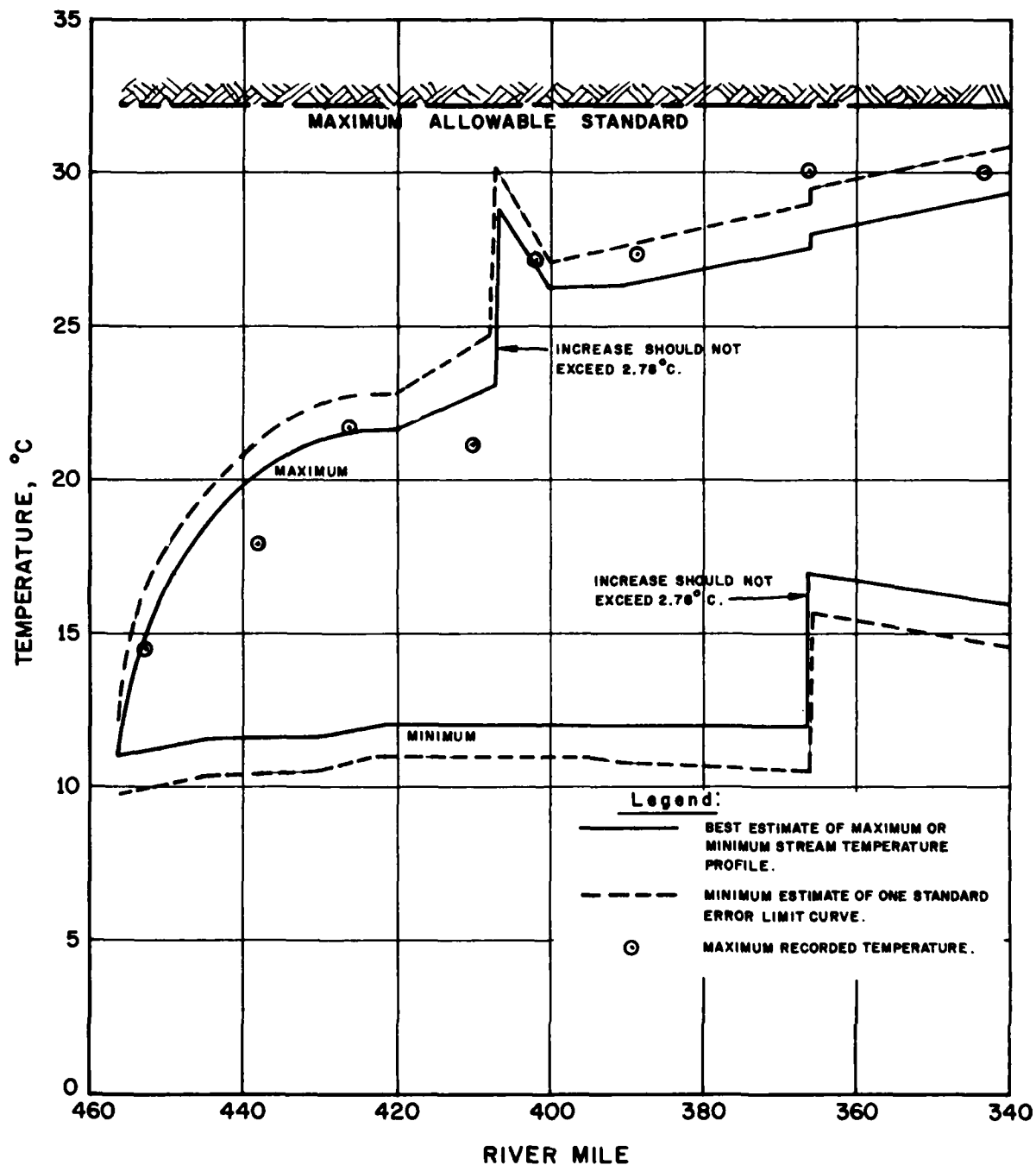


Figure VI-9 MAXIMUM AND MINIMUM NORMALLY EXPECTED STREAM TEMPERATURE PROFILES FOR AUGUST-OCTOBER

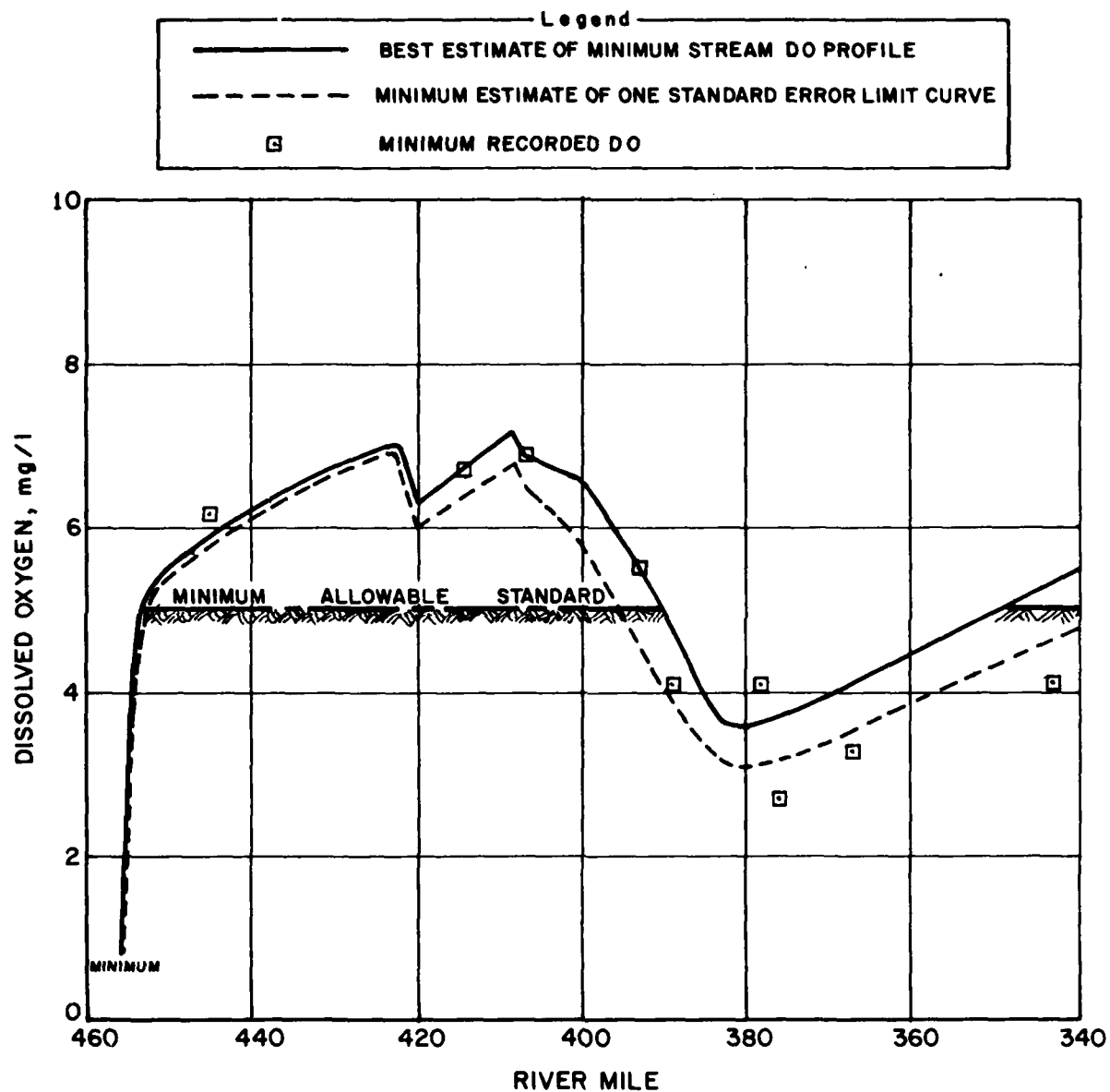


Figure VI-10. MINIMUM NORMALLY EXPECTED DO STREAM PROFILE
FOR AUGUST-OCTOBER

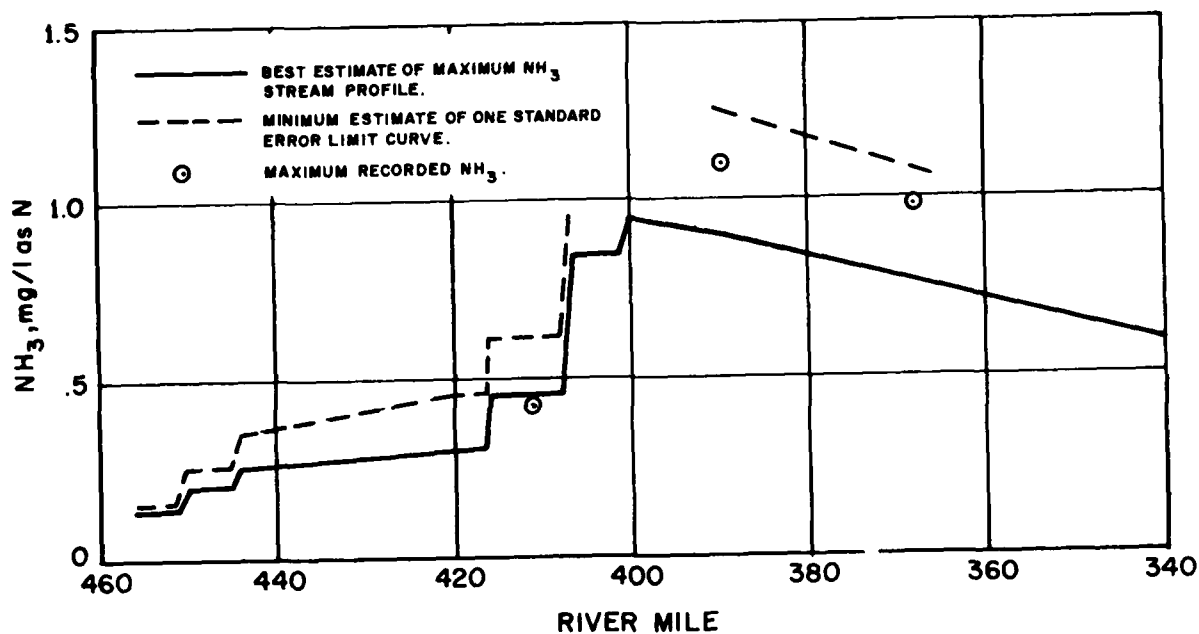


Figure VI-11. MAXIMUM NORMALLY EXPECTED NH_3 STREAM PROFILE FOR AUGUST-OCTOBER

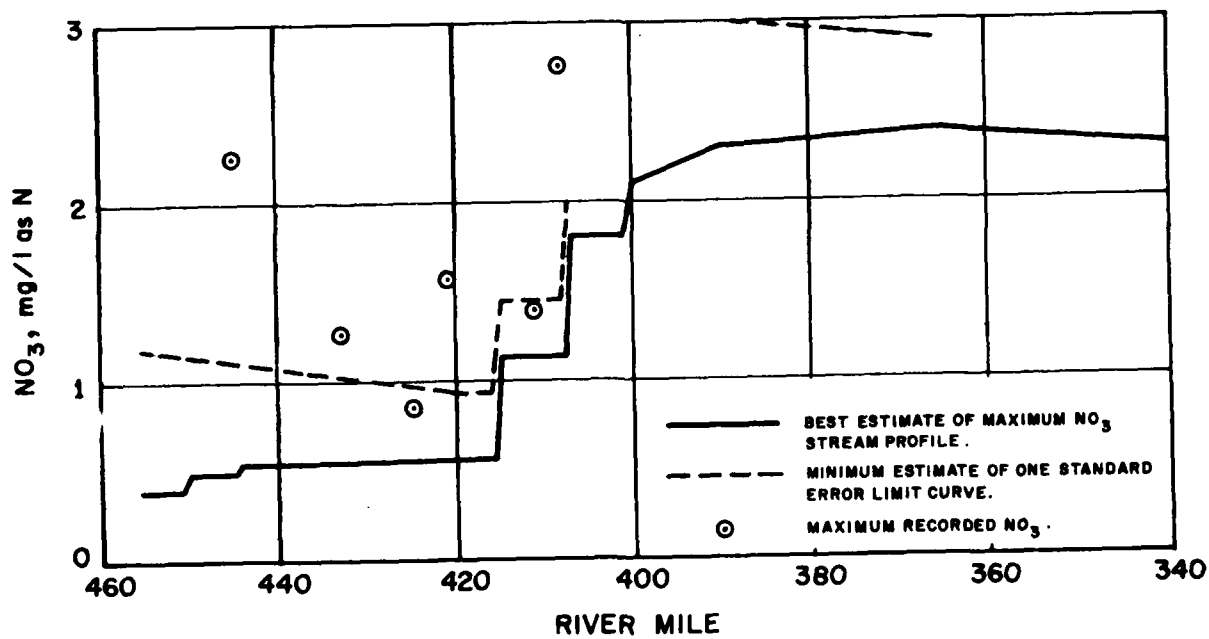


Figure VI-12 MAXIMUM NORMALLY EXPECTED NO_3 STREAM PROFILE FOR AUGUST-OCTOBER

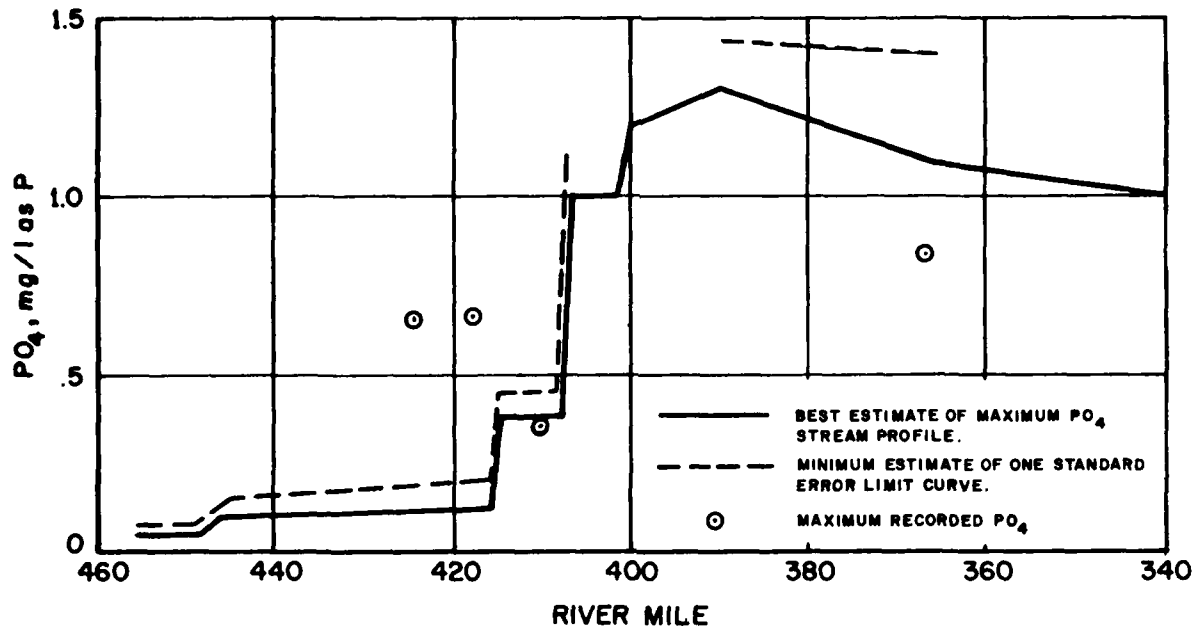


Figure VI-13. MAXIMUM NORMALLY EXPECTED PO_4 STREAM PROFILE FOR AUGUST-OCTOBER.

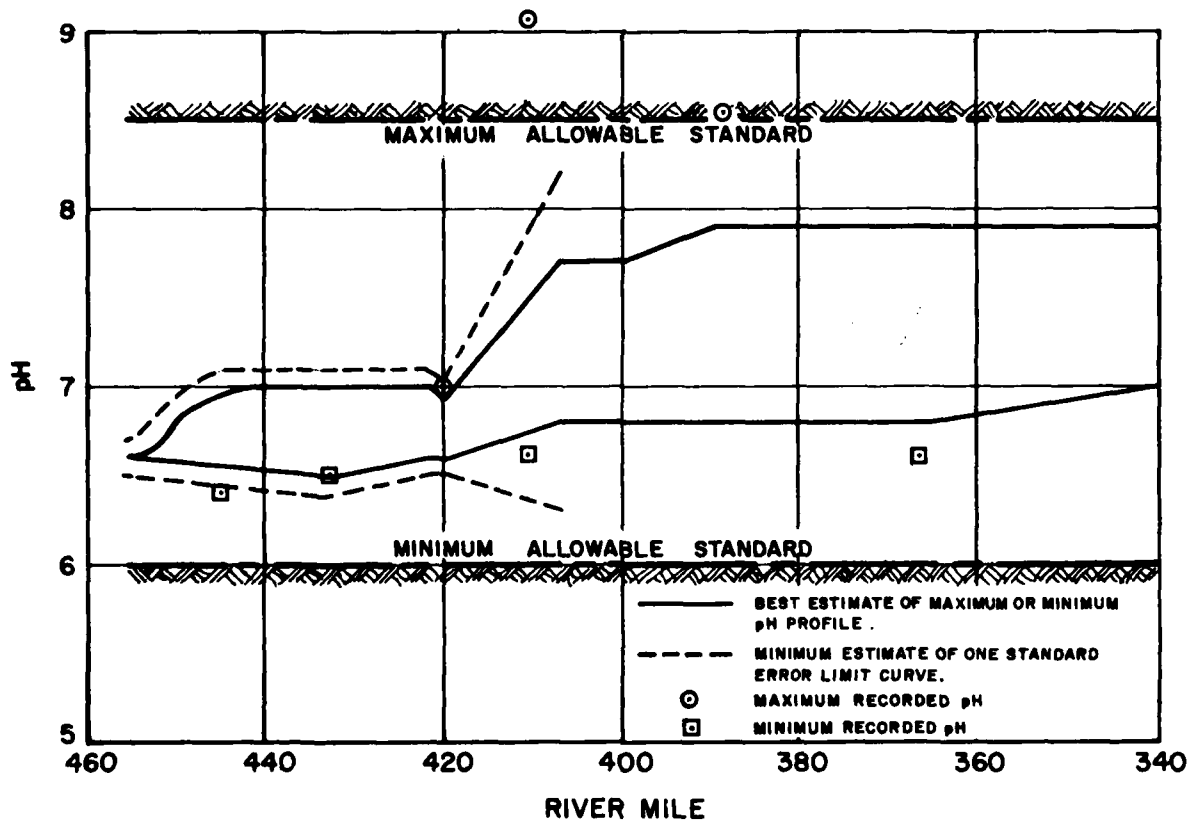


Figure VI-14. MAXIMUM AND MINIMUM NORMALLY EXPECTED pH STREAM PROFILE FOR AUGUST-OCTOBER.

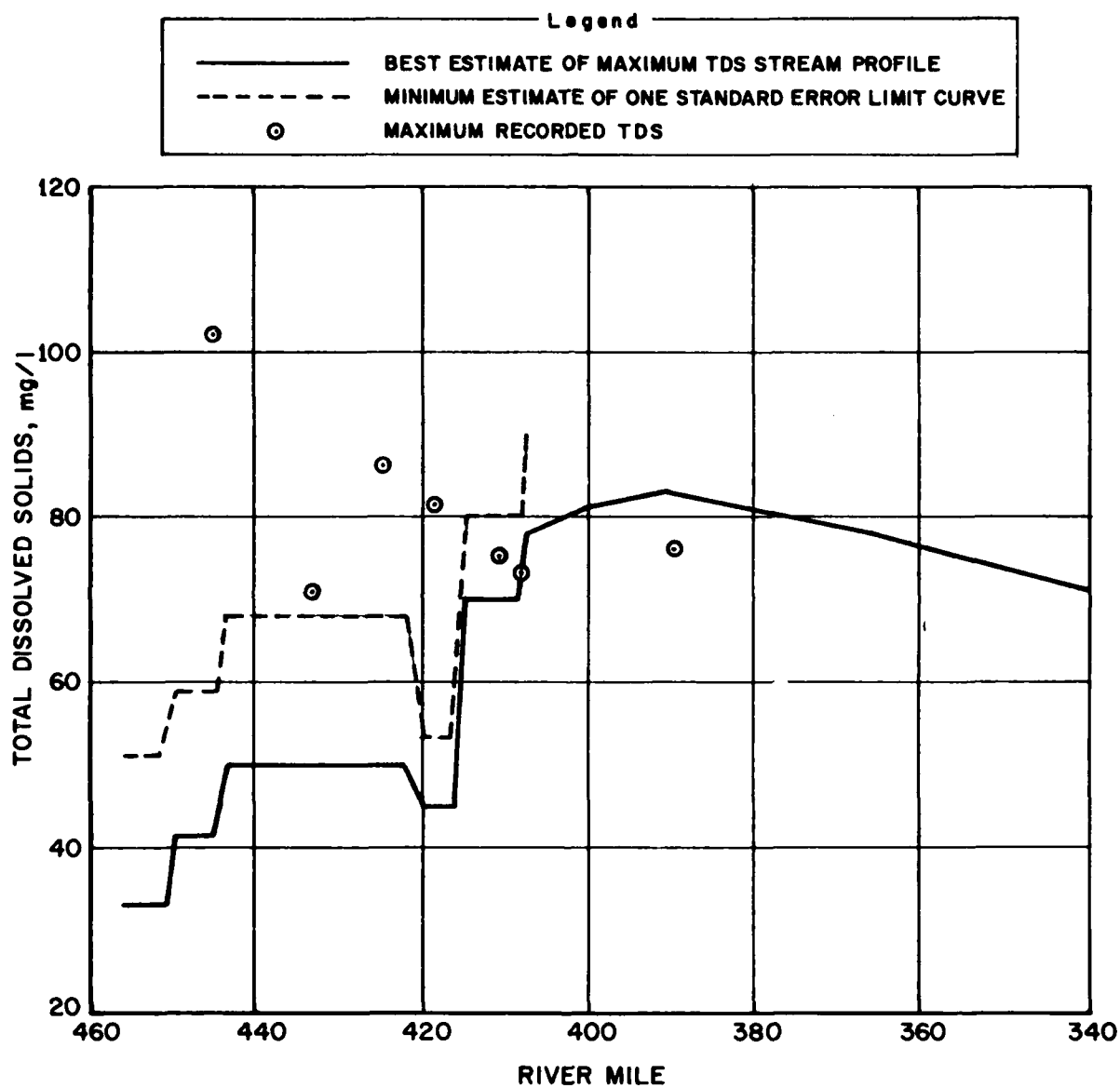


Figure VI-15. MAXIMUM NORMALLY EXPECTED TDS STREAM PROFILE
FOR AUGUST-OCTOBER

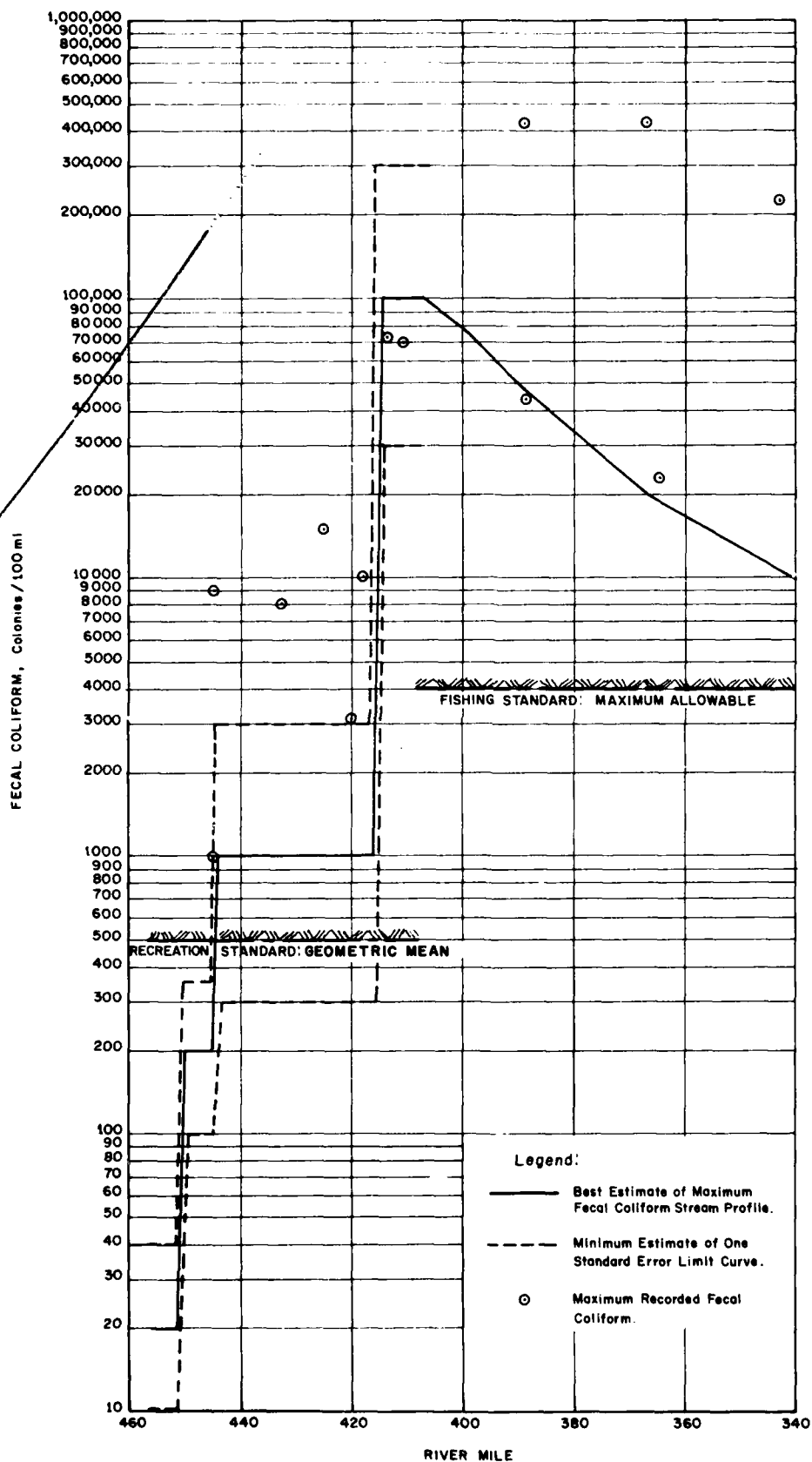


Figure VI-16 MAXIMUM NORMALLY EXPECTED FECAL COLIFORM STREAM PROFILE FOR AUGUST-OCTOBER.
VI-18

An estimate of one standard error (i.e., if the true error was known and used, an 84% confidence error limit curve) above the maximum curve and below the minimum curve has been included for assistance in interpreting the confidence of a "best estimated value" from the curves. An example of the uses of these error limit curves might be beneficial. If an estimate of a "maximum normally expected" temperature at river mile 410.7 (Atlanta gage) is desired, figure VI-9 shows it to be 22.6°C with approximately 84% confidence. By doubling the distance between the "best estimate" curve and the error limit curve, it can be estimated that the "true" value would not be expected to exceed 25.8°C with approximately 98% confidence.

Comparison With Water Quality Standards

1. General. A copy of the Georgia state stream standards and the associated stream classifications has been included in appendix G. The relevant standards have been superimposed on figures VI-9 through VI-16 for comparison with the "maximum normally expected" or "minimum normally expected" existing conditions.

2. Temperature. Notice in figure VI-9 that although water temperatures for existing conditions normally do not exceed the 32.2°C (90°F) temperature standard, the heat effluent from Georgia Power's thermal power plants can potentially cause a receiving water temperature rise in excess of the allowable 2.78°C (5°F). This potential violation of the standards based on the calculated values was caused by using a constant input from the thermal plant running at full capacity. In practice Georgia Power attempts to monitor their effluents to prevent this from occurring. The modeling effort did not attempt to simulate the actual hourly variations in cooling water flows. No other temperature problems seem to be apparent.

It is interesting to note that water temperature variations during a day were often as large as 5°C (9°F). This rather large diurnal variation was substantiated by examination of AWW's continuous recorder charts which result from monitors located at several points along the Chattahoochee River and from thermal studies by Dr. Edinger (7).

This large variation in daily temperature is caused by large diurnal differences in stream velocities which are due to the hydropower operations at Buford Dam and Morgan Falls. When the stream velocities are lowest [i.e., reservoir releases less than 20 cms (706 cfs)], the amount of time that a given unit of water is exposed to short wave radiation is approximately twice as long as when the stream velocities are highest [i.e., hydropower releases in excess of 225 cms (7945 cfs)]. This dependency between the stream water quality condition and the river hydraulics is the reason for the importance of using a dynamic river water quality model.

Diurnal water temperature variations were usually around 1° to 2°C (1.8° to 3.6°F) during storm events. This again is due partially to the higher velocities in the stream system, but the cause must also be partially attributed to the meteorologic conditions during the storm period.

Examples exist where the stream temperature has been maintained between 11°C and 13°C down to Plant Yates. This was caused by high velocities and cool weather conditions.

Some maximum recorder temperature data have also been shown in figure IX-9.

3. Dissolved Oxygen. As shown in figure IX-10, the minimum DO profile will normally exceed the DO standard of 5 mg/l only in the reach from 3 miles below Buford Dam to Camp Creek. The DO in the remainder of the Chattahooche River will often go below the standard.

The portion of the river between Camp Creek and Franklin is a potential problem area for DO during adverse conditions. Observed data have been recorded in this reach of the river that substantiates these simulated results. Some minimum recorded DO data have also been shown in figure IX-10.

4. Plant Nutrients. The state standards for nutrient (i.e., NH_3 , NO_3 and PO_4) concentrations are specified only in the river reach between Buford Dam and Peachtree Creek. In this reach, the nutrient concentrations

must not exceed the "Federal Drinking Water Standards." Although the concentrations shown in figures IX-11 through IX-13 are considerably below concentrations allowed for drinking water, it is important to note that they are all considerably above the concentrations which would tend to limit the growth of algae. While the growth of suspended algae (phytoplankton) was not simulated with the model, no visible level was encountered during field observations. This apparent lack of production was probably due to the turbidity normally present, rather than any nutrient limitations. If the turbidity was removed or decreased substantially, the potential would exist for rapid growth of algae in any slack water (i.e., low velocities) portions of the stream channel.

It should be noted in figures VI-11 through VI-13 that all the nutrient concentrations at the Fairburn gage are approximately double the concentrations at the Atlanta gage. The majority of this significant increase through the Atlanta urban area can be attributed to the 7 sewage treatment plants in this 21 miles of stream channel.

As shown in figures VI-12 and VI-13, the simulated results for NO_3 and PO_4 in the reach from Buford Dam to Atlanta are significantly low. While the calculated results cannot be relied upon as accurate simulations, the conclusions previously stated are undoubtedly correct.

5. pH. The pH simulation results shown in figure VI-14 are always within the state standards. The one observed sample that exceeded the state standards was obtained at the Atlanta gage (i.e., river mile 410.7) during an intense storm period on 29 August. During the same storm event, a sample equal to the maximum standard was obtained at the Fairburn gage (i.e., river mile 389.4). Large pH values like these should only be expected to occur under very adverse conditions.

6. Total Dissolved Solids. The state standards on TDS are only listed for the river reach between Buford Dam and Peachtree Creek. In this reach the TDS concentrations must not exceed the "Federal Drinking Water Standard". The concentrations of TDS for the entire length of the river shown in figure VI-15 to be well below levels required for this conclusion is undoubtedly valid even though the

simulated results cannot be relied upon between Buford Dam and Atlanta.

The TDS concentration has a significant increase through the Atlanta urban area mostly due to the 7 sewage treatment plants in the 21 miles between the Atlanta and Fairburn gages.

7. Coliform Bacteria. The level of fecal coliform is probably the most serious problem in the Chattahoochee River. The state standards for the river reach from Suwanee Creek to Peachtree Creek are often exceeded for recreation uses as shown in figure VI-16, and from Peachtree Creek to Franklin for fishing. While several observed values lie above the simulated results, the conclusions remain the same as to the exceedence of state standards.

Cost Analysis

The computer costs on a high speed computer, like the CDC 7600 at the Lawrence Radiation Laboratory in Berkeley, are approximately \$360 for simulating the 116 miles of river with 41 tributaries, load points and withdrawals for 92 days using hourly inputs. The cost may be increased by as much as 20% if excessive output is requested. Costs at commercial computer centers may be considerably higher.

Analysis of Modified Conditions

General

The study objectives included evaluating the impact on the water quality of the Chattahoochee River due to modifications of the effluent from existing sewage treatment plants (STP's) and from storm water runoff. Several levels of treatment are being considered as part of the Atlanta Urban Study. The scope of this study, however, allows for evaluating only one of the levels under consideration by Metro Atlanta

with the remaining levels to be evaluated in further studies.

The various levels of treatment under consideration are shown in table VI-2. The level identified as ABT-5" was selected by the Savannah District Corps of Engineers as the one level to be evaluated in this study. To be able to interface the treatment criteria provided with this specific modeling effort, it was necessary to make two assumptions. The level of treatment provided for P was assumed to be the same for PO_4 and the suspended solids level was assumed to be 25% detritus (volatile solids).

