SOUTHEAST TEMPERATURE STUDY

Environmental Protection Agency
Southeast Water Laboratory
Technical Services Program
Athens, Georgia

July 1971

FOREWORD

The Southeast Temperature Study was initiated in September 1968 to provide additional information for the states to establish an approved water quality temperature standard. Response to the project was very enthusiastic. Contributions were made from state agencies, electrical power companies, industry and federal agencies. In an effort to consolidate the vast input into the project, relevant correspondence, all analytical analyses, and any pertinent general information were merged into this bound copy. The material was categorized by state -- Alabama, Florida, Georgia, Mississippi, and Tennessee -- preceded by a general section which leads into the nature and scope of the project. The general section also contains information that is applicable to all the states and/or any two.

The computer print-outs, one for each state, were the major emphasis of the project. Their objective was to fill in the "data gap" by providing a valid sample population of ambient river temperatures to establish a justifiable state temperature standard. A summary of maximum values observed has been included in each state section. The print-outs have been included intact in the appendix section.

Mr. John R. Thoman
Regional Director

August 29, 1968

Water Quality Standards Coordinator

Proposed Temperature Study

Reference has been made in Water Quality Standards approval letters to Mississippi and Alabama regarding a study to establish temperature criteria. The need for a study in Florida, Georgia, and Tennessee is also apparent. We are obviously stalemated until additional information is available on this subject.

The proposal I am suggesting should be discussed with state pollution administrators for some general agreement on the recommendations, and should also be cleared through the Interior Department Task Force Review Committee (that is to say Dr. J. I. Bregman) prior to initiation. This would clear other Regional Interior Department participation and give some status to acceptance by the Task Group when completed.

The study could be completed in approximately one year and would include collection of some field temperature and biological data. Elements of the study would be generally as follows:

1. Selection of an ad hoc committee in each state with representation from the State Water Pollution Control Agency, State Game and Fish Department, Bureau of Sport Fisheries and Wildlife, and State University or College representation, For coastal areas, Bureau of Commercial Fisheries should also be included. The FWPCA regional representative would chair the committee.

2. An analysis of existing temperature data be made by FWPCA (of which considerable is available) to determine the general range of maximum temperatures in each respective state. Field sampling stations could then be selected for specific areas below existing heated effluents to determine temperature increases, and duration of thermal effects.

3. Biological sampling should be included at certain selected stations to determine if there are significant changes in invertebrates and vegetation due to heat, and if so, some measure of the degree of change. Fish population sampling, both quantative and qualitative should be included by the state game and fish agencies.

4. A program as outlined under 1-3 above should be discussed with the ad hoc committee and additional supplements obtained if possible. Meetings for review of data and final reporting and recommendations would also be held.

I recognize that there is a potential problem in getting state agencies to go along with this proposal. There are also possible problems of manpower within our region, although these are not necessarily severe in the outline proposed.

The biggest problem would be, of course, what do we do about temperature in the interim period? Here I think we could tenatively accept NTAC recommendations to provide for control in the range of 5 degrees F rise, with provisions for treatment of heated effluents. The latter should be supported by a headquarters policy statement. Our greatest problem is Florida with regard to nuclear power plants, and the TVA proposal for Wheeler Reservoir in Alabama. Maybe we could rely, for the time being at least, on anti-degradation statements from these states until our study is complete.

I would appreciate the opportunity for further discussion on this subject.

Howard D. Zeller

cc: Mr. Traina

Temp study for Standards file

September 19, 1968

Mr. Howard D. Zeller
Water Quality Standards Coordinator
Atlanta, Georgia

Director, Technical Programs
Southeast Water Laboratory

Proposed Temperature Study
(Reference your August 29, 1968, memo to Mr. Thoman)

To supplement your remarks we would add the following. (Bear in mind that Technical Programs would provide the input designated for FWPCA).

First, the analysis of available temperature data is important and is a considerable undertaking. The burden for performing this task should be shared by the states. This would help to make the study a "cooperative" effort. To subdivide a data review, the states could analyze their own data while FWPCA checks data obtained by Federal agencies. The states also may wish to inquire of power interests if any further data is available, e.g. from Plant Hammond on the Coosa River. In the analysis, not only should we be seeking the general range of maximum values throughout the Region, but also any short-term (daily) variation extremes. The temperature data could be organized along basin, state, and geographical lines. A reporting form with headings similar to the following is suggested:

Location	Date(s)	Time	Temperature or Range	Remarks	Source of Info
		(if more than one measurement per day)	(^{o}F)	(e.g. Is measurement affected by nearby thermal influencing source).	

An inventory of existing thermal power plants is available to help guide the search for temperature data. Proposed plant sites should also be determined and background temperature data sought for these areas.

Before all past data are reviewed, no more than two or three thermal power plant sites should be selected for detailed study by FWPCA. The states, again, should be involved in this selection. A one-year program with approximately four one-week intensive studies at each plant site is suggested. During these intensives, emphasis would be on: (1) temperature extremes and variation-spatially, with time (daily, weekly, seasonal), and as a function of streamflow and cooling water characteristics; (2) the effect of temperature on oxygen saturation; and (3) the effect of temperature on the aquatic biota.

In this latter category, we would rely heavily on artificial substrate samplers for examination of thermal effects on invertebrates. A control station (or stations) would be established above the power plant. Sampling should be performed at the intake and outlet of power plants to determine if damage is occurring to aquatic life passing through the cooling system. Fish population studies, we agree, is the function of state game and fish agencies. Finally, plankton sampling should also be performed.

At this time, it does not seem feasible to utilize temperature recording instruments in the study. Servicing and selection of representative installation sites are critical problems. We would suggest a three-man team (engineer, biologist, and aide) to perform the field work.

Paul J. Traina

JALittle:rnb 9/19/68

JAL 9/19/68

Thermal Pollution File

Jan 1969

Thermal Pollution File

THERMAL DISCHARGES - SOUTHEAST REGION - POSSIBLE POLLUTIONAL PROBLEMS

1. Turkey Point - Dade County, Florida

Florida Power and Light Company is presently operating two fossil fuel generating units which require 1270 cfs of cooling water. When the nuclear units are in operation by 1972, 4250 cfs (2750 mgd) will be discharged to Biscayne Bay with a predicted maximum temperature increase of 13° F to 16° F over background. Daily cooling water requirements will represent about 3% of the total volume of water in South Biscayne Bay. All units will have a normal full load of 2,080,000 KW or 87% of capacity.

Studies conducted by FWPCA from April to August 1968 in Biscayne Bay to show the temperature effect of the fossil fuiled generators indicated temperature increases of 9° - 11° F over background temperatures in the Bay. The rate of temperature increase was as high as 4.5°F per hour at distances up to 850 yards offshore.

An application for a permit for a discharge canal for the cooling waters for the nuclear units is pending and is the subject of considerable controversy.

2. Browns Ferry - Limestone County, Alabama

Tennessee Valley Authority is constructing a nuclear power facility on Wheeler Lake of the Tennessee River. When completed in October 1972, the facility will have a maximum generator capacity of about 3,450,000 KW from three units. Cooling water requirements will be 4400 cfs (2840 mgd) with a predicted temperature increase across the condensers of 25° F.

Cooling water will be discharged through three diffuser pipes along the bottom of the channel which carries about 65% of the total flow through the reservoir. There will be a continual 10° F rise in temperature at the discharge point with a maximum across the section of 93° F. Minimum flow in the reservoir at all times must be 17,000 cfs and must be 21,000 cfs at temperatures above 85°F background.

Hydraulic and engineering studies have been conducted by TVA. There is a scarcity of biological data. However, there are data showing that entrained organisms are destroyed at a temperature exceeding 97°F. With a 25°F temperature increase, this level will be exceeded in the cooling water continuously from April to October each year.

3. Plant Hammond - Floyd County, Georgia

On February 3, 1967, the Georgia Power Company announced plans to expand the Plant Hammond facility on the Coosa River from 300,000 KW to 800,000 KW by 1970. Control of cooling water discharge will be attempted through a diffuser system. The problem of water quality in the river is compounded, however, by large organic waste discharges in the immediate vicinity and low river flows caused by regulation at the upstream Allatoona Reservoir. Additionally, the location of the cooling water and organic waste discharges at the headwaters of Weiss impoundment, a hydroelectric facility further reduces the assimilation capacity and retards the recovery of the river to suitable water quality levels. Thus, a combination of high water temperature, pollutional discharges, outfall locations and low river flows has a synergistic effect in inhibiting the desired use of this part of the Coosa River for a warm water sport fishery.

4. Crystal River - Citrus County, Florida

Two nuclear reactors are to be added to the existing plant by 1972, giving a rated capacity of 2,560,000 KW. Cooling water will be discharged to the Gulf of Mexico near shellfish harvesting areas. Specific data regarding the cooling system is not available. Additional data concerning the flow patterns and advective currents in the discharge area are also required.

5. Hatch Plant - Appling County, Georgia

A one unit nuclear reactor with a rated capacity of 2,436,000 KW will be constructed by Georgia Power on the Altamaha River near Baxley, Georgia to commence operation in 1972. Investigations are now under way by the company to select a technique for handling cooling water. Alternatives under consideration include: a closed recirculation system; a once through use which may raise the temperature of the receiving water by a maximum of 12^{o}F at low flows.

6. Sequoyah Plant - Hamilton County, Tennessee

A two unit nuclear reactor facility is to be constructed on the west shore of the Chickamauga impoundment of the Tennessee River, 12 miles north of Chattanooga. The rated capacity of the units is 3,423,000 KW each. No information has been received on the volume of cooling waters. Flows in Chickamauga Lake vary over a considerable range due to regulation and impoundments exhibit stratification under differential heating conditions. Density currents may travel great distances receiving only moderate mixing.

7. Puerto Rico

Much of the electricity for the south coast's industries and towns is generated at the South Coast Steam plant on the banks of Tallaboa Bay. Spent cooling water from this 253,000 KW plant is returned directly to the bay. The volume and temperature of the cooling water is not known. Neither is the effect on the receiving waters. High temperature wastes and cooling water from petrochemical refining plants are also discharged to this bay. Plans are being developed for the installation of desalinization facilities on a large scale throughout Puerto Rico. Most of the suitable sites have receiving waters composed of enclosed bays which have poor flushing and mixing characteristics.

8. Miscellaneous

Cooling water is discharged from Georgia Power Company installations above Atlanta on the Chattahoochee River. This is complicated by regulation above the generating facilities which reduce flow and the discharge of a major part of Atlanta's municipal waste effluent below. Further, there is active consideration being given to impounding the river below Atlanta for navigation and recreation uses.

The Gannon plant of the Tampa Electric Company located on Hillsborough Bay, Florida will expand to a capacity of 1,256,000 KW. This plant currently uses 900 mgd of cooling water. Although thermal effects on the bay may be occurring, it is so highly polluted anyway from other sources that, at this stage, it is probably a minor contribution to the overall water quality degradation.

The Marlee Branch plant of the Georgia Power Company will expand to 1,059,000 KW and discharges cooling water to Lake Sinclair ~~in Cobb County,~~ Georgia. No objection by the Government has been made to the intake and outfall facilities.

9. Technical Needs

It is apparent from a consideration of the above that very little regulatory attention has been given to the problem of thermal dishcarges. This accounts for the relative lack of information presented and, consequently, the absence of reasonable analysis and evaluation of effects. Instead, we have been treated to glittering generalities of utter vacuity by the ecologists and pompous economic justifications by the engineers for the power companies such that conclusions have been reached in a hysterical atmosphere of confrontation.

What is required is that each of these waterways must be recognized as a system which supports multiple uses. Pertinent data gathered in the planning phases of these projects by objective people would permit the evolution of a rational water quality management plan which could make the optimum utilization (or most effective disposal) of waste heat without unduly constraining other desirable uses.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Director, Technical Programs

DATE: February 18, 1969

FROM : Chief, Impoundment Studies

SUBJECT: Field Studies for Temperature Standards

You have seen a first draft of the attached thermal study proposal before. This is the final version.

Our intent in this field study is to document within our Region some of the effects of thermal discharges on aquatic biota and/or on certain water quality parameters, e.g. temperature and D.O. The biological groups listed were chosen because they are of great importance as food producers and primary consumers in the complex food chain of the aquatic environment. If a heated discharge is detrimental to the in situ biotic community, this would be reflected in an alteration of some or all of these groups. We will compare natural seasonal succession with changes caused by thermal "pollrichment."

As you can see, the outline suggests a rather ambitious program for any one study site. It describes an optimal study. Because of staff and scheduling limitations, we know that a 145 day study effort is impractical. Consequently, we will make a determination on eliminating selected aspects of the study during reconnaissance. At present, it appears that the estuary site will be dropped, and we will work only on a stream (probably Suwannee at Ellaville, Florida).

Messrs. Schneider, Weldon, and Cafaro will be the principal participants in the study. We will probably need to extend the work a little into CY 70. Results of this work should, for the first time in this Region, give us an example of the presence or absence of damage from cooling water discharges.

John A. Little

Attachment

cc: Howard Zeller
Robert Schneider
Dennis Cafaro

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5010-108

THERMAL STUDY PROPOSAL

TITLE: A seasonal study of some effects of thermal discharges on the aquatic environment.

OBJECTIVES: To compare, seasonally, the effects of a heated discharge on: (1) certain water quality parameters, (2) periphyton, (3) benthos, (4) plankton, and (5) higher plants.

SCOPE: Four 10-day surveys at each of two sites to be conducted seasonally and completed in one calender year. (Study sites will be limited to one stream and one estuary situation, preferably in areas unaffected by waste discharges).

PRELIMINARY DATA REQUIRED: Water temperature, dissolved oxygen, and biological data from state or Federal agencies for each site to be studied.

RECONNAISSANCE NEEDED: A 3-day monitoring survey of each area to determine the number and location of field sampling stations. Also a 2-day biological survey to determine, in general, the standing crop for benthos, phytoplankton and other biota at selected locations.

PROCEDURE: Each field station will consist of a transect of the receiving water with a sampling area near each bank and one in mid-stream.

A. Water Quality - Thermistors will be used for daily temperature transects. In addition different maximum-minimum thermometers will be suspended from buoys at different depth intervals for temperature monitorin at each field station. Readings will be made at various plant loadings.

Dissolved oxygen, heavy metals, fungicides, pH, and slainity values (where needed) will be monitored daily during peak and minimum loads at the power plants. Water samples for these analyses will be collected from the same sites being monitored for temperature. The affect of thermal discharges on oxygen saturation values will be a point of emphasis.

B. Periphyton - Artificial substrate samplers similar to those described by Hester-Dendy (1961, Auburn Univ., Ag. Exp. Sta., pp 1-14) will be used for periphyton. Plexiglass plates will be substituted for the masonite plates suggested by Hester and Dendy. Additionally, nylon cord will hold the plates together, eliminating corrosion problems in the estuary study. Emplacement of the substrates will be completed at each station, one month prior to the survey period. The samplers will be buoyed and suspended approximately 10 inches below the water surface. During the survey (after 30 days exposure) the plates will be removed and handled in the following manner. Two plates will be placed separately in two pint-sized plastic refrigerator boxes containing 4 percent formalin (or a 4 percent seawater-formalin mixture as needed). The remaining plates will be placed separately in similar pint-sized plastic boxes containing 95 percent ethanol. These boxes will have been previously painted black on their outside (similar to primary productivity dark bottles).

Later in the laboratory, periphyton accumulation will be scraped from the formalin preserved plates for qualitative analysis. Periphyton accumulation on alcohol preserved plates will be scraped similarly after plates have remained in the alcohol a minimum of 24 hours. This material will be dried and weighed to estimate the relative abundance of biomass. The alcohol will be analyzed to determine the amount of chlorophyll extracted from certain organisms. The dried material from each plate will be ashed and from these data a ratio between the total chlorophyll and the total organic matter (ash-free dry weight) can be developed. These data give a measure of heterotrophic versus autotrophic organism development. Grzenda and Ball (1968, Quarterly Bulletin, Mich. Ag. Exp. Sta., Vol. 50, No. 3, pp. 296-303) found that the functional composition of periphyton which colonize on plexiglass plates was a possible index of pollution. The value of such an index in heated water is unknown but certainly worthwhile investigating.

C. Benthos - Atrificial substrate samplers will be used to determine the relative abundance of macroinvertebrates during each season. These samplers will be similar in design to the rock-type sampler described by Mason et. al. (1957, Progressive Fish-Culturist, Vol. 29, No. 2, p. 74.). Modifications will include the replacement of the metal basket with a nylon net bag to eliminate corrosion problems in the estuary. Substrate samplers will be exposed at each station (10 inch depth) for the same period as the plexiglass plates, i.e. one month. After this exposure in the aquatic habitat, the community of macroinvertebrates established among the limestone rocks will be assumed to have attained an ecological equalibrium. The substrates will be lifted, macroinvertebrat removed, sorted and recorded by number and weight for each taxonomic group.

Additionally, two Petersen and/or Ekman dredge hauls will be taken from each station. These data will serve to supplement information concerning the benthic invertebrate distribution and abundance.

D. Plankton - Surface water samples (3 foot depth) for phytoplankton analysis will be collected with a 2-liter Kemmerer sampler at each station. The samples will be preserved in polyethylene wide-mouth jars (2 liter-size) with 4 percent formalin.

In the laboratory, total plankton counts will be determined and organisms will be categorized according to the following algal groups: (1) blue-green, (2) green, (3) red, (4) brown, (5) flagellates, and (6) diatoms.

E. Higher plants - Samples of floating, submerged and emergent vegetation will be collected from selected stations. These plants will be identified to genera and, if flowering parts are present, some will be specifically identified.

MATERIALS:

Item	Amount
Boat	1
Motor	1
Kemmerer (2 liter size)	
Ekman Dredge	
Petersen Dredge	
Plastic Refrigerator boxes	
Plexiglass Plates (assembled)	
Max-min thermometers (8)	
Nylon net bags	
Limestone (size 1" to 3")	
Formaldehyde	
Ethanol (95%)	
Black Paint	
Buoys	
Nylon rope	
Reagents for DO determination (or probe)	
Whirl-paks (for vegetation samples)	
pH meter	
Salinometer	
Salinity titration apparatus	

Wide-mouth jars (plankton)
Recording fathometer
Submarine Photometer
Flow meter
Secchi disc
Recording thermometer (for profiles)

PERSONNEL:
One biologist, in charge
One engineer
One technician

TIME: (per survey site)

Reconnaissance	- 5 days
Field Study	-10 days (winter)
	10 days (spring)
	10 days (summer)
	10 days (fall)
Laboratory and report	-100 days
TOTAL	145 days

Robert F. Schneider

Robert F. Schneider

1/27/70
Draft

STUDY METHODS

In order to determine steam power plant locations suitable for studies of thermal discharge effects, a list of the larger (in terms of megawatt-electric capacity) plants in the Southeast was reviewed. Basic criteria for study site selection included:

(a) location on a stream rather than impoundment or estuary,

(b) absence of municipal and/or industrial waste effects,

(c) small stream size in relation to plant size, and

(d) no similar past, present, or future studies planned for the site by other groups.