Modified Storm Water Runoff

To evaluate the impact due to modified storm water runoff, the results from STORM (i.e., quality of direct runoff) required modification prior to their use in calculating a mass balance with base flow in each tributary. Rather than correcting the data cards from STORM, the program logic was modified to check each water quality parameter from STORM against the BOD_5 , NH_3 , P and detritus (i.e., 25% of suspended solids) concentrations from table VI-2, treatment level ABT-5, and correct them to the specified level when appropriate. The DO concentration is not predicted by STORM, but whenever the base flow level was less than 6 mg/l, a mass balance between base flow and direct runoff was computed using the input value of DO for the base flow concentration and using 6 mg/l for the DO concentration in the direct runoff.

Modified Sewage Treated Effluent

Preparation of a data deck for evaluating the impact due to modified sewage treatment plant effluents required changing only a few cards in the data deck for existing conditions. The existing condition data deck was modified only when the STP effluent concentrations for BOD_5 , NH_3 , PO_4 or detritus (i.e., 25% of suspended solids) exceeded the levels in table VI-2, treatment level ABT-5, or when the STP effluent concentrations for DO were less than 6 mg/l. Since reach I does not have any STP's, no evaluation in reach I was necessary.

TABLE VI -2
TREATMENT LEVELS

Treatment Level	Effluent Concentrations				
	BOD ₅ (mg/l)	NH ₃ -N (mg/l)	P (mg/l)	D.O. (mg/l)	Suspended Solids (mg/l)
ABT-1	< 5	< 0.5	< 0.1	6.0	< 2.0
ABT-2	5	1.0	1.0	6.0	
ABT-3	10	2.0	1.0	6.0	
ABT-4	30	20.0	10.0	6.0	30.0
ABT-5	20	3.0	1.0	6.0	20.0

Comparison of Existing and Modified Conditions

Storm Water Runoff

The impact on water quality in the Chattahoochee River due to treating storm water runoff to the ABT-5 treatment level is insignificant under existing conditions. A relevant future study might be to evaluate this same impact after first improving the effluents from the major sewage treatment plants.

Sewage Treatment Plant Effluent

The impact on water quality in the Chattahoochee River due to improving treatment of sewage to the ABT-5 treatment level is quite insignificant. The improvements that can be expected in DO, NH_3 and PO_4 are summarized in table VI-3 and the stream profiles with and without the improved treatment are compared in figures VI-17 through VI-19. These graphs compare the "worst" normally expected existing condition with the "average" improvement for the modified condition. This comparison using the average improvement is considered to be more appropriate than using the maximum improvement, but both statistics are shown in table VI-3.

The DO improvement with ABT-5 treatment is significant but not sufficiently adequate to maintain a DO standard of 5 mg/l.

Since the NH_3 and PO_4 concentrations without the improved treatment were already below the state standards in the reaches below the first treatment plant, the improved condition may appear to be of minor consequence. However, the resulting improved condition is seen in figures VI-18 and VI-19 to have much less change in concentration compared to the concentration upstream of the Atlanta gage.

The predicted decrease in concentrations of the nutrients is sufficiently large to be of substantial potential significance in eutrophication of the Chattahoochee River system. If these changes in stream quality are considered as to their potential impact on water quality conditions in downstream impoundments (i.e., West Point Reservoir), the

TABLE VI -3
CHATTAHOOCHEE RIVER WATER QUALITY IMPROVEMENTS
DUE TO IMPROVED TREATMENT* OF SEWAGE

<u>Parameter</u>	<u>Statistic of Improvement</u>	<u>End of Reach</u>				
		<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
DO (mg/l)	Maximum	+ .3	+ .5	+ .6	+ .9	+ .2
	Mean	+ .2	+ .3	+ .4	+ .5	+ .2
NH ₃ (mg/l as N)	Maximum	- .45	- .55	- .40	- .20	- .10
	Mean	- .30	- .38	- .29	- .16	- .09
PO ₄ (mg/l as P)	Maximum	- .83	-1.03	.1.00	-1.00	- .80
	Mean	- .56	- .69	- .69	- .73	- .74

*Improved treatment to ABT-5 level in table VI-2.

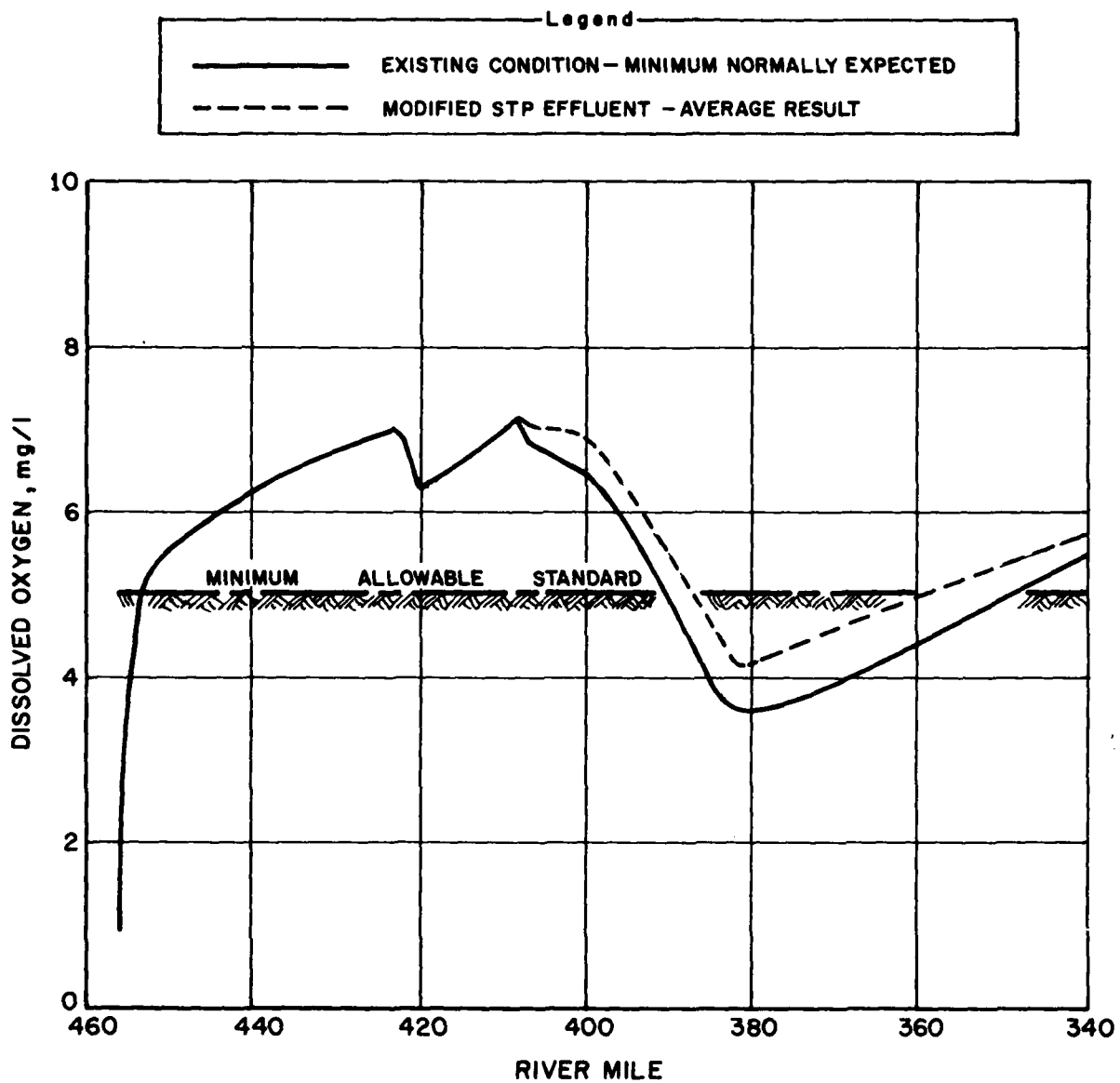


Figure VI-17. IMPACT ON DO DUE TO MODIFIED STP EFFLUENT

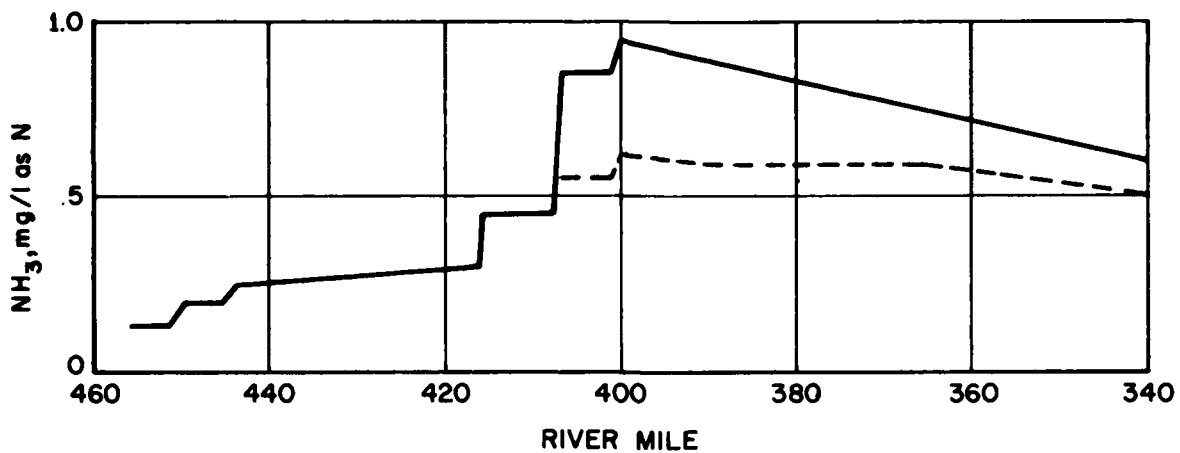


Figure VI-18. IMPACT ON NH₃ DUE TO MODIFIED STP EFFLUENT

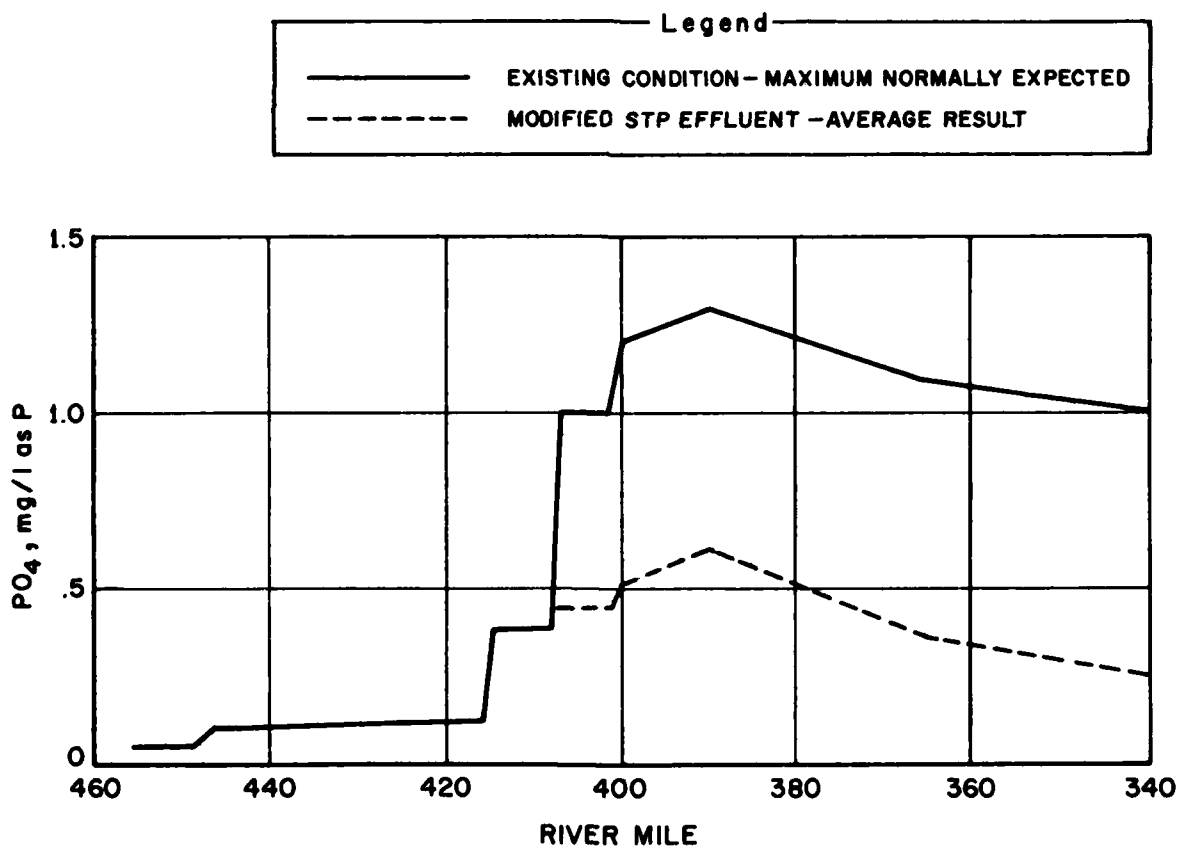


Figure VI-19. IMPACT ON PO₄ DUE TO MODIFIED STP EFFLUENT

significance of the change is viewed in a more appropriate way. Reservoir modeling studies need to be conducted to evaluate the quantitative impact on West Point due to this predicted improvement in the inflow quality.

The general conclusion from examination of figures VI-17 through VI-19 would suggest evaluation of several more advanced levels of treatment and a balancing of their costs against increments of improvements.

VII. SENSITIVITY AND COMPARISON STUDIES

R.M. Clayton Effluent

On the State's records for R.M. Clayton sewage treatment plant effluent, there was a note suggesting significant quantities of unmonitored flow had bypassed the treatment system during the study period. Because the quantity and the quality of the bypassed material were unknown, the Chattahoochee River system was tested for sensitivity of error due to this loading.

The quality of the monitored discharge was modified by increasing the BOD, NH_3 and detritus (i.e., volatile solids). It was assumed that 50 percent of the raw sewage bypassed the treatment system and was a typical sewage of medium strength.

Textbooks (14 and 15) suggest that medium strength raw sewage might have BOD, NH_3 and detritus concentrations of 200, 30 and 250 mg/l respectively. These raw sewage concentrations were evenly weighted with the estimated sewage treated effluent concentrations and the river system was resimulated and compared with the "existing conditions" simulation. The main reason for the comparison was to identify how much of the error in prediction of DO was due to the unknown effluent from the R.M. Clayton plant.

When the comparisons were made, the decrease in DO resulting from the increased loadings was .01 mg/l after 1 mile, .1 mg/l after 8 miles, and .4 mg/l after 18 miles. While these differences are quite significant, they were obviously not the total source of error in the predicted DO as shown in table VI-1.

Atmospheric Turbidity

The WQRRS model has an input coefficient which indexes the atmospheric turbidity or particle density. The coefficient varies from 2 for an unpolluted atmosphere to 5 for a highly polluted atmosphere. The higher this value, the more attenuation in short-wave radiation and therefore less warming of the river water. The higher the atmospheric turbidity, the more heat-

ing potential due to long-wave radiation and therefore more warming of the river water. While the short-wave attenuation and the increased long-wave radiation have opposite effects, the decreased short-wave warming apparently dominates.

In reach I, simulations were made with the atmospheric turbidity equal to 2 and 3. The decrease in stream temperature was as large as $.3^{\circ}\text{C}$ ($.54^{\circ}\text{F}$). While this is a significant increment, when other sources of potential error (e.g., unknown tributary inflow temperatures) are considered, a stream temperature error of $.3^{\circ}\text{C}$ seems less important.

In the study, an atmospheric turbidity of 2 was used for analysis down to Morgan Falls, 3 was used from Morgan Falls to Camp Creek, and 2 was used again from Camp Creek to Franklin.

DOSAG II Model Comparison

The State of Georgia Environmental Protection Division (EPD) has performed computer modeling studies on this same reach of Chattahoochee River using a steady-state water quality model developed by the Texas Water Development Board and modified by EPD. The model, DOSAG II, predicts DO and BOD with known inputs for the same parameters for a given steady discharge at each inflow location.

A comparison of results between DOSAG II and the WQRRS model (used in a steady flow/steady state mode) was made using the same loading but using different reaeration rates and geometry, for technical reasons. A detailed discussion of the comparison and a graphical display of the results is shown in appendix H.

VIII. REFERENCES

1. "Water Quality for River-Reservoir Systems," Computer Program Description Corps of Engineers, Hydrologic Engineering Center, 1977.
2. "Flood Hydrograph Package - HEC-1," Computer Program Description (Users Manual), Corps of Engineers, Hydrologic Engineering Center, January 1973.
3. "Water Surface Profiles - HEC-2," Computer Program Description (Users Manual), Corps of Engineers, Hydrologic Engineering Center, October 1973.
4. "Geometric Elements from Cross Section Coordinates," Computer Program Description, Corps of Engineers, Hydrologic Engineering Center, October 1974.
5. "Urban Storm Water Runoff - STORM," Computer Program Description, Corps of Engineers, Hydrologic Engineering Center, January 1975.
6. "Flood Plain Information - Chattahoochee River: Buford Dam to Whitesburg, Georgia," Report to the Atlanta Regional Commission, Corps of Engineers, Mobile District, November 1973.
7. "Analysis of the Thermal Characteristics of the Chattahoochee River," by D.H. Evans and John Eric Edinger, Georgia Power Company.
8. "Ecologic Simulation for Aquatic Environments," Final report to Office of Water Resources Research, Drs. Chen and Orlob, Water Resources Engineers, December 1972.
9. "Flow Routing and Water Quality Simulation for River-Reservoir Systems," Computer Program Description (Draft), Corps of Engineers, Hydrologic Engineering Center, Dr. Ian King, Resource Management Associates, June 1975.
10. "Catalog of Information on Water Data," Water Resources Region 03, Parts A, B, and C, U.S. Geological Survey, Office of Water Data Coordination, Edition 1972.
11. "Chlorophyll A Data Report for the Analyses and Data Collection on the Chattahoochee-Flint Rivers," Report to EPA, James H. Duke, Jr., Water Resources Engineers, September 1973.
12. "FY 1973 Annual Report on the Quality of Urban Storm Runoff Entering San Francisco Bay," R.G. Willey and Bill S. Eichert, The Hydrologic Engineering Center, 11 July 1973.
13. "Non Point Pollution Evaluation, Atlanta Urban Area," Black, Crow and Eidness Inc., and Jordan Jones, & Goulding, Inc. May 1975.

14. "Sewerage and Sewage Treatment," H.E. Babbitt and E.R. Baumann, Wiley 1958.
15. "Engineering Management of Water Quality," P.H. McGauhey, McGraw-Hill, 1968.
16. "IBP - Desert Biome Aquatic Program," Wayne G. Minshall, Aquatic Coordinator, Idaho State University, August 1970.

APPENDIX A

DATA SOURCE CONTACTS

AD-A102 033

HYDROLOGIC ENGINEERING CENTER DAVIS CA
CHATAHOOCHEE RIVER WATER QUALITY ANALYSIS.(U)
APR 78 R G WILLEY, D HUFF

F/6 13/2

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APPENDIX A - DATA SOURCE CONTACTS

<u>Name</u>	<u>Firm</u>	<u>Phone</u>	<u>Specialty</u>
Dave Callaway	NOAA - Ashville, NC	704-254-0203	Weather Information
John Drago	Mobile Dist., Mobile, AL	205-690-2737	Reservoir Regulation
Jim Duke	WRE, Austin, TX	512-345-6651	Previous WQ Studies
Jim Harris	Mobile Dist., Mobile, AL	205-690-2724	WQ Data
Roy Herwig	Georgia EPD, Atlanta, GA	404-656-4988	Q and WQ Data
Joe Hutton	Mobile Dist., Mobile AL	205-690-2691	Cross-Section Data
Harold Kerkhoff	Gwinnett County, GA	404-476-3311	Gwinnett Intake Q
Larry Lyons	CofE, Atlanta, GA	404-526-4435	General Information
Gary McDonald	Mobile Dist., Mobile, AL	205-690-2734	Q Data
Jim Motz	Georgia Power, Atlanta, GA	404-521-3400	Q and WQ Data
Larry Neal	Georgia EPD, Atlanta, GA	404-656-4988	General Information
Harold Reheis	Georgia EPD, Atlanta, GA	404-656-4708	STP Data
Gary Samples	Cobb County, GA	404-971-1911	Cobb Intake Q Data
Neal Spivey	Atlanta Water Works, GA	404-355-8234	WQ Data
Bill Stokes	USGS, Atlanta, GA	404-526-4858	Q and WQ Data
John Tapp	EPA, Atlanta, GA	404-526-2156	General Information
Max Woods	Dekalb County, GA	404-457-4776	Dekalb Intake Q Data

APPENDIX B

U.S. WEATHER SERVICE METEOROLOGICAL DATA

Table of Contents

<u>Item</u>	<u>Description</u>	<u>Page</u>
B.1	Order Form for Weather Service Data	B-1
B.2	CD-144 Reference Manual	B-3
B.3	Local Climatological Data	B-17

PROJECT ORDER		1. ☐ FIXED PRICE ☐ COST REIMBURSEMENT	2. DATE 29 January 1975				
(See Reverse Side for Instructions for Issuing Project Order)							
3. ORDERING COMPONENT							
NAME		ADDRESS					
US ARMY ENGINEER DISTRICT, SACRAMENTO CORPS OF ENGINEERS (S-04167)		650 CAPITOL MALL SACRAMENTO, CALIFORNIA 95814					
		4. PROJECT ORDER NO. SPK HEC-75-8					
		5. AMENDMENT NO.					
6. PERFORMING ESTABLISHMENT							
NAME		ADDRESS					
National Climatic Center ATTN: Dave Callaway		Federal Building Asheville, NC 28801					
		STATION NUMBER					
7. DELIVERY INSTRUCTIONS							
PLACE		DATE	METHOD				
8. DESCRIPTION OF WORK TO BE PERFORMED AND OTHER INSTRUCTIONS (If Additional Space Is Required, Use Supplemental Data Section on Reverse Side Hereof or Attach Additional Sheets)							
<i>Additional Instructions: The amount authorized by this order may not be exceeded without written authorization from the ordering component (Item 3 above). Submit billing on SF 1080 monthly, and cite the order number shown in item 4 above, indicating either a partial or final billing. Receipt of final billing will constitute a termination of this order and an automatic withdrawal of any unused balance.</i> Transfer of funds is made to pay for the following data as discussed in the telephone call between Dave Callaway and Robert G. Willey on 29 January 1975: <table style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;"><u>Station</u></td> <td style="text-align: center;"><u>Years</u></td> </tr> <tr> <td style="text-align: center;">Atlanta Airport</td> <td style="text-align: center;">Jan 65 - Dec 74</td> </tr> </table> The tapes should be prepared on 7-track tape in Card Deck 144 format with 10 cards per record at a density of 556.				<u>Station</u>	<u>Years</u>	Atlanta Airport	Jan 65 - Dec 74
<u>Station</u>	<u>Years</u>						
Atlanta Airport	Jan 65 - Dec 74						
SAMPLE							
9. DATE ORDERED	TYPED NAME AND TITLE OF ORDERING OFFICER		SIGNATURE				
29 Jan 75	BILL S. EICHERT, Director, HEC						
10 a. ACCOUNTING CLASSIFICATION			b. AMOUNT				
96X4902 Revolving Fund, S04-167, (YW81 2010 000 0000)			\$90.00				
11. THIS ORDER IS PLACED IN ACCORDANCE WITH THE PROVISIONS OF 41 USC 23, AND DEPARTMENT OF DEFENSE DIRECTIVE 7220.1. WORK TO BE PERFORMED AND MATERIAL TO BE PROCURED PURSUANT TO THIS OFFER ARE PROPERLY CHARGEABLE TO THE APPROPRIATION OR OTHER ACCOUNTS INDICATED ABOVE UNTIL _____ (Day - Month - Year)							
THE EXPIRATION DATE OF THIS PROJECT ORDER. FUNDS IN THE AMOUNT INDICATED ABOVE HAVE BEEN COMMITTED AND WILL BE OBLIGATED UPON RECEIPT OF ACCEPTANCE COPY.							
TYPED NAME AND TITLE OF AUTHORIZING OFFICER			SIGNATURE				
H. A. DAMESYN FINANCE AND ACCOUNTING OFFICER (S-04167)							
12. THE ABOVE TERMS AND CONDITIONS ARE SATISFACTORY AND ARE ACCEPTED.							
DATE ACCEPTED	TYPED NAME AND TITLE OF ACCEPTING OFFICER		SIGNATURE				

INSTRUCTIONS

This form is intended for use by components of military departments in placing project orders with Government-owned and operated establishments within and outside the Department of Defense.

ITEM 1 - Check appropriate box indicating type of project order; i.e., fixed price or cost reimbursement.

ITEM 2 - Date of project order or amendment.

ITEM 3 - Name and address of ordering component.

ITEM 4 - Number assigned to project order by ordering component for control purposes.

ITEM 5 - Number assigned to project order amendment by ordering component for control purposes. Formal amendments shall be numbered consecutively.

ITEM 6 - Name, address, and station number of performing establishment.

ITEM 7 - Instructions for place, date and method of delivery, if applicable. If additional space is required, use Supplemental Data Section below.

ITEM 8 - Full description of work ordered (*this may be incorporated by reference*) and such other instructions as conditions of inspections, shipping, packing and marking,

etc. Use Supplemental Data Section or attach additional sheets if necessary. Limitations, if any, applicable to the appropriations or other accounts relevant to this order are shown in the Supplemental Data Section below.

ITEM 9 - Self-explanatory.

ITEM 10 - Insert the complete accounting classifications chargeable and the amount of the project order or amendment.

ITEM 11 - Insert in the spaces provided, the expiration date of the project order, the name, title and signature of officer or his authorized representative controlling or having responsibility for the administration of the funds cited on the project order or amendment. If authorizing officer is other than one having fiscal responsibility, the ordering department must have on file as support to the certificate, a written statement by such an officer substantiating the fiscal portion of the certificate.

ITEM 12 - The performing establishment shall indicate acceptance in this space. Duplicate, bearing acceptance date, name, title and signature of accepting officer shall be returned to the ordering component. If the performing establishment is unable to accept the project order, it shall return promptly the original project order form to the ordering office with appropriate explanation.

SUPPLEMENTAL DATA SECTION

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
21-79	Missing Data	B	Blank	Unknown	Blank indicates unknown or missing data.
1-5	Station Number WBAN		00001-99999	WBAN Number	A five digit number formulated to designate the station. A list of stations with their coordinates, elevation and period of record is maintained at the NCC in Asheville, N. C.
6-7	Year		00-99	Last two digits of year	
8-9	Month		01-12	01 Jan to 12 Dec	
10-11	Day		01-31	Day of month	
12-13	Hour		00-23	15 ^h	
14-16	Ceiling Height	hhh	000-990 XX 888	Hundred of feet 0-99,000 feet Unlimited Cirroform ceiling, height unknown	For information relating to time of observation changes and reduction of punches from 24 to 8 observations per day, reference SUPPLEMENTARY NOTE A, page 9 and OBSERVATION TIME, page 1. Reporting practices are described in SUPPLEMENTARY NOTE B, page 9.
17-20	Sky Condition First Sky Cover Layer Second Sky Cover Layer Third Sky Cover Layer Fourth Sky Cover Layer	O -- -- -- -- -- -- -- --	0 1 2 4 5 7 8 Blank X	Clear Cloud cover <.05 Columns 18-20 punched 000 Thin scattered Scattered Cloud cover .1 thru .5 Thin broken Broken Cloud cover .6 thru .9 Thin overcast Cloud cover 1.0 Overcast Cloud cover 1.0 Columns 18-20 punched 000 Partial Obscuration Columns 18-20 punched 0-8 0.1 or more but not all sky hidden by surface based layer Obscuration All of sky hidden by a surface based layer. Columns 18-20 punched 000.	Effective 1 Sep 56. Punching of 888 for Cirroform ceiling, height unknown, was discontinued on 1 Apr 70. Four column field for up to 4 layers. 0 in unused columns. Thin sky cover is a designation given any layer for which the ratio of transparency to total sky cover at that level is $\frac{1}{2}$ or more. Prior to September 1956 dark scattered, dark broken, and dark overcast were coded 3, 6, and 9, respectively. Reporting practices of sky conditions, etc. are described in more detail in SUPPLEMENTARY NOTE C, pages 9-10.

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USCIB-1001-1001-1111

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
21-23	Visibility	VW	000-006 006-020 020-027 027-030 030-150 150-950 990	0 - 3/8 miles 3/8 - 2 miles 2 - 2 1/2 miles 2 1/2 - 3 miles 3 - 15 miles 15 - 95 miles 100 miles or more Visibilities reported other than standard punched for next lower value.	1/16 mile increments Refer to Code 3 on page 12. 1/8 mile increments 1/4 mile increments 1/2 mile increments 1 mile increments 5 mile increments Effective 1 Apr 70, visibilities greater than 7 miles will not be recorded unless a marker is located at a distance greater than 7 miles.
24-31	Weather and/or Obstruction to Vision				*7/8 was not reported prior to Jul 52; and 1 1/8, 1 3/8, 1 5/8 and 1 7/8 until May 53. 1 1/8, 1 3/8, and 1 5/8 were punched as 1, 1 1/4, and 1 1/2 until Jan 56. 7/8 and 1 7/8 are punched as 3/4 and 1 3/4. See page 8 for intensity definition Columns 24-31.
24	Thunderstorm Heavy/Severe Thunderstorm Tornado Waterspout Squall	T T+ Tor Q	0 1 2 3 5	None Thunderstorm Heavy thunderstorm/ Severe thunderstorm Tornado - Land Waterspout - Water Squall	See note, page 8, on thunderstorm intensities. Heavy thunderstorm redefined Severe Thunderstorm 1 Jul 66. Reported as rain or snow squalls (RQ, SQ) before 1949. Intensity reported prior to 1 Jun 51. Definition is given on page 8.
25	Liquid Precipitation	R- R R+ RW- RW RW+ ZR- ZR ZR+	0 1 2 3 4 5 6 7 8 9	None Light rain Moderate rain Heavy rain Light rain showers Moderate rain showers Heavy rain showers Light freezing rain Moderate freezing rain Heavy freezing rain	
26	Liquid Precipitation	L- L L+ ZL- ZL ZL+	0 4 5 6 7 8 9	None Light drizzle Moderate drizzle Heavy drizzle Light freezing drizzle Moderate freezing drizzle Heavy freezing drizzle	Codes 1, 2 and 3, light, moderate and heavy rain squalls reported prior to 1949. Drizzle intensity explained in SUPPLEMENTARY NOTE D, page 10.

Revised: November 1970

CARD CONTENT					REMARKS
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	
27	Frozen Precipitation	S- S S+ SP- SP SP+ IC	0	None	Code 7, IC - and code 9, IC +; intensity reported prior to 1 Apr 63
			1	Light snow	
			2	Moderate snow	
			3	Heavy snow	
			4	Light snow pellets	
			5	Moderate snow pellets	
			6	Heavy snow pellets	
			8	Ice crystals	
28	Frozen Precipitation	SW- SW SM+ SG- SG SG+	0	None	Codes 4, 5 and 6, light, moderate and heavy snow squalls reported prior to 1949.
			1	Light snow showers	
			2	Moderate snow showers	
			3	Heavy snow showers	
			7	Light snow grains	
			8	Moderate snow grains	
			9	Heavy snow grains	
			9	Heavy snow grains	
29	Frozen Precipitation	IP- IP IP+ A AP	0	None	Prior to 1 Apr 70 Ice Pellets were coded as Sleet (S-, E, E+). On this date Sleet and Small Hail were redefined as Ice Pellets. Ice Pellet Showers (IPW) are coded as Ice Pellets; Sleet Showers were coded as Sleet. Hail intensities reported prior to 1 Sep 56: Codes 4, 6, 7, and 9, A-, A+, AP- and AP+. Deleted 1 Apr 70; redefined as Ice Pellets.
			1	Light Ice Pellets	
			2	Moderate Ice Pellets	
			3	Heavy Ice Pellets	
			5	Hail	
			8	Small Hail	
			8	Small Hail	
			8	Small Hail	
30	Obstructions to Vision	F IF GF BD BN	0	None	SUPPLEMENTARY NOTE E, Page 10 explains the reporting practices of these elements. OBSTRUCTIONS TO VISION are recorded only when the visibility is less than 7 miles.
			1	Fog	
			2	Ice fog	
			3	Ground fog	
			4	Blowing dust	
			5	Blowing sand	
			5	Blowing sand	
			5	Blowing sand	
31	Obstructions to vision	K H KH D BS BY	0	None	Effective 1 Jul 52.
			1	Smoke	
			2	Haze	
			3	Smoke and haze	
			4	Dust	
			5	Blowing snow	
			6	Blowing spray	
			6	Blowing spray	

DATA PROCESSING DIVISION, ETAC, USAF
NATIONAL CLIMATIC CENTER, NOAA

REFERENCE MANUAL

WIBAN HOURLY SURFACE OBSERVATIONS 144

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
32-35	Sea Level Pressure	PPPP	0000-9999	Millibars and tenths 0000 = 1000.0 mb 9999 = 999.9 mbs.	Thousands digit not punched. Antarctic stations, see SUPPLEMENTARY NOTE H, page 11. AWS punched 3-hourly only effective 1 Jul 58.
36-38	Dew Point Temperature	T ^T T ^T d ^d	000-099 X01-X99	0 to 199 Whole degrees F. -1 to -99 X in Column 36 for negative values.	Before 1919, dew point was computed with respect to ice if temperature was below 32°F. Beginning Jan 19, it was computed with respect to water regardless of temperature.
39-40	Wind Direction	dd	00-36	True direction, in tens of degrees, from which wind is blowing (Code 1, page 12 eff. 1 Jan 64).	Prior to 1964, wind directions were reported according to Code 2, page 12. See SUPPLEMENTARY NOTE H, page 11, for punching procedures at Admundsen-Scott Station, Antarctica.
41-42	Wind Speed	ff	00-99 X/	Knots X overpunch in Column 41 indicates 100 or more knots	Prior to Jan 55 in miles per hour at AF and WB stations; in knots at most Navy stations.
43-46	Station Pressure	PPPP	1000-3999	10.00 to 39.99 inches to Hundreds Hg.	Station pressure is the pressure at the assigned station elevation. AWS punched 3-hourly only effective 1 Jul 58, 6-hourly effective 1 Jan 64, and 3-hourly eff. on receipt of order dated 1 Jun 65.
47-49	Dry Bulb Temperature	TTT	000-199 X01-X99 X - X 100 199	Whole degrees F. 0 to 199 -1 to -99 -100 to -199	Column 47 punched X or Y overpunch for values below zero.
50-52	Wet Bulb Temperature		000-199 X01-X99	Whole degrees F. 0 to 199 -1 to -99	Column 50 punched X for minus. AWS began phasing out punching wet bulb data 1 Jul 58. WB and Navy discontinued punching wet bulb data 1 Jan 65. See SUPPLEMENTARY NOTE F, page 10 for hygrometer input. For methods of computation of wet bulb temperature and relative humidity, refer to page 13.
53-55	Relative Humidity	RH	000-100	0 to 100, whole percent Cols.	AWS discontinued punching Columns 53-55 1 Jul 58. WB discontinued punching Columns 53-55 1 Jan 65. NWS, effective 1 Apr 70, RH is punched only when entered on Form 1-10B; entry of RH on form is optional. Relative humidity computations respect to ice, etc. reporting practices explained in SUPPLEMENTARY NOTE F, page 10.
56-79	Clouds and Obscuring Phenomena Total Sky Cover		0-9 X	Tenths 10 Tenths	See SUPPLEMENTARY NOTE G, page 11 for information on cloud layers.