The initial review narrowed the field of possible study sites down to fifteen. Each of these are listed below by state. Although reconnaissance was made at some sites, none were selected for intensive study for various reasons. Under the column entitled Comment, the reason for elimination is stated briefly.

ALABAMA:

Steam Plant Name	Location	Comment
Gorgas, Alabama Power Company	Black Warrior River near Gorgas	Site eliminated because Bankhead Reservoir alters river flow (downstream)
Barry, Alabama Power Company	Mobile River near Bucks	Industrial and municipal pollution exist in the proximity of the plant.
Ernest C. Gaston, Alabama, Power Co.	Coosa River near Wilsonville	Stream impounded and pollution from a nearby papermill.

FLORIDA:

Steam Plant Name	Location	Comment
Suwannee, Florida Power Corp.	Suwannee River near Ellaville	FWPCA conducted a reconnaissance study in February, 1969. No significant temperature change was observed in the river due to the plant discharge.
Crystal River, Florida Power Corp.	Crystal River near the city of Crystal River	The Florida State Board of Conservation is conducting a thermal research project at this site. Did not want to duplicate the work.
Port Everglades, Florida Power & Light Co.	Atlantic Ocean near Port Everglades	FWPCA has studied a similar site at Turkey Point in lower Biscayne Bay. The complexities of ocean discharges are beyond the scope of the short-term studies proposed here by the SEWL.
F. J. Gannon, Florida Power & Light Co.	Tampa Bay near Tampa	Industrial and municipal pollution exist in the proximity of the plant.

GEORGIA:

McDonough, Georgia Power Co.	Chattahoochee River near Smyrna	Industrial and municipal waste from Atlanta area affects this site.
Arkwright, Georgia Power Co.	Ocmulgee River near Macon	Industrial and municipal waste affect the aquatic environment.
Mitchell, Georgia Power Co.	Flint River near Albany	Same as above
Yates, Georgia Power Co.	Chattahoochee River near Whitesburg	Affected by waste discharges from Atlanta area.
Harlee Branch, Georgia Power Co.	Lake Sinclair near Milledge-ville	Impoundment, largest plant in State.

MISSISSIPPI:

Steam Plant Name	Location	Comment
Jack Watson, Mississippi Power Co.	Biloxi River estuary near Gulfport	Johns Hopkins University is conducting a thermal study at this site for Edison Electric Institute.

TENNESSEE:

Steam Plant Name	Location	Comment
John Sevier, TVA	Holston River, near Rogersville	The site is the headwaters of an impoundment and upstream pollution alters the biotic community.

VIRGINIA:

Steam Plant Name	Location	Comment
Clinch River, Appalachian Power Co.	Clinch River near Carbo	FWPCA conducted a reconnaissance study in September 1969. A fly-ash spill (1967) has changed the benthic environment significantly by "blanketing" portions of the stream bottom with fine sediment.

Director, Technical Programs | February 18, 1969

Chief, Impoundment Studies

Field Studies for Temperature Standards

You have seen a first draft of the attached thermal study proposal before. This is the final version.

Our intent in this field study is to document within our Region some of the effects of thermal discharges on aquatic biota and/or on certain water quality parameters, e.g. temperature and D.O. The biological groups listed were chosen because they are of great importance as food producers and primary consumers in the complex food chain of the aquatic environment. If a heated discharge is detrimental to the *in situ* biotic community, this would be reflected in an alteration of some or all of these groups. We will compare natural seasonal succession with changes caused by thermal "pollrich-ment."

As you can see, the outline suggests a rather ambitious program for any one study site. It describes an *optimal* study. Because of staff and scheduling limitations, we know that a 14.5 day study effort is impractical. Consequently, we will make a determination on eliminating selected aspects of the study during reconnaissance. At present, it appears that the estuary site will be dropped, and we will work only on a stream (probably Suwannee at Ellaville, Florida).

Messrs. Schneider, Weldon, and Cafaro will be the principal participants in the study. We will probably need to extend the work a little into CY 70. Results of this work should, for the first time in this Region, give us an example of the presence or absence of damage from cooling water discharges.

John A. Little

Attachment

cc: Howard Zeller
Robert Schneider
Dennis Cafaro

JALittle:rnb 2/18/69

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Files

DATE: February 26, 1969

FROM : R. F. Schneider and M. R. Weldon

SUBJECT: Trip Report to Suwannee River, Florida

In an effort to select a site for a thermal study Mr. Weldon and I visited the Florida Power Corporation's Suwannee River Plant. The power plant is located near Ellaville, Florida approximately 3/4 mile downstream from the junction of the Suwannee and Withlacoochee Rivers. On February 23, 1969 we made a reconnaissance trip by boat from the junction of the two rivers to Anderson Springs, approximately 3 miles downstream. Surficial water temperatures were measured and recorded. Additionally, Taylor maximum-minimum thermometers were submerged (6 inch depths) in selected locations for 24-hour monitoring of the temperature.

The U.S.G.S. has a gauge station located at the junction of the two rivers and another gauge "pole" placed in the river approximately 30 feet downstream from the power plant effluent or discharge ditch. Readings from these locations were taken and recorded as follows:

Date	Location	Gauge Reading
2/23/69	River junction	4.26 feet
2/23/69	Plant discharge	5.20 feet
2/24/69	River junction	4.34 feet
2/24/69	Plant discharge	5.60 feet

On February 24, 1969 D.O. and temperature measurements were made and river profiles were constructed. These data are shown on the attached diagrammatic map of the area (see last page).

On February 25, we talked with Mr. E. M. Haywood, plant superintendent and his assistant, Mr. J. G. Porter. We informed them that the Southeast Water Laboratory was attempting to select a site in our area to study certain effects of a heated discharge upon physical, chemical and biological characteristics in a stream. These gentlemen were very cooperative and we toured the entire plant and grounds. They informed us that the plant was built in 1952. Presently, it has 3 units operating on natural gas and oil. The plant capacity is 155,000 KW. During our reconnaissance monitoring, all 3 units were on line therefore a maximum water discharge of 120,000 gpm was being released. The units vary in size and discharge as follows (1) one unit 30,000 gpm, (2) two units 60,000 gpm, (3) all three units 120,000 gpm. The maximum rise in water temperature through the plant is 10°F. (This is in agreement with our findings). Mr. Haywood quickly scanned the river temperatures for 1968

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5010-108

and told us that maximum temperatures upstream from the plant reached 79°F in June, July and August. This period coincided with record low river flows for the Suwannee River.

Mr. Haywood and Mr. Porter asked if we were aware of all the possible pollution sources that might affect our study plan. They mentioned an upstream papermill on the Withlacoochee River, the phosphate mining upstream on the Suwannee River and a poultry waste discharge (Goldkist Poultry Corp.) 1½ miles downstream from their power plant. We have records for all but the later.

The data recorded herein tend to eliminate this site as a thermal study area in the Southeastern Region.

Robert F. Schneider

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Director, Technical Programs **DATE:** October 10, 1969

FROM : Assistant Chief, Impoundment Studies

SUBJECT: Field Studies for Temperature Standards

On September 29, 1969, M. R. Weldon and R. F. Schneider traveled to western Virginia. The purpose of the trip was to make a reconnaissance of a potential "thermal pollution" site. Specifically, the site being considered was the Clinch River at River Mile 267-268 near Carbo, Virginia. This stretch of the river receives the effluent from the Appalachian Power Company. The steam generation plant is one of the largest fossil fuel electric facilities in the state of Virginia (700 magawatt output). Reconnaissance included updating the physical plant layout, observing physical and biological river conditions and recording longitudinal temperature profiles in this portion of the Clinch River. The series of photographs and tabulated data attached to this report show some of these features. In brief, the section of the Clinch River from River Mile 267 to 267.8 is in poor condition. Fine sediment blankets most of the bottom in this area. The source of this sediment was probably the 1967 "fly ash" spill. Details of that spill are recorded in reports by FWPCA (June 1967) and TVA (July 1967). Sediment affects the river in two obvious ways: (1.) it reduces the habitat for bottom-dwelling organisms to a single type; (2.) it is partially in suspension, increasing turbidity in this river stretch.

5010-108

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An earth-filled dam has been constructed by the steam plant at River Mile 267.9. Fifty yards upstream from the dam, in the pool area, is the steam plant intake structure (Figure 1). The plant produces 700,000 KW, ranking it as the sixth largest generating facility in the region. Five cooling towers are used to reduce thermal enrichment in the Clinch River. Effluents from these towers enter the river at four locations (Figure 2). Temperatures recorded at each discharge point showed a range from 16 to 24°C. Temperatures in the Clinch River, upstream from the steam plant, were 16°C. Taylor maximum/minimum thermometers were left in the river, 175 yards downstream from the plant for a 24-hour period. Water temperatures ranged from 15.0 to 18.3°C at this site (mile 267.4).

Based on the data presented herewith, it is recommended that no further consideration be given to this site for thermal study.

Robert F. Schneider

cc: John Little
Howard Zeller
Dennis Cafaro
Ronald Weldon

THERMAL STUDY DATA

DATE: September 29 - October 2, 1969

STUDY LOCATION:

STREAM: Clinch River

COUNTY: Russell STATE: Virginia BASIN: Tennessee River

NEAREST CITY or TOWN: Carbo (Va.)

FLOW RECORD: (USGS)

Clinch River at Cleveland, Virginia

DATE: October 1, 1969 TIME: 10:30 a.m.

GAGE HEIGHT: 1.3 feet

DISCHARGE: 48 cfs AVERAGE DISCHARGE: 698 cfs (48 years)

PHYSICAL DATA FROM CLINCH RIVER

River Mile	Turbidity J.C.U.	Surface Water Temperature °C Right*	Left
268.3	---	16	16
267.9	8	16	16 (effluent "A")
267.85**	8	15	15
267.8	---	15	18 (effluent "B")
267.7	---	16	16
267.6	---	16	19 (effluent "C")
267.5	---	16	24 (effluent "D")
267.4	43	16	18
267.3	---	16	17
267.2	---	16	16
267.1	---	16	16
267.0	---	16	16
254.9	10	---	---

*Right and left side of the river channel were determined while facing downstream

**Mouth of Dumps Creek

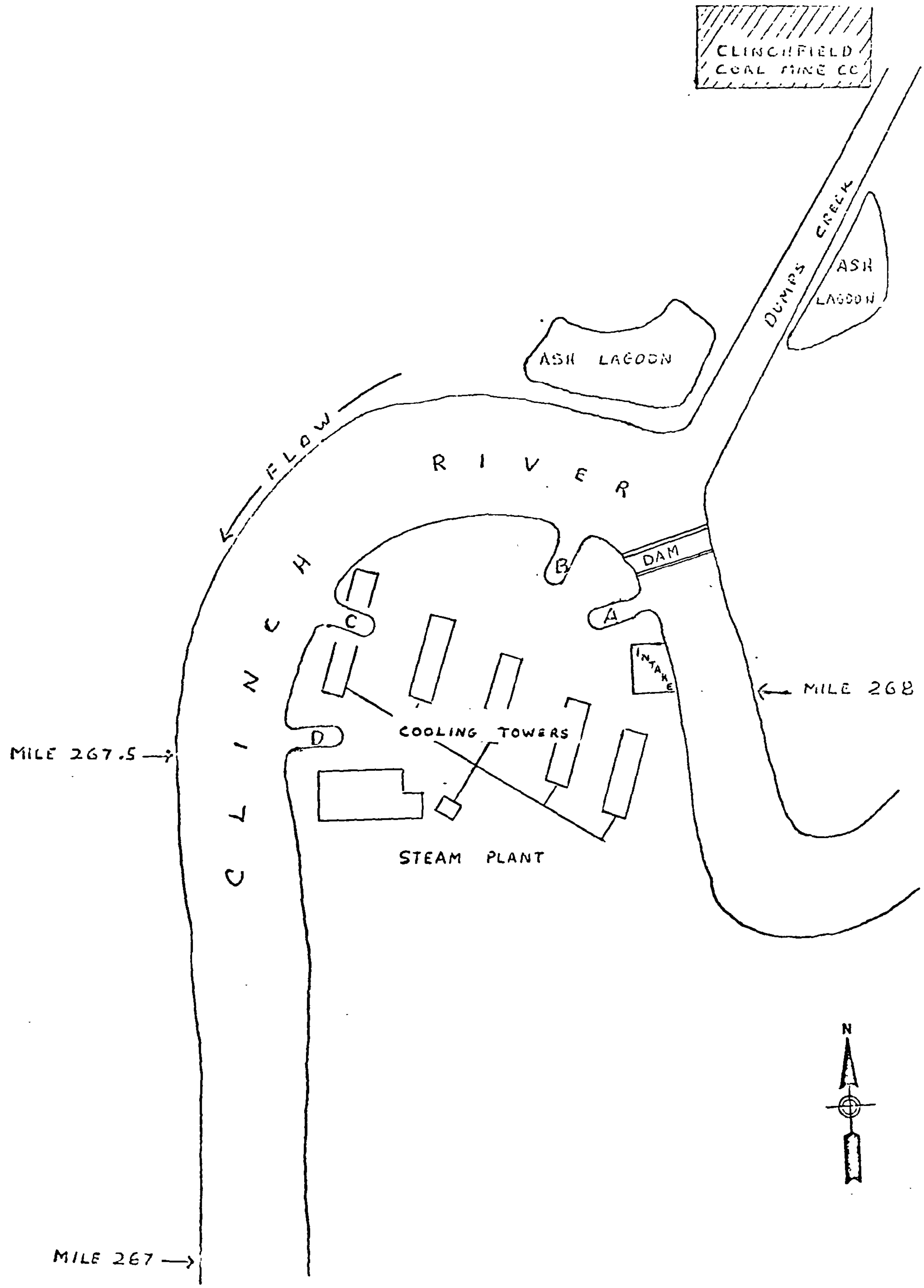


FIGURE 1. DIAGRAMMATIC MAP OF THE APPALACHIAN POWER COMPANY STEAM PLANT AND A PORTION OF THE CLINCH RIVER, VIRGINIA (Symbols A,B, C, and D indicate steam plant effluents)

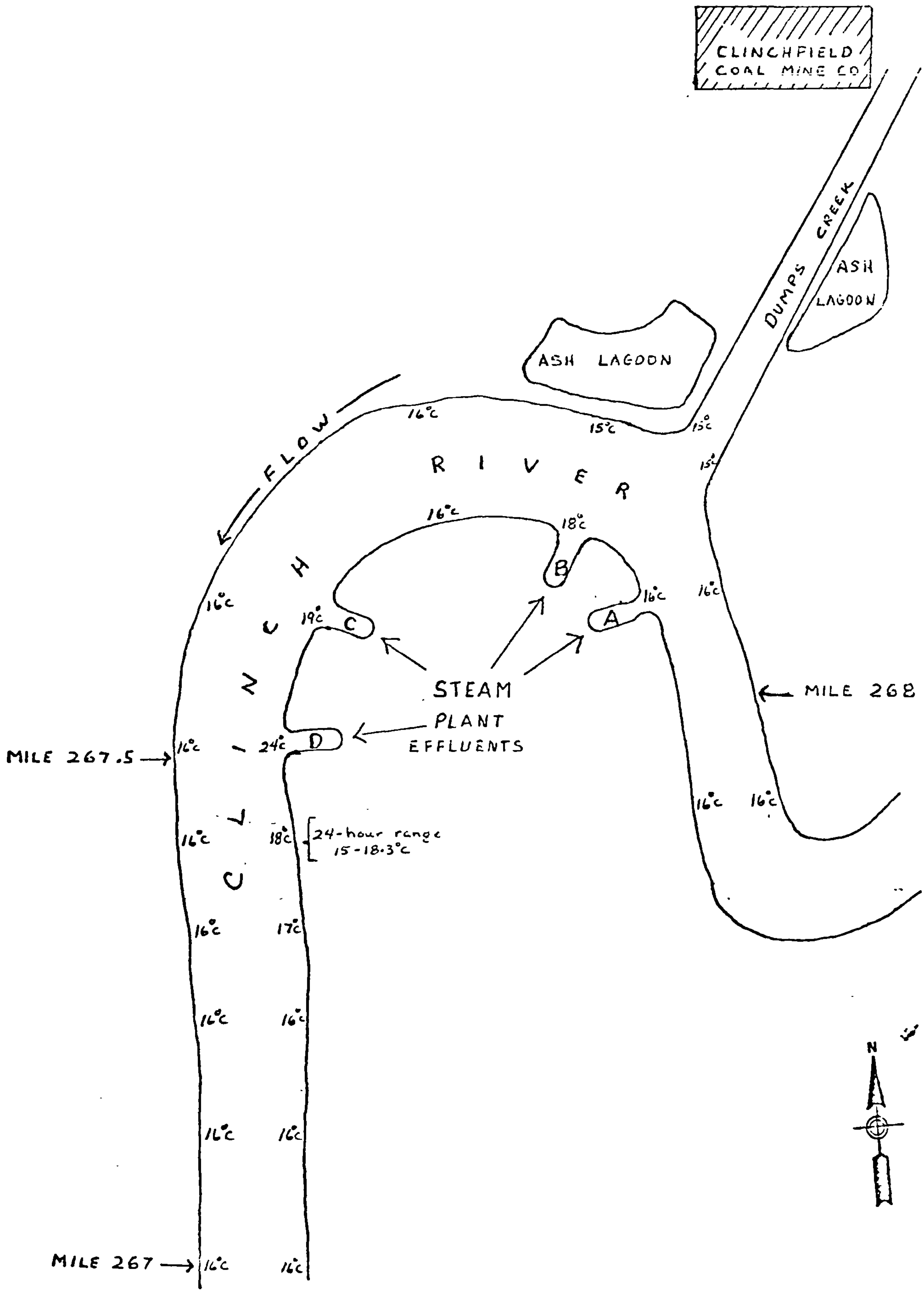
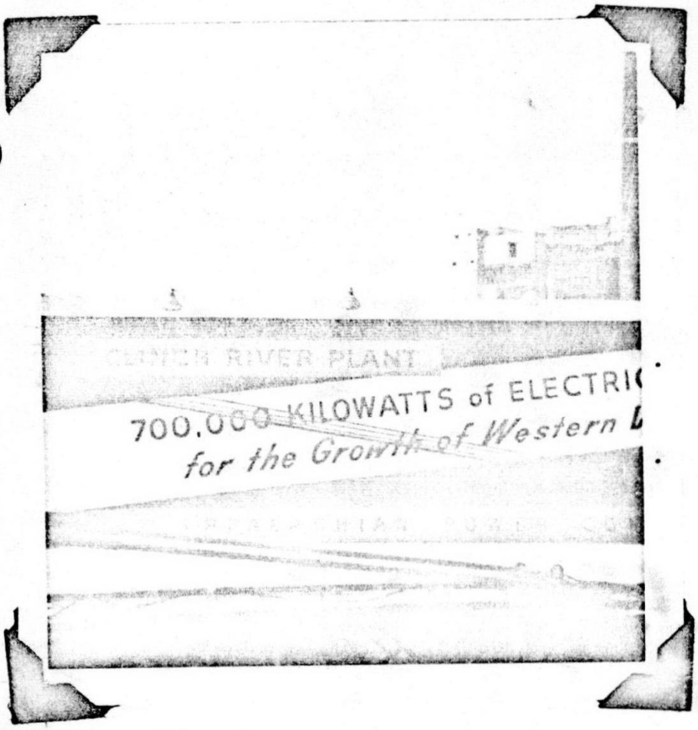
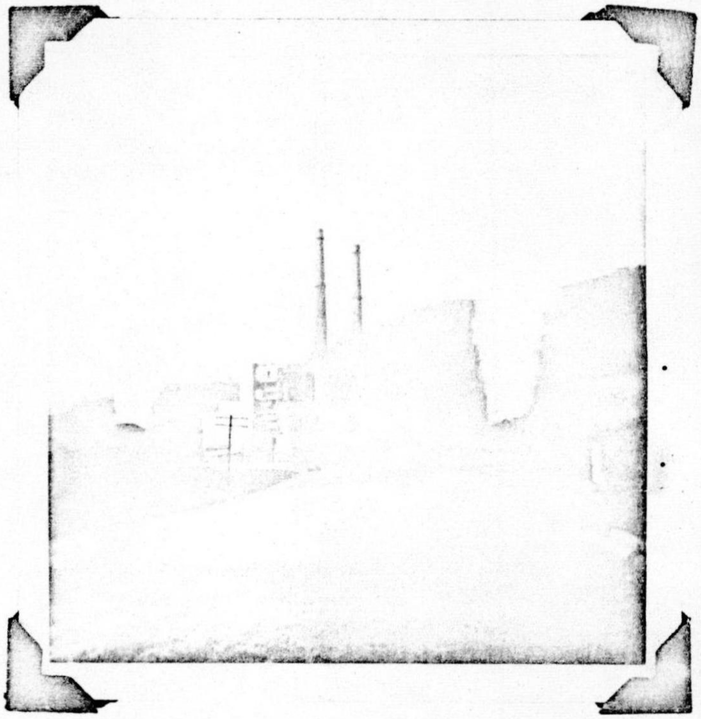