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USCIB-NOAA-ASMP1113

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
57	Amount of Lowest Layer		0-9	Tenths	Weather Bureau stations reported detailed cloud observations (Cols. 56-78) only every 3 hours, based upon the time of synoptic observations, until June 1951 and Jan 1965-present. Only Col. 56, Total Sky Cover, was punched for the intermediate observations. Beginning Jun 51, complete cloud observations were reported and punched (Cols. 56-79) for every record obs. as was the practice with Air Force and Navy stations. In all cards of FAM(CAA) stations, Cols. 57-78 are not punched. Note: Air Force stations coverage beginning 1 Jul 58, Cols. 57-79 were reduced from hourly to 3-hourly punching. Except for Korean and down range stations, punching of Cols. 58-61 and 63-79 was discontinued on 1 Jan 64, and Cols. 57 and 62 on 1 Jul 65. Sf was contraction prior to 1 Apr 70. Fs (Fractostratus) prior to 1 May 61. Cf was contraction prior to 1 Apr 70. Fc (Fractocumulus) prior to 1 May 61. Cm was contraction prior to 1 Apr 70.
			X	None/clear	
			0	Fog	
			1	Stratus	
			2	Stratocumulus	
			3	Cumulus	
			4	Cumulonimbus	
			5	Altostratus	
			6	Altostratus	
			7	Cirrus	
58	Type of Cloud		8	Cirrus	
			9	Cirrostratus	
			X	Stratus Fractus	
			2	Cumulus Fractus	
			X	Cumulonimbus mamma	
			4	Nimbostratus	
			5	Altostratus	
			6	Altostratus	
			7	Cirrocumulus	
			X	Cirrocumulus	
59-61	Height of Lowest Layer		X	Obscuring phenomenon other than fog	
			000-990	Hundreds of feet	
			888	0 to 99,000 ft.	
			XXX	Unknown height of a cirroform layer	
			0-9	Unlimited vertical visibility	
			X	Tenths	
			0-9	10 tenths	
			X	See Column 58	
			X	See Columns 59-61	
			62	Amount of Second Layer	
X	Clear, no clouds reported or surface based partial obscuring phenomena (first layer only).				
0-9					
X					
0-9					
X					
0-9					
X					
X					
63	Type of Second Layer				
			X		
			0-9		
			X		
			0-9		
			X		
			0-9		
			X		
			X		
			64-66	Height of Second Layer	
X					
0-9					
X					
0-9					
X					
0-9					
X					
X					

CARD CONTENT					
COLUMN	ITEM OR ELEMENT	SYMBOLIC LETTER	CARD CODE	CARD CODE DEFINITION	REMARKS
67	Summation Amount at Second Layer		0-9 X	Tenths	
68	Amount of Third Layer		0-9 X	Tenths	
69	Type of Third Layer		0-9 X/	See Column 58	
70-72	Height of Third Layer			See Columns 59-61	
73	Summation Amount at Third Layer		0-9 X	Tenths	
74	Amount of Fourth Layer		0-9 X	Tenths	
75	Type of Fourth Layer		0-9 X/	See Column 58	
76-78	Height of Fourth Layer			See Columns 59-61	
79	Total Opaque Sky Cover		0-9 X	Tenths	Effective Jun 51. 1 Jun 62 - Opaque Sky Cover was re-defined: Those portions of cloud layers or obscurations which hide the sky and/or higher clouds. Translucent sky cover which hides the sky but through which the sun and moon (not stars) may be dimly visible will be considered as opaque. 1 Apr 70 - Opaque Sky Cover: The amount (to the nearest tenth) of cloud layers or obscuring phenomena (aloft or surface-based) that completely hides all or a portion of the sky and/or higher clouds that may be present.
80	Not used				

METHODS FOR DETERMINING INTENSITY OF WEATHER

2025 RELEASE UNDER E.O. 14176

Revised: November 1970

DATA PROCESSING DIVISION, ETAC, USAF
NATIONAL CLIMATIC CENTER, NOAA

REFERENCE MANUAL

WEAN HOURLY SURFACE OBSERVATIONS 144

SUPPLEMENTARY NOTE A: OBSERVATION TIME Columns 14-15

The time punched is that of the record observations, taken within 10 minutes prior to the hour punched (ex. 1955 punched 1L). Prior to Jun 57, obs. were taken within 10 minutes prior to the half hour; minutes are disregarded in punching (ex. 0222 punched 02; 1L28. 14. All "War Times" and "Standard Meridian Times" were converted to Local Standard Time before punching. For Air Force stations in the United States, the times were punched in accordance with the established time zones. Time entries for Air Force stations outside the United States were edited prior to punching and where necessary converted to the Local Standard Time of the nearest meridian evenly divisible by 15 degrees.

SUPPLEMENTARY NOTE B: CEILING HEIGHT Columns 14-16

Ceiling was recorded in hundreds of feet above the ground to nearest 100 feet up to 5000 feet, to nearest 500 feet up to 10,000 feet, to nearest 1000 feet above that. Before 1949, Air Force stations recorded ceilings up to and including 20,000 feet, above which point the ceiling was classified as unlimited; Weather Bureau and Navy stations recorded ceiling only up to and including 9,500 feet, above which point the ceiling was considered unlimited. Beginning in 1949, ceiling was re-defined to include the vertical visibility into obscuring phenomena not classified as thin, that, in summation with all lower layers, cover 6/10 or more of the sky. Also at that time all limits to height of ceiling were removed, so that unlimited ceiling became simply less than 6/10 sky cover, not including thin obscuration. Then, beginning 1 Jun 51, ceiling heights were no longer established solely on the basis of coverage. The ascribing of ceilings to thin broken or overcast layers was eliminated. A layer became classified as "thin" if the ratio of transparency to total coverage at that level is $\frac{1}{2}$ or more.

SUPPLEMENTARY NOTE C: SKY CONDITIONS Columns 17-20

Jan 1945-Dec 1948: If there is only one cloud symbol, except for low scattered and obscured, Column 17 was punched with appropriate code, Cols. 18-19 with "X" and Col. 20 was left blank. If clouds were high (above 2,500 ft.) Col. 17 was X overpunched. If clouds were low scattered, "X" was punched in Col. 17, height in Cols. 18-19, and code in Col. 20. Cols. 18-19 were left blank if height was missing. When two cloud symbols were reported, the higher cloud was punched in Col. 17 and the lower in Col. 20. In 1946, obscured (continued on next page)

TABLE OF SKY CONDITIONS

The table below shows the punching practices in Columns 17-20 for the periods Jan 45 through Dec 48, and Jan 49 through May 51.

SKY CONDITION	REMARKS	1945-1948 17181920	1949-5/51 17181920
Clear ○		0 X X 0	0 X X 0
Low Scattered ○ at 2500 ft		0 2 5 2	0 2 5 2
High Scattered ○ (over 9500 ft)		X X X X	0 9 9 2
Hi Sctd Lwr Sctd ○/95 ○ at 9500 ft		X X X X	2 9 5 2
Broken at 12000 ft 12 ○		5 X X X	0 X X 5
High Brkn Lwr Brkn ○/○ Ceiling 5000 ft		X X X X	5 X X 5
High Ovc Lwr Sctd at 2500 ft ○/○		X X X X	8 2 5 2
High Ovc Lwr Brkn ○/○		X X X X	8 X X 5
Overcast ⊕		8 X X X	0 X X 8
Ovc Sctd at 3000 ft ⊕ 30 ○		8 3 0 2	8 3 0 2
Ovc Brkn at 2500 ft ⊕ 25 ○		8 X X 5	8 X X 5
Obscured X		0 X X X	0 X X X
Thin Obscured -X		0 X X	0 X X

SUPPLEMENTARY NOTE C (Continued)

sky was reported only when heavy obstructions to vision and/or heavy precipitation reduced the ceiling to zero and/or the visibility to less than $\frac{1}{2}$ mile; and when the visibility was $\frac{1}{2}$ mile or more, a sky symbol was always reported. Effective 1 Jan 47, the symbol "I", for obscured sky, received the same latitude of usage as all other symbols. "I" then represented sky cover of $\frac{6}{10}$ or more, obscured by precipitation or obstructions to vision either alone or in combination with lower clouds, and irrespective of higher clouds and ceiling and/or visibility limits. In August 1947, the use of "I", for thin obscured, was authorized. In 1946 if a layer of scattered clouds above a layer of broken clouds was clearly observable, it was so reported. In 1947 and 1948, symbols corresponding to higher cloud layers indicated the amount of sky covered not only by their respective layers, but by all layers below them. In all years, the presence of few clouds (less than 1/10) was recorded in Remarks.

Jan 49 through May 51: When only one sky symbol was reported it was punched in Col. 20. The use of an "X" overpunch for high (/) layers was discontinued. (/ indicates over 9500 ft). The height of scattered clouds above 9500 ft was punched in Cols. 18-19 as 99.

Effective 1 Jun 51, the reporting of height of low scattered was discontinued, and provision was made to report any number of sky condition symbols, with the height of each. The ceiling layer was not reported separately as before, but was identified by the entry of a ceiling classification letter immediately preceding the height. Sky condition symbols were reported in ascending order of height, and were punched in that order, unless more than four were reported. In that case, the last (highest) symbol was punched in Column 20, and the first three in Columns 17-19, unless the ceiling symbol was thereby excluded. In the latter case, the first two symbols were punched in Columns 17-18, the ceiling symbol in Column 19, and the highest symbol in Column 20. No symbols were reported in Remarks, as was the practice before June 1951.

Sky condition symbols were also re-defined so that obscuring phenomena aloft and clouds were reported in the same manner (i.e., obscuring phenomena aloft were reported by 0, 0, and 0, rather than X and -X). X and -X were used only to indicate the amount

of sky hidden by surface-based phenomena. -X was re-defined as partial obscuration (1/10 to less than 10/10 sky hidden). The symbols X and -X unlike 0, 0, and 0, were defined by the amount of the sky hidden by surface-based phenomena, and -X did not indicate the amount of sky covered. The meaning of "thin" was re-defined. If the total opaque cover created by any layer in combination with lower layers was $\frac{1}{2}$ or less of the summation total cover at that level, the layer was classified as thin. Note that the minus sign, when applied to 0, 0, or 0 means "thin"; when applied to X, means "partial".

SUPPLEMENTARY NOTE D: INTENSITY OF DRIZZLE Column 26

In 1946, intensity determined by visibility (as for smoke) only if drizzle occurred alone. When drizzle was accompanied by other forms of precipitation and/or obstructions to vision, its intensity was determined by rate of fall. In 1947, visibility limitations were dropped, and intensity was determined by rate of fall, even though drizzle occurred alone. In June 1951, previous visibility limits were re-instituted. Intensity of freezing drizzle determined in same manner as for drizzle. See page 8 for limits of intensities.

SUPPLEMENTARY NOTE E: OBSTRUCTIONS TO VISION Columns 30-31

Intensity of light, moderate, or heavy were assigned to obstructions to vision, through 1946. Effective Jan 47, the reporting and punching of all intensities of obstructions to vision were discontinued. Prior to 1 Jan 49, the distinction between F and GF was arbitrary, but beginning with that date an objective distinction was established. If the sky was not hidden above an angle of 33° from horizontal (less than 0.6 hidden), the fog was reported as ground fog (GF). Effective 1 Apr 70, Fog (F)-Ground Fog (GF): This hydrometeor is reported as F when it hides more than half (0.5-1.0) of the sky or extends upward into existing cloud layers. Otherwise it is reported as GF.

SUPPLEMENTARY NOTE F: WET BULB TEMP. & RH Columns 50-55

From Aug 60 - Dec 64, at WB stations with a hygrometer, wet-bulb temp. was computed and punched at MCC when instrument was operational above -35°F ; when non-operational or -35°F and lower, the wet-bulb temp. was punched at the station from values obtained from standby equipment. At stations not equipped with a hygrometer, the wet bulb temperature is considered to be the same as the dry bulb temperature whenever the dry bulb temperature is below -35°F . The same value is entered in parenthesis on the WBAN with dew point being computed in

SUPPLEMENTARY NOTE F (Continued)

respect to water and this value punched into WBAN Card. The relative humidity would then be computed by machine, same as for stations equipped with a hygrometer.

Prior to Jan 49, relative humidity computed with respect to ice if the dry bulb temperature was less than 32°F. Beginning Jan 49, computed with respect to water, regardless of temperature. Relative humidity machine calculated from 1 Aug 60. RH was not punched for FAA (CAA) stations except in special cases.

SUPPLEMENTARY NOTE G: CLOUD LAYERS Columns 56-79

Provisions are made for punching as many as four layers of clouds and/or obscuring phenomena existing at one time. If more than four layers existed, the data for levels above the fourth were entered in the Remarks portion of WBAN 10B, and were not punched. Their presence is indicated by the entry for total sky cover. Layers were punched in ascending order of elevation. All fields above a layer which prevented observation were left blank. If two or more types of clouds were observed at the same height, only the predominating type was punched, their amounts being combined. For each layer, the amount, type, and height were punched, and for the second and third layer, the summation amount at the level involved was punched, reflecting the total amount of sky covered by that layer and those below it. The summation total is not necessarily the sum of the individual layers.

In addition to the total sky cover, provision was made in Jun 51 for recording and punching the total amount of opaque sky cover, which is the amount of sky hidden by clouds or obscuring phenomena, as distinguished from the total amount of sky cover.

The height of the layers of clouds or obscuring phenomena aloft was recorded in hundreds of feet, and for fully obscuring phenomena based on the ground, the vertical visibility into it was recorded, with no prescribed limit. All heights were recorded to the nearest 100 feet from the surface to 5,000 feet; to the nearest 500 feet between 5,000 and 10,000 feet; and to the nearest 1,000 feet above 10,000 feet. For obscuring phenomena prescribed as "thin", a condition reportable from Aug 47 through May 51, the height of the base was punched, and in the case of thin fog, was always zero. Before Jan 47, obscuration was not reportable as a cloud type.

SUPPLEMENTARY NOTE G (Cont.) Columns 56-79

Some Weather Bureau and Navy cards in this deck were punched from the old type of reporting form (the WBAN 10 with which deck 11? is aligned) and in which five cloud layers were reported with no summation totals. In these cases, the summation total columns were left blank, and the five layers, if reported, were condensed into four.

SUPPLEMENTARY NOTE H: ANTARCTICA STATION NOTES Columns 32-35, 39-40

I. ADMUNDSEN-SCOTT STATION:

1. Wind Direction on all cards was punched according to the following system:

- A. A wind from 0° longitude was punched as N or 360.
- B. A wind from 90° east longitude was punched as E or 090.
- C. A wind from 180° longitude was punched as S or 180.
- D. A wind from 90° west longitude was punched as W or 270.

2. In place of sea level pressure (Column 32-35) the height of the 700 mb surface in whole meters was punched. This applies to the period 1 Dec 57 through Jan 66. Station pressure in millibars and tenths punched beginning Feb 66.

II. BYRD STATION, ANTARCTICA

1. In place of sea-level pressure (Columns 32-35) the height of the 850 mb surface was punched in whole meters through Jan 66. Station pressure in millibars and tenths punched beginning Feb 66.

III. FLATEAU STATION, ANTARCTICA 12/65-12/68

1. In place of sea-level pressure (Columns 32-35) the height of the 700 mb surface was punched in whole meters through Jan 66. Station pressure in millibars and tenths punched beginning Feb 66.

CODE TABLES

When coding a meteorological report, symbolic letters are replaced by figures, which specify the value or the direction of the corresponding element. In some cases, the substitution of the symbolic letter (or group of letters) is sufficient to permit direct transcription into figures (e.g., 00 or 999). In other cases, these figures are obtained by means of a special code table (or code, in short) for each element.

The codes elaborated to this end, as far as they are in world-wide use, are called international meteorological code tables. These same codes are used inversely for decoding observations and thus making available the information contained in them.

Besides the specifications given by the code tables in world-wide use, other sets of code tables are established by the WMO for regional use. Further arbitrary codes have been made necessary by the need to encode data in card decks which were never encoded into WMO form.

Only codes pertinent to this card deck are included in the present manual. They appear in the order in which the elements were introduced in the description of the card content. They are numbered consecutively, and if applicable, the corresponding WMO code numbers are shown.

Code 1

(1949 WMO Code 23)
(1960 WMO Code 0877)

dd - True direction, in tens of degrees, from which wind is blowing (or will blow)

Code Figure	Code Figure
00 CALM	19 105° - 194°
01 5° - 14°	20 195° - 204°
02 15° - 24°	21 205° - 214°
03 25° - 34°	22 215° - 224°
04 35° - 44°	23 225° - 234°
05 45° - 54°	24 235° - 244°
06 55° - 64°	25 245° - 254°
07 65° - 74°	26 255° - 264°
08 75° - 84°	27 265° - 274°
09 85° - 94°	28 275° - 284°
10 95° - 104°	29 285° - 294°
11 105° - 114°	30 295° - 304°
12 115° - 124°	31 305° - 314°
13 125° - 134°	32 315° - 324°
14 135° - 144°	33 325° - 334°
15 145° - 154°	34 335° - 344°
16 155° - 164°	35 345° - 354°
17 165° - 174°	36 355° - 364°
18 175° - 184°	

Code 2

dd - Wind Direction

Code Figure	Code Figure
00 CALM	340° - 349°
11 North	350° - 359°
12 North North	360° - 369°
13 North North	370° - 379°
22 North	380° - 389°
33 East	390° - 399°
34 East North	400° - 409°
44 East	410° - 419°
54 East South	420° - 429°
55 South	430° - 439°
56 South South	440° - 449°
66 South	450° - 459°
77 South West	460° - 469°
78 West	470° - 479°
79 West North	480° - 489°
88 North	490° - 499°

Code 3

WVW - Visibility (Statute Miles)

Code Miles	Code Miles
000 0	012 1-1/8
001 1/16	014 1-1/4
002 1/8	016 1-3/8
003 3/16	017 1-1/2
004 1/4	018 1-5/8
005 5/16	019 1-3/4
006 3/8	020 2
007 1/2	024 2-1/4
008 5/8	027 2-1/2
009 3/4	030-150 3-15.1 mile
010 1	150-950 15-95.5 mile
	990 100 or more

*Increments

COMPUTATION OF WET BULBDry Bulb zero and above

$$TW = T - (.03LN - .00072N (N - 1)) (T + Tdp - 2P + 108)$$

If temperature is less than 100°

$$TW \text{ Rounded} = TW + .9 \text{ if col. 48 is 0, 1, 2}$$
$$TW + (.9 - .01 (T + .9)) \text{ if col. 48 is 3, 4}$$
$$TW + .4 \text{ if col. 48 is 5 through 9}$$

If temperature is 100° or greater:

$$TW \text{ Rounded} = TW + .9.$$

for Dry Bulb temperatures less than zero:

$$TW = T - (.03LN - .00072N^2) (.6(T + Tdp) - 2P + 108)$$

$$TW \text{ Rounded} = TW - .01Tdp$$

T = dry bulb temperature in °F

TW = wet bulb in °F

Tdp = dew point in °F

$$N = \frac{T - Tdp}{10}$$

P = Station pressure measured in inches of mercury

In all cases TW should be computed to at least two decimal places prior to applying the rounding factor.

COMPUTATION OF RELATIVE HUMIDITY

$$RH = \left(\frac{173 - .1T + Tdp}{173 + .9T} \right)^6$$

Where T = Air Temp. in °F
T_{dp} = Dew Point Temp. in °F

Reference to the above formula may be found in "An Approximation Formula to Compute Relative Humidity from Dry Bulb and Dew Point Temperatures" by Julius F. Eosen, Monthly Weather Review, Vol. 86, No. 12, Dec. 1958, page 186.

WBAN HOURLY SURFACE OBSERVATIONS 144

REFERENCE MANUAL

**DATA PROCESSING DIVISION, ETAC, USAF
NATIONAL CLIMATIC CENTER, NOAA**

OTHER CARD DECKS CONTAINING HOURLY OBSERVATIONS

DECK	GENERAL PERIOD
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0019	London Airport Hourly Surface	1948-1961
0021	USAAF in Great Britain Surface	1942-1946
1332	Canadian Hourly Surface Obs.	1946-1951
1334	Canadian Hourly Surface Obs.	1951-1953
1335	Canadian Hourly Surface Obs.	1950-1967
1339	Japanese Airway Obs. Hourly Sfc.	1958-1961
1421	WBAN Hourly Surface Obs.	1937-1945
1442	WBAN Hourly Surface Obs.	1945-1948
1556	British Hourly Obs.	1941-1948
1557	Turkish Hourly Surface Obs.	1930-1959
1558	German Hourly Obs. GZMO	1955-1961
1558	German Hourly Obs. GZMO	1962-1964
1559	Korean Hourly Obs. ROK	1954-1964
1559	Korean Hourly Obs. ROK	1965-1967
1660	Azores Hourly Obs.	1951-1955
1771	Nanking Hourly Obs.	1928-1937
1772	Yungun Hourly Obs.	1978-1942
1775	Taihung Hourly Obs.	1952-1956
1928	Hourly Marine Sfc OSV's	1965-1970

ELEMENTS (ITEMS) PUNCHED

Page	Page
2	2
CEILING	SKY CONDITION
CLOUDS (4 layers)	STATION NUMBER
Amount, Type, Height	TEMPERATURE
Amount Total	Dew Point
Amount Total Opaque	Dry Bulb
	Wet Bulb
DATE	VISIBILITY
Yr Mo Day Hour	WEATHER AND/OR
HUMIDITY Relative %	OBSTRUCTIONS TO VISION
PRESSURE	WIND
See Level	
Station	

~~CARD DECK 144 ACRONYMS~~

AF	Air Force
AMS	Air Weather Service
CAA	Civil Aeronautics Administration (same as FAA)
ESSA	Environmental Science Services Administration (NOAA after 3 Oct 1970)
ETAC	Environmental Technical Applications Center
FAA	Federal Aviation Administration (formerly CAA)
GZMO	German Zonal Meteorological Organization
GMT	Greenwich Mean Time
ID	Identification (cards)
METAR	Meteorological Aviation Routine Weather Report
MF	Meteorological Form
NCC	National Climatic Center (formerly National Weather Records Center (NWRC))
NWS	NOAA National Weather Service (formerly WB)
NOAA	National Oceanic and Atmospheric Administration (eff. 3 Oct 1970)
NWS	Naval Weather Service
OSV	Ocean Station Vessel
ROK	Republic of Korea
USAF	United States Air Force
WB	Weather Bureau (changed to NWS 3 Oct 1970)
YBAN	Weather Bureau - Air Force - Navy
WMO	World Meteorological Organization



ATLANTA, GEORGIA
NAT WEATHER SERVICE FCST SVC
HARTSFIELD ATLANTA INTL AP
AUGUST 1974

LATITUDE 33° 39' N LONGITUDE 84° 26' W ELEVATION (GROUND) 1010 FT. STANDARD TIME USED: EASTERN LOGAN 013074

DATE	TEMPERATURE °F								HEATHER TYPES OR DATES OF OCCURRENCE		SNOW-ICE PELLETS ON EQUIV. IN. AT 07 AM	PRECIPITATION		STATION NAME ELEV. 1034 FEET M.S.L.	WIND		SUNSHINE		SKY COVER TENTHS		OBS.																												
	MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE OVERCAST	DEGREE DAYS BASE 59°		1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 BLAZE 7 DUSTSTORM 8 DRIVING SNOW	WATER LEVEL IN.	SNOW-ICE PELLETS IN.		DIRECTION	RESULTANT SPEED M.P.H.		AVERAGE SPEED M.P.H.	FASTEST MILE M.P.H.	DIRECTION	HOURS AND TENTHS	PERCENT POSSIBLE	SUMMERS TO SUBMIT		HIGHEST TO LOWEST																											
						HEATING	COOLING																7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22										
1	88	68	78	0	64	0	13	3	0	0	0	0	28.05	08	1.8	6.8	27	N	8.8	84	6	1																											
2	81	68	76	-2	60	0	11	1	0	0	0	0	28.05	17	4.4	6.3	18	SE	4.9	32	8	2																											
3	81	68	76	-2	60	0	11	1	0	0	0	0	28.05	18	8.4	6.9	18	S	6.6	28	10	3																											
4	83	69	76	-1	61	0	11	2	0	0	0	0	28.05	18	9.5	6.8	17	SE	4.7	17	4	4																											
5	80	68	74	-4	60	0	9	1	0	0	0	0	28.05	10	2.3	9.5	11	SE	2.6	10	8	5																											
6	82	67	75	-3	67	0	10	1	0	0	0	0	28.06	14	6.7	7.6	19	E	9.3	38	7	6																											
7	73	68	71	-7	60	0	6	1	0	0	0	0	28.05	10	9.2	6.4	17	S	0.0	0	10	7																											
8	78	68	73	-5	60	0	0	1	0	0	0	0	28.07	14	3.0	4.0	9	SE	0.0	7	10	10																											
9	84	70	77	0	68	0	12	1	0	0	0	0	28.00	27	1.8	4.0	10	W	4.3	32	8	8																											
10	87	68	78	0	68	0	10	1	0	0	0	0	28.07	10	9.5	6.8	18	SE	9.2	38	6	10																											
11	85	70	78	0	70	0	11	1	0	0	0	0	28.07	30	5.3	6.6	14	W	11.0	81	5	12																											
12	82	69	75	-3	68	0	10	1	0	0	0	0	28.05	25	1.9	4.8	10	W	3.4	26	10	7																											
13	86	66	76	-2	68	0	11	2	0	0	0	0	28.07	28	3.4	4.0	11	W	7.0	58	5	13																											
14	81	67	74	-4	68	0	0	1	0	0	0	0	28.06	08	2.7	5.0	23	W	1.8	13	8	14																											
15	85	68	77	-1	60	0	12	1	0	0	0	0	28.05	18	2.0	4.0	10	S	4.0	36	8	15																											
16	85	69	77	-1	70	0	12	1	0	0	0	0	28.07	18	1.5	5.0	9	N	5.4	40	7	16																											
17	88	70	78	1	70	0	14	1	0	0	0	0	28.06	28	6.0	7.6	12	W	8.9	52	4	17																											
18	88	69	78	0	69	0	13	1	0	0	0	0	28.06	28	1.7	4.4	28	SE	9.2	38	6	18																											
19	88	67	78	0	67	0	13	1	0	0	0	0	28.01	32	4.2	5.0	9	NW	13.3	100	5	19																											
20	83	68	76	-2	66	0	11	1	0	0	0	0	28.08	08	9.0	8.0	17	E	13.3	100	8	20																											
21	83	68	76	-1	66	0	11	1	0	0	0	0	28.06	08	9.0	10.4	17	E	8.9	48	6	21																											
22	85	67	76	-1	66	0	11	1	0	0	0	0	28.07	08	6.2	7.1	10	E	8.0	61	4	22																											
23	86	69	78	1	66	0	13	1	0	0	0	0	28.04	06	5.5	6.0	11	NE	9.8	72	3	23																											
24	87	68	78	1	68	0	13	1	0	0	0	0	28.02	04	1.8	3.7	9	NW	4.2	95	2	24																											
25	88	70	78	2	68	0	14	1	0	0	0	0	28.02	10	2.1	3.2	7	S	9.8	78	4	25																											
26	88	69	78	0	68	0	14	1	0	0	0	0	28.02	10	14	12.0	8	W	12.0	82	2	26																											
27	91	70	81	4	69	0	16	8	0	0	0	0	28.00	26	2.6	5.2	9	S	10.0	77	5	27																											
28	91	71	81	5	69	0	16	8	0	0	0	0	28.06	24	4.6	5.2	12	SW	12.0	82	6	28																											
29	86	69	77	1	70	0	12	3	0	0	0	0	28.06	24	4.1	6.2	17	W	8.1	47	9	29																											
30	87	69	78	2	69	0	13	3	0	0	0	0	28.01	24	6.8	6.0	24	S	7.6	58	7	30																											
31	86	70	78	2	68	0	13	3	0	0	0	0	28.08	28	4.1	5.9	18	SW	7.9	58	8	31																											
SUM																						SUM		SUM		SUM		SUM		SUM		SUM		SUM		SUM		SUM		SUM									
287																						217		28		NUMBER OF DAYS		28		TOTAL		28.08		18		1.2		8.2		211.0		182							
AVG.																						AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.							
84.7																						68.6		76.7		-0.8		58		-20		PRECIPITATION		0.01 INCH		13		2.72		DAYS IN		414.8		81		8.7		6.4	
SEASON TO DATE																						TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL	
NUMBER OF DAYS																						TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL		TOTAL	
MAXIMUM TEMP.																						MINIMUM TEMP.		0		1267		THUNDERSTORMS		12		PRECIPITATION		SNOW, ICE PELLETS		SNOW, ICE PELLETS		SNOW, ICE PELLETS		SNOW, ICE PELLETS		SNOW, ICE PELLETS		SNOW, ICE PELLETS		SNOW, ICE PELLETS		SNOW, ICE PELLETS	
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2						T	T						.10	T					T	.04	.02	T	T		2
3		T			T	T	.02							T		.06	.02	.01							3
4			T											T											4
5												T		T								T	T		5
6																									6
7						T	T	.03	T	.15				T		.02	.70	.02	.18	.08	.02	.03	T	.01	7
8	.01	.04	T	T	T	.05	.02	.05	T	.01			T	T						T	T				8
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ATLANTA. GEORGIA

- # RECORDING TEMPERATURES FOR THE MONTH. NOT BE THE LAST OF EACH YEAR AND DECEMBER.
- BELOW ZERO TEMPERATURE OR NEGATIVE DEPARTURE FROM NORMAL.
- o 10 AT ALL STATIONS.
- o ALSO ON AN EARLIER DATE, ON DATES.
- # WEATHER AND VISIBILITY TO 1/4 MILE OR LESS.
- F IN THE MONTHLY PRECIPITATION TABLE AND IN COLUMNS 9, 10, AND 11 INDICATES AN AMOUNT TOO SMALL TO

THE SPEEDS FOR THESE DATA BEGINS WITH JULY FOR HEATING DATA IN COLUMNS 01-12. JULY, 1968, IS BASED ON 8 OBSERVATIONS PER DAY AT 3-HOUR INTERVALS. WIND DIRECTIONS ARE FROMED FROM THE WIND DIRECTION. THE WIND DIRECTION IS THE VECTOR SUM OF WIND DIRECTIONS. WIND SPEEDS DIVIDED BY THE SQUARE OF THE WIND SPEEDS FOR DIRECTIONS AND TENDS OF DECREASED FROM THE WINDS 1.2, 10-10.5, 10-10.5, 27-28, 30-30. WINDS IN COL. 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820

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WILLIAM H. HAGGARD
DIRECTOR, NATIONAL CLIMATE CENTER

DIRECTOR, NATIONAL CLIMATIC CENTER

SUMMARY BY HOURS

AVERAGES														RESULTANT	
HOUR	MIN	LAT	LONG	STATION PRESSURE	TEMPERATURE					RELATIVE HUMIDITY 1	WIND SPEED	WIND DIRECTION	SPEED	DIRECTION	
					AIR	WET	SEA SURF	HGT. 1000 FT.	MOISTURE 2						
01	0	29.00	75	86	84	86	86	6.3	14	1.0	1.0				
04	0	29.08	70	86	87	81	4.0	1.0	1.0	1.0	1.0				
07	6	29.01	70	86	80	91	9.0	08	1.0	1.0	1.0				
10	6	29.04	77	72	88	77	6.0	18	1.0	1.0	1.0				
13	7	29.01	81	72	86	86	7.3	22	1.0	1.0	1.0				
16	7	29.08	83	78	86	85	7.3	27	1.0	1.0	1.0				
19	7	29.07	72	72	86	85	7.3	27	1.0	1.0	1.0				
22	9	29.01	75	70	86	86	8.0	15	1.0	1.0	1.0				

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OBSERVATIONS AT 3-HOUR INTERVALS

[illegible]

NOTES

CEILING COLUMN
WHL INDICATED ON WHL LISTED
CEILING

WEATHER COLUMN

0	TORNADO
1	THUNDERSTORM
2	SQUALL
3	RAIN
4	RAIN SHOWERS
5	FREZZING RAIN
6	DRIZZLE
7	FREZZING DRIZZLE
8	SNOW
9	SNOW PELLETS
10	ICE CRYSTALS
11	SNOW SHOWERS
12	SNOW GRAINS
13	ICE PELLETS
14	HAIL
15	FOG
16	ICE FOG
17	GROUND FOG
18	BLOWING DUST
19	BLOWING SNOW
20	BLOWING SAND
21	BLOWING SPRAY
22	SMOG

WIND COLUMNS-

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

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ATLANTA, GEORGIA
NAT WEATHER SERVICE FCST OFC
HARTSFIELD ATLANTA INTL AP
SEPTEMBER 1974

LATITUDE 33° 38' N LONGITUDE 04° 26' W ELEVATION (ROUND) 1010 FT. STANDARD TIME USED: EASTERN

MOON 813875

[illegible]

HOURLY PRECIPITATION (WATER EQUIVALENT) IN INCHES

[illegible]

- A. EXTREME TEMPERATURES FOR THE MONTH. MAY BE THE LAST OF MORE THAN ONE OCCURRENCE.
- BELOW ZERO TEMPERATURE OR NEGATIVE DEPARTURE FROM NORMAL.
- TO AT ALASKAN STATIONS.
- ALSO ON AN EARLIER DATE, OR DATES.
- MEANS THE WEATHER'S VISIBILITY IS 1/4 MILE OR LESS.
- IN THE MONTHLY PRECIPITATION TABLE AND IN COLUMNS 9, 10, AND 11 INDICATES AN AMOUNT TOO SMALL TO MEASURE

THE SEASON FOR DEGREE DAYS BEGINS WITH JULY FOR HEATING AND ENDING FOR COOLING. THE NUMBER OF DEGREE DAYS FOR HEATING OR COOLING IS THE SUM OF POSITIVE OR NEGATIVE DIFFERENCES OBSERVATIONS PER DAY AT 1.5 HOUR INTERVALS. THE WIND DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. RESULTANT WIND IS THE VECTOR SUM OF WIND DIRECTIONS AND SPEEDS DIVIDED BY THE NUMBER OF OBSERVATIONS. FIGURES FOR DIRECTIONS ARE REAS OF DEGREES FROM TRUE NORTH. I.E., 20-FAST, 180-SOUTH, 270-EST, 90-WEST. WIND-CHILL, WIND DIRECTION AND WIND SPEED OF DEGREES IN COL. 17, 18, 19. IN COL. 16 ARE HASTERS' REPORTED 1 MINUTE SPEEDS IF IT APPEARS IN COL. 17, SPEEDS ARE DUSTS.