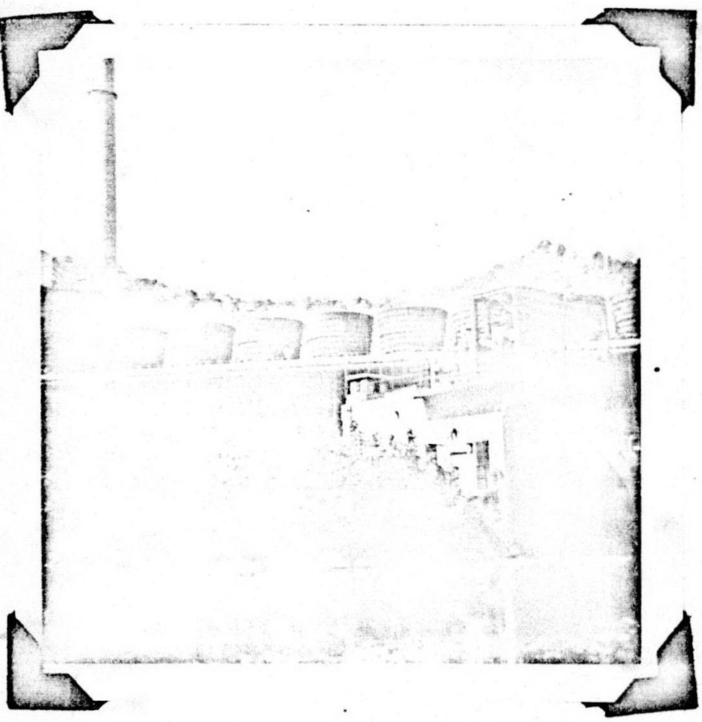
FIGURE 2. MAP SHOWING SURFACE WATER TEMPERATURES IN THE CLINCH RIVER NEAR CARBO, VIRGINIA (September 30, 1969).



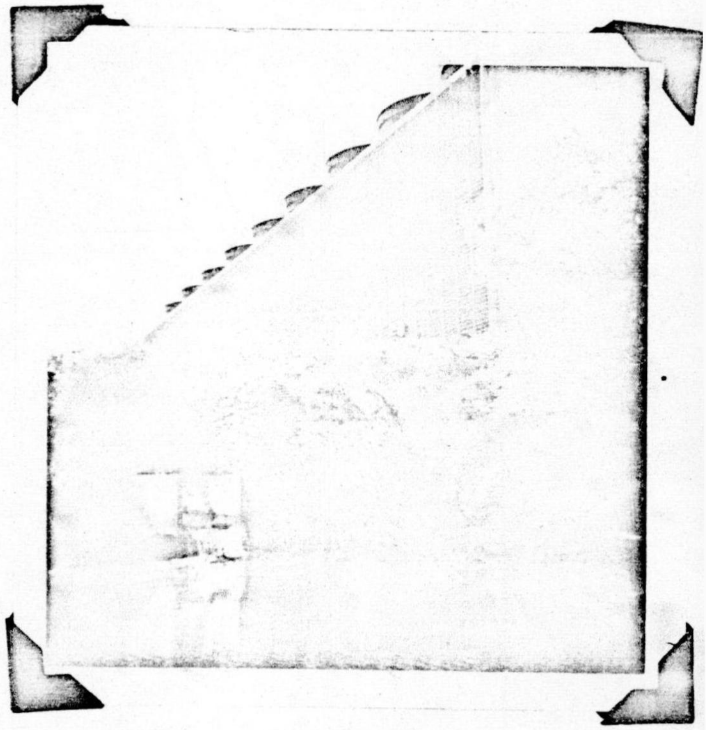
Appalachian Power Co. stream plant near Carbo, Virginia.



Steam plant and two of the five forced-air cooling towers.

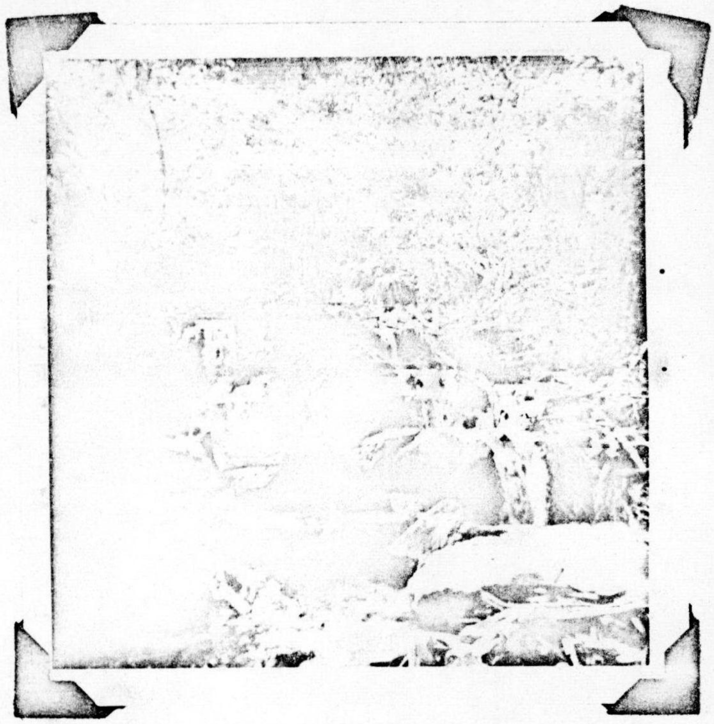


Steam plant water intake structure on the Clinch River, Virginia (mile 268)



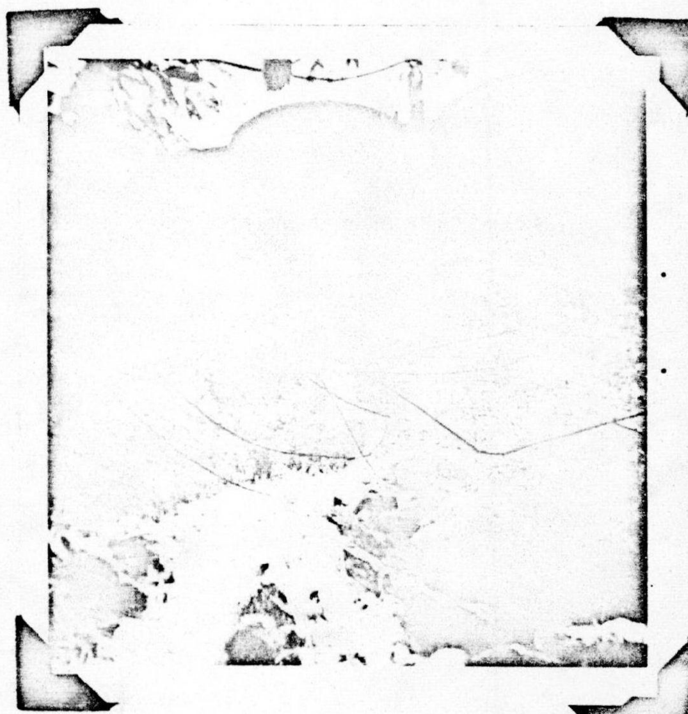
Steam plant effluent "A" emptying into the Clinch River, Virginia (mile 267.9)

An upstream view of the earth-filled dam in the Clinch River, Virginia (mile 267.87) (note water intake pool formed behind the dam).



Steam plant effluent "B" (mile 267.8)

Effluent "B" emptying into the Clinch River, Virginia (mile 267.8)



Steam plant effluent "C". In the background is a portion of a cooling tower structure (mile 267.6)

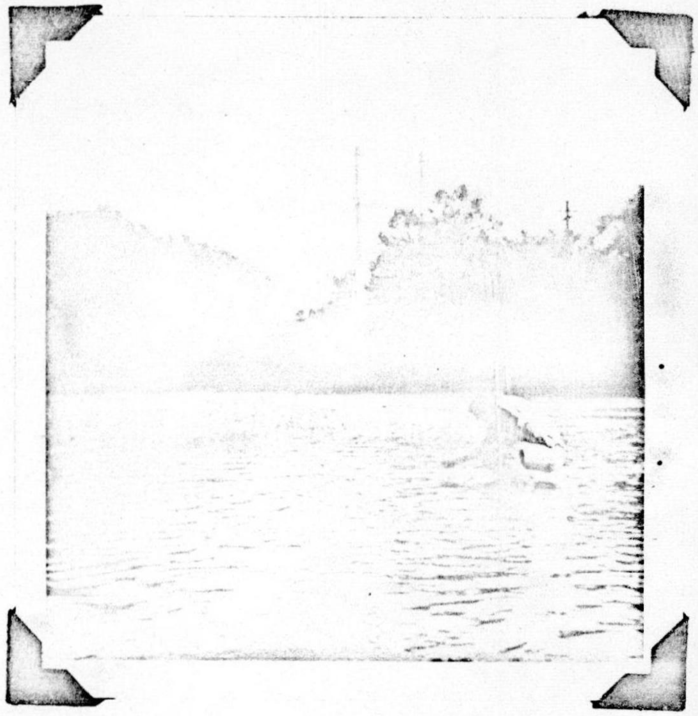
Effluent "D" emptying into the Clinch River, Virginia (mile 267.5)

View of effluent "D" as it enters the Clinch River (mile 267.5)

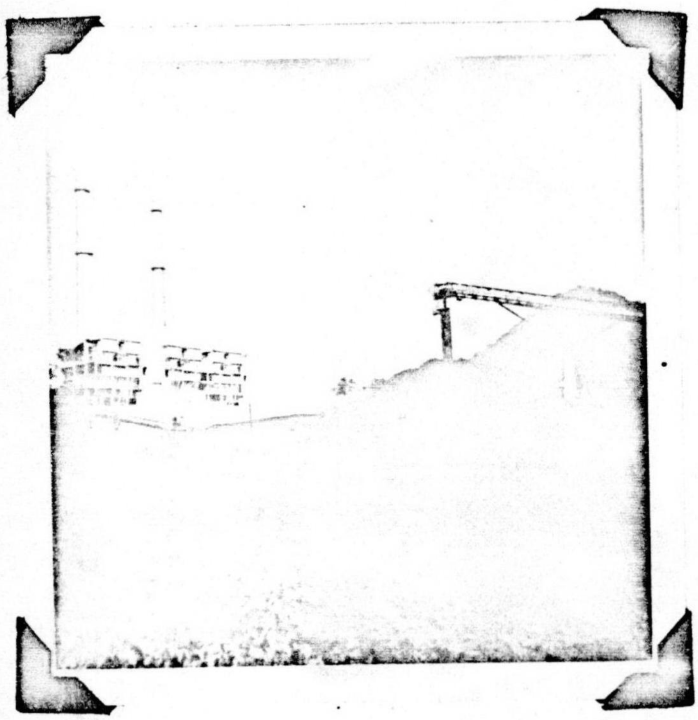
Clinch River, Virginia looking upstream from mile 267.4. The exposed substrate is a deposit of fly-ash from the "1967 Spill".

Shoreline of the Clinch River, Virginia showing depth sediment. (mile 267.4)

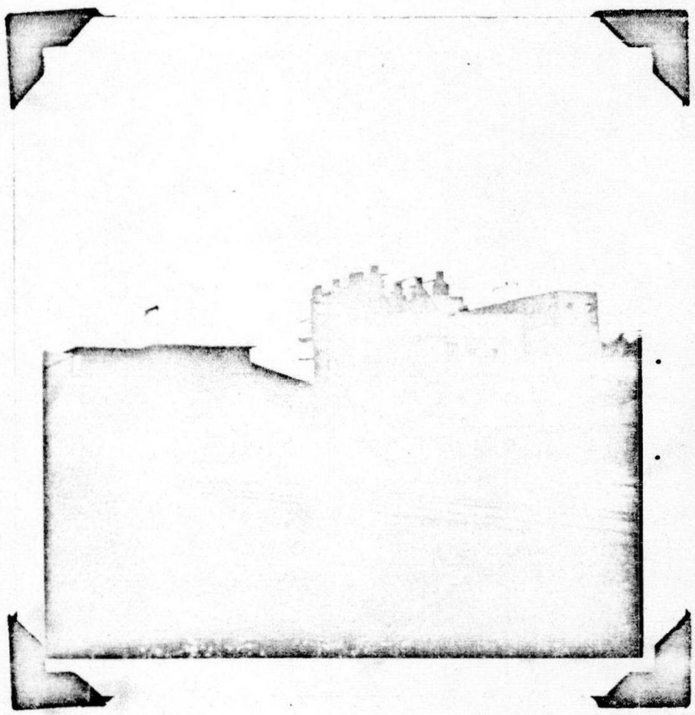
Shoreline of the Clinch River, Virginia showing unconsolidated state of the substrate (mile 267.3)



An upstream view of the Clinch River, Virginia from mile 267.2. In the background is the steam plant. (river flow 48 cfs.)



Coal conveyor at the Appalachian Power Co. steam plant, Clinch River, Virginia



Clinchfield Coal Mining Co. The fuel supplier for the Clinch River steam generating facility.

C

Mr. Howard Zeller
Atlanta, Georgia

April 13, 1970

Chief, Impoundment Studies
Southeast Water Laboratory

Temperature Criteria for the Water Quality Standards

Our review of historical temperature data has produced a large amount of information needed to determine:

(1) maximum allowable temperatures,
(2) allowable daily, monthly, and/or seasonal temperature variations, and
(3) a means of expressing temperature criteria in a meaningful manner.

The NTAC Report states that "no single temperature requirement can be applied to the United States as a whole, or even to one State." In terms of estimating how far the natural temperature may be exceeded without harmful effects, the Report further states "... a temperature increment based on the natural water temperature is more appropriate than an unvarying number." Information on natural temperatures which the Report indicates is required has been collected for the States of Alabama, Florida, Georgia, Mississippi, and Tennessee.

Tens of thousands of individual temperature measurements have been subjected to analysis of extremes, central tendency and probability of occurrence on a monthly basis. The raw data were separated by basin (or sub-basin) and by waterbody types, e.g. streams, reservoirs, and coastal waters. Every effort was made to eliminate areas for which temperatures were increased artificially, such as in the vicinity of cooling water return or waste discharges. Where continuous temperature recording data were available (less than a half dozen sites in most states), the opportunity was presented to analyze daily and monthly variations.

The analysis of monthly variations has direct application to the NTAC recommendation for Warm Waters. This recommendation includes wording such as:

> "During any month of the year, heat should not be added to a stream in excess of the amount that will raise the temperature of the water (at the expected minimum daily flow for that month)* more than 5°F."

This temperature increase, according to NTAC, should "be based on the monthly average of the maximum daily temperature." An analysis of temperature maxima for various areas pf the Southeast is presented in the attached table. What the table actually shows is that the power industry would be placed in an untenable position with the NTAC recommendation. The natural monthly maximum at the locations shown in the table exceeded the mean (average) of the daily maxima by more than 5°F approximately half of the time. This means that even with complete cooling, thermal

*I don't understand the need for this minimum flow clause.

power plants would not be able to operate during those periods when natural stream temperatures were 5°F or more hotter than the monthly average of the daily maxima.

A second feature of the NTAC warm waters recommendation is that "normal daily and seasonal temperature variations .... should be maintained." Daily variations at selected sites have been analyzed and are attached in a second set of tables. On the larger streams, daily temperature differences of 1 to 2°F are common, but on smaller streams these differences are greater.

In view of the difficulties presented by the 5°F degree-rise NTAC criteria, let me evaluate some different approaches which have been discussed from time to time.

Alternative #1 - A Maximum Allowable Temperature Only

The historical data review will permit establishment of a naturally-occurring, not-to-be-exceeded maximum temperature for any given state, river basin, and/or water body type. You will readily recognize that the flaw in a single, maximum number approach is that it would permit such a maximum to exist year-round. Desirable daily and seasonal temperature fluctuations needed for propagation of aquatic life could be circumvented by the heated effluent discharger.