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William H. Wagner

DIRECTIONS, NATIONAL CLIMATIC CENTER

SUMMARY BY HOURS

TIME	LATITUDE	LONGITUDE	AVERAGES								RESULTANT WIND	
			STATION	TEMPERATURE				RELATIVE HUMIDITY %	WIND SPEED	DIRECTION	SPEED	DIRECTION
				PRESSURE	AIR °F	WET BULB °F	DWY PT. °F					
01	8	28.06	66	67	63	61	76	7.0	7.0	2.0	2.0	
04	6	28.95	64	64	61	61	75	7.0	7.0	4.0	3.0	
07	0	28.97	64	62	60	60	72	7.0	7.0	2.0	3.0	
10	7	29.00	70	65	62	62	75	8.3	8.0	2.0	2.0	
13	7	28.98	75	67	62	65	65	8.1	10.3	2.0	2.0	
16	6	29.00	75	67	62	65	65	8.0	10.0	2.0	2.0	
18	6	29.94	71	65	62	62	72	8.0	8.0	2.0	2.0	
22	3	28.97	69	69	62	61	74	9.0	7.0	2.0	2.0	

ATLANTA. GEORGIA

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10/10/74

OBSERVATIONS AT 3-HOUR INTERVALS

[illegible]

NOTE

CEILING COLUMN-
JOINT INDICATED ON WALLS PER
CEILING

WEATHER COLUMN-

A FORWARD
T THUNDERSTORM
Q SQUALL
R RAIN
RH RAIN SHOWERS
ZB FREEZING RAIN
L DRIZZLE
ZL FREEZING DRIZZLE
S SNOW
3P SNOW PELLETS
IC ICE CRYSTALS
SH SNOW SHOWERS
SG SNOW GRAINS
IP ICE PELLETS
A MAIL
F FOG
IF ICE FOG
GF GROUND FOG
BD BLUING DUST
BS BLUING SAND
BL BLUING SMOKE
BY BLUING SPRAY
M SMOKE
H HAZE
O DUST

11 TWO COLUMNS-

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 08 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS.
MULTIPLY BY 1.15 TO CONVERT
TO MILES PER HOUR.

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B-20



LATITUDE 33° 30' N LONGITUDE 04° 26' W ELEVATION (GROUND) 1010 FT. STANDARD TIME USED: EASTERN MBAN 013074

SUN	SUN			TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:		TOTAL		SUN	SUN								
2304	1988			140	41	NUMBER OF DAYS	1-22	0	29.12	35	2.2	23	E	292.7	FOR	91	72						
AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	% PRECIPITATION	DEP			DATE: 21-		MOBILE		AVG.									
74.3	48.3	61.3	-5.1	43	11	@ INCH	2	-1.29				581.6	82	2.9	2.7								
				SEASON TOTAL				SNOW, ICE PELLETS								GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW			
MAXIMUM TEMP.				TOTAL				O				PRECIPITATION				SHOW				ICE PELLETS ON ICE AND DATE			
90	1	32	0	32	0	THUNDERSTORMS	0																
0	1	0	0	0	29	HEAVY FOG	0	1.22	19-18														
				CLEAN FOG				PARTLY CLOUDY & CLOUDY				5											

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

* STATE TEMPERATURES FOR THE MONTH, AND BE THE LAST
 OF ABOVE TYPE AND OCCURRENCE.
 * BECOMES ZERO TEMPORAL ON NEGATIVE DEPARTURE FROM
 ZEROING.
 * NOT IN ALGEBRAIC STATINGS.
 * ALSO ON AN EMPLOYED DATE, OR DATES.
 * MEANS FOR DISTRICTS AVAILABILITY TO 1/4 MILE OR LESS.
 * IN THE MONTH, PRECIPITATION TIME AND IN COLUMNS
 0 AND 1 INDICATES NO REPORT FOR SAME
 MONTHS.
 * THE MONTH FOR TEMPERATURE BEGINS WITH JULY FOR HEATING
 AND JANUARY FOR COOLING.
 * DATA IN COLUMNS 6, 12, 18, 24, AND 30 ARE BASED ON 0
 TO 1000 HOURS OF THE DAY, 12 HOURS INTERVALS.
 * WIND DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS.
 * DIRECTION WIND IS THE NUMBER TYPE OF WIND DIRECTIONS
 * BASED ON DIRECTION OF WIND DIRECTIONS.
 * FLOWING DIRECTIONS ARE TYPE OF COLUMNS FROM THE
 MONTHS, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776,

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, NORTH CAROLINA, 20001

SUMMARY BY HOURS

TIME	LAT.	LONG.	SEA COVER	WIND DIRECTION	AVERAGES										RESULTANT WIND		
					SPEED	TEMPERATURE					HUMIDITY					SPEED	DIRECTION
						PRESSURE	AIR °	WET °	DEW PT. °	RELATIVE %	WIND SPEED	WIND DIRECTION					
01	2	29.12	94	43	68	9.6	33	2.0									
04	2	29.11	92	40	74	6.8	36	2.0									
07	2	29.14	90	47	73	5.2	01	2.0									
10	3	29.17	83	50	65	5.3	7.0	2.0									
13	3	29.13	71	56	63	37	8.0	09									
16	3	29.08	73	57	63	36	7.9	34									
19	2	29.10	77	63	67	37	9.6	39									
22	3	29.09	89	51	60	37	9.6	39									

USCOMM - WORA - ASHEVILLE 029
11/18/74

OBSERVATIONS AT 3-HOUR INTERVALS

DAY 01										DAY 02										DAY 03										DAY 04										DAY 05										DAY 06										DAY 07										DAY 08										DAY 09										DAY 10										DAY 11										DAY 12										DAY 13										DAY 14										DAY 15										DAY 16										DAY 17										DAY 18										DAY 19										DAY 20										DAY 21										DAY 22										DAY 23										DAY 24										DAY 25										DAY 26										DAY 27										DAY 28										DAY 29										DAY 30										DAY 31																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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NOTES

CEILING COLUMN-
UNL INDICATED ON UNLIFIED
CEILING

WEATHER COLUMN.

```

0  TOWNADD
1  THUNDERSTORM
Q  SQUALL
R  RAIN
RN  RAIN SHOWERS
FR  FREEZING RAIN
L  DRIZZLE
FL  FREEZING DRIZZLE
S  SNOW
SH  SNOW PELLETS
IC  ICE CRYSTALS
SM  SNOW SHOWERS+
SG  SNOW GRAINS
IP  ICE PELLETS

```

F FOG
 IF ICE FOG
 GF GROUND FOG
 OQ BLOWING DUST
 ON BLOWING SAND
 OS BLOWING SNOW
 OF BLOWING SPRAY
 R SMOKE
 H HAZE
 O DUST

MIND COLUMNS-

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS.
MULTIPLY BY 1.15 TO CONVERT
TO MILES PER HOUR.

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

ON EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE

210



FIRST CLASS



APPENDIX C

CHATTAHOOCHEE RIVER FIELD INSPECTIONS

APPENDIX C

CHATTAHOOCHEE RIVER FIELD INSPECTIONS*

By

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Tetra Tech, Inc.
Lafayette, California 94549

BACKGROUND AND PURPOSE

The U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) is adapting a dynamic water quality ecologic model to the Chattahoochee River in Georgia. While the model can calculate the population dynamics of algae, zooplankton, benthic animals and fish, time and budget do not allow for a detailed calibration of that portion of the model. Since the primary purpose of the model will be to evaluate the transient water quality impact of urban runoff and waste discharges, the biological section of the model was modified, on an interim basis, to remain constant during the simulation.

To provide a good estimate of the biological "constant" and to become familiar with the general setting of the river, a field inspection with a helicopter was made on August 18, 1975. The crew included Mr. R. G. Willey of HEC, Mr. Larry Lyons of the Savannah District Corps of Engineers, Mr. Larry Neal of the Georgia Department of Natural Resources, Environmental Protection Division, and myself. After the field trip, I had discussions with biologist, Mr. Daniel R. Holder of the Georgia Department of Natural Resources, Game and Fish Division, and Mr. R. M. Gaddis of the Georgia Department of Natural Resources, Environ-

*Report submitted to Hydrologic Engineering Center for a consulting assignment, Contract DACW05-5-76-P-0481

mental Protection Division. Pertinent reports on water quality and biological surveys were reviewed.

This brief report documents the findings of the field inspection and the discussion with local field biologists.

RIVER SETTING

The headwater of the Chattahoochee River originates from Buford Dam behind Lake Lanier, a very clean body of water. Water is released for hydro-power generation during the peak hours of power demand on weekdays. The minimum flow of the river is 600 cfs. During the course of a day, the flow of the river can change drastically.

The river is full of shoal areas with riffles and pools. Exceptions are the areas subject to the backwater effects of low level dams, i.e., Morgan Falls Dam and West Point. Shallow areas are approximately two to three feet deep and pool areas six feet deep. The velocity of the river flow is approximately one to three feet per second.

The river banks are full of trees that may drop leaves into the river. Urban developments and spot deforestations along the river appear to contribute heavy sediment loads to the river. The turbidity increases as the river receives tributary flows downstream.

FISHERY RESOURCES

Before the construction of Buford Dam, the river was primarily full of warm water fish. The low level release of water

from Buford Dam makes the upstream section of the river suitable for cold water fish.

Within the study area, the river can be divided into three sections in terms of fishery resources. The cold water section extends from Buford Dam to the Atlanta Water Works Intake. From Atlanta to Franklin is a section that has been polluted by sewage, industrial wastes and thermal discharges. From Franklin to West Point is a section that has recovered from upstream pollution.

The water quality in Section I has been suitable for water supply and cold water fishery. Georgia Fish and Game has stocked this area with both fingerlings and trout of catchable size. Eighty thousand (80,000) fish per year of catchable size are planted from April to October. It is estimated that the standing crop of cold water fish is on the order of thirty (30) to fifty (50) lb/acre. This is equivalent to approximately thirty-five (35) to sixty (60) lb/river mile. For model simulation, five (5) lb/mile may be used for cold water fish on a dry weight basis. For warm water fish and bottom feeders, one half (0.5) lb/mile may be appropriate.

For Section II, it was felt that the river was too polluted to support any fishery. However, the low values of 0.1 lb/mile for cold water fish and 2 lb/mile for warm water fish and bottom feeders may be assigned.

For Section III, warm water fishery predominates. Fishery biologists feel that the standing crop of warm water fish should be on the order of 200 to 300 lb/acre. In a pre-impoundment survey of the proposed West Point Reservoir, W. L. Shelton of Auburn University reported a value of 100 lb/acre, predominantly sunfish (*L. Auritus*), large mouth bass (*N. Salmonoides*), and

channel catfish (*Panctatus*). For model simulation, approximately 12 to 15 lb/mile of warm water fish on a dry weight basis is appropriate. Among them, 4 to 5 lb/mile are bottom feeders. Cold water fish may be 0.5 lb/mile.

ORGANIC SEDIMENT

Total organic carbon in the water ranges from 1 to 7 mg/l as C. The detritus content of the water is therefore 2 to 14 mg/l.

The solid content of organic sediment ranges from 60 to 80 percent. The volatile solid fraction ranges from 2 to 6 percent. Chemical oxygen demand ranges from 20,000 to 68,000 mg/kg. Assuming a specific gravity of 1.6 to 2.0 for sediment, the organic content in the top two (2) inches of depth is calculated to range from 5 g/m² to 15 g/m². The low value is a reflection of flow characteristics as well as waste discharge conditions.

Based on this calculation, it is proposed that 10 g/m² be used for river reaches that do not receive waste water discharges. Downstream of waste discharges, 20 g/m² of organic sediment may be assigned. For the river reaches subject to backwater effects of a low level dam, organic sediment may be 150-200 g/m².

ALGAL DENSITY

Water released from Buford Dam contains little algae because of the low level intake structure. River water is soft, containing little nutrients, i.e., 0.02 - 0.15 mg/l NH₃N, 0.02 - 0.05 mg/l PO₄P, 0.2-0.7 mg/l NO₃N. Flow is swift, providing little residence time for algal growth.

For these reasons, chlorophyll a content is low, i.e., 0.5 to 2 $\mu\text{g/l}$. This is equivalent to 0.001 mg/l of algae on a dry weight basis. This will have zero impact on the oxygen resources of the river. Oxygenation of the river water comes primarily from surface reaeration.

Zooplankton density has not been reported. It may be presumed low, near zero.

Benthic (periphyton) algae has been monitored by the U.S. Geological Survey. For the upstream section, the periphyton density is on the order of 1.1 g/m^2 . In the polluted section, non-chlorophyllous unit predominate ($\sim 3 \text{ g/m}^2$). Downstream, chlorophyllous periphyton grows to approximately 4 g/m^2 .

MACROINVERTEBRATES

The benthic animal population was studied by submerging limestone substrate (LSS) in the river water for two months. Animals that colonized on the substrate were obtained for qualitative and quantitative analysis. Surface areas of LSS were not reported. For this calculation, it is assumed to be one square foot. The estimated value can be adjusted accordingly when the surface area of LSS becomes available at a later date.

The benthic animal densities were reported to be 0.538 g/LSS at Cobb County water intake, 0.366 g/LSS at Georgia Highway 92 bridge, and 0.127 g/LSS at U.S. Highway 27 bridge. It is not known if the biomass was expressed in dry or wet weight. Judging from the relative order of magnitude, they are presumed to be wet weight. Assuming the surface area of LSS to be one square foot, these values are converted to 5.8 g/m^2 , 3.9 g/m^2 , and 1.4 g/m^2 respectively.

The biomass by the LSS method represents only that fraction of animals favoring stone strata. There is no known ratio between LSS biomass to total biomass.

Estimates can only be made on a rough basis. For the model, it is proposed to use the following data.

1. From Buford Dam to Gwinnett Intake 0.3 g/m^2
2. From Gwinnett Intake to Dekalb Intake 0.6 g/m^2
3. From Dekalb Intake to Morgan Falls Dam 1.0 g/m^2
4. From Atlanta to Franklin 0.2 g/m^2 , and
5. From Franklin to Westport 0.6 g/m^2

All the values are on a dry weight basis. It must be noted that benthic animal biomass in the upper clean water reaches will be mostly insects. From Atlanta to Franklin, they will be mostly oligochaet worms. From Franklin to West Point, a mixture of both will exist on the substrate.

APPENDIX D

EXAMPLE INPUT DATA

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D.1	Inflow Quality	D-1
D.2	Withdrawal Data	D-38

INFLOW QUALITY

		Buford Dam Release River Mile 456.2		
Parameter		Source	Remarks	Quality
TEMP	°F	Mobile Dist.	daily grab <u>1/</u> sample	52
OXY	mg/l	Mobile Dist.	time variant	<u>2/</u>
BOD5	mg/l	AWW	mean of grab samples	0.8
COLIF	col./100 ml	AWW	mean of grab samples	10
DETRITUS	mg/l	estimate		.60
NH3	mg/l (N)	AWW	mean of grab samples	0.13
NO3	mg/l (N)	AWW	mean of grab samples	0.39
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	AWW	mean of grab samples	0.05
TDS	mg/l	AWW	mean of grab samples	33
ALGAE(1)	mg/l	estimate		.08
ALGAE(2)	mg/l	estimate		.04
ZOO	mg/l	estimate		.006
PH		Mobile Dist.	daily grab <u>3/</u> sample	6.6
ALKA	mg/l (CaCO ₃)	AWW	mean of grab sample	10.5
<u>1/</u>	see figure D - 1			
<u>2/</u>	see figure D - 3			
<u>3/</u>	see figure D - 2			

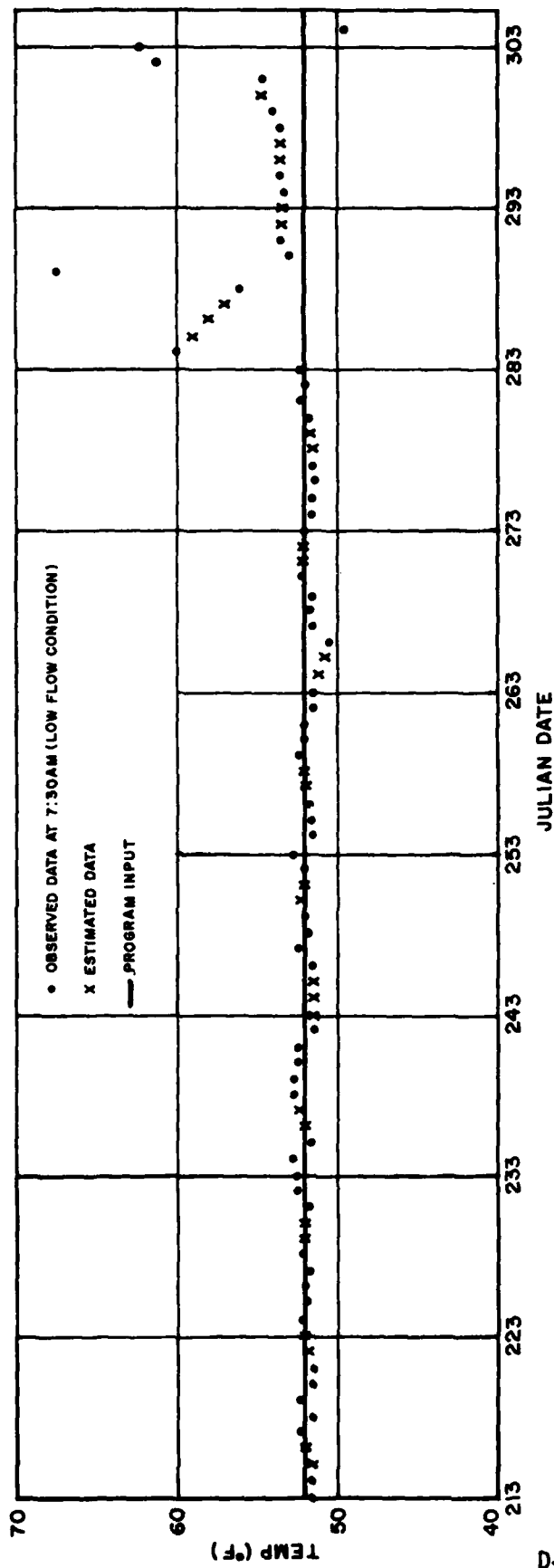


Figure D-1. BUFORD TEMPERATURE vs TIME

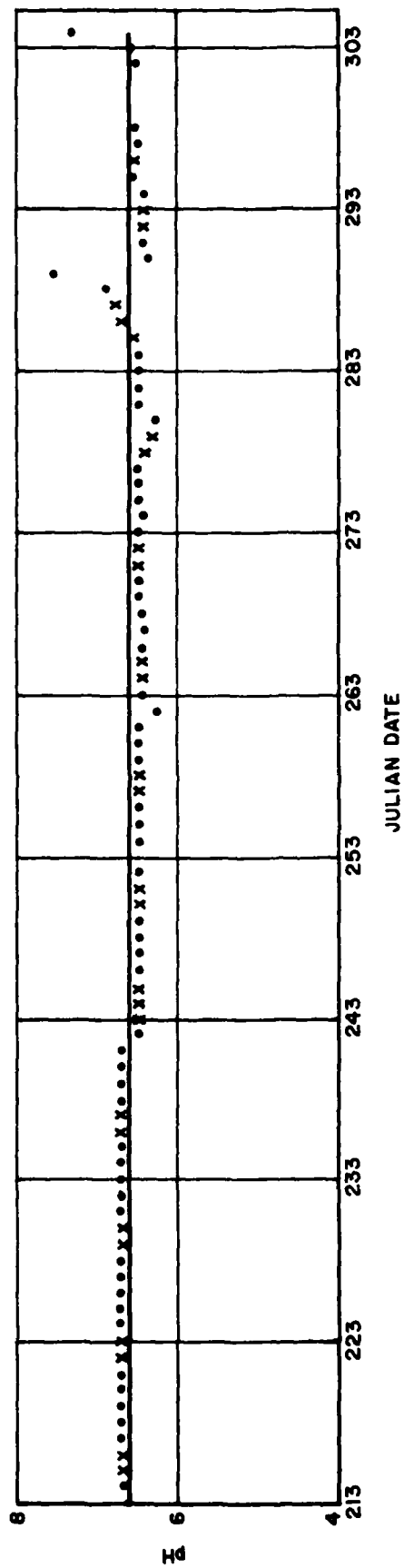


Figure D-2. BUFORD pH vs TIME

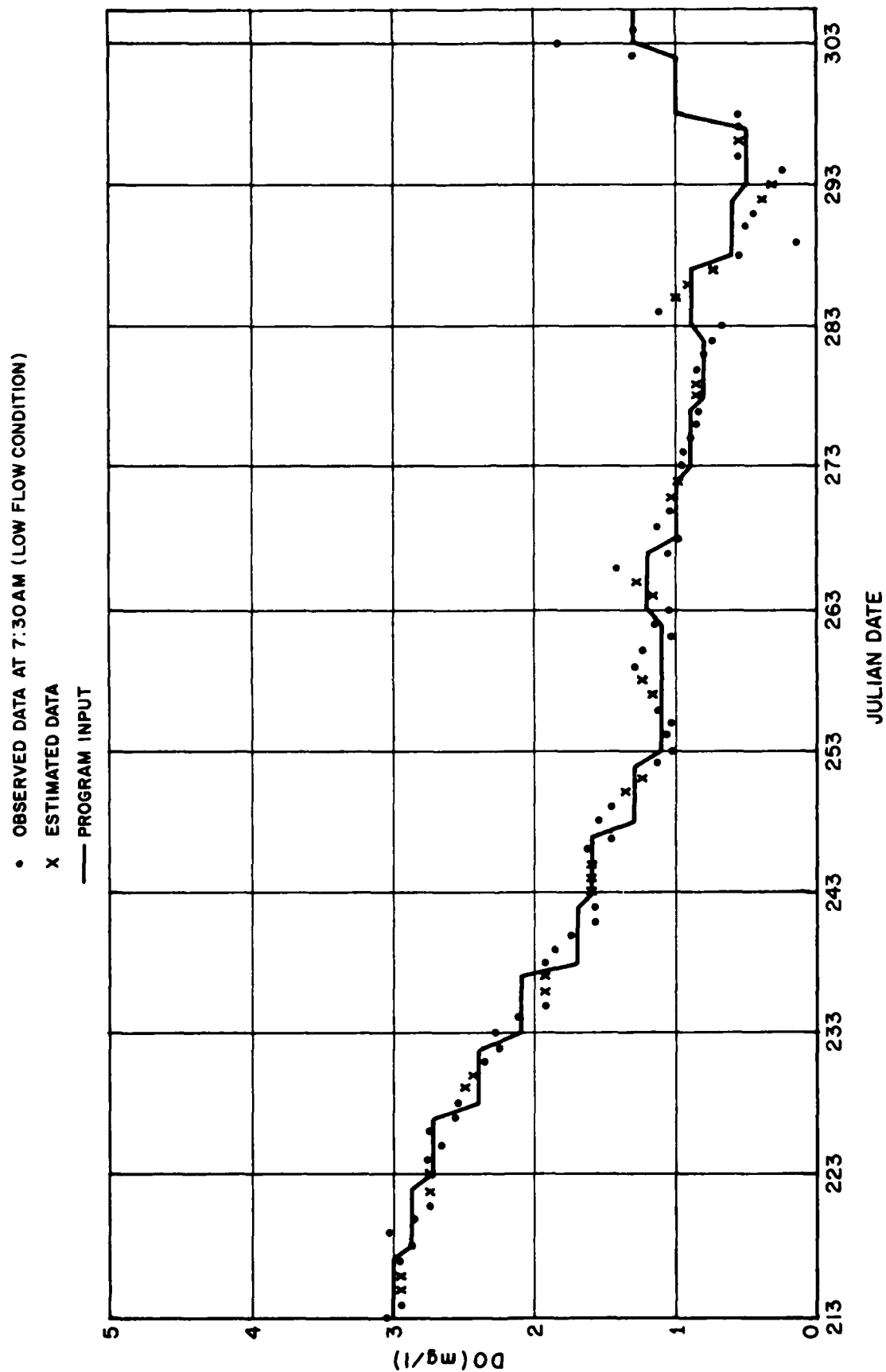


Figure D-3 BUFORD DO vs TIME

INFLOW QUALITY

		Buford Local River Mile 451.2	
<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F		time variant estimate	1/
OXY mg/l	estimate		8
BOD5 mg/l	estimate		1
COLIF col./100 ml	estimate		100
DETRITUS mg/l	estimate		0.5
NH3 mg/l (N)	estimate		.1
NO3 mg/l (N)	estimate		.4
NO2 mg/l (N)	estimate		0.01
PO4 mg/l (P)	estimate		0.20
TDS mg/l	estimate		50
ALGAE(1) mg/l	estimate		.001
ALGAE(2) mg/l	estimate		.005
ZOO mg/l	estimate		.001
PH	estimate		7.5
ALKA mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 3° F

INFLOW QUALITY

		Suwannee Creek River Mile 445.6		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	AWW	mean of grab samples	7.9
BOD5	mg/l	AWW	mean of grab samples	2.2
COLIF	col./100 ml	AWW	mean monthly	Aug. 7400 Sep. 4200 Oct. 560
DETRITUS	mg/l	estimate		3
NH3	mg/l (N)	AWW	mean of grab samples	0.30
NO3	mg/l (N)	AWW	mean of grab samples	0.70
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	AWW	mean of grab samples	0.10
TDS	mg/l	AWW	mean of grab samples	96
ALGAE(1)	mg/l	estimate		.04
ALGAE(2)	mg/l	estimate		.06
ZOO	mg/l	estimate		.01
PH		AWW	mean of grab samples	7.1
ALKA	mg/l (CaCO ₃)	AWW	mean of grab samples	27

1/ daily air temperature minus 30° F

INFLOW QUALITY

		Johns Creek River Mile 436.8		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	estimate		8
BOD5	mg/l	estimate		1
COLIF	col./100 ml	estimate		100
DETRITUS	mg/l	estimate		1
NH3	mg/l (N)	estimate		.1
NO3	mg/l (N)	estimate		.4
NO2	mg/l (N)	estimate		.01
PO4	mg/l (P)	estimate		.20
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		.02
ALGAE(2)	mg/l	estimate		.04
ZOO	mg/l	estimate		.006
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 30° F

INFLOW QUALITY

		Chattahoochee Local River Mile 432.2		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	estimate		8
BOD5	mg/l	estimate		1
COLIF	col./100 ml	estimate		100
DETRITUS	mg/l	estimate		1
NH3	mg/l (N)	estimate		.1
NO3	mg/l (N)	estimate		.4
NO2	mg/l (N)	estimate		.01
PO4	mg/l (P)	estimate		.20
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		.001
ALGAE(2)	mg/l	estimate		.005
ZOO	mg/l	estimate		.001
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 30° F

INFLOW QUALITY

Big Creek
River Mile 424.9

<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F	EPD	mean monthly	Aug. 71 Sep. 66 Oct. 59
OXY mg/l	AWW	mean of grab samples	8.5
BOD5 mg/l	AWW	mean of grab samples	1.1
COLIF col./100 ml	AWW	mean monthly	Aug. 3500 Sep. 2600 Oct. 2200
DETRITUS mg/l	estimate		5
NH3 mg/l (N)	AWW	mean of grab samples	.08
NO3 mg/l (N)	AWW	mean of grab samples	0.45
NO2 mg/l (N)	estimate		.01
PO4 mg/l (P)	AWW	mean of grab samples	0.17
TDS mg/l	AWW	mean of grab samples	60
ALGAE(1) mg/l	estimate		.03
ALGAE(2) mg/l	estimate		.05
ZOO mg/l	estimate		.008
PH	AWW	mean of grab samples	7.2
ALKA mg/l (CaCO ₃)	AWW	mean of grab samples	21

INFLOW QUALITY

		Willeo Creek River Mile 422.7		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate	2/	6
BOD5	mg/l	estimate		20
COLIF	col./100 ml	estimate		400
DETRITUS	mg/l	estimate		10
NH3	mg/l (N)	estimate		1.00
NO3	mg/l (N)	estimate		0.50
NO2	mg/l (N)	estimate		0.01
P04	mg/l (P)	estimate		1.00
TDS	mg/l	estimate		100
ALGAE(1)	mg/l	estimate		.06
ALGAE(2)	mg/l	estimate		.12
ZOO	mg/l	estimate		.02
PH		estimate		7.4
ALKA	mg/l (CaCO3)	estimate		50

1/ daily air temperature minus 3° F

2/ estimates include waste discharges into tributary

INFLOW QUALITY

		Sope Creek River Mile 416.2		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	AWW	mean of grab samples	7.7
BOD5	mg/l	AWW	mean of grab samples	15.9
COLIF	col./100 ml	AWW	mean monthly	Aug. 1600K ^{2/} Sep. 1195K Oct. 4.43K
DETRITUS	mg/l	estimate		5.1
NH3	mg/l (N)	AWW	mean of grab samples	1.62
NO3	mg/l (N)	AWW	mean of grab samples	.45
NO2	mg/l (N)	estimate		0.01
P04	mg/l (P)	AWW	mean of grab samples	1.57
TDS	mg/l	AWW	mean of grab samples	109
ALGAE(1)	mg/l	estimate		.04
ALGAE(2)	mg/l	estimate		.06
ZOO	mg/l	estimate		.01
PH		AWW	mean of grab samples	7.4
ALKA	mg/l (CaCO ₃)	AWW	mean of grab samples	43

1/ daily air temperature minus 3° F

2/ K = 1000's

INFLOW QUALITY

Long Island Creek
River Mile 412.2

<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F	AMW	mean monthly	Aug. 72.5 Sep. 67.1 Oct. 53.6
OXY	mg/l	AMW	grab sample mean	8.7
BOD5	mg/l	AMW	grab sample mean	0.7
COLIF	col./100 ml	AMW	mean monthly	Aug. 4100 Sep. 550 Oct. 400
DETRITUS	mg/l	estimate		1.4
NH3	mg/l (N)	AMW	grab sample mean	.11
NO3	mg/l (N)	AMW	grab sample mean	.11
NO2	mg/l (N)	estimate		.01
PO4	mg/l (P)	AMW	grab sample mean	.06
TDS	mg/l	AMW	grab sample mean	64
ALGAE(1)	mg/l	estimate		.030
ALGAE(2)	mg/l	estimate		.015
ZOO	mg/l	estimate		.005
PH		AMW	grab sample mean	7.4
ALKA	mg/l (CaCO ₃)	AMW	grab sample mean	32

INFLOW QUALITY

		Rottenwood Creek River Mile 411.9		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	AWW	mean of grab samples	9.2
BOD5	mg/l	AWW	mean of grab samples	1.8
COLIF	col./100 ml	AWW	mean monthly	Aug. 16.9K ^{2/} Sep. 12.5K Oct. 9.3K
DETRITUS	mg/l	estimate		5
NH3	mg/l (N)	AWW	mean of grab samples	.16
NO3	mg/l (N)	AWW	mean of grab samples	.29
NO2	mg/l (N)	estimate		0.01
P04	mg/l (P)	AWW	mean of grab samples	.18
TDS	mg/l	AWW	mean of grab samples	69
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		0
PH		AWW	mean of grab samples	7.5
ALKA	mg/l (CaCO ₃)	AWW	mean of grab samples	26

1/ daily air temperature minus 3° F

2/ K = 1000's

INFLOW QUALITY

		Peachtree Creek River Mile 408.1		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F	EPD	mean monthly	Aug. 78 Sep. 73 Oct. 64 8.3
OXY	mg/l	AWW, USGS	mean of grab samples	
BOD5	mg/l	AWW, USGS	mean of grab samples	4.1
COLIF	col./100 ml	AWW	mean monthly	Aug. 20K ^{1/} Sep. 10K Oct. 4.6K 15
DETRITUS	mg/l	estimate		
NH3	mg/l (N)	AWW, USGS	mean of grab samples	.13
NO3	mg/l (N)	AWW	mean of grab samples	.65
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	AWW, USGS	mean of grab samples	.06
TDS	mg/l	AWW	mean of grab samples	99
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		0
PH		AWW, USGS	mean of grab samples	7.4
ALKA	mg/l (CaCO ₃)	AWW, USGS	mean of grab samples	41
<u>1/</u>	K = 1000's			

INFLOW QUALITY

		R.M. Clayton STP River Mile 408.0		
Parameter		Source	Remarks	Quality
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate		0
BOD5	mg/l	Plant records	mean	64
COLIF	col./100 ml	estimate		200
DETRITUS	mg/l	estimate		16
NH3	mg/l (N)	estimate		9
NO3	mg/l (N)	estimate		18
NO2	mg/l (N)	estimate		.05
PO4	mg/l (P)	estimate		12
TDS	mg/l	estimate		250
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		.02
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		100

1/ daily air temperature minus 3° F

INFLOW QUALITY

Chattahoochee River STP River Mile 408.0				
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate		0
BOD5	mg/l	Plant records	mean monthly	Aug. 5 Sep. 4 Oct. 7
COLIF	col./100 ml	estimate		Aug. 200 Sep. 7 Oct. 100
DETRITUS	mg/l	estimate		Aug. 2 Sep. 3 Oct. 5
NH3	mg/l (N)	estimate		9
NO3	mg/l (N)	estimate		18
NO2	mg/l (N)	estimate		.05
PO4	mg/l (P)	estimate		12
TDS	mg/l	estimate		250
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		.02
PH		Plant records	mean monthly	Aug. 6.9 Sep. 6.7 Oct. 6.7
ALKA	mg/l (CaCO ₃)	estimate		100

1/ daily air temperature minus 3° F

INFLOW QUALITY

Plants Atkinson - McDonough
River Mile 407.0

<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F	GP	GP plant capacity	<u>1/</u>
OXY mg/l	estimate		<u>2/</u>
BOD5 mg/l			
COLIF col./100 ml			
DETRITUS mg/l			
NH3 mg/l (N)			
NO3 mg/l (N)			
NO2 mg/l (N)			
P04 mg/l (P)			
TDS mg/l			
ALGAE(1) mg/l			
ALGAE(2) mg/l			
ZOO mg/l			
PH			
ALKA mg/l (CaCO ₃)			

1/ change between inflow and outflow temperature = 15.1° F

2/ all parameters except temperature are assumed equal to river quality

INFLOW QUALITY

		Proctor Creek River Mile 405.0		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate 2/		8
BOD5	mg/l	estimate		3
COLIF	col./100 ml	estimate		10,000
DETRITUS	mg/l	estimate		5
NH3	mg/l (N)	estimate		.20
NO3	mg/l (N)	estimate		0.30
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	estimate		0.20
TDS	mg/l	estimate		100
ALGAE(1)	mg/l	estimate		.040
ALGAE(2)	mg/l	estimate		.020
ZOO	mg/l	estimate		.006
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		30

1/ daily air temperature minus 3° F

2/ estimates include waste discharges into tributary

INFLOW QUALITY

		Nickajack Creek River Mile 403.2		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate	2/	8
BOD5	mg/l	estimate		3
COLIF	col./100 ml	estimate		10,000
DETRITUS	mg/l	estimate		5
NH3	mg/l (N)	estimate		.20
NO3	mg/l (N)	estimate		0.30
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	estimate		0.20
TDS	mg/l	estimate		100
ALGAE(1)	mg/l	estimate		.040
ALGAE(2)	mg/l	estimate		.020
ZOO	mg/l	estimate		.006
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		30

1/ daily air temperature minus 3° F

2/ estimates include waste discharges into tributary

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		Sandy Creek River Mile 403.1 time variant estimate	1/
OXY	mg/l	estimate	2/	8
BOD5	mg/l	estimate		3
COLIF	col./100 ml	estimate		10,000
DETRITUS	mg/l	estimate		5
NH3	mg/l (N)	estimate		.20
NO3	mg/l (N)	estimate		0.30
NO2	mg/l (N)	estimate		.01
PO4	mg/l (P)	estimate		.20
TDS	mg/l	estimate		100
ALGAE(1)	mg/l	estimate		.040
ALGAE(2)	mg/l	estimate		.020
ZOO	mg/l	estimate		.006
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		30

1/ daily air temperature minus 3° F

2/ estimates include waste discharges into tributary

INFLOW QUALITY

		Sandy Creek STP River Mile 403.1		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	estimate		0
BOD5	mg/l	Plant records	mean	126
COLIF	col./100 ml	estimate		200
DETRITUS	mg/l	estimate		17
NH3	mg/l (N)	estimate		9
NO3	mg/l (N)	estimate		18
NO2	mg/l (N)	estimate		.05
PO4	mg/l (P)	estimate		12
TDS	mg/l	estimate		250
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		.02
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		100

1/ daily air temperature minus 3° F

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate		0
BOD5	mg/l	Plant records	mean monthly	Aug. 15 Sep. 118 Oct. 26
COLIF	col./100 ml	Plant records	mean monthly	Aug. 7 Sep. 200 Oct. 7
DETRITUS	mg/l	Plant records	mean monthly	Aug. 2 Sep. 22 Oct. 5
NH3	mg/l (N)	estimate		9
NO3	mg/l (N)	estimate		18
NO2	mg/l (N)	estimate		.05
PO4	mg/l (P)	estimate		12
TDS	mg/l	estimate		250
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		.02
PH		Plant records	mean	7.0
ALKA	mg/l (CaCO ₃)	estimate		100

1/ daily air temperature minus 3° F

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	<u>Fulco STP</u> <u>River Mile 407.6</u> <u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate		0
BOD5	mg/l	Plant records	mean	379
COLIF	col./100 ml	estimate		1,000,000
DETRITUS	mg/l	Plant records	mean	34
NH3	mg/l (N)	estimate		50
NO3	mg/l (N)	estimate		.4
NO2	mg/l (N)	estimate		.10
PO4	mg/l (P)	estimate		12
TDS	mg/l	estimate		250
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		0
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		100

1/ daily air temperature minus 3° F

INFLOW QUALITY

<u>Parameter</u>	<u>Source</u>	Utoy Creek River Mile 399.0	<u>Quality</u>
		<u>Remarks</u>	
TEMP °F		time variant estimate	1/
OXY mg/l	estimate 2/		8
BOD5 mg/l	estimate		2
COLIF col./100 ml	estimate		10,000
DETRITUS mg/l	estimate		5
NH3 mg/l (N)	estimate		0.20
NO3 mg/l (N)	estimate		0.30
NO2 mg/l (N)	estimate		0.01
PO4 mg/l (P)	estimate		0.20
TDS mg/l	estimate		100
ALGAE(1) mg/l	estimate		.040
ALGAE(2) mg/l	estimate		.020
ZOO mg/l	estimate		.006
PH	estimate		7.5
ALKA mg/l (CaCO ₃)	estimate		30

1/ daily air temperature minus 3° F

2/ estimates include waste discharges into tributary

INFLOW QUALITY

		Utoy Creek STP River Mile 399.0	
<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F		time variant estimate	1/
OXY mg/l	estimate		0
BOD5 mg/l	estimate		20
COLIF col./100 ml	estimate		200
DETRITUS mg/l	estimate		6
NH3 mg/l (N)	estimate		9
NO3 mg/l (N)	estimate		18
NO2 mg/l (N)	estimate		.05
PO4 mg/l (P)	estimate		12
TDS mg/l	estimate		250
ALGAE(1) mg/l	estimate		0
ALGAE(2) mg/l	estimate		0
ZOO mg/l	estimate		.02
PH	estimate		7.5
ALKA mg/l (CaCO ₃)	estimate		100

1/ daily air temperature minus 3° F

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F	EPD	mean monthly	Aug 74 Sep 68 Oct 59
OXY	mg/l	USGS	mean of grab samples	6
BOD5	mg/l	USGS	mean of grab samples	3.6
COLIF	col./100 ml	USGS	mean of grab samples	7500
DETRITUS	mg/l	estimate		5
NH3	mg/l (N)	USGS	mean of grab samples	.20
NO3	mg/l (N)	USGS	mean of grab samples	.24
NO2	mg/l (N)	estimate		.01
PO4	mg/l (P)	USGS	mean of grab samples	.17
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		0
PH		USGS	mean of grab samples	7
ALKA	mg/l (CaCO ₃)	USGS	mean of grab samples	32

INFLOW QUALITY

Camp Creek
River Mile 391.2

<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F	EPD	mean monthly (N. Fork Camp Cr.)	Aug 77 Sep 73 Oct 65
OXY mg/l	estimate ^{1/}		8
BOD5 mg/l	estimate		3
COLIF col./100 ml	estimate		10,000
DETRITUS mg/l	estimate		5
NH3 mg/l (N)	estimate		0.20
NO3 mg/l (N)	estimate		0.30
NO2 mg/l (N)	estimate		0.01
PO4 mg/l (P)	estimate		0.20
TDS mg/l	estimate		100
ALGAE(1) mg/l	estimate		.040
ALGAE(2) mg/l	estimate		.020
ZOO mg/l	estimate		.006
PH	estimate		7.5
ALKA mg/l (CaCO ₃)	estimate		30

^{1/} Estimates include waste discharges into tributary

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	Camp Creek STP River Mile 391.2 <u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate		0
BOD5	mg/l	estimate		50
COLIF	col./100 ml	estimate		200
DETRITUS	mg/l	estimate		13
NH3	mg/l (N)	estimate		9
NO3	mg/l (N)	estimate		18
NO2	mg/l (N)	estimate		.05
P04	mg/l (P)	estimate		12
TDS	mg/l	estimate		250
ALGAE(1)	mg/l	estimate		0
ALGAE(2)	mg/l	estimate		0
ZOO	mg/l	estimate		.02
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		100

1/ Daily air temperature minus 3°F

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	<u>Anneewakee Creek River Mile 389.1</u> <u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	estimate		8.0
BOD5	mg/l	estimate		3.0
COLIF	col./100 ml	estimate		10,000
DETRITUS	mg/l	estimate		5.0
NH3	mg/l (N)	estimate		0.20
NO3	mg/l (N)	estimate		0.30
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	estimate		0.20
TDS	mg/l	estimate		100
ALGAE(1)	mg/l	estimate		.040
ALGAE(2)	mg/l	estimate		.020
ZOO	mg/l	estimate		.006
PH		estimate		7.5
ALKA	mg/l (CaCO ₃)	estimate		30

1/ Daily air temperature minus 3°F

INFLOW QUALITY

Bear Creek River Mile 382.7				
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	est. ^{2/}		8.5
BOD5	mg/l	est.		1.5
COLIF	col./100 ml	est.		400
DETRITUS	mg/l	est.		1
NH3	mg/l (N)	est.		.01
NO3	mg/l (N)	est.		.20
NO2	mg/l (N)	est.		.01
PO4	mg/l (P)	est.		.02
TDS	mg/l	est.		50
ALGAE(1)	mg/l	est.		.03
ALGAE(2)	mg/l	est.		.02
ZOO	mg/l	est.		.005
PH		est.		7.2
ALKA	mg/l (CaCO ₃)	est.		15

^{1/}Daily air temperature minus 3°F

^{2/}Estimates based on known average data for Dog River

INFLOW QUALITY

		Dog River River Mile 382.2		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	1/
OXY	mg/l	USGS	mean of grab samples	8.6
BOD5	mg/l	USGS	mean of grab samples	1.4
COLIF	col./100 ml	USGS	mean of grab samples	390
DETRITUS	mg/l	estimate		1
NH3	mg/l (N)	USGS	mean of grab samples	0.01
NO3	mg/l (N)	USGS	mean of grab samples	0.17
NO2	mg/l (N)	USGS	mean of grab samples	0.01
PO4	mg/l (P)	USGS	mean of grab samples	0.02
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		.03
ALGAE(2)	mg/l	estimate		.02
ZOO	mg/l	estimate		.005
PH		USGS	mean of grab samples	7.2
ALKA	mg/l (CaCO ₃)	USGS	mean of grab samples	15

1/ daily air temperature minus 3° F

INFLOW QUALITY

<u>Parameter</u>		<u>Source</u>	<u>Local River Mile 380.2</u> <u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	estimate	<u>2/</u>	8.5
BOD5	mg/l	estimate		1.5
COLIF	col./100 ml	estimate		400
DETRITUS	mg/l	estimate		1
NH3	mg/l (N)	estimate		.01
NO3	mg/l (N)	estimate		.20
NO2	mg/l (N)	estimate		.01
PO4	mg/l (P)	estimate		.02
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		.03
ALGAE(2)	mg/l	estimate		.02
ZOO	mg/l	estimate		.005
PH		estimate		7.2
ALKA	mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 3° F

2/ estimates based on known average data for Dog River

INFLOW QUALITY

		Snake Creek River Mile 369.3		
Parameter		Source	Remarks	Quality
TEMP	°F	EPD	mean monthly	Aug. 74 Sep. 69 Oct. 62 8.5
OXY	mg/l	estimate	1/	
BOD5	mg/l	estimate		1.5
COLIF	col./100 ml	estimate		400
DETRITUS	mg/l	estimate		1
NH3	mg/l (N)	estimate		0.01
NO3	mg/l (N)	estimate		0.20
NO2	mg/l (N)	estimate		0.01
P04	mg/l (P)	estimate		0.02
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		.03
ALGAE(2)	mg/l	estimate		.02
ZOO	mg/l	estimate		.005
PH		estimate		7.2
ALKA	mg/l (CaCO ₃)	estimate		15

1/ estimates based on known average data for Dog River

INFLOW QUALITY

		Plant Yates River Mile 365.5	
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>
TEMP	°F	GP	Plant Capacity
OXY	mg/l	estimate	
BOD5	mg/l		
COLIF	col./100 ml		
DETRITUS	mg/l		
NH3	mg/l (N)		
NO3	mg/l (N)		
NO2	mg/l (N)		
PO4	mg/l (P)		
TDS	mg/l		
ALGAE(1)	mg/l		
ALGAE(2)	mg/l		
ZOO	mg/l		
PH			
ALKA	mg/l (CaCO ₃)		

1/ change between inflow and outflow temperature = 14.9° F

2/ all parameters except temperature are assumed equal to river quality

INFLOW QUALITY

Wahoo Creek
River Mile 364.2

<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F		time variant estimate	<u>1/</u>
OXY mg/l	estimate <u>2/</u>		8.5
BOD5 mg/l	estimate		1.5
COLIF col./100 ml	estimate		400
DETRITUS mg/l	estimate		1
NH3 mg/l (N)	estimate		0.01
NO3 mg/l (N)	estimate		0.20
NO2 mg/l (N)	estimate		0.01
PO4 mg/l (P)	estimate		0.02
TDS mg/l	estimate		50
ALGAE(1) mg/l	estimate		.03
ALGAE(2) mg/l	estimate		.02
ZOO mg/l	estimate		.005
PH	estimate		7.2
ALKA mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 3° F

2/ estimate based on known average data for Dog River

INFLOW QUALITY

		Whooping Creek River Mile 358.3		
<u>Parameter</u>		<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP	°F		time variant estimate	<u>1/</u>
OXY	mg/l	estimate <u>2/</u>		8.5
BOD5	mg/l	estimate		1.5
COLIF	col./100 ml	estimate		400
DETRITUS	mg/l	estimate		1
NH3	mg/l (N)	estimate		0.01
NO3	mg/l (N)	estimate		0.20
NO2	mg/l (N)	estimate		0.01
PO4	mg/l (P)	estimate		0.02
TDS	mg/l	estimate		50
ALGAE(1)	mg/l	estimate		.03
ALGAE(2)	mg/l	estimate		.02
ZOO	mg/l	estimate		.005
PH		estimate		7.2
ALKA	mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 3° F

2/ estimate based on known average data for Dog River

INFLOW QUALITY

Yellowdirt Creek
River Mile 356.2

<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F		time variant estimate	<u>1/</u>
OXY mg/l	estimate <u>2/</u>		8.5
BOD5 mg/l	estimate		1.5
COLIF col./100 ml	estimate		400
DETRITUS mg/l	estimate		1
NH3 mg/l (N)	estimate		0.01
NO3 mg/l (N)	estimate		0.20
NO2 mg/l (N)	estimate		0.01
PO4 mg/l (P)	estimate		0.02
TDS mg/l	estimate		50
ALGAE(1) mg/l	estimate		.03
ALGAE(2) mg/l	estimate		.02
ZOO mg/l	estimate		.005
PH	estimate		7.2
ALKA mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 3° F

2/ estimate based on known average data for Dog River

INFLOW QUALITY

Centralhatchee Creek
River Mile 344.2

<u>Parameter</u>	<u>Source</u>	<u>Remarks</u>	<u>Quality</u>
TEMP °F		time variant estimate	<u>1/</u>
OXY mg/l	estimate <u>2/</u>		8.5
BOD5 mg/l	estimate		1.5
COLIF col./100 ml	estimate		400
DETRITUS mg/l	estimate		1
NH3 mg/l (N)	estimate		0.01
NO3 mg/l (N)	estimate		0.20
NO2 mg/l (N)	estimate		0.01
PO4 mg/l (P)	estimate		0.02
TDS mg/l	estimate		50
ALGAE(1) mg/l	estimate		.03
ALGAE(2) mg/l	estimate		.02
ZOO mg/l	estimate		.005
PH	estimate		7.2
ALKA mg/l (CaCO ₃)	estimate		15

1/ daily air temperature minus 3° F

2/ estimate based on known average data for Dog River

WITHDRAWAL DATA

<u>Name</u>	<u>River Mile</u>	<u>Withdrawal (cfs)</u>
Gwinnett Intake	445.5	Aug. 14 Sep. 14 Oct. 15
Dekalb Intake	433.0	Aug. 92 Sep. 86 Oct. 94
Cobb Water Intake	418.1	Aug. 30 Sep. 29 Oct. 32
Atlanta Water Intake	408.2	Aug. 194 Sep. 175 Oct. 180

APPENDIX E

CALIBRATION AND APPLICATION OF STORM

APPENDIX E CALIBRATION AND APPLICATION OF STORM

by
Jess Abbott¹

I. INTRODUCTION

This appendix describes the calibration and application of STORM to the Atlanta Metropolitan area and vicinity. The model was used to generate storm water loadings which were used in assessments of water quality conditions in the Chattahoochee River.

II. STORM MODEL CONCEPTS

STORM is a continuous simulation model that can be used for prediction of the quantity and quality of storm water runoff. The quantity portion of the program was developed for the City of San Francisco by Water Resources Engineers, Inc. (WRE) of Walnut Creek, California. The Hydrologic Engineering Center (HEC) contracted in 1972 with WRE for addition of storm water quality computations. Since then the HEC has added other capabilities including snowmelt and land surface erosion computations and prespecified hydrographs. Resource Analysis, Inc., of Cambridge, Massachusetts, has recently added the capability to simulate the quantity and quality of dry weather sewage.

Wet weather surface runoff pollutographs can be predicted for individual historical (or synthetic) events. The model requires hydrological, land use, and water quality input data. The STORM pollutographs can be used as input for a receiving water assessment model.

Another portion of the output from STORM provides statistical information based on analysis of the precipitation record (10-30 years of hourly data). Statistics such as average annual runoff, average annual washoff of each pollutant, average annual overflow, and average annual pollutant overflow can be used to aid the selection of storage capacities and treatment rates required to achieve desired control of storm water runoff. These and other features of the model are discussed in detail in the users manual (reference 1).

III. CALIBRATION

STORM was calibrated on four small research watersheds in the Peachtree Creek basin to provide a basis for prediction of storm water loadings for the study area. The following table shows the land use makeup of each research watershed.

¹Jess Abbott, Research Hydraulic Engineer, The Hydrologic Engineering Center.

<u>Watershed</u>	<u>Drainage Area (sq. mi.)</u>	<u>Land Use (%)</u>				
		<u>SIN</u>	<u>MUL</u>	<u>COM</u>	<u>IND</u>	<u>OPEN</u>
South Fork Peachtree Creek at Montreal Road	5.4	30	6	6	18	40
Tributary to North Fork Peachtree Creek at Drew Valley Road	2.9	90	0	0	10	0
Tributary to South Fork Peachtree Creek at Parkside Circle	1.2	40	13	15	3	29
Tributary to Nancy Creek at Plantation Lane	1.3	14	0	18	58	10

NOTE: Data from reference 2.

Rainfall and runoff data for the four watersheds were provided by the Atlanta office of the U. S. Geological Survey. The storm water quality data were reported in reference 2.

Quantity

The quantity calibration involved adjusting the pervious area runoff coefficient (C_{PERV}) and the impervious area runoff coefficient (C_{IMP}) for each basin so that the computed runoff most nearly matched the observed runoff. The values of C_{PERV} and C_{IMP} for the research watersheds were used for those basins in the study which had comparable land use patterns. C_{IMP} is applied to the input hydrographs to arrive at the runoff rate from the impervious areas. The runoff rate from the impervious areas is used to "drive" the pollutant washoff equations. Tables E-1 through E-4 show comparisons between observed rainfall and runoff and computed runoff for all major storms that occurred during the period of July-November 1974.

Quality

Two important sets of coefficients regulate the quality of storm water runoff predicted by STORM. These are the dust and dirt accumulation rates for each land use and the pollutant fractions of the dust and dirt for each land use. These coefficients, which should normally be obtained by field sampling, were not available for this study. The quality calibration was based on adjustment of program default values for these coefficients so that the predicted masses and concentrations of pollutants most nearly matched those measured during selected runoff events from the four research watersheds. The default values were developed from a study done in Chicago (reference 3).

TABLE E-1
South Fork Peachtree Creek at Montreal Road

Date (1974)	Hours	Rain (In.)	Observed ^{1/} Runoff (In.)	Computed ^{2/} Runoff (In.)
19 July	16-22	.48	.06	.07
23 July	18-23	1.32	.09	.23
26-27 July	20-04	.15	.10	.03
1 August	19-24	.44	.03	.06
3 August	12-22	.81	.16	.13
7 August	16-24	2.56	.66	.48
14 August	13-21	.67	.09	.11
16-17 August	22-04	.45	.15	.07
18 August	14-22	.83	.13	.14
29 August	13-19	.45	.03	.07
29-30 August	19-04	.89	.20	.16
1 September	15-24	.53	.07	.07
2 September	16-22	.95	.24	.16
3 September	15-21	.08	.02	.01
14 September	11-16	.99	.09	.17
16 September	0-12	1.12	.16	.21
11 November	18-24	.79	.03	.15
18 November	3-6	.58	.02	.11
20 November	7-13	.55	.10	.09
TOTALS		14.64	2.54	2.52

^{1/}Surface runoff (obtained by manual separation of surface and base flow on hydrographs from U.S.G.S. gage records).

^{2/}Surface runoff computed by STORM

TABLE E-2

Tributary to North Fork Peachtree Creek at Drew Valley Road

Date (1974)	Hours	Rain (In.)	Observed ^{1/} Runoff (In.)	Computed ^{2/} Runoff (In.)
23 July	12-14	.13	.01	.01
1 August	19-20	.61	.06	.14
2 August	20-22	.53	.15	.14
3 August	12-15	1.01	.31	.26
7 August	16-21	2.74	.81	.74
11 August	19-22	.33	.16	.08
18 August	14-16	.23	.05	.04
29 August	19-21	.18	.14	.02
15-16 Sept.	22-06	1.19	.17	.32
11 November	16-20	.67	.12	.17
17 November	23-04	.61	.11	.15
TOTALS		7.63	1.99	2.07

^{1/}, ^{2/} See notes Table E-1

TABLE E-3

Tributary of South Fork Peachtree Creek at Parkside Circle

Date (1974)	Hours	Rain (In.)	Observed ^{1/} Runoff (In.)	Computed ^{2/} Runoff (In.)
23 July	18-20	.93	.16	.21
1 August	19-21	.43	.04	.09
7 August	16-21	2.03	.46	.47
14 August	13-15	.82	.23	.18
16 August	22	.42	.19	.08
18 August	15	.68	.14	.17
29 August	14-21	.48	.23	.09
15-16 October	23-6	.91	.12	.22
11 November	16-20	.78	.10	.19
17 November	17-20	.41	.07	.10
20 November	7-9	.67	.14	.14
TOTALS		8.56	1.88	1.94

^{1/}, ^{2/} See notes Table E-1

TABLE E-4
Tributary to Nancy Creek at Plantation Lane

(1974)	Hours	Rain (In.)	Observed ^{1/} Runoff (In.).	Computed ^{2/} Runoff (In.)
26 July	17-19	1.51	.34	.73
1 August	19-21	.41	.11	.16
2 August	20-22	.50	.29	.25
3 August	13-15	.81	.33	.38
11 August	20-21	.72	.12	.32
14 August	12-15	1.30	.50	.62
16 August	22-24	1.17	.22	.58
18 August	14-15	.83	.34	.38
29 August	18-20	.34	.25	.17
1 September	12-22	.51	.33	.21
15 October	22-6	1.26	1.07	.60
5 November	6-9	.48	.37	.20
11 November	17-20	.67	.45	.32
17 November	23-3	.63	.41	.27
20 November	6-10	.83	.53	.38
TOTALS		11.97	5.66	5.57

^{1/}, ^{2/} See notes Table E-1

Certain other coefficients, which normally remain fixed, were modified for this study. The equations used to compute BOD, total nitrogen (TN) and total phosphorus (TP) are made up of three terms each, one term for the soluble contribution and two other terms for the insoluble contributions. (TP was the only form of phosphorus that was measured so the coefficients were also adjusted to predict TP instead of total orthophosphate.) The insoluble contributions are computed as fractions of both suspended solids (SUSP) and settleable solids (SETL). These fractions are not input variables and thus remain fixed unless the program is changed by the user. Since the measured data from each watershed showed very low BOD to suspended solids ratio the equations normally used in the model produced BOD values in excess of the measured values when suspended solids values were accurately predicted. The effect of reducing the soluble contribution to zero (i.e., BOD fraction of the dust and dirt) produced BOD values in excess of measured, therefore, it was justified to reduce the nonsoluble contributions. The revised nonsoluble contribution coefficients that were developed during calibration and used to generate the BOD, TN, and TP loadings for the river water quality model are shown below:

<u>Parameter</u>	<u>Fraction of Suspended Solids</u>	<u>Fraction of Settleable Solids</u>
BOD	0.01	0.002
TN	0.0025	0.0005
TP	0.002	0.0005

The following table shows dust and dirt accumulation rates and pollutant constituents of the dust and dirt that were developed during calibration.

<u>Land Use</u>	<u>Dust and Dirt Accumulation Rate (lbs/100 ft. gutter/day)</u>	<u>Pollutant Constituents (lbs pollutant/100 lbs DD)</u>				
		<u>SUSP</u>	<u>SETL</u>	<u>BOD</u>	<u>TN</u>	<u>TP</u>
Single	2.20	40.0	1.1	0.50	0.048	0.002
Multiple	6.90	32.0	0.8	0.36	0.061	0.002
Commercial	6.90	68.0	1.7	0.77	0.041	0.002
Industrial	13.30	68.0	0.7	0.30	0.043	0.001
Open	4.50	40.0	1.1	0.50	0.048	0.0002

The values do not necessarily make up a unique set, but rather are those that were judged to best reproduce the observed data from the four research watersheds. The calibration was based not only on reproduction of the time value of pollutant concentrations, but also on the total masses of pollutants washed off by the event. Montreal is the only basin where there exists more than one measured sample per storm (other than several composite samples on Plantation and Parkside). A single sample per storm precludes computing an accurate observed pollutograph and therefore is of little value in calibration.

IV. APPLICATION OF STORM TO ATLANTA AND VICINITY

Input Data

The precipitation record is the primary input data set for STORM. Data were most readily available for the U.S. Weather Service station at the Atlanta Airport. Hourly precipitation was obtained on magnetic tape from the National Weather Service in Asheville, North Carolina. The data from the tape was processed, reformatted and placed in fast access storage in the Lawrence Berkeley Laboratory Computer System. STORM is capable of accessing this stored data so as to avoid handling a large amount of data in card form.

A representative sample of the twenty-five years of record was chosen so as to reduce computer time usage. The years 1970-1974 were chosen as representative based on equivalent average annual pollutant washoff. The STORM model has the capability of processing any portion of the precipitation record. The sample period was used to generate the pollutant loadings for the August-September 1974 Chattahoochee River study period.

Land use information makes up the second main block of input data. The storm water loadings generated represent 1975 land use conditions. The land use data was supplied by the Savannah District.

Storm Water Simulation

The storm water simulation consisted of dividing the entire study area into a number of subcatchments which would correspond to water quality loading points used in the river simulation. Twenty-five loading points were used along the study reach of the Chattahoochee River. Table E-5 shows the contents and land use of each of the subcatchments. The contributing area designation numbers were taken

Table E-5
Land Use for Subcatchments

River Mile	Contributing Areas from WQMU Map	Area (Acres)	Land Use Percentages ^{4/}				
			SI	MU	CO	IN	OP
451.2	1205 A, 1206 A	20,893	4.6	0.1	0.4	0.4	94.5
445.6	1206 Ivy Creek, 1206 Suwannee Creek	33,357	4.0	0.1	0.4	0.4	95.1
436.8	1207 Johns Creek	20,196	2.9	.3	.2	0	96.6
432.2	1208 Chattahoochee I	29,568	10.8	.4	.5	2.2	86.1
424.9	1209 Big Creek ^{1/}	32,442	7.2	.2	.5	.1	92.0
422.7	1210 Willet Creek	16,384	8.8	.2	.5	.2	90.3
416.2	1211 Sope Creek	21,768	16.4	1.1	1.6	.9	80.1
411.9	1211 Central Cobb	22,493	18.9	2.5	2.9	5.7	70.0
403.2	1211 Nickajack Creek	23,910	25.4	1.3	1.4	2.0	69.9
412.2	1212 Long Island	14,651	42.3	2.5	1.8	.8	52.6
408.1	1212 Nancy Creek, 1212 Peachtree Creek, 1212 S. F. Peachtree Cr. ^{2/}	83,394	36.3	5.8	5.3	4.7	47.9
405.0	1212 Proctor Creek	11,685	21.6	9.9	4.5	7.7	56.3
403.1	1213 A Sandy Creek	6,400	26.7	3.6	1.8	5.8	62.1
399.0	1213 Utoy Creek, 1213 B Sweetwater	26,557	26.7	3.6	1.8	5.8	62.1
396.2	1214 Wiley Cr., Noses Cr., Powder Spr. Creek, Gothards Creek, Sweetwater Creek ^{3/}	178,382	9.7	.2	.6	.5	89.0
391.2	1215 Camp Creek, 1215 Deep Creek	47,203	12.1	1.3	1.0	.6	85.0
389.1	1215 A, 1216 Anneewakee	28,673	5.6	.1	.4	.2	93.7
382.2	1217 Dog R., 1217 B	39,279	1.8	0	.1	.2	97.9
382.7	1217 A, 1218 Bear Cr., 1218 B	42,752	2.8	.1	.2	.1	96.8
380.2	1218 A	21,616	.9	0	.1	0	99.9
369.3	Snake Cr.	31,360	0.9	0	0.1	0	99.9
364.2	Wahoo Cr.	41,600	0.9	0	0.1	0	99.9
358.3	Whooping Cr.	34,560	0.9	0	0.1	0	99.9
356.2	Yellow Dirt Cr.	5,120	0.9	0	0.1	0	99.9
344.2	Centralhatchee Cr.	78,720	0.9	0	0.1	0	99.9

^{1/} Gaged, area above gage = 47,080 acres.

^{2/} Gaged, area above gage = 55,600 acres.

^{3/} Gaged, area above gage = 157,500 acres.

^{4/} 1975 Land Use Conditions.

from a Water Quality Management Unit Map supplied by the Savannah District.

The discharge hydrographs from each subcatchment were provided as input. The hydrographs were derived by stream routing optimizations using HEC-1 (as discussed earlier) and were judged to be more accurate than those produced by the runoff coefficient method in STORM. The option of prespecified hydrographs was then used to allow the STORM model to use the hydrographs in the washoff quality computations.