Alternative #2 - A Maximum Allowable Temperature Coupled with a Degree-Rise Feature

The problems with the NTAC degree-rise approach have been discussed. I would also discard a 10°F degree-rise criteria as totally inconsistent with current research findings. An alternative to the NTAC suggestion is to couple a maximum allowable annual temperature (easily obtained with our data) with a 5°F degree-rise clause. The 5°F increase could be based on natural, background temperature occurring at any given instant.

A max allowable, 5°F rise criteria would require the heated effluent discharger to:

(1) determine the history of natural temperatures for his design (our data would help),
(2) design for total cooling when at the maximum allowable temperature naturally, and
(3) monitor intake temperatures and operate according to the degree-rise requirements.

A maximum allowable monthly temperature, also obtainable with our data, could be substituted for an annual allowable. Either approach would permit desirable daily and seasonal temperature variations to occur.

Howard, there are other alternatives which we can discuss on your next visit. One further item which needs consideration is what happens to the thermal power plant located downstream from a storage reservoir -- which reservoir releases cool, hypolimnetic waters during the warm-weather months. A 5°F rise criteria would penalize such plants.

Attachment

John A. Little

cc: Paul J. Traina w/copy tables
Dennis Cafaro w/copy tables

rnb

AN ANALYSIS
OF
WATER TEMPERATURE ($^{\circ}$F) MAXIMA
AT
CONTINUOUS RECORDING SITES - SOUTHEASTERN UNITED STATES

AN ANALYSIS OF WATER TEMPERATURE (°F) MAXIMA AT CONTINUOUS RECORDING SITES

LOCATION	MONTH	GREATEST RANGE IN MAXIMUM DAILY VALUES FOR PERIOD OF RECORD RANGE	MEAN	RANGE OF MONTHLY MEANS OF MAXIMUM DAILY VALUES	COMMENTS
Toccoa River at Dial, Georgia, (177 sq. mi. drainage area)	Jan	36 to 53	45	--	Record for July 1964 thru September 1965 only.
	Feb	36 to 55	45	--	
	March	42 to 55	49	--	
	April	51 to 66	60	--	
	May	61 to 70	66	--	
	June	64 to 72	68	--	
	July	65 to 75	71	71 & 73	
	Aug	62 to 77	72	72 & 73	
	Sept	63 to 75	69	69 & 69	
	Oct	51 to 67	56	--	
	Nov	43 to 60	53	--	
	Dec	37 to 54	46	--	
Alapaha River at Alapaha, Georgia, (520 cfs average flow)	Jan	44 to 62	51	47 to 54	Used record for April 1953 thru July 1957
	Feb	44 to 61	53	53 to 62	
	March	48 to 72	61	60 to 67	
	April	58 to 73	67	65 to 72	
	May	69 to 82	75	72 to 76	
	June	78 to 90	84	78 to 84	
	July	77 to 87	82	80 to 84	
	Aug	74 to 87	81	81 to 85	
	Sept	68 to 84	76	76 to 82	
	Oct	59 to 86	74	68 to 74	
	Nov	48 to 67	59	56 to 61	
	Dec	42 to 60	52	51 to 56	

Don't Xerox

AN ANALYSIS OF WATER TEMPERATURE (°F) MAXIMA AT CONTINUOUS RECORDING SITES

LOCATION	MONTH	GREATEST RANGE IN MAXIMUM DAILY VALUES FOR PERIOD OF RECORD: RANGE	MEAN	RANGE OF MONTHLY MEANS OF MAXIMUM DAILY VALUES	COMMENTS
Flint River near Culloden, Georgia, (2400 cfs average flow)	Jan	37 to 51	43	[illegible] & 45	Used records for October 1960 thru September 1961 and for October 1962 thru September 1963 only.
	Feb	42 to 58	51	[illegible] & 51	
	March	47 to 63	57	[illegible] & 59	
	April	58 to 72	62	[illegible] & 67	
	May	61 to 77	72	[illegible] & 72	
	June	70 to 85	77	[illegible] & 77	
	July	75 to 88	82	[illegible] & 82	
	Aug	71 to 88	80	[illegible] & 85	
	Sept	72 to 87	81	[illegible] & 80	
	Oct	60 to 81	73	[illegible] & 73	
	Nov	52 to 62	57	[illegible] & 57	
	Dec	35 to 55	46	[illegible] & 46	
Pearl River near Monticello, Miss., (6,000 cfs average flow)	Jan	43 to 57	49	--	November 1965 thru September 1966
	Feb	43 to 55	49	--	
	March	49 to 66	58	--	
	April	65 to 70	68	--	
	May	70 to 75	72	--	
	June	74 to 82	79	--	
	July	82 to 89	86	--	
	Sept	75 to 84	80	--	
	Nov	62 to 66	65	--	
	Dec	50 to 59	54	--	
Choctawhatchie River near Newton, Alabama, (960 cfs average flow)	June	73 to 85	78	--	June 1965, thru September 1965
	July	80 to 87	--	--	
	Aug	74 to 83	80	--	
	Sept	66 to 83	78	--	

AN ANALYSIS OF WATER TEMPERATURE (^{o}F) MAXIMA AT CONTINUOUS RECORDING SITES

LOCATION	MONTH	GREATEST RANGE IN MAXIMUM DAILY VALUES FOR PERIOD OF RECORD: RANGE	MEAN	RANGE OF MONTHLY MEANS OF MAXIMUM DAILY VALUES	COMMENTS
Conecuh River at Brantley, Ala., (670 cfs average flow)	June	74 to 82	77	--	June 1965, thru September 1965
	July	78 to 83	81	--	
	Aug	75 to 82	79	--	
	Sept	69 to 81	77	--	
Coosa River at Gadsden, Ala. (9300 cfs average flow)	Jan	43 to 52	--	--	October 1964 thru September 1965
	Feb	45 to 51	--	--	
	March	45 to 56	50	--	
	April	56 to 68	63	--	
	May	67 to 76	--	--	
	June	--	--	--	
	July	80 to 85	82	--	
	Aug	83 to 86	84	--	
	Sept	75 to 84	80	--	
	Oct	60 to 74	64	--	
	Nov	51 to 63	60	--	
	Dec	45 to 50	48	--	
Alabama River at Selma, Alabama, (26,300 cfs average flow)	Jan	--	--	--	October 1964 thru September 1965
	Feb	--	--	--	
	March	46 to 57	51	--	
	April	57 to 64	61	--	
	May	64 to 76	72	--	
	June	75 to 80	77	--	
	July	78 to 81	80	--	
	Aug	79 to 83	81	--	
	Sept	71 to 81	79	--	
	Oct	66 to 77	68	--	
	Nov	61 to 67	64	--	
	Dec	57 to 61	59	--	

AN ANALYSIS OF WATER TEMPERATURE (°F) MAXIMA AT CONTINUOUS RECORDING SITES

LOCATION	MONTH	GREATEST RANGE IN MAXIMUM DAILY VALUES FOR PERIOD OF RECORD: RANGE	MEAN	RANGE OF MONTHLY MEANS OF MAXIMUM DAILY VALUES	COMMENTS
Sopchoppy River near Sopchoppy, Florida, (250 cfs average flow)	Jan	43 to 60	52	--	October 1965 thru September 1966
	Feb	42 to 57	51	--	
	March	51 to 67	60	--	
	April	66 to 78	72	--	
	May	73 to 80	76	--	
	June	73 to 82	78	--	
	July	77 to 86	81	--	
	Aug	75 to 81	78	--	
	Sept	72 to 81	77	--	
	Oct	60 to 76	70	--	
	Nov	59 to 66	63	--	
	Dec	50 to 57	54	--	

AN ANALYSIS OF DAILY TEMPERATURE VARIATIONS

AT SELECTED STREAM SITES

FLINT RIVER AT ALBANY, GEORGIA (6,300 cfs avg. flow)

Period of Record: October 1957-September 1959
October 1960-March 1961
October 1961-September 1964

Daily Diff.	JANUARY # of Occ.	JANUARY % Prob. of Occ.	JANUARY % ≥	FEBRUARY # of Occ.	FEBRUARY % Prob. of Occ.	FEBRUARY % ≥
6	2	1	1	--	--	--
5	1	0.6	2	--	--	--
4	7	4	6	4	2	2
3	23	14	20	9	5	8
2	42	25	45	38	23	31
1	68	40	85	65	39	70
0	24	14	99	49	30	99
Max.		6			4	
Min.		0			0	
Avg.		2			1	
Total # of Occ.		167			165	

Daily Diff. °F	MARCH # of Occ.	MARCH % Prob. of Occ.	MARCH % ≥	APRIL # of Occ.	APRIL % Prob. of Occ.	APRIL % ≥
6	--	--	--	1	0.8	0.8
5	4	2	2	--	--	--
4	4	2	4	9	7	8
3	13	7	12	15	12	20
2	35	19	31	30	24	44
1	77	43	74	51	41	85
0	46	26	99	17	14	99
Max.		5			6	
Min.		0			0	
Avg.		1			2	
Total # of Occ.		179			123	

Daily Diff.	MAY # of Occ.	MAY % Prob. of Occ.	MAY % ≥	JUNE # of Occ.	JUNE % Prob. of Occ.	JUNE % ≥
8	--	--	--	1	0.8	0.8
7	--	--	--	2	2	3
6	2	2	2	7	6	8
5	18	14	16	14	12	20
4	22	17	33	21	18	38
3	16	13	46	15	13	50
2	26	20	66	13	11	61
1	33	26	92	33	28	89
0	9	7	99	12	10	99
Max.		6			8	
Min.		0			0	
Avg.		3			3	
Total # of Occ.		126			118	