Efficient transfer of output from STORM required modifying STORM so that it would punch the flow and concentration data for each loading point on cards in a format that was directly useable by the WQRRS model.

V. DISCUSSION

The storm water loadings were judged to be fairly accurate but subject to several limitations caused by inadequate data for calibration and/or inaccurate input data. These limitations are discussed in the following paragraphs.

Quantity

The most serious limitation in the quantity of runoff computations was the low magnitude and yet highly variable observed runoff coefficient during the study period. The events experienced during the period were thunderstorms over quite dry summer-fall watershed conditions. The problem was partly alleviated by the use of input hydrographs that were developed by routing optimization using observed streamflow.

Quality

The quality calibration was somewhat inadequate because of total or partial lack of data on certain coefficients which regulate the quality of runoff.

No data were available for two very important sets of site-specific coefficients used in the model. These are the dust and dirt accumulation rates for each land use and the pollutant constituents of the dust and dirt for each land use.

The lack of the dust and dirt accumulation rates and the pollutant fractions required that the calibration be based entirely on the observed storm water runoff data from the four watersheds. The observed storm water runoff data was inadequate for development of a highly accurate calibration. Montreal Road was the only site for which there existed quality data for more than one grab sample during any given event although several composite samples were taken during

three events at Plantation and Parkside. Montreal had only three events with greater than four samples per event. Only one of these events had multiple samples during the actual "runoff" hydrograph.

VI. RECOMMENDATIONS

A well-designed data collection program should be implemented to collect data on the dust and dirt accumulation rates, the pollutant fractions of the dust and dirt, and additional storm water runoff data. It is recommended that the basins be of a single land use. Coefficients that are a function of land use can thus be defined. A representative segment of a street in each basin should be swept at appropriate intervals so as to estimate the dust and dirt accumulation rate for the specific land use. The dust and dirt should then be analyzed to obtain the fractions of the pollutants of interest.

It is imperative that additional storm water runoff data be collected so as to refine the coefficients which regulate the quantity and quality of runoff. A sampling program should be set up to collect sufficient data on several storms that occur throughout a year so as to adequately define the pollutographs for those events. This will probably involve use of some automatic sampling equipment in order to initiate sampling at the beginning of a significant rise in stage and continue sampling at frequent intervals throughout the event.

Some sampling stations should be located to better define the downtown Atlanta commercial/industrial contribution. It is believed that these basins would show higher loads than the basins previously sampled.

The calibration should be reevaluated using the new data recommended by the above paragraphs. If the calibration coefficients are significantly different than that developed during this study, part of the river water quality assessment should be reevaluated so as to better define the true impact of storm water runoff on the Chattahoochee River.

References (Appendix E)

1. The Hydrologic Engineering Center, Urban Storm Water Runoff (STORM) Generalized Computer Program 723-S8-L2520, August 1975.
2. Black, Crow and Eidness Inc. and Jordan Jones, & Goulding, Inc. Non Point Pollution Evaluation, Atlanta Urban Area. May 1975.
3. Federal Water Pollution Control Administration, Water Pollution Aspects of Urban Runoff, January 1969.

APPENDIX F

PHYSICAL, CHEMICAL AND BIOLOGICAL RATE COEFFICIENTS

APPENDIX F

PHYSICAL, CHEMICAL AND BIOLOGICAL RATE COEFFICIENTS

General

With the exception of the conservative constituents (i.e., alkalinity and TDS), all the water quality equations incorporate one or more physical, chemical or biological coefficients. Most of these coefficients are based upon an empirical understanding of a process. For example, the BOD decay rate is a simplified description of a complex bacterial action. Thus, values for many of the coefficients can be variable depending upon such factors as regional climatic variation, general levels of pollution, treatment, and industry.

Table F-1 lists the coefficients* used in this study.

Temperature Coefficients

The Q10 temperature coefficients for coliform and reaeration are used to adjust the rate coefficients to reflect changes in temperature by the following general expression

$$K = K_2 \theta^{(T-20)} \quad \text{F-1}$$

where

K = Coliform decay or reaeration rate coefficient at the
local temperature

*These values are obtained in general from reference 16, but judgement and experience have also been taken into account in establishing these coefficients.

TABLE F-1

COEFFICIENTS

Q10 Temperature Coefficients

COLIFORM DIEOFF	1.040
REAERATION	1.022

Chemical Composition of Biota and Detritus

	C	N	P
ALGAE	.5	.09	.012
ZOOPLANKTON	.5	.09	.012
FISH	.5	.09	.012
BENTHO	.5	.09	.012
DETRITUS	.5	.09	.012

Digestive Efficiency of Biota

ZOOPLANKTON	.7
FISH	.6
BENTHO	.4

Stoichiometric Equivalence of Chemical and Biologic Transformation

O ₂ /NH ₃ DECAY	3.5
O ₂ /NO ₂ DECAY	1.2
O ₂ /DETRITUS DECAY	2.0
O ₂ /BIOMASS RESPIRATION	2.0
CO ₂ /BOD DECAY	0.2
O ₂ /ALGAL GROWTH*	1.6

*Oxygenation factor for Phytoplankton

TABLE F-1 (cont'd)

COEFFICIENTS

Temperature Limits

(°C)

K Factors

	T ₁	T ₂	T ₃	T ₄	K ₁	K ₄
ALGAE 1	5	22	25	34	.1	.1
ALGAE 2	10	28	30	40	.1	.1
ZOOPLANKTON	5	28	30	38	.1	.1
BENTHO	5	22	25	38	.1	.1
FISH 1	5	20	20	25	.1	.1
FISH 2	10	27	30	38	.1	.1
FISH 3	5	22	30	36	.1	.1
BOD	4	30			.1	-
NH ₃ -N	4	30			.1	-
NO ₂ -N	4	30			.1	-
DETRITUS	4	30			.1	-

Settling Rate

(M/Day)

ALGAE 1	.15
ALGAE 2	.15
DETRITUS	.15

Zooplankton Feeding Preference

For ALGAE 1 as a fraction of 1 .67

Mortality Rates

(Rate/Day)

ZOOPLANKTON	.005
FISH	.001
BENTHO	.001

TABLE F-1 (cont'd)

COEFFICIENTS

Maximum Specific Growth Rates/Day

ALGAE 1	1.00
ALGAE 2	2.00
ZOOPLANKTON	.150
FISH 1	.020
FISH 2	.025
FISH 3	.020
BENTHO	.020

Half Saturation Constants of Phytoplankton

	Light	CO ₂	N	P
ALGAE 1	.003	.02	.2	.03
ALGAE 2	.005	.02	.1	.05

Half Saturation Constants

ZOOPLANKTON	graze on ALGAE	.55
FISH 1	graze on ZOOPLANKTON	.05
FISH 2	graze on ZOOPLANKTON	.05
FISH 3	graze on BENTHO	500
BENTHO	graze on SEDMT	50

Decay Coefficients/Day

BOD	.100
AMMONIA	1.00
NITRITE	3.00
DETRITUS	.001
COLIFORM	.500

TABLE F-1 (cont'd)

COEFFICIENTS

Respiration Rates

(Rate/Day)

PHYTOPLANKTON	.050
ZOOPLANKTON	.020
FISH	.001
BENTHO	.001

K_2 = Coliform decay or reaeration rate coefficient at 20°C
 θ = Q10 temperature coefficient
T = Local temperature

By using the temperature coefficient concept, the decay or reaeration rate coefficients can be specified for a common temperature (20°C) and automatically adjusted within the program for temperature differences. These Q10 coefficients are only of real concern for temperatures greater than 30°C or less than 10°C and may thus be treated as constants during the calibration process, unless specific evidence to the contrary is available.

Chemical Composition of Biota and Detritus

The chemical composition data are used to maintain continuity of mass within the system by removing an appropriate amount of a particular constituent with biota growth and returning mass due to biota respiration and detritus decay. Unfortunately, exact continuity of mass will not be maintained unless the composition of all the constituents are the same, because all biota contribute to detritus on a one to one basis.

Digestive Efficiency of Biota

The digestive efficiency is that fraction of the food consumed by biota which is utilized for growth. The remainder is used for metabolic processes (i.e., respiration and excretion).

Stoichiometric Equivalences

Stoichiometric equivalence is the ratio of the amount of two constituents needed for a given chemical or biologic reaction. For example, 3.5 grams of oxygen are consumed when one gram of ammonia nitrogen is oxidized to nitrite.

Temperature Limits

The temperature limits define the curves used to modify the growth, respiration, and mortality rates of the biota and the decay rates of the abiotic substances. The temperatures, T_1 and T_4 , are the lower and upper threshold limits, respectively, for growth or decay. The temperatures T_2 and T_3 define the range at which the growth or decay rate is a maximum. If the maximum rate occurs at a single temperature, $T_2 = T_3$. T_3 and T_4 have no significance for abiotic substances.

Settling Rates

The settling rate defines the rate of fall of algae and detritus through the water column. It is of particular significance in the reservoir section where the algae and detritus may settle through hundreds of meters.

Zooplankton Feeding Preferences

The zooplankton feeding preference is used to establish an effective algae concentration for determining the zooplankton growth rate. This allows input of only one half saturation constant for zooplankton growth based on algae 1 and adjustment of the concentration of algae accordingly.

Mortality Rates

The mortality rate is that fraction of the biomass which is converted to detritus by death of the particular biota. The rate coefficients for mortality and respiration are in 1/day units and are utilized in the following general natural logarithmic function

$$C(t + \Delta t) = C_t e^{(k\Delta t)} \quad F-2$$

where

$C(t + \Delta t)$ = Concentration at the end of the time step

C_t = Concentration at the beginning of the time step

K = Mortality or respiration rate

Δt = Computational time step

Note that mortality for algae is incorporated directly into respiration and algae are assumed to become sediment when they settle to the bottom of a stream or reservoir. The mortality rate coefficients are modified by the temperature limit coefficients and two exponential curves.

Respiration Rates

The respiration rate is that fraction of the biomass which is converted back to inorganic carbon, nitrogen and phosphorus by the normal process of respiration of the organism. The respiration rate coefficients are modified by the temperature limit coefficients and two exponential curves.

Maximum Specific Growth Rates

The maximum specific growth rate is the maximum fractional increase in biomass which can occur without any nutrient limiting. The maximum growth rate and the decay rate coefficients are modified by the temperature limit coefficients and one or more exponential curves.

Half Saturation Constants

The half saturation constants or Michaelis-Menton constants are used to adjust the growth rate of the biota to the available nutrient or food supply. The half saturation constant is actually the concentration of the nutrient at which the biota will grow at half the maximum rate. The following expression is used to adjust the growth rates:

$$\mu = \mu_m \left(\frac{C}{K+C} \right)$$

F-3

where

- μ = Actual growth rate
- μ_m = Maximum growth rate
- C = Nutrient concentration
- K = Half saturation constant

Decay Rates

The decay rate is that fraction of the constituent which is removed or converted into other constituents by bacterial or chemical decomposition. In some cases this decay is dependent on the presence of oxygen; for example, BOD, NH_3 and NO_2 decay may generally be considered as aerobic reactions. However, decay of sediments and detritus may be either aerobic or anaerobic with different decay rates for each type. Such refinements are not presently incorporated into the model, although oxygen dependent reactions are programmed to be inhibited by a lack of available oxygen.

APPENDIX G

GEORGIA WATER QUALITY STANDARDS

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**rules and
regulations
for
water quality
control**

**Chapter 391-3-6
Revised
June, 1974**

Georgia Department of
NATURAL RESOURCES



**Environmental Protection Division
47 Trinity Avenue, S.W.
Atlanta Georgia 30334**

**RULES
OF
GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION**

**CHAPTER 391-3-6
WATER QUALITY CONTROL**

TABLE OF CONTENTS

391-3-6-.01	Organization and Administration	391-3-6-.04	Water Quality Standards
391-3-6-.02	Preparation and Submission of Engineering Reports and Plans and Specifications	391-3-6-.05	Marine Sanitation Devices
391-3-6-.03	Water Use Classifications and	391-3-6-.06	Emergency Actions
			Waste Treatment and Permit Requirements

391-3-6-.01 Organization and Administration.

(1) **Purpose.** The purpose of Paragraph 391-3-6-.01 is to establish the organizational and administrative procedures to be followed in the administration and enforcement of the Georgia Water Quality Control Act, as amended, and to carry out the purposes and requirements of said Act and of the Federal Water Pollution Control Act Amendments of 1972, as amended.

(2) **Definitions.** All terms used in this Paragraph shall be interpreted in accordance with the definitions as set forth in the Georgia Water Quality Control Act, as amended, unless otherwise defined in this Paragraph or in any other Paragraph of these rules:

(a) "Act" means the Georgia Water Quality Control Act, as amended.

(b) "Board" means the Board of Natural Resources of the State of Georgia.

(c) "Department" means the Department of Natural Resources of the State of Georgia.

(d) "Director" means the Director of the Division of Environmental Protection of the Department of Natural Resources, State of Georgia.

(e) "Division" means the Division of Environmental Protection of the Department of Natural Resources, State of Georgia.

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(f) "E.P.A." means the United States Environmental Protection Agency.

(g) "Federal Act" means the Federal Water Pollution Control Act Amendments of 1972, as amended.

(h) "National Pollutant Discharge Elimination System" (NPDES) means the national system for the issuance of permits under Section 402 of the Federal Water Pollution Control Act Amendments of 1972.

(i) "Regional Administrator" means the Regional Administrator for the EPA region which includes the State of Georgia.

(3) **Organization.** The Division of Environmental Protection of the Department of Natural Resources is responsible for enforcing those environmental protection laws of the State of Georgia as specified in the Executive Reorganization Act of 1972, as amended. Requests for information and submission of materials should be made to the Division office.

(4) **Administrative Hearings.**

(a) Hearings may be held in accordance with the Act in connection with the following matters:

1. To determine whether or not an alleged pollution is contrary to the public interest.
2. In connection with the securing, within the time specified by order or permit of the Director, of such operating results as are reasonable and practicable of attainment toward the control, abatement or prevention of pollution of the waters of the State and the preservation of the necessary quality for the reasonable use thereof.
3. In connection with notice to the holder of a permit of intent to revoke, suspend, or modify the permit.
4. In connection with the refusal of any person to cooperate with the efforts of the Division to reduce pollution, and upon the issuance of an order by the Director, to bring about the reduction or elimination of pollution within a reasonable time.
5. Any person who is aggrieved or adversely affected by any order or action of the Director and who petitions the Director for

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a hearing within thirty (30) days of the issuance of such order or notice of such action. Such person shall be granted a hearing before a hearing officer appointed by the Board of Natural Resources. The initial hearing and any administrative review thereof shall be conducted in accordance with Section 17(a) of the Executive Reorganization Act of 1972, as amended.

6. Any person against whom an emergency order is directed, provided such person petitions the Director for a hearing within the thirty (30) days of the issuance of such order. Such person shall be afforded a hearing as soon as possible.

7. In connection with public hearings required pursuant to Section 402(b) (3) of the Federal Act and Federal Regulations, 40 C.F.R. 124.36.

8. In connection with public hearings or public participation required pursuant to Section 101(e) of the Federal Act.

(b) Insofar as applicable to the administrative procedures required pursuant to the Georgia Water Quality Control Act, as amended, Sections 14, 15, 16, 17, and 18 of the Georgia Administrative Procedure Act, as amended, and Section 17(a) of the Executive Reorganization Act of 1972, as amended, shall apply.

(5) **Notice.** Notice of all hearings provided for above shall be issued in accordance with Section 14 of the Georgia Administrative Procedure Act, as amended, and Federal Regulations, 40 C.F.R. 124.37.

(6) **Notice to File Plan of Correction or Improvement.**

(a) In order to carry out a comprehensive plan to prevent and control pollution, the Division, as required by Section 5 of the Act and Section 303 of the Federal Act, may conduct studies and perform evaluations to determine waste load allocations in order to specify the degree of treatment and or technology necessary to achieve the established effluent limitations; the maintenance of existing wastewater treatment technology; supplementary treatment or other specific measures necessary to attain and maintain applicable water quality standards, and protect the down stream users; or such other measures necessary to prevent further pollution or reduce existing pollution. Upon the establishment of the necessary corrective action, the discharger will be required to file a plan and schedule of improvement with the Division. The Director

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may issue a notice to any person to submit within a specified time a plan of improvement and schedule for compliance with the specified requirements.

(b) The Director is authorized to approve plans, specifications, and related material, and to issue permits on behalf of the Division to persons who apply for such permits in accordance with Section 10 of the Act and such rules as are adopted and promulgated pursuant to same.

(7) Effective Date. This Paragraph shall become effective on June 30, 1974.

Authority: Ga. Laws 1964, p. 416, as amended; Ga. Laws 1972, p. 1015, as amended. Effective June 30, 1974. Administrative History: Original Rule was filed on June 10, 1974, effective June 9, 1974.

391-3-6-.02 Preparation and Submission of Engineering Reports and Plans and Specifications.

(1) **Purpose.** The purpose of Paragraph 391-3-6-.02 is to establish procedures to be followed by persons submitting to the Division engineering reports, plans and specifications, and related materials for the construction of any system for the disposal or treatment of pollutants.

(2) **Definitions.** All terms used in this Paragraph shall be interpreted in accordance with the definitions as set forth in the Act, unless otherwise defined in this Paragraph or in any other Paragraph of these Rules:

(a) **"Professional Engineer."** A person registered to practice professional engineering in accordance with the provisions of an Act Governing the Practice of Professional Engineering in Georgia (Ga. L. 1945, p. 294, as amended; Ga. Code Section 84-2100).

(b) **"Owner."** Any person owning or operating any system for the disposal or treatment of pollutants.

(c) **"Sewerage System"** means any system for the treatment or disposal of pollutants including treatment works, pipe lines or conduits, pumping stations and force mains, and all other constructions, devices, and appliances appurtenant thereto, used for conducting pollutants to the point of ultimate disposal.

(3) **General Provisions.**

(a) Any person who desires to erect, modify, or alter a sewerage

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system shall obtain approval of any plans, specifications and related materials for such system from the Division prior to commencement of construction.

(b) **Engineering material submitted to the Division shall be prepared by a Professional Engineer competent in the treatment of water pollutants.**

(c) During the early stages of planning for the construction of a sewerage system, and prior to the formal submission of an application and accompanying materials for any permit required pursuant to the Act, or materials submitted for Division approval pursuant to these rules, a conference between the project owner or his representative and representatives of the Division shall be held at the request of either the Director or the project owner, in order to reach a clear understanding of the proposal to be formally submitted to the Division at a later time. Such conference shall be granted within sixty (60) days after a written request to the Division by the project owner or his representative. If a conference is not granted within such period, then such permit application or other materials shall be filed and acted upon by the Division after the expiration of such period.

(d) Sufficient copies of completed reports, plans and specifications, and related materials shall be submitted to the Division to cover necessary distribution when approved. Such material, accompanied by a letter of transmittal, shall be submitted by the project owner or his representative well in advance of any critical date involved, in order that time will be available for review, discussion and revision when necessary. The submittal of such material shall be complete, accurate, distinct, legible, and relevant in respect to the project to which it applies. Permit applications shall be processed as provided in Paragraph 391-3-6-.06.

(e) Plans for a sewerage system submitted to the Division will be considered for approval by the Division only when designed so as to minimize the passage of rainwater from roofs, streets or other areas and all groundwater, other than unavoidable infiltration, through such sewerage system.

(f) All proposed lift stations must be approved by the Division.

(4) **Engineering Reports.** Engineering reports submitted to the Division shall contain a comprehensive description of the proposed project and shall include the following:

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- (a) Pertinent information regarding the existing sewerage system, if applicable;
- (b) Characteristics of existing pollutants and existing or proposed treatment of such pollutants;
- (c) Demonstration of the need for the proposed sewerage system;
- (d) Evaluation of alternatives to define the most cost effective method for meeting established effluent limitations, water quality goals, and treatment requirements;
- (e) Results to be expected from treatment process;
- (f) Sufficient maps, charts, tables, calculations, basis of design data and graphs to make the report readily understandable;
- (g) An operation and maintenance program description;
- (h) Such other pertinent engineering information as the Division may require.
- (5) **Plans and Specifications.** Plans and specifications submitted to the Division for a sewerage system shall include the following:
 - (a) A map showing the area to be served by the sewerage system;
 - (b) Profiles of proposed sewers;
 - (c) Construction details of manholes and other special sewer structures;
 - (d) General and detail plans for the treatment facility;
 - (e) Complete design data for the treatment facility plans, to be submitted in duplicate on forms specified by the Division;
 - (f) Specifications for the construction of the sewerage system;
 - (g) Such other plans and specifications as the Division may require.
- (6) **General Map Plans.** General map plans submitted to the

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Division for a sewerage system shall include the following:

- (a) A map plan that shows the entire area to be served, drawn to a scale of from 100 to 300 feet per inch. The map plan may be divided into sections, provided the sheets are bound together and indexed to show the area covered by each sheet.
- (b) All existing and proposed streets in the area to be served; surface elevations at all street intersections; the location of all existing sewers, separate or combined; the location of the treatment facility; the location of the existing and proposed sewer outlets or overflows; the elevation of the highest known stream water level at the outlets and the treatment facility; and clear identification of any areas from which sewage is to be pumped.
- (c) Clear designation on the plan by suitable symbols of all sewer appurtenances, including, but not limited to, manholes, siphons and pumps.
- (d) Such other information as the Division may require.
- (7) **Sewer Plans and Profiles.** Sewer plans and profiles submitted to the Division for a sewerage system shall include the following:
 - (a) Sewers and force mains, drawn at a scale that shows the profile for all manholes, siphons, railroad crossings, street or stream crossings, elevations of stream beds, normal stream water levels, and sizes and grades of sewers which show surface elevations and sewer invert elevations.
 - (b) Detailed drawings of all sewer appurtenances, including, but not limited to, manholes, inspection chambers, siphons, lift stations, and any special structures to accompany the sewer plans. Detailed drawings shall be to a scale suitable to clearly show the design details.
- (8) **Treatment Facilities Plans.** Plans for treatment facilities submitted to the Division shall include the following:
 - (a) A general plan that clearly identifies the exact location of the facilities, areas reserved for future expansion, access roads to the various units, and the point at which the access roads connect with existing road or street systems. It shall also show sufficient detail of the units, pipelines or any other features so as to make the proposed treatment process clearly and easily understood. The

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elevations of all units and water surfaces shall be shown.

(b) Detail plans which show longitudinal and transverse sections sufficient to explain the construction of each treatment unit.

(c) Flow measuring devices at appropriate points in the plan. Sampling and recording devices may be required by the Division when deemed necessary.

(d) Such other information as the Division may require.

(9) Approval of Plans and Specifications. Approval of the plans and specifications by the Division does not include or imply approval of the structural, electrical, or mechanical integrity of the sewerage system, treatment facilities, units or equipment.

(10) Deviation from Approved Plans and Specifications. No deviations from approved plans and specifications shall be made during construction unless documentation showing proposed changes has been submitted to and approved by the Division.

(11) Effective Date. This Paragraph shall become effective on June 30, 1974.

Authority: Ga. Laws 1964, p. 416, as amended. Effective June 30, 1974. Administrative History: Original Rule was filed on June 10, 1974; effective June 10, 1974.

391-3-6-.03 Water Use Classifications and Water Quality Standards.*

(1) Purpose. The establishment of water quality standards.

(2) Water Quality Enhancement:

(a) The purposes and intent of the State in establishing Water Quality Standards are to provide enhancement of water quality and prevention of pollution; to protect the public health or welfare in accordance with the public interest for drinking water supplies; conservation of fish, game and other beneficial aquatic life, and agricultural, industrial, recreational, and other beneficial uses.

(b) Those waters in the State whose existing quality is better than the minimum levels established in standards on the date standards become effective will be maintained at high quality; with the State having the power to authorize new developments, when

*Applicable to Intrastate and Interstate Waters of Georgia

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it has been affirmatively demonstrated to the State that a change is justifiable to provide necessary social or economic development; and provided further that the level of treatment required is the highest and best practicable under existing technology to protect existing beneficial water uses.

(c) In applying these policies and requirements, the State of Georgia will recognize and protect the interest of the Federal Government in interstate (including coastal and estuarine) waters. Toward this end the State will consult and cooperate with the Environmental Protection Agency on all matters affecting the Federal interest.

(3) Definitions. All terms used in this Paragraph shall be interpreted in accordance with definitions as set forth in the Act and as otherwise herein defined:

(a) "Reasonable and necessary uses" means drinking water supplies, conservation of fish, game and other aquatic life, agricultural, industrial, recreational, and other legitimate uses.

(b) "Shellfish" refers to clams, oysters, scallops, mussels, and other mollusks.

(c) "Intake temperature" is the natural or background temperature of a particular waterbody unaffected by any man-made discharge or thermal input.

(d) "Coastal waters" are those littoral recreational waters on the ocean side of the Georgia coast.

(4) Water Use Classifications. Water use classifications for which the criteria of this Paragraph are applicable are as follows:

(a) Drinking Water Supplies

(b) Recreation

(c) Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life

(d) Agricultural

(e) Industrial

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(f) Navigation

(g) Wild River

(h) Scenic River

(i) Urban Stream

(5) **General Criteria for All Waters.** The following criteria are deemed to be necessary and applicable to all waters of the State:

(a) All waters shall be free from materials associated with municipal or domestic sewage, industrial waste or any other waste which will settle to form sludge deposits that become putrescent, unsightly or otherwise objectionable.

(b) All waters shall be free from oil, scum and floating debris associated with municipal or domestic sewage, industrial waste or other discharges in amounts sufficient to be unsightly or to interfere with legitimate water uses.

(c) All waters shall be free from material related to municipal, industrial or other discharges which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses.

(d) All waters shall be free from toxic, corrosive, acidic and caustic substances discharged from municipalities, industries or other sources in amounts, concentrations or combinations which are harmful to humans, animals or aquatic life.

(e) Applicable State and Federal requirements and regulations for the discharge of radioactive substances shall be met at all times.

(f) No man-made physical or other alteration of stream beds that may violate established water quality standards, or reduce the waste assimilative capacity of the streams, will be permitted without the expressed approval of the Environmental Protection Division.

(6) **Specific Criteria for Classified Water Usage.** The following criteria are deemed necessary and shall be required for the specific water usage as shown:

(a) Drinking Water Supplies:

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1. Those waters approved by the Environmental Protection Division and requiring only approved disinfection and meeting the requirements of the Federal Drinking Water Standards; or waters approved by the Environmental Protection Division for human consumption and food-processing or for any other use requiring water of a lower quality:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of 50 per 100 ml based on at least four samples taken over a 30-day period and not to exceed 200 per 100 ml in more than five percent of the samples in any 90-day period.

(ii) Floating solids, settleable solids, sludge deposits or any taste, odor or color producing substances: None associated with any waste discharge.

(iii) Sewage, industrial or other wastes: None.

2. Those raw water supplies requiring approved treatment to meet the requirements of the Environmental Protection Division and the Federal Drinking Water Standards or which are approved by the Environmental Protection Division for human consumption and food-processing; or for any other use requiring water of a lower quality:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples taken over a 30-day period and not to exceed a maximum of 4,000 per 100 ml.

(ii) Dissolved Oxygen: A daily average of 6.0 mg/l and no less than 5.0 mg/l at all times for waters designated as trout streams by the State Game and Fish Division. A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for water supporting warm water species of fish.

(iii) pH: Within the range of 6.0 - 8.5.

(iv) No material or substance in such concentration that, after treatment, would exceed the requirements of the Environmental Protection Division and the latest edition of Federal Drinking Water Standards.

(v) Temperature: Not to exceed 90°F. At no time is the temperature of the receiving waters to be increased more than 5°F above intake temperature except that in estuarine waters the increase

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will not be more than 1.5°F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperature.

(b) Recreation:

1. General recreational activities such as water skiing, boating, and swimming, or for any other use requiring water of a lower quality. These criteria are not to be interpreted as condoning water contact sports in proximity to sewage or industrial waste discharges regardless of treatment requirements:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of:

(I) Coastal Waters - 100 per 100 ml

(II) All other recreational waters - 200 per 100 ml

(III) Should water quality and sanitary studies show natural fecal coliform levels exceed 200/100 ml (geometric mean) occasionally in high quality recreational waters, then the allowable geometric mean fecal coliform level shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing fresh water streams.

I. The geometric mean will be used as the method of criteria expression. This technique will be applied to no less than four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours.

(ii) Dissolved Oxygen: A daily average of 6.0 mg/l and no less than 5.0 mg/l at all times for waters designated as trout streams by the State Game and Fish Division. A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish.

(iii) pH: Within the range of 6.0 - 8.5.

(iv) Toxic Wastes, Other Deleterious Materials: None in concentrations that would harm man, fish and game or other beneficial aquatic life.

(v) Temperature: Not to exceed 90°F. At no time is the temperature of the receiving waters to be increased more than 5°F above intake temperature except that in estuarine waters the increase

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will not be more than 1.5°F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperatures.

(c) Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life; or for any other use requiring water of a lower quality:

1. Dissolved Oxygen: A daily average of 6.0 mg/l and no less than 5.0 mg/l at all times for waters designated as trout streams by the State Game and Fish Division. A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish.

2. pH: Within the range of 6.0 - 8.5.

3. Bacteria: Fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples taken over a 30-day period and not exceed a maximum of 4,000 per 100 ml.

4. Bacteria: (Applicable only to waters designated as approved shellfish harvesting waters by the appropriate State agencies.) The requirements will be consistent with those established by the State and Federal agencies responsible for the National Shellfish Sanitation Program.

5. Temperature: Not to exceed 90°F. At no time is the temperature of the receiving waters to be increased more than 5°F above intake temperature except that in estuarine waters the increase will not be more than 1.5°F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperatures.

6. Toxic Wastes, Other Deleterious Materials: None in concentrations that would harm man, fish and game or other beneficial aquatic life.

(d) Agricultural:

1. For general agricultural uses such as stock watering and irrigating; or for any other use requiring water of a lower quality:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of 5,000 per 100 ml based on at least four samples taken over a 30-day period.

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- (ii) Dissolved Oxygen: No less than 3.0 mg/l at any time.
- (iii) pH: Within the range of 6.0 - 8.5.
- (iv) Temperature: Not to exceed 90°F. At no time is the temperature of the receiving waters to be increased more than 5°F above intake temperature except that in estuarine waters the increase will not be more than 1.5°F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperatures.
- (v) Toxic Substances, Other Deleterious Materials: None in concentrations that would interfere with or adversely affect uses for general agricultural purposes or would prevent fish survival.

(e) Industrial:

- 1. For processing and cooling water with or without special treatment; or for any other use requiring water of a lower quality:

(i) Dissolved Oxygen: No less than 3.0 mg/l at any time.

(ii) pH: Within the range of 6.0 - 8.5.

(iii) Toxic Substances, Other Deleterious Materials: None in concentrations that would prevent fish survival or interfere with legitimate and beneficial industrial uses.

(iv) Temperature: Not to exceed 90°F. At no time is the temperature of the receiving waters to be increased more than 5°F above intake temperature except that in estuarine waters the increase will not be more than 1.5°F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperatures.

(f) Navigation:

- 1. To provide for commercial ship traffic and protection of seamen or crews:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of 5,000 per 100 ml based on at least four samples taken over a 30-day period.

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- (ii) Dissolved Oxygen: No less than 3.0 mg/l at any time.
- (iii) pH: Within the range of 6.0 - 8.5.
- (iv) Toxic Substances, Other Deleterious Materials: None in concentrations that would damage vessels, prevent fish survival or otherwise interfere with commercial navigation.
- (v) Temperature: Not to exceed 90°F. At no time is the temperature of the receiving waters to be increased more than 5°F above intake temperature except that in estuarine waters the increase will not be more than 1.5°F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperatures.

(g) Wild River:

- 1. This classification will be applicable to any waters of the State when so designated by an authorized State or Federal Agency and will be effective simultaneously with that Agency's proper designation.

- 2. For all waters designated as "Wild River," there shall be no alteration of natural water quality from any source.

(h) Scenic River:

- 1. This classification will be applicable to any waters of the State when so designated by an authorized State or Federal Agency and will be effective simultaneously with that Agency's proper designation.

- 2. For all waters designated as "Scenic River," there shall be no alteration of natural water quality from any source.

(i) Urban Stream:

- 1. This classification is applicable to streams in highly developed urban areas:

(i) All conditions specified under "General Criteria for All Waters" [391-3-6-.03(5)] will apply, and in addition, the waters so classified are to be aesthetically compatible to adjacent areas.

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(ii) Bacteria: Fecal coliform not to exceed a geometric mean of 2,000 per 100 ml based on at least four samples taken over a 30-day period and not to exceed a maximum of 5,000 per 100 ml.

(iii) pH: Within the range of 6.0 - 8.5.

(iv) Dissolved Oxygen: No less than 3.0 mg/l at any time.

(7) Natural Water Quality. It is recognized that certain natural waters of the State may have a quality that will not be within the general or specific requirements contained herein.

(8) Treatment Requirements. Notwithstanding the above criteria, the requirements of the State relating to secondary or equivalent treatment of all waste shall prevail. The adoption of these criteria shall in no way preempt the treatment requirements.

(9) Streamflows. Specific criteria or standards set for the various parameters apply to all flows on regulated streams. On unregulated streams, they shall apply to all streamflows equal to or exceeding to 7-day, 10-year minimum flow.

(10) Mixing Zone. Effluents released to streams or impounded waters shall be fully and homogeneously dispersed and mixed insofar as practical with the main flow or water body by appropriate methods at the discharge point. Use of a reasonable and limited mixing zone may be permitted on receipt of satisfactory evidence that such a zone is necessary and that it will not create an objectionable or damaging pollution condition.

(11) Effective Date. This Paragraph shall become effective on June 30, 1974.

Authority Ga. Laws 1964, p. 416, as amended; Reorganization Act of 1972, Ga. Laws 1972 Sections 32, 1517 and 1518. Effective June 30, 1974. Administrative History. Original Rule was filed on June 10, 1974; effective June 30, 1974.

391-3-6-.04 Marine Sanitation Devices.

(1) Purpose. The purpose of Paragraph 391-3-6-.04 is to prescribe procedures pertaining to construction, installation and operation of marine sanitation devices, facilities or methods of sewage disposal.

(2) Definitions. All terms used in this Paragraph shall be interpreted in accordance with the definitions as set forth in the Act unless otherwise herein defined in this Paragraph or in any other Paragraph of these Rules.

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(a) "Boat" means any vessel or watercraft, whether moved by oars, paddles, sails, or other power mechanism, inboard or outboard, or any other vessel or structure floating upon the waters of this State whether or not capable of self locomotion, including, but not limited to, cabin cruisers, houseboats, barges and similar floating objects.

(b) "Marine Toilet" means any toilet on or within any boat.

(c) "Other Disposal Unit" means any device on or within any boat, other than marine toilet, which is intended for use in the disposal of human body wastes or sewage.

(d) "Blender" means any mechanical device capable of reducing sewage solids into a finely divided state such that a liquid disinfecting agent may be effectively dispersed throughout the blended sewage.

(e) "Marine Sanitation Devices" mean any equipment for installation on a boat which is designed to receive, retain, treat, or discharge sewage or any process to treat such sewage.

(f) "Sewage," for the purposes of this Paragraph only, means water carried wastes, which are generated by human beings or their activities.

(3) General Provisions.

(a) Any marine toilet or other disposal unit located on or within any boat operated on waters of this State shall have securely affixed to the interior discharge toilet or unit a suitable marine sanitation device designed, constructed, and operated in accordance with requirements prescribed herein. All sewage passing into or through the marine toilet or other disposal unit shall discharge solely to the marine sanitation device.

(b) This Paragraph shall not apply to ocean going vessels of 20 tons displacement or more.

(4) Waste Treatment Devices and Equipment.

(a) All discharges from marine sanitation devices into or upon the waters of this State shall be in compliance with the Federal standards of performance and regulations for marine sanitation

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at reasonable times for the purpose of determining whether or not there is compliance with the provisions of the Act and the rules of the Division.

(6) **Effective Date.** This Paragraph shall become effective June 30, 1974.
Authority: Ga. Laws 1964, p. 416, as amended Effective June 30, 1974. Administrative History: Original Rule was filed on June 10, 1974, effective June 10, 1974.

391-3-6-.05 Emergency Actions.

- (1) **Purpose.** The purpose of Paragraph 391-3-6-.05 is to provide procedures to handle any emergency which endangers the waters of the State.
- (2) **Definitions.** All terms used in this Paragraph shall be interpreted in accordance with the definitions as set forth in the Act unless otherwise defined in this Paragraph or in any other Paragraph of these Rules.

(3) **Notice Concerning Endangering Waters of the State.** Whenever, because of an accident or otherwise, any toxic or taste-and-color producing substance, or any other substance which would endanger downstream users of the waters of the State or would damage property, is discharged into such waters, or is so placed that it might flow, be washed, or fall into them, it shall be the duty of the person in charge of such substances at the time to forthwith notify the Division in person or by telephone of the location and nature of the danger, and it shall be such person's further duty to immediately take all reasonable and necessary steps to prevent injury to property and downstream users of said water.

(4) **Emergency Orders.** The Director shall have the authority to issue an emergency order pursuant to Section 20 of the Act, and Section 17(a) of the Executive Reorganization Act of 1972, as amended.

(5) **Effective Date.** This Paragraph shall become effective on June 30, 1974.
Authority: Ga. Laws 1964, p. 416, as amended Effective June 30, 1974. Administrative History: Original Rule was filed on June 10, 1974, effective June 30, 1974.

391-3-6-.06 Waste Treatment and Permit Requirements.

- (1) **Purpose.** The purpose of this Paragraph 391-3-6-.06 is to provide for the degree of waste treatment required and the uniform procedures and practices to be followed relating to the application for or the issuance or revocation of permits for the discharge of

devices promulgated pursuant to Section 312 of the Federal Act.

- (b) Until such time as said Federal standards and regulations are formally promulgated, the following interim requirements will apply:

1. Marine toilets shall be provided with a blender; a device for the addition of a disinfecting agent in such a manner that the disinfection will be thoroughly mixed with and dispersed throughout the blended sewage; and a detention chamber such that the blended sewage and the disinfecting agent will be in contact for not less than ten minutes but not so long as to cause the septic decomposition of the blended sewage. The treatment equipment shall be firmly fastened to the discharge outlet of the marine toilet. The disinfecting agent shall be a five-percent hypochlorite solution or some other solution approved by the Division.

2. An exception to the requirement that treatment equipment be fastened to the discharge outlet of a marine toilet shall be granted when such discharge outlet is connected to a holding tank located on the boat; provided that:

- (i) such holding tank is constructed so as to prevent the removal of the sewage held therein except by pumping;
- (ii) the holding tank is properly vented to the outside air in such fashion as not to foul up the interior of the boat structure;
- (iii) chemicals which are added to the holding tank are only those approved by the Division; and
- (iv) the contents of holding tanks are disposed of only through onshore facilities approved by the Division.

(c) All onshore discharges from marine sanitation devices or other disposal units shall be accomplished only at or through onshore facilities approved by the Division.

(d) Other wastes, including, but not limited to, garbage, rubbish and litter, shall be deposited onshore in approved receptacles for ultimate disposal in a manner prescribed by the Rules and Regulations of the Solid Waste Management Section of the Division.

- (5) **Right of Entry.** Personnel of the Division or other duly authorized agents of the Department shall have access to any boat

any pollutant into the waters of the State.

(2) **Definitions.** All terms used in this Paragraph shall be interpreted in accordance with the definitions as set forth in the Act unless otherwise defined in this Paragraph or in any other Paragraph of these Rules:

(a) "Effluent Limitation" means any restriction or prohibition established under the Act on quantities, rates, or concentrations, or a combination thereof, of chemical, physical, biological, or other constituents which are discharged from point sources into the waters of the State, including, but not limited to, schedules of compliance.

(b) "NPDES Permit Application" means any application filed by any person with the Director for an NPDES Permit.

(c) "NPDES Permit" means any permit issued by the Division to regulate the discharge of pollutants from any point source into the waters of the State.

(d) "Construction" means any placement, assembly, or installation of facilities or equipment (including contractual obligations to purchase such facilities or equipment) at the premises where such equipment will be used, including preparation work at such premises.

(3) Permit Requirement.

(a) Any person discharging or proposing to discharge any pollutant from a point source into the waters of the State, under any of the circumstances described in Section 10(3) of the Act, shall obtain a permit from the Division to make such discharge.

(b) Any person discharging or proposing to discharge any pollutant from a non-point source into the waters of the State, under the circumstances described in Section 10(4) of the Act, shall obtain a permit from the Division to make such discharge.

(c) Any person owning or operating treatment works, from which a discharge into the waters of the State could possibly occur, excluding discharges which could result from Acts of God, shall apply to the Division for a permit.

(4) Degree of Waste Treatment Required.

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(a) All pollutants shall receive such treatment or corrective action so as to insure compliance with the terms and conditions of the issued permit and with the following, whenever applicable:

1. Effluent limitations established by EPA pursuant to Sections 301 and 302 of the Federal Act.

2. Standards of performance for new sources established by the EPA pursuant to Section 306 of the Federal Act.

3. Effluent limitations and prohibitions and pretreatment standards established by the EPA pursuant to Section 307 of the Federal Act.

4. Notwithstanding the above, more stringent effluent limitations may be required as deemed necessary by the Division to meet (a) any other existing Federal laws or regulations, and (b) to insure compliance with any applicable State water quality standards, effluent limitations, treatment standards, or schedules of compliance.

5. With regard to any non-point source, such effluent limitations as are required to insure compliance with applicable State water quality standards.

(b) The foregoing requirements shall be applied in considering all applications made pursuant to Section 10 of the Act and no such application will be approved unless the waste treatment facilities contemplated thereby will achieve such limitations and standards upon completion thereof or within such reasonable time thereafter as the Division may provide.

(c) Until such time as such standards, limitations, and prohibitions are formally promulgated pursuant to Sections 301, 302, 306, and 307 of the Federal Act, the Division shall apply such standards, limitations, and prohibitions necessary to achieve the purposes of said sections of the Federal Act. With respect to individual point sources, such limitations, standards, or prohibitions shall be based upon an assessment of technology and processes, to-wit:

1. To existing point sources, other than publicly owned treatment works, effluent limitations based on application of the best practicable control technology currently available;

2. To publicly owned treatment works, effluent limitations based upon the application of secondary treatment;

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3. To any point source, other than publicly owned treatment works, whose construction commences after the effective date of this Paragraph, effluent limitations which reflect the greatest degree of effluent reduction which the Division determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants;

4. To any point source, as appropriate, effluent limitations or prohibitions designed to prohibit the discharge of toxic pollutants in toxic amounts or to require pretreatment of pollutants which interfere with, pass through, or otherwise are incompatible with the operation of publicly owned treatment works; and

5. To any point source, as appropriate, more stringent effluent limitations as are required to insure compliance with applicable State water quality standards.

(5) Application for Permit.

(a) Applications for permits under Section 10 of the Act shall be on forms as may be prescribed and furnished from time to time by the Division. Applications shall be accompanied by all pertinent information as the Division may require in order to establish effluent limitations in accordance with subparagraph 391-3-6-06 (4), including, but not limited to, complete engineering reports, schedule of progress, plans, specifications, maps, measurements, quantitative and qualitative determinations, records, and all related materials.

(b) Engineering reports, plans, specifications, and other material submitted to the Division shall be prepared by a Professional Engineer competent in the field of sewage and industrial waste treatment.

(c) Material submitted shall be complete and accurate.

(d) Any State or NPDES Permit Application form or any other NPDES form submitted to the Division shall be signed as follows:

1. For a corporation, by a principal executive officer of at least the level of vice president, or his duly authorized representative, if such representative is responsible for the overall operation of the facility from which the discharge described in the State or NPDES Permit Application form originates.

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2. For a partnership, by a general partner.

3. For a sole proprietorship, by the proprietor.

4. For a municipal, State, or other public facility, by either a principal executive officer, ranking elected official or other duly authorized employee.

(6) Receipt and Use of Application and Data.

(a) Applications for permits will be reviewed together with such other information as may be necessary to ascertain the effect of the discharge of any such pollutant upon the waters into which such pollutant will be discharged.

(b) Copies of the complete NPDES Permit Application received by the Division shall be transmitted to the Regional Administrator for any comment in such manner as the Director and the Regional Administrator shall agree.

(c) The Division shall receive any relevant data collected by the Regional Administrator prior to the Division's participation in the NPDES in such manner as the Director and the Regional Administrator shall agree.

(7) Notice and Public Participation.

(a) Tentative Determination and Draft Permits:

1. When the Division is satisfied that the application is complete, a tentative determination will be made to issue or deny the permit. If the tentative determination is to issue the permit, a draft permit will be prepared in accordance with Federal Regulations, 40 C.F.R. Section 124.31, and applicable State laws prior to the issuance of a public notice.

(b) Public Notice:

1. Public notice of every complete permit application will be prepared and circulated in a manner designed to inform interested and potentially interested persons of the proposed discharge and of the proposed determination to issue or deny a permit for the proposed discharge. Procedures for circulation of the public notice shall include the following:

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(i) Within the geographical area of the proposed discharge the public notice shall be circulated by at least one of the following: posting in the post office or other public buildings near the premises of the applicant in which the discharge is located; posting at the entrance to the applicant's premises or nearby; or publication in one (1) or more newspapers of general circulation in the area of the applicant.

(ii) Posting of the public notice in the office of the Secretary of State.

(iii) A copy of the public notice shall be mailed to the permit applicant and a copy shall be available at the Division office in Atlanta.

(iv) Mailing of the public notice to any person or group upon written request. The Division shall maintain a mailing list for distribution of public notices and fact sheets. Any person or group may request that their names be added to the mailing list. The request should be in writing to the Division office in Atlanta and shall be renewed in December of each year. Failure to renew the request shall result in the removal of such name from the mailing list.

(v) The Division shall provide a period of not less than thirty (30) days following the date of the public notice in which interested persons may submit their written views on the tentative determination with respect to the NPDES Permit Application. All written comments submitted during the thirty (30) day comment period will be retained by the Division and considered in the final determination with respect to the permit application. The comment period may be extended at the discretion of the Director.

(vi) The contents of the public notice will be in accordance with Federal Regulations, 40 C.F.R. 124.32(c), and applicable State laws.

(vii) The Division will prepare and distribute a fact sheet in accordance with Federal Regulations, 40 C.F.R. 124.33, and applicable State laws. A copy of the fact sheet will be available for public inspection at the Division office in Atlanta. Any person may request in writing a copy of the fact sheet and it will be provided. The Division shall add the name of any person or group upon request to the mailing list to receive copies of fact sheets.

(viii) The Director will notify other appropriate governmental

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agencies of each complete permit application and will provide such agencies an opportunity to submit their written views and recommendations in accordance with Federal Regulations, 40 C.F.R. 124.34, and applicable State laws.

(ix) Copies of the proposed permits shall be transmitted to the Regional Administrator for review and comments in such manner as the Director and Regional Administrator shall agree.

(x) The Division shall transmit to the Regional Administrator a copy of every issued NPDES Permit, immediately following issuance, along with any and all terms, conditions, requirements or documents which are part of such permit or which affect the authorization by the permit of the discharge of pollutants.

(c) Public Hearings:

1. The Director shall provide an opportunity for an applicant, any affected state or interstate agency, the Regional Administrator or any other interested agency, person or group of persons to request a public hearing with respect to an NPDES Permit Application. Any such request for a public hearing shall be filed within the 30-day comment period prescribed in sub-paragraph 391-3-6-.06 (7) (b) (v) and shall indicate the interest of the party filing such a request, the reasons why a hearing is requested, and those specific portions of the application or other NPDES form or information to be considered at the public hearing. The Director shall hold a hearing if he determines that there is sufficient public interest in holding such a hearing.

2. Any public hearing held pursuant to this subparagraph shall be held in the geographical area of the proposed discharge or other appropriate location at the discretion of the Director.

3. The Director may hold one public hearing on related groups of permit applications.

4. Public notice of any hearing held pursuant to this subparagraph shall be provided at least thirty (30) days in advance of the hearing date and shall be circulated in accordance with Federal Regulations, 40 C.F.R. 124.37.

(d) Public Access to Information:

1. A copy of the NPDES Permit Application, public notice, fact

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Administrator of EPA under Section 402 (d) of the Federal Act. and

4. Any discharge from a point source which is in conflict with a plan or amendment thereto approved pursuant to Section 208 (b) of the Federal Act.

(c) The terms and conditions specified on the permit issued shall be in accordance with Federal Regulations, 40 C.F.R. 124.42 and 124.45 and applicable State laws and regulations promulgated thereunder.

(9) Publicly Owned Treatment Works.

(a) If the permit is for a discharge from a publicly owned treatment works, assurance shall be obtained from the applicant prior to issuance of any permit that notice shall be provided to the Director of the following:

1. Any new introduction of pollutants into such treatment works from a source which would be a new source as defined in Section 306 of the Federal Act if such source were discharging pollutants;

2. Except as to such categories and classes of point sources or discharges specified by the Director, any new introduction of pollutants into such treatment works from a source which would be subject to Section 301 of the Federal Act if such source were discharging pollutants; and

3. Any substantial change in volume or character of pollutants being introduced into such treatment works by a source introducing pollutants into such works at the time of issuance of the permit.

(b) If the permit is for a discharge from a publicly owned treatment works, the permittee shall require any industrial user of such treatment works to comply with the requirements of Sections 204 (b), 307, and 308 of the Federal Act. As a means of insuring compliance with Section 307 of the Federal Act, the permittee shall require each industrial user subject to the requirements of said Section 307 to forward to the Director periodic notice of progress (over intervals not to exceed 9 months) toward full compliance with Section 307 requirements.

(10) Schedules of Compliance.

(a) Any person who obtains an NPDES Permit or other dis-

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sheet, draft permit and other NPDES forms related thereto, including written public comments thereon and other reports, files and information not involving methods of processes entitled to protection as trade secrets, shall be available for public inspection and copying during normal business hours at the Division office in Atlanta. Effluent data shall not be considered as information entitled to protection. Public access to such information shall be in accordance with Federal Regulations, 40 C.F.R. 124.35.

2. Any information submitted in an NPDES Permit Application form, together with reports, records or plans that are considered confidential by the applicant for an NPDES Permit should be clearly labeled "Confidential" and be supported by a statement as to the reasons that such information should be considered confidential. If the Director, with the concurrence of the Regional Administrator, determines that such information is entitled to confidential protection, he shall label and handle same accordingly.

3. When the information being considered for confidential treatment is contained in an NPDES form, the Director shall forward such information to the Regional Administrator for his concurrence in any determination of confidentiality.

4. Any information accorded confidential status whether or not contained in an NPDES form shall be made available, upon written request, to the Regional Administrator or his authorized representative who shall maintain the information as confidential.

(8) Terms and Conditions of Permits.

(a) Terms and conditions under which the discharge will be permitted will be specified on the permit issued.

(b) No NPDES Permit shall be issued authorizing any of the following discharges:

1. The discharge of any radiological, chemical, or biological warfare agent or high-level radioactive waste into navigable waters.

2. Any discharge which the Secretary of the Army acting through the Chief of Engineers finds would substantially impair anchorage and navigation.

3. Any discharge to which the Regional Administrator has objected in writing pursuant to any right to object provided the

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(e) A discharger who fails or refuses to comply with an interim or final date of compliance specified in a permit may be deemed by the Director to be in violation of the permit and may be subject to enforcement action pursuant to the Act.

(11) Monitoring, Recording and Reporting Requirements. Any discharge authorized by a permit issued pursuant to the Act may be subject to such monitoring, recording and reporting requirements as may be reasonably required by the Director including the installation, use and maintenance of monitoring equipment or methods; specific requirements for recording of monitoring activities and results; and periodic reporting of monitoring results. The monitoring, recording and reporting requirements shall be specified in a permit when issued, provided, however, the Director may modify or require additional monitoring, recording and reporting by written notification to the permittee.

(a) The monitoring requirement of any discharge authorized by any such permit shall be consistent with Federal Regulations, 40 C.F.R. 124.61 and applicable State laws.

(b) Any permit which requires monitoring of the authorized discharge shall comply with the recording requirements specified by Federal Regulations, 40 C.F.R. 124.62 and applicable State laws. The permittee shall be required to retain any records of monitoring activities and results for a minimum of three (3) years, unless otherwise required or extended by the Director upon written notification.

(c) Any holder of a permit which requires monitoring of the authorized discharge shall report periodically to the Division the results of all required monitoring activities on appropriate forms supplied by the Division. The Director shall notify the permittee of the frequency of reporting but in no case shall the reporting frequency be less than once per year.

(12) Modification, Suspension and Revocation of Permits.

(a) The Director may revise or modify the schedule of compliance set forth in an issued permit if the permittee requests such modification or revision in writing and such modification or revision will not cause an interim date in the compliance schedule to be extended more than one hundred twenty (120) days or affect the final date in the compliance schedule. If the permittee requests in writing a modification or revision of a schedule of compliance set forth in

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charge permit pursuant to the Act but who is not in compliance with applicable effluent standards and limitations or other requirements contained in such permit at the time same is issued, shall be required to achieve compliance with such standards and limitations or other requirements in accordance with a schedule of compliance as set forth in such permit, or in the absence of a schedule of compliance, by the date set forth in such permit which the Director has determined to be the shortest, reasonable period of time necessary to achieve such compliance.

(b) In any case where the period of time for compliance specified in sub-paragraph 391-3-6-.06 (10) (a) of these Rules exceeds 9 months, a schedule of compliance shall be specified in the permit which will set forth interim requirements and the dates for their achievement. In no event shall more than 9 months elapse between interim dates, and, to the extent practicable, shall fall on the last day of the months of March, June, September and December.

(c) Within fourteen (14) days after an interim date of compliance or the final date of compliance specified in such permit, the permittee shall provide the Director with written notice of his compliance or noncompliance with the requirements or conditions specified to be completed by such date. Failure to submit the written notice is just cause for the Division to pursue enforcement action pursuant to the Act.

(d) On the last working day of the months of February, May, August, and November, the Director shall prepare and submit to the Regional Administrator a list of all dischargers holding NPDES permits which, as of the thirty (30) days prior to the date of the list, have submitted to the Director a report showing noncompliance with the requirements set forth in the permit and those which have not filed a timely report. The noncompliance list shall be available to the public at appropriate Division offices for inspection and copying, and shall contain the following information:

1. The name and address of each non-complying permittee;
2. A concise description of the nature of noncompliance;
3. A description of proposed actions to be taken by the Division or the permittee to correct the noncompliance; and
4. Any other information deemed necessary by the Division to explain or mitigate an instance of noncompliance.

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an issued permit which, if granted, would cause an interim date in the compliance schedule to be extended more than one hundred twenty (120) days or affect the final date in the compliance schedule, the Director may revise or modify such schedule of compliance if within thirty (30) days following receipt of notice of such request from the Director, the Regional Administrator does not object to same in writing and file such written objection with the Director. The Director may grant requests in accordance with this subparagraph if he determines after a documented showing by the permittee that good and valid cause (including Acts of God, strikes, floods, material shortages or other events over which the permittee has little or no control) exists for such revision.

(b) The Director may modify, suspend or revoke an issued permit in whole or in part during its term for cause, including, but not limited to, failure or refusal of the permittee to carry out the requirements listed in Federal Regulations, 40 C.F.R. 124.45(c), the causes listed in Federal Regulations, 40 C.F.R. 124.45(b), or the causes listed in the Act or regulations promulgated pursuant thereto, if within thirty (30) days following receipt of notice of such proposed modification, suspension or revocation from the Director, the Regional Administrator does not object to same in writing and file such written objection with the Director. Prior to any such modification, suspension or revocation of an issued permit by the Director (other than modification or revision of a compliance schedule pursuant to subparagraph (a) above or modification of monitoring, recording or reporting requirements), the Director will provide public notice in accordance with the procedures set forth in subparagraph 391-3-6.06(7) (b) and an opportunity for public hearing in accordance with the procedures set forth in subparagraph 391-3-6.06(7) (c).

(13) **Non-governmentally Owned Sewerage Systems.** In cases involving non-governmentally owned sewerage systems, a trust indenture or other legal contract or agreement, approved by the Division, assuring continuity of operation of the system, shall be filed with the application for a permit. This provision shall not be applicable to systems discharging only industrial waste.

(14) **Control of Disposal of Pollutants into Wells.** If the permit proposes to discharge to a well or subsurface water, the Director shall specify additional terms and conditions which shall (a) prohibit the proposed disposal, or (b) control the proposed disposal in order to prevent pollution of ground and surface water resources and to protect the public health and welfare. Any permit issued for

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the disposal of pollutants into wells shall comply with Federal Regulations, 40 C.F.R. 124.80, and applicable State laws.

(15) **Duration of Permits.** Any permit issued under Section 10(3) and (4) of the Act shall have a fixed term not to exceed five (5) years. Upon expiration of such permit, a new permit may be issued by the Director in accordance with Section 10(6) of the Act and Federal Regulations, 40 C.F.R. 124.52, provided that an application for such new permit is filed with the Director at least 180 days prior to the expiration date of the existing permit. The issuance of such new permit shall likewise have a fixed term not to exceed five (5) years.

(16) **Enforcement.** Any person who violates any provision of the Act, any rule promulgated and adopted pursuant thereto, or any term, condition, schedule of compliance or other requirement contained in a permit issued pursuant to the Act shall be subject to enforcement proceedings pursuant to the Act.

(17) **Effective Date.** This Paragraph shall become effective on June 30, 1974.

Authority: Ga. Laws 1964, p. 416, as amended; Ga. Laws 1972, p. 1015, as amended. Effective June 30, 1974. Administrative History: Original Rule was filed on June 10, 1974, effective June 30, 1974.

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**CLASSIFICATIONS FOR THE WATERS
OF THE STATE OF GEORGIA**

**DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION**

MAY 1975



JOE D. TANNER
Commissioner

J. LEONARD LEDBETTER
Division Director

Department of Natural Resources

ENVIRONMENTAL PROTECTION DIVISION
270 WASHINGTON STREET, S.W.
ATLANTA, GEORGIA 30334

INTRODUCTION

This document lists the classifications for the waters of the State of Georgia in force as of May 1975. The classifications are in accord with the Georgia Water Quality Control Act and the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500).

The initial stream classifications were made in July 1967 and applied to interstate waters only. In June 1972, the State classified approximately 1,420 miles of major intrastate streams. In March 1974, classifications for the remaining unclassified streams were adopted. Additionally, more than 3,000 miles of north Georgia streams have also been designated as trout waters by the Game and Fish Division of the Department of Natural Resources. An amendment to the Wild and Scenic Rivers Act in May 1974 has also designated 8.1 miles of Georgia streams as "Wild and Scenic."

Water quality criteria applicable to the various stream classifications are published in Chapter 391-3-6 of the document entitled Rules and Regulations for Water Quality Control, Georgia Department of Natural Resources, Environmental Protection Division, which is based on the State of Georgia Water Quality Control Act as Amended Through 1974. The criteria relating to the "Wild and Scenic" classification can be found in Public Law 93-279.





Department of Natural Resources
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Stream Categories

Streams and stream reaches not listed below for specific classifications will fit into the following categorical classifications:

- A.** Streams and stream reaches which are not shown on the Georgia Department of Transportation's official county maps are not classified unless they receive a wastewater discharge. In that case, they are classified as fishing.
- B.** Streams and stream reaches which are shown as naturally intermittent, ephemeral or a combination thereof on the Georgia Department of Transportation's official county maps or which can be documented as being intermittent by records of the United States Geological Survey are not classified unless they receive a wastewater discharge. In that case, they are classified as fishing.
- C.** Stream channels, drainage ditches and canals which are naturally intermittent, ephemeral or a combination thereof are not classified.
- D.** Streams and stream reaches not specifically classified below and not categorically classified above (A, B, or C) are classified as fishing.



Department of Natural Resources
ENVIRONMENTAL PROTECTION DIVISION

CLASSIFICATIONS FOR THE WATERS
OF THE STATE OF GEORGIA

MAY, 1975

SAVANNAH RIVER BASIN

CLASSIFICATION

Savannah River	Georgia-North Carolina State Line to Clark Hill Dam (Mile 238)	Recreation
Savannah River	Clark Hill Dam (Mile 238) to Augusta, 13th Street Bridge	Drinking Water
Savannah River	Augusta, 13th Street Bridge to U.S. Hwy. 301 Bridge (Mile 129)	Fishing
Savannah River	U.S. Hwy. 301 Bridge (Mile 129) to U.S. Hwy. 17 Bridge (Mile 22)	Drinking Water
Savannah River	U.S. Hwy. 17 Bridge (Mile 22) to Field's Cut (Mile 5)	Industrial Navigational
Savannah River	Field's Cut (Mile 5) to Fort Pulaski (Mile 0)	Fishing
Savannah River	Fort Pulaski (Mile 0) to Open Sea and all littoral waters of Tybee Island	Recreation
Butler Creek (and its tributaries)	Headwaters in Augusta to confluence with Savannah River	Urban
Cason's Dead River (and its tributaries)	Headwaters in Augusta to confluence with Savannah River	Urban
Chattooga River	Georgia-North Carolina State Line to Tugaloo Reservoir (0.8 mi)	Wild and Scenic
West Fork Chattooga River	Confluence of Overflow Creek and Clear Creek to confluence with Chattooga River (7.3 mi)	Wild and Scenic



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OGEECHEE RIVER BASIN

		<u>CLASSIFICATION</u>
Ogeechee River	Headwaters to U.S. Hwy 80 Bridge	Fishing
Ogeechee River	U.S. Hwy 80 Bridge to U.S. Hwy 17 Bridge	Fishing
Ogeechee River	U.S. Hwy 17 Bridge to Open Sea and littoral waters of Skidaway, Ossabaw, Sapelo and St. Catherines Islands	Recreation
Little Ogeechee River	Headwaters to U.S. Hwy 80 Bridge	Fishing
Little Ogeechee River	U.S. Hwy 80 Bridge to South End of White Bluff Road near Carmelite Monastery	Fishing
Little Ogeechee River	South End of White Bluff Road near Carmelite Monastery to Open Sea and littoral waters of skidaway and Ossabaw Islands	Recreation

OCONEE RIVER BASIN

		<u>CLASSIFICATION</u>
Middle Oconee River	Headwaters to Georgia Highway 82	Fishing
Middle Oconee River	Georgia Highway 82 to U.S. Hwy 78	Drinking Water
Middle Oconee River	U.S. Hwy 78 to confluence with North Oconee River	Fishing
North Oconee River	Headwaters to State Route 2434	Fishing
North Oconee River	State Route 2434 to Athens Water Intake.	Drinking Water
North Oconee River	Athens Water Intake to confluence with Middle Oconee River	Fishing
Oconee River	From confluence of North and Middle Oconee Rivers to Georgia Hwy 16	Fishing
Oconee River	Georgia Highway 16 to Sinclair Dam	Recreation
Oconee River	Sinclair Dam to Georgia Highway 22	Drinking Water
Oconee River	Georgia Highway 22 to Georgia Hwy 57	Fishing
Oconee River	Georgia Highway 57 to U.S. Hwy 80	Drinking Water
Oconee River	U.S. Hwy 80 to confluence with Ocmulgee River	Fishing



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OCONEE RIVER BASIN (con't)

Trail Creek

Headwaters in Athens to confluence
with N. Oconee River

CLASSIFICATION

Urban

UPPER OCMULGEE RIVER BASIN

South River

Headwaters to Georgia Highway 81

Urban

South River

Georgia Highway 81 to Georgia
Highway 36

Fishing

Yellow River

Headwaters to Georgia Highway 124

Fishing

Yellow River

Georgia Highway 124 to Porterdale
Water Intake

Drinking Water

Yellow River

Porterdale Water Intake to Georgia
Highway 36

Fishing

Alcovy River

Headwaters to Georgia Highway 138

Fishing

Alcovy River

Georgia Highway 138 to Covington
Water Intake

Drinking Water

Alcovy River

Covington Water Intake to Newton
Factory Road Bridge

Fishing

Jackson Lake

From South River at Georgia Hwy 36
From Yellow River at Georgia Hwy 36
From Alcovy River at Newton
Factory Road Bridge to Lloyd Shoals Dam

Recreation

Intrenchment Creek

Headwaters in Atlanta to confluence
with South River

Urban

Shoal Creek

Headwaters in Dekalb County to
confluence with South River

Urban

Conley Creek

Headwaters near Atlanta Army Depot
to confluence with South River

Urban

Doolittle Creek

Headwaters in Dekalb County to
confluence with South River

Urban

Snapfinger Creek

Headwaters in Dekalb County to
confluence with South River

Urban



Department of Natural Resources
ENVIRONMENTAL PROTECTION DIVISION

LOWER OCMULGEE RIVER BASIN

		<u>CLASSIFICATION</u>
Ocmulgee River	Lloyd Shoals Dam to Georgia Highway 18	Fishing
Ocmulgee River	Georgia Highway 18 to Macon Water Intake	Drinking Water
Ocmulgee River	Macon Water Intake to Georgia Highway 96	Industrial
Ocmulgee River	Georgia Highway 96 to confluence with Oconee River	Fishing
Towaliga River	Headwaters to Georgia Highway 36	Drinking Water
Towaliga River	Georgia Highway 36 to High Falls Dam	Recreation
Walnut Creek	Macon City Limits to confluence with Ocmulgee River	Urban
Cabin Creek	Headwaters in Griffin to Parham Road	Urban
Tobesofkee Creek	Lake Tobesofkee	Recreation
Tobesofkee Creek	Tobesofkee Dam to confluence with Ocmulgee River	Urban

ALTAMAHA RIVER BASIN

		<u>CLASSIFICATION</u>
Altamaha River	Confluence of Oconee and Ocmulgee Rivers to U.S. Hwy 301	Fishing
Altamaha River	U.S. Hwy 301 to Altamaha Sound	Fishing
	All littoral waters on the ocean side of St. Simons, Sea, and Sapelo Islands.	Recreation
Ochoopee River	Headwaters to confluence with Altamaha River	Fishing
Mackay River	Confluence with Altamaha River to St. Simons Sound	Fishing
Back River	Northern confluence with Mackay River to Southern confluence with Mackay River	Fishing
Frederica River	Northern confluence with Mackay River to Southern confluence with Mackay River	Fishing



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SATILLA RIVER BASIN

		<u>CLASSIFICATION</u>
Satilla River	Headwaters to Seaboard Coast Line Railroad	Fishing
Satilla River	Seaboard Coast Line Railroad to St. Andrews Sound	Fishing
Little Satilla River	Seaboard Coast Line Railroad to St. Andrews Sound	Fishing
East River	South End to West End	Navigation
Turtle and Brunswick Rivers	Headwaters to St. Simons Sound	Fishing
	All littoral waters on ocean side of Cumberland and Jekyll Islands	Recreation
Kettle Creek	Headwaters at Waycross to confluence with Satilla River	Urban
City Creek	Headwaters at Waycross to confluence with Satilla River	Urban
Twenty-Mile Creek	Georgia Highway 353 near Douglas to confluence with Seventeen-Mile Creek	Urban

ST. MARYS RIVER BASIN

		<u>CLASSIFICATION</u>
St. Marys River	Headwaters to Cumberland Sound	Fishing
North River	Headwaters to confluence with St. Marys River	Industrial
	All littoral waters on ocean side of Cumberland Island	Recreation

SUWANNEE RIVER BASIN

		<u>CLASSIFICATION</u>
Suwannee River	Headwaters to Georgia-Florida State line.	Fishing
Alapaha River	Headwaters to Georgia-Florida State line.	Fishing
Withlacoochee River (Withlacoochee Creek)	Headwaters to Georgia-Florida State line	Fishing



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OCHLOCKNEE RIVER BASIN

Ochlocknee River	Headwaters to Georgia-Florida State line
Aucilla River (including Aucilla Creek)	Headwaters to Georgia-Florida State line
Oquina Creek (and its tributaries)	Headwaters in Thomasville to confluence with Ochlocknee River
Parkers Mill Creek	Headwaters in Cairo to confluence with Tired Creek

CLASSIFICATION

Fishing

Fishing

Urban

Urban

FLINT RIVER BASIN

Flint River	Headwaters to Georgia Highway 54
Flint River	Georgia Highway 54 to S1061, Woolsey Road
Flint River	S1061, Woolsey Road, to Georgia Highway 16
Flint River	Georgia Highway 16 to Georgia Highway 27
Flint River	Georgia Highway 27 to Georgia Power Company Dam at Lake Worth, Albany
Flint River	Georgia Power Company Dam at Lake Worth, Albany to Bainbridge, U.S. Hwy 84 Bridge
Flint River	Bainbridge, U.S. Hwy 84 Bridge to Jim Woodruff Dam, Lake Seminole
Sullivan Creek	Headwaters in College Park to Confluence with Flint River
Mud Creek	Headwaters in Hapeville to confluence with Flint River

CLASSIFICATION

Industrial

Fishing

Drinking Water

Fishing

Recreation

Fishing

Recreation

Urban

Urban

CHATTAHOOCHEE RIVER BASIN

Chattahoochee River	Headwaters to Buford Dam
Chattahoochee River	Buford Dam to Atlanta (Peachtree Creek)

CLASSIFICATION

Recreation

Drinking Water
& Recreation



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Chattahoochee River	Atlanta (Peachtree Creek) to Cedar Creek	Fishing*
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*Condition: Specific Criteria apply at all times when the River flow measured at a point immediately upstream from Peachtree Creek equals or exceeds 750 cfs (Atlanta gage flow minus Atlanta water supply withdrawal) unless violations occur due to uncontrolled urban storm run off and/or combined sewer overflows.

Chattahoochee River	Cedar Creek to Franklin, Georgia (U.S. Hwy 27)	Fishing
Chattahoochee River	U.S. Hwy 27 Bridge at Franklin to West Point Dam	Recreation
Chattahoochee River	West Point Dam to West Point Mfg. Company Water Intake	Drinking Water
Chattahoochee River	West Point Mfg. Company Water Intake to Osanippa Creek	Fishing
Chattahoochee River	Osanippa Creek to Columbus, Georgia (14th Street Bridge)	Recreation Drinking Water
Chattahoochee River	Columbus, Georgia (14th Street Bridge) to Cowikee Creek	Fishing
Chattahoochee River	Cowikee Creek to Great Southern Division of Great Northern Paper Company	Recreation
Chattahoochee River	Great Southern Division of Great Northern Paper Company to Georgia Highway 91 (Neal's Landing)	Fishing
Chattahoochee River	Georgia Highway 91 (Neal's Landing) to Jim Woodruff Dam	Recreation
Flat Creek	Headwaters in Gainesville to Chattahoochee River	Urban
Sope Creek	Headwaters in Marietta to Chattahoochee River	Urban
Rottenwood Creek	Headwaters in Marietta to Chattahoochee River	Urban
Nickajack Creek	Headwaters in Marietta to Chattahoochee River	Urban
Peachtree Creek (and its tributaries)	Headwaters to Chattahoochee River	Urban



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Proctor Creek	Headwaters in Atlanta to Chattahoochee River	Urban
Sandy Creek	Headwaters in Atlanta to Chattahoochee River	Urban
Utoy Creek	Headwaters in East Point to Chattahoochee River	Urban
Olley Creek	Headwaters in Marietta to Sweetwater Creek	Urban

TALLAPOOSA RIVER BASIN

CLASSIFICATION

Tallapoosa River	Headwaters to Georgia Highway 100	Drinking Water
Tallapoosa River	Georgia Highway 100 to Georgia-Alabama State Line	Fishing
Little Tallapoosa River	Headwaters to SCS Dam No. 36 (Carrollton Raw Water Intake)	Drinking Water
Little Tallapoosa River	SCS Dam No. 36 (Carrollton Raw Water Intake) to Georgia-Alabama State Line.	Fishing

COOSA RIVER BASIN

CLASSIFICATION

Conasauga River	Georgia Highway 2 to Dalton Water Intake	Drinking Water
Conasauga River	Dalton Water Intake to confluence with Coosawattee River	Fishing
Ellijay River	Headwaters to Ellijay Water Intake	Drinking Water
Ellijay River	Ellijay Water Intake to confluence with Cartecay River	Fishing
Cartecay River	Headwaters to Ellijay Water Intake	Drinking Water
Cartecay River	Ellijay Water Intake to confluence with Ellijay River	Fishing
Coosawattee River	From confluence of Ellijay and Cartecay Rivers to confluence with Mountaintown Creek	Fishing
Coosawattee River	Confluence of Mountaintown Creek to Carters Dam	Recreation
Coosawattee River	Carters Dam to confluence with Conasauga River	Fishing



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Oostanaula River	Confluence of Conasauga and Coosawattee Rivers to Calhoun Water Intake	Drinking Water
Oostanaula River	Calhoun Water Intake to confluence with Armuchee Creek	Fishing
Oostanaula River	Confluence with Armuchee Creek to Rome Water Intake	Drinking Water
Oostanaula River	Rome Water Intake to confluence with Etowah River	Fishing
Etowah River	Headwaters to State Route 2551	Fishing
Etowah River	State Route 2551 to Canton Water Intake	Drinking Water
Etowah River	Canton Water Intake to Georgia Highway 20	Fishing
Etowah River	Georgia Highway 20 to Allatoona Dam	Recreation Drinking Water
Etowah River	Allatoona Dam to Cartersville Water Intake	Drinking Water
Etowah River	Cartersville Water Intake to confluence with Oostanaula River	Fishing
Coosa River	Rome - confluence of Oostanaula and Etowah Rivers to Georgia-Alabama State Line	Fishing
Coosa River	Alabama State Line	Recreation
Chattooga River	Headwaters to Georgia-Alabama State Line	Fishing
Mill Creek	Headwaters to Dalton Water Supply	Drinking Water
Mill Creek	Dalton Water Supply to confluence with Coahulla Creek	Urban
Drowning Bear Creek	From confluence with Tar Creek in Dalton to Conasauga River	Urban
Silver Creek	Headwaters to confluence with Etowah River near Rome	Urban
City Creek	Headwaters to confluence with Chattooga Creek at LaFayette	Urban



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TENNESSEE RIVER BASIN

CLASSIFICATION

Little Tennessee River	Headwaters to Georgia-North Carolina State Line	Fishing
Hiwassee River (including Lake Chatuge)	Headwaters to Georgia-North Carolina State Line	Recreation
Nottely River	Headwaters to Georgia-North Carolina State Line	Recreation
Toccoa River (including Lake Blue Ridge)	Headwaters to Georgia-Tennessee State Line	Recreation
South Chickamauga Creek	Headwaters to Georgia-Tennessee State Line	Fishing
West Chickamauga Creek	Headwaters to Georgia-Tennessee State Line	Fishing
Spring Creek	Headwaters to Georgia-Tennessee State Line	Fishing
Dry Creek	Headwaters to Georgia-Tennessee State Line	Fishing
Chattanooga Creek	Headwaters to Georgia-Tennessee State Line	Fishing
Lookout Creek	Headwaters to Georgia-Tennessee State Line	Fishing

APPENDIX H

CHATTAHOOCHEE RIVER COMPARATIVE MODEL

STUDY USING DOSAG II AND WQRRS

APPENDIX H
CHATTAHOOCHEE RIVER COMPARATIVE MODEL
STUDY USING DOSAG II AND WQRRS

by
Ken Iceman¹

I. INTRODUCTION

An integral part of the Chattahoochee River Study conducted by HEC for the Savannah District and WES was the comparison of the WQRRS water quality model (1) and the present version of DOSAG II (2). The DOSAG II model operates in a steady-state hydraulic mode with a temporal accounting of the BOD₅ and dissolved oxygen (DO) stream concentrations subject to their interdependencies, external loadings, and reaeration.

In an effort to operate the WQRRS model in the same hydraulic mode as DOSAG II, the program was executed for several days with constant tributary flows until a steady state condition was observed for the temperature, BOD₅, and DO. A simulation period of six to eight days was sufficient to attain this condition in all reaches. When these parameters remained constant for two or more days, the results were compared and plotted on figure H-1 along with the DOSAG II concentration profiles over the reach length.

Through this demonstration problem of the WQRRS water quality model, the ability to produce similar profiles to those of the DOSAG II model for BOD₅ and dissolved oxygen is shown. Where deviations do exist, an effort is made to point out some technical model differences which can explain these variances and should be judged accordingly.

It is suggested, by way of these comparisons, that the WQRRS water quality model has the ability to predict the BOD₅ and dissolved oxygen with similar results to DOSAG II, as well as having the flexibility of modeling additional water quality parameters. With time dependent flows,

¹Ken Iceman, Research Hydraulic Engineer, The Hydrologic Engineering Center.

a dynamic simulation state can be achieved with the WQRRS model for all constituents in addition to the steady-state method of operation, as noted previously.

II. IMPORTANT TECHNICAL MODEL DIFFERENCES

Geometry

The WQRRS computer model requires as input a distribution of the cross-section characteristics of each subreach along with the associated hydraulic radius, Mannings n factor and elevation. These data, in conjunction with a Muskingum routing procedure, are used in the determination of flow through the river system. Due to this method of computing flows and velocities from channel geometry and characteristics, the velocities are generally different than those computed from the empirical exponential relation used by DOSAG II.

These variances in velocity can significantly alter the reaeration contribution to the DO concentration through the dependence of the K_2 reaeration coefficient on velocity. This is elaborated upon later in the discussion about reaeration.

Heat Budget and Temperature

The WQRRS model uses a complete heat budget analysis incorporating such variables as weather conditions, short and long wave radiation, cloudiness, sun angle, latitude, longitude, and atmospheric turbidity. These parameters may be input as variable or constant throughout the simulation period, depending on desired accuracy and availability of adequate information. The DOSAG II model accounts for temperature variation through measured basin data during the study period. Tributary inputs and fluctuations over the day and month are incorporated in the data reduction methods used to obtain the stretch basin parameters. Once these temperatures and quality parameters are reduced for the DOSAG II model, they remain constant throughout each stretch, which may contain one or more tributary inputs.

An effort was made in preparing the input data to the WQRRS model to delineate each inflow temperature for every stream reach. This was accomplished either through communications with data collection agencies in Georgia or from the DOSAG II input descriptions sent to HEC by the EPD (Environmental Protection Division - Georgia, State Department of Natural Resources).

As a result of the discretization of load quality parameters and the incorporation of a complete heat budget, the temperatures computed in the study area take on different and slightly higher values than those indicated in the DOSAG II results. The slight variations in temperature seldom exceed two or three degrees centigrade and, therefore, may account for only minor changes in quality. Never the less, the contribution to the water quality through temperature changes as a function of time should be acknowledged, and will affect the exact comparability of model results.

Reaeration

The method of determining the reaeration coefficient K_2 in DOSAG II for this portion of the Chattahoochee River is through the expression:

$$K_2 = c \left(\frac{\Delta h}{t_f} \right)$$

where both c and Δh are input values by reach segments and are described as the constant of proportionality and change in water surface elevation respectively. The travel time, t_f , and reaeration coefficient, K_2 , within each reach segment are computed internally by DOSAG II.

In the WQRRS development, the method of calculating K_2 is left up to the individual user. Although a complete sensitivity analysis on the K_2 calculation was not performed, it was concluded by experimentation with the various methods on Reach 1 that the O'Conner and Dobbins expression for K_2 would result in DO concentration profiles most similar to the DOSAG II method. Exact values of K_2 were not used from DOSAG II since the computation of velocity was different between the two models.

The different methods used for the calculation of K_2 in DOSAG II and WQRRS models lead to some discrepancies in concentration profiles. If the values of velocities throughout the study area are investigated, it is seen that the concentration profiles of DO deviate in places where the velocities have the greatest difference. This is consistent with the alternative methods of computing K_2 in each model.

III. COMPARISON OF RESULTS

The concentration profiles of both dissolved oxygen and BOD_5 are seen in figure J-1 to compare very well in response to tributary loading conditions over the study area.

The greatest variance of dissolved oxygen occurs between river miles 375 and 344 where the velocities computed by WQRRS were generally 20 to 100 percent greater than those computed in DOSAG II. This velocity variation, along with the method of computing K_2 in the WQRRS model, would definitely imply higher values of DO.

A run of Reach 6 (river miles 366 to 340) was made using the exact values of K_2 , as computed through the DOSAG II equation $K_2 = c(\frac{\Delta h}{t})$. Although these values had to be interpolated at a few points because of our differing river mile delineations, the main concept of using the DOSAG II K_2 values was incorporated. More importantly, the direct dependence on velocity was eliminated. The results showed the DO concentrations in Reach 6 nearly 1.5 mg/l less than when K_2 was computed by the O'Conner and Dobbins methods. This demonstrated that the differing velocities between the two models was a significant contributor to the discrepancies noted in the DO profiles given by the WQRRS method of calculating K_2 .

The BOD concentration profiles show very similar responses throughout the study area. Where the R.M. Clayton sewage treatment plant discharges to the Chattahoochee, the BOD concentrations vary the most. This is due, in part, to the method of decay used in the WQRRS model where both

nitrogenous and carbonaceous BOD are decayed simultaneously and at the same rate when use is not being made of the nitrogen cycle portions of the WQRRS logic. In DOSAG II, the decay can be split between carbonaceous and nitrogenous BOD, as well as at different rates. Since only carbonaceous BOD is decayed in DOSAG II until downstream of R.M. Clayton, the DOSAG II model would be expected to experience a more amplified loading than the WQRRS model. Downstream of the R.M. Clayton plant where both nitrogenous and carbonaceous BOD₅ are decayed in DOSAG II, we see a much greater similarity of profiles. In upstream reaches the agreement is quite good, but there is very little BOD available.

It is from this figure, H-1, which shows a complete concentration profile comparison plot for both dissolved oxygen and BOD₅ (C + N), and the previously mentioned model differences, that the resulting conclusions have been derived.

IV. CONCLUSIONS

The results of the WQRRS model have been demonstrated to compare adequately with the DOSAG II program results. The additional capabilities of dynamic hydraulic computation and complete heat budget analysis give a greater degree of flexibility and completeness in water quality studies of rivers. Any discrepancies present in concentration profiles throughout the study area can be adequately explained by references to the technical model differences. It is with this knowledge and understanding, determined in the Chattahoochee River study, that HEC recommends the use of the WQRRS water quality model for future studies of river systems which require dynamic analysis.

References:

- 1) "Flow Routing and Water Quality Simulation for River-Reservoir Systems," Resource Management Associates, Lafayette, California, 1975.
- 2) "DOSAG II Computer Model," Georgia State Department of Natural Resources, Environmental Protection Division, Atlanta, Georgia.

Concentration Profiles on Chattahoochee River

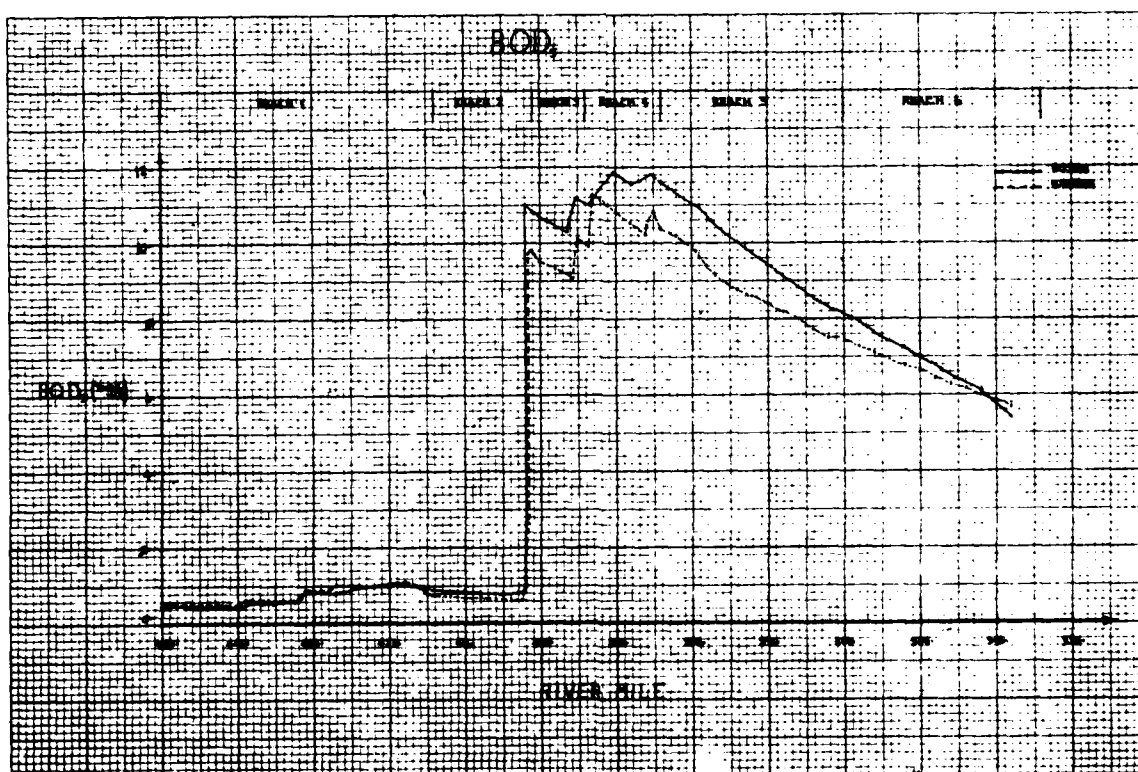
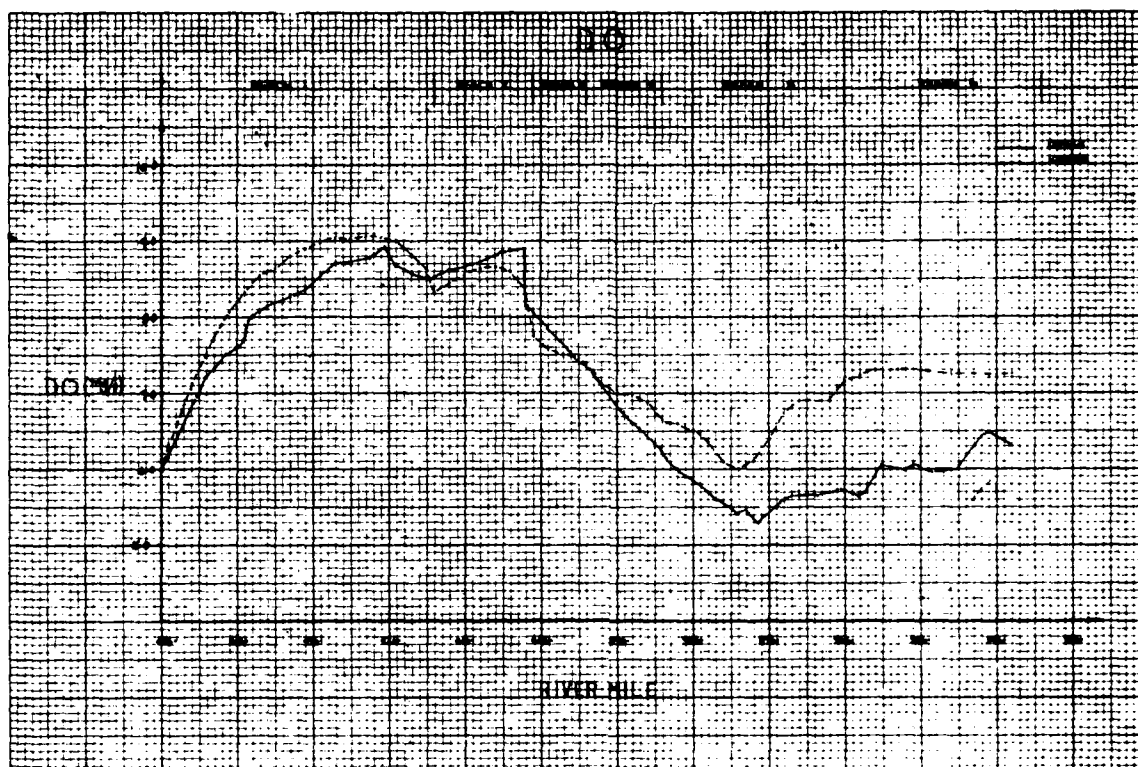


Figure H-1

H-6

APPENDIX I

METRIC-ENGLISH UNIT

CONVERSION TABLES

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<u>Item</u>	<u>Description</u>	<u>Page</u>
I.1	Temperature Conversion	I-1
I.2	Depth Conversion - Feet to Meters	I-2

TEMPERATURE CONVERSION										
Absolute Temperatures			Conversion Factors			Interpolation Figures				
$^{\circ}\text{Kelvin} = ^{\circ}\text{C} + 273$			$^{\circ}\text{F} - 32 = \frac{^{\circ}\text{C} \times 9}{5}$			$^{\circ}\text{F}$	$^{\circ}\text{C}$	$^{\circ}\text{F}$	$^{\circ}\text{C}$	
$^{\circ}\text{Rankine} = ^{\circ}\text{F} + 460$			$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32) \times 5}{9}$			1.8	1	0.6	10.8	6
						3.6	2	1.1	12.6	7
						5.4	3	1.7	14.4	8
						7.2	4	2.2	16.2	9
						9.0	5	2.8	18.0	10
										5.6
The bold figures are the temperature readings in $^{\circ}\text{C}$ or $^{\circ}\text{F}$, which can be converted to $^{\circ}\text{F}$ or $^{\circ}\text{C}$, respectively										
14 $^{\circ}\text{F}$	-10	-23.3 $^{\circ}\text{C}$	104 $^{\circ}\text{F}$	40	4.44 $^{\circ}\text{C}$	194 $^{\circ}\text{F}$	90	32.2 $^{\circ}\text{C}$	770 $^{\circ}\text{F}$	410
15.8	-9	-22.8	106	41	5.00	196	91	32.8	788	420
17.6	-8	-22.2	108	42	5.56	198	92	33.3	806	430
19.4	-7	-21.7	109	43	6.11	199	93	33.9	824	440
21.2	-6	-21.1	111	44	6.67	201	94	34.4	842	450
23.0	-5	-20.6	113	45	7.22	203	95	35.0	860	460
24.8	-4	-20	115	46	7.78	205	96	35.6	878	470
26.6	-3	-19.4	117	47	8.33	207	97	36.1	896	480
28.4	-2	-18.9	118	48	8.89	208	98	36.7	914	490
30.2	-1	-18.3	120	49	9.44	210	99	37.2	932	500
32.0	0	-17.8	122	50	10.0	212	100	37.8	950	510
33.8	1	-17.2	124	51	10.6	214	101	38.3	968	520
35.6	2	-16.7	126	52	11.1	216	102	38.9	986	530
37.4	3	-16.1	127	53	11.7	217	103	39.4	1004	540
39.2	4	-15.6	129	54	12.2	219	104	40.0	1022	550
41.0	5	-15.0	131	55	12.8	221	105	40.6	1040	560
42.8	6	-14.4	133	56	13.3	223	106	41.1	1058	570
44.6	7	-13.9	135	57	13.9	225	107	41.7	1076	580
46.4	8	-13.3	136	58	14.4	226	108	42.2	1094	590
48.2	9	-12.8	138	59	15.0	228	109	42.8	1112	600
50.0	10	-12.2	140	60	15.6	230	110	43.3	1130	610
51.8	11	-11.7	142	61	16.1	248	120	48.9	1148	620
53.6	12	-11.1	144	62	16.7	266	130	54.4	1166	630
55.4	13	-10.6	145	63	17.2	284	140	60.0	1184	640
57.2	14	-10.0	147	64	17.8	302	150	65.6	1202	650
59.0	15	-9.44	149	65	18.3	320	160	71.1	1220	660
60.8	16	-8.89	151	66	18.9	338	170	76.7	1238	670
62.6	17	-8.33	153	67	19.4	356	180	82.2	1256	680
64.4	18	-7.78	154	68	20.0	374	190	87.8	1274	690
66.2	19	-7.22	156	69	20.6	392	200	93.3	1292	700
68.0	20	-6.67	158	70	21.1	410	210	98.9	1310	710
69.8	21	-6.11	160	71	21.7	428	220	104	1328	720
71.6	22	-5.56	162	72	22.2	446	230	110	1346	730
73.4	23	-5.00	163	73	22.8	464	240	116	1364	740
75.2	24	-4.44	165	74	23.3	482	250	121	1382	750
77.0	25	-3.89	167	75	23.9	500	260	127	1400	760
78.8	26	-3.33	169	76	24.4	518	270	132	1418	770
80.6	27	-2.78	171	77	25.0	536	280	138	1436	780
82.4	28	-2.22	172	78	25.6	554	290	143	1454	790
84.2	29	-1.67	174	79	26.1	572	300	149	1472	800
86.0	30	-1.11	176	80	26.7	590	310	154	1490	810
87.8	31	-0.56	178	81	27.2	608	320	160	1508	820
89.6	32	0	180	82	27.8	626	330	166	1526	830
91.4	33	0.56	181	83	28.3	644	340	171	1544	840
93.2	34	1.11	183	84	28.9	662	350	177	1562	850
95.0	35	1.67	185	85	29.4	680	360	182	1580	860
96.8	36	2.22	187	86	30.0	698	370	188	1598	870
98.6	37	2.78	189	87	30.6	716	380	193	1616	880
100.4	38	3.33	190	88	31.1	734	390	199	1634	890
102.2	39	3.89	192	89	31.7	752	400	204	1652	900

DEPTH CONVERSION-FEET TO METERS

Feet	0	1	2	3	4	5	6	7	8	9
0	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7
10	3.0	3.4	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8
20	6.1	6.4	6.7	7.0	7.3	7.6	7.9	8.2	8.5	8.8
30	9.1	9.4	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9
40	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6	14.9
50	15.2	15.5	15.8	16.1	16.5	16.8	17.1	17.4	17.7	18.0
60	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0
70	21.3	21.6	21.9	22.3	22.6	22.9	23.2	23.5	23.8	24.1
80	24.4	24.7	25.0	25.3	25.6	25.9	26.2	26.5	26.8	27.1
90	27.4	27.7	28.0	28.3	28.7	29.0	29.3	29.6	29.9	30.2
100	30.5	30.8	31.1	31.4	31.7	32.0	32.3	32.6	32.9	33.2
110	33.5	33.8	34.1	34.4	34.7	35.1	35.4	35.7	36.0	36.3
120	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.0	39.3
130	39.6	39.9	40.2	40.5	40.8	41.1	41.5	41.8	42.1	42.4
140	42.7	43.0	43.3	43.6	43.9	44.2	44.5	44.8	45.1	45.4
150	45.7	46.0	46.3	46.6	46.9	47.2	47.5	47.9	48.2	48.5
160	48.8	49.1	49.4	49.7	50.0	50.3	50.6	50.9	51.2	51.5
170	51.8	52.1	52.4	52.7	53.0	53.3	53.6	53.9	54.3	54.6
180	54.9	55.2	55.5	55.8	56.1	56.4	56.7	57.0	57.3	57.6
190	57.9	58.2	58.5	58.8	59.1	59.4	59.7	60.0	60.4	60.7
200	61.0	61.3	61.6	61.9	62.2	62.5	62.8	63.1	63.4	63.7
210	64.0	64.3	64.6	64.9	65.2	65.5	65.8	66.1	66.4	66.8
220	67.1	67.4	67.7	68.0	68.3	68.6	68.9	69.2	69.5	69.8
230	70.1	70.4	70.7	71.0	71.3	71.6	71.9	72.2	72.5	72.8
240	73.2	73.5	73.8	74.1	74.4	74.7	75.0	75.3	75.6	75.9
250	76.2	76.5	76.8	77.1	77.4	77.7	78.0	78.3	78.6	78.9
260	79.2	79.6	79.9	80.2	80.5	80.8	81.1	81.4	81.7	82.0
270	82.3	82.6	82.9	83.2	83.5	83.8	84.1	84.4	84.7	85.0
280	85.3	85.6	86.0	86.3	86.6	86.9	87.2	87.5	87.8	88.1
290	88.4	88.7	89.0	89.3	89.6	89.9	90.2	90.5	90.8	91.1
Feet	00	10	20	30	40	50	60	70	80	90
300	91.4	94.5	97.5	100.6	103.6	106.7	109.7	112.8	115.8	118.9
400	121.9	125.0	128.0	131.1	134.1	137.2	140.2	143.3	146.3	149.4
500	152.4	155.4	158.5	161.5	164.6	167.6	170.7	173.7	176.8	179.8
600	182.9	185.9	189.0	192.0	195.1	198.1	201.2	204.2	207.3	210.3
700	213.4	216.4	219.5	222.5	225.6	228.6	231.6	234.7	237.7	240.8
800	243.8	246.9	249.9	253.0	256.0	259.1	262.1	265.2	268.2	271.3
900	274.3	277.4	280.4	283.5	286.5	289.6	292.6	295.7	298.7	301.8
Feet	000	100	200	300	400	500	600	700	800	900
1,000	305	335	366	396	427	457	488	518	549	579
2,000	610	640	671	701	732	762	792	823	853	884
3,000	914	945	975	1,006	1,036	1,067	1,097	1,128	1,158	1,189
4,000	1,219	1,250	1,280	1,311	1,341	1,372	1,402	1,433	1,463	1,494
5,000	1,524	1,554	1,585	1,615	1,646	1,676	1,707	1,737	1,768	1,798
6,000	1,829	1,859	1,890	1,920	1,951	1,981	2,012	2,042	2,073	2,103
7,000	2,134	2,164	2,195	2,225	2,256	2,286	2,316	2,347	2,377	2,408
8,000	2,438	2,469	2,499	2,530	2,560	2,591	2,621	2,652	2,682	2,713
9,000	2,743	2,774	2,804	2,835	2,865	2,896	2,926	2,957	2,987	3,018

APPENDIX J

JULIAN DATE CALENDAR

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J.1	Julian Date Calendar: Non-Leap Years	J-1
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JULIAN DATE CALENDAR

(PERPETUAL)

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

FOR LEAP YEAR USE REVERSE SIDE

JULIAN DATE CALENDAR

FOR LEAP YEARS ONLY

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	061	092	122	153	183	214	245	275	306	336	1
2	002	033	062	093	123	154	184	215	246	276	307	337	2
3	003	034	063	094	124	155	185	216	247	277	308	338	3
4	004	035	064	095	125	156	186	217	248	278	309	339	4
5	005	036	065	096	126	157	187	218	249	279	310	340	5
6	006	037	066	097	127	158	188	219	250	280	311	341	6
7	007	038	067	098	128	159	189	220	251	281	312	342	7
8	008	039	068	099	129	160	190	221	252	282	313	343	8
9	009	040	069	100	130	161	191	222	253	283	314	344	9
10	010	041	070	101	131	162	192	223	254	284	315	345	10
11	011	042	071	102	132	163	193	224	255	285	316	346	11
12	012	043	072	103	133	164	194	225	256	286	317	347	12
13	013	044	073	104	134	165	195	226	257	287	318	348	13
14	014	045	074	105	135	166	196	227	258	288	319	349	14
15	015	046	075	106	136	167	197	228	259	289	320	350	15
16	016	047	076	107	137	168	198	229	260	290	321	351	16
17	017	048	077	108	138	169	199	230	261	291	322	352	17
18	018	049	078	109	139	170	200	231	262	292	323	353	18
19	019	050	079	110	140	171	201	232	263	293	324	354	19
20	020	051	080	111	141	172	202	233	264	294	325	355	20
21	021	052	081	112	142	173	203	234	265	295	326	356	21
22	022	053	082	113	143	174	204	235	266	296	327	357	22
23	023	054	083	114	144	175	205	236	267	297	328	358	23
24	024	055	084	115	145	176	206	237	268	298	329	359	24
25	025	056	085	116	146	177	207	238	269	299	330	360	25
26	026	057	086	117	147	178	208	239	270	300	331	361	26
27	027	058	087	118	148	179	209	240	271	301	332	362	27
28	028	059	088	119	149	180	210	241	272	302	333	363	28
29	029	060	089	120	150	181	211	242	273	303	334	364	29
30	030		090	121	151	182	212	243	274	304	335	365	30
31	031		091		152		213	244		305		366	31

(USE IN 1964, 1968, 1972, etc.)

GPO. 1964 O-722-085