Daily Diff. °F	JULY # of Occ.	JULY % Prob. of Occ.	JULY % ≥	AUGUST # of Occ.	AUGUST % Prob. of Occ.	AUGUST % ≥
8	--	--	--	--	--	--
7	--	--	--	1	0.8	0.8
6	6	5	5	10	8	9
5	14	11	16	31	26	35
4	15	12	27	22	18	53
3	25	20	47	8	7	60
2	27	21	68	18	15	74
1	23	18	86	24	20	94
0	17	13	99	6	5	99
Max.		6			7	
Min.		0			0	
Avg.		3			3	
Total # of Occ.		127			120	

FLINT RIVER AT ALBANY (CONT'D)

Daily Diff. °F	SEPTEMBER # of Occ.	% Prob. of Occ.	% ≥	OCTOBER # of Occ.	% Prob. of Occ.	% ≥
8	1	0.9	0.9	--	--	--
7	2	2	3	1	0.5	0.5
6	18	15	18	2	1	2
5	18	15	33	39	21	23
4	17	15	48	41	22	45
3	15	13	61	22	12	57
2	14	12	73	18	10	67
1	26	22	95	37	20	87
0	5	4	99	22	12	99
Max.		8			7	
Min.		0			0	
Avg.		3			3	
Total # of Occ.		116			182	

Daily Diff. °F	NOVEMBER # of Occ.	% Prob. of Occ.	% ≥	DECEMBER # of Occ.	% Prob. of Occ.	% ≥
6	2	1	1	1	0.6	0.6
5	4	2	3	2	1	2
4	23	13	16	7	4	6
3	37	21	37	29	16	22
2	28	16	53	45	25	46
1	56	32	85	77	43	89
0	26	15	99	19	10	99
Max.		6			6	
Min.		0			0	
Avg.		2			2	
Total # of Occ.		176			180	

Da Diff. °F	OVERALL # of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
8	2	0.1	0.1						
7	6	0.3	0.4						
6	51	3	3						
5	145	8	11						
4	192	11	22						
3	227	13	35						
2	334	19	54						
1	570	32	86						
0	252	14	100						
Max.		8							
Min.		0							
[illegible]									
Avg.		2							
Total # of Occ.		1779							

Daily Diff.	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
7									
6									
5									
4									
3									
2									
1									
0									
Max.									
Min.									
Range									
Avg.									
Total # of Occ.									

DUCK RIVER BASIN

DUCK RIVER ABOVE HURRICANE MILLS; TENN. (3,900 cfs avg. flow)

Period of Record - January 1961 - June 1964

	JAN.			FEB.			MARCH		
Daily Diff.	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
7	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
5	1	1	1	1	1	1	2	2	2
4	2	2	2	-	-	-	8	7	8
3	11	9	11	7	7	8	7	9	14
2	37	30	41	32	30	38	36	30	44
1	56	46	87	54	51	89	52	43	87
0	15	12	99	11	10	99	14	12	99
Max.	6			6			5		
Min.	0			0			0		
Avg.	1.4			1.4			1.6		
Total # of Occ.	122			105			119		

	APR.			MAY			JUNE		
Daily Diff. °F	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
7	-	-	-	-	-	-	1	1	1
6	1	1	1	1	1	1	2	3	4
5	5	4	5	11	9	10	21	28	32
4	13	11	16	36	30	40	19	25	57
3	17	14	30	28	24	64	20	26	83
2	31	26	55	31	26	90	8	11	93
1	48	40	95	11	9	99	4	5	99
0	5	4	99	-	-	-	-	-	-
Max.	6			6			7		
Min.	0			1			1		
Avg.	2.0			3.1			3.7		
Total # of Occ.	120			118			75		

DUCK RIVER

Da Diff.	JULY # of Occ.	JULY % Prob. of Occ.	JULY % ≥	AUGUST # of Occ.	AUGUST % Prob. of Occ.	AUGUST % ≥	SEPT. # of Occ.	SEPT. % Prob. of Occ.	SEPT. % ≥
7	-	-	-	-	-	-	1	1	1
6	-	-	-	3	4	4	2	2	4
5	12	14	14	17	21	24	3	4	7
4	27	31	45	42	51	76	28	33	40
3	25	29	74	11	13	89	28	33	73
2	20	23	97	7	9	98	17	20	93
1	2	2	99	1	1	99	5	6	99
0	-	-	-	-	-	-	-	-	-
Max.	5			6			7		
Min.	1			1			1		
Avg.	3.3			3.9			3.2		
Total # of Occ.	86			81			84		

Dai Diff. °F	OCT # of Occ.	OCT % Prob. of Occ.	OCT % ≥	NOV. # of Occ.	NOV. % Prob. of Occ.	NOV. % ≥	DEC. # of Occ.	DEC. % Prob. of Occ.	DEC. % ≥
7	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
5	7	8	8	4	4	4	-	-	-
4	39	42	49	3	3	8	2	2	2
3	20	22	71	26	29	36	7	7	10
2	25	27	98	28	31	67	38	40	50
1	-	-	-	25	25	95	32	34	84
0	1	1	99	4	4	99	14	15	99
Max.	5			5			4		
Min.	0			0			0		
Avg.	3.3			2.1			1.5		
Total # of Occ.	92			90			93		

DUCK RIVER

Da. Diff. °F	OVERALL # of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
7	2	0.2	0.2						
6	9	0.8	0.9						
5	84	7	8						
4	219	18	26						
3	207	17	44						
2	310	26	70						
1	290	24	95						
0	64	5	100						
Max.	7								
Min.	0								
Avg.	2.4								
Total # of Occ.	1185								

Daily Diff. °F	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
7									
6									
5									
4									
3									
2									
1									
0									
Max.									
Min.									
Range									
Avg.									
Total # of Occ.									

ELK RIVER AT FAYETTEVILLE, TENNESSEE (1,400 cfs avg. flow)

Period of Record: 1961-1964

Daily Diff. °F	January # of Occ.	January % Prob. of Occ.	January %	February # of Occ.	February % Prob. of Occ.	February %	March # of Occ.	March % Prob. of Occ.	March %
7	--	--	--	--	--	--	1	0.8	0.8
6	--	--	--	--	--	--	--	--	--
5	2	2	2	--	--	--	--	--	--
4	5	4	6	3	3	3	5	4	5
3	12	10	15	8	7	9	11	9	14
2	38	30	45	39	33	42	34	28	42
1	42	33	79	48	40	82	55	45	87
0	26	21	99	20	17	99	15	12	99
Max.		5			5			7	
Min.		0			0			0	
Avg.		1			1			2	
Total # of Occ.		125			118			121	

Daily Diff. °F	April # of Occ.	April % Prob. of Occ.	April %	May # of Occ.	May % Prob. of Occ.	May %	June # of Occ.	June % Prob. of Occ.	June %
7	1	0.8	0.8	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--
4	2	2	2	1	0.8	0.8	3	3	3
3	12	10	12	16	13	14	20	17	20
2	40	32	44	67	54	67	47	40	60
1	55	44	87	37	30	97	38	32	92
0	15	12	99	3	2	99	8	7	99
Max.		7			4			4	
Min.		0			0			0	
Avg.		1			2			2	
Total # of Occ.		125			124			116	

	July			August			September		
Da Diff. °F	# of Occ.	% Prob. of Occ.	%	# of Occ.	% Prob. of Occ.	%	# of Occ.	% Prob. of Occ.	%
7	--	--	--	--	--	--	--	--	--
6	1	0.8	0.8	1	0.8	0.8	--	--	--
5	--	--	--	--	--	--	--	--	--
4	2	2	2	1	0.8	2	1	0.9	0.9
3	10	8	10	10	8	10	8	7	8
2	55	44	54	75	63	73	47	43	51
1	52	42	97	25	21	94	47	43	94
0	3	2	99	6	5	99	6	5	99
Max.		6			6			4	
Min.		0			0			0	
Avg.		2			2			1	
Total # of Occ.		123			118			109	

	October			November			December		
Daily Diff °F	# of Occ.	% Prob. of Occ.	%	# of Occ.	% Prob. of Occ.	%	# of Occ.	% Prob. of Occ.	%
7	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--
4	1	1	1	3	4	4	3	3	3
3	7	7	8	4	5	9	6	7	10
2	37	36	44	22	28	37	28	31	41
1	46	45	89	37	47	84	35	38	79
0	10	10	99	12	15	99	18	20	99
Max.		4			4			4	
Min.		0			0			0	
Avg.		1			1			1	
Total # of Occ.		101			78			90	

Da. °F Diff.	Overall # of Occ.	% Prob. of Occ.	%
7	2	0.1	0.1
6	2	0.1	0.3
5	2	0.1	0.4
4	30	2	3
3	124	9	12
2	529	39	51
1	517	38	89
0	142	11	100
Max.		7	
Min.		0	
Avg.		2	
Total # of Occ.		1,348	

CLINCH RIVER WATERSHED
POWELL RIVER NEAR ARTHUR, TENNESSEE (1100 cfs avg. flow)

PERIOD OF RECORD: January 1963 - December 1964

	January			February			March		
Daily Diff. °F	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
8	-	-	-	-	-	-	-	-	-
7	1	2	2	-	-	-	-	-	-
6	2	3	5	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-
4	3	5	10	3	5	5	8	13	13
3	14	24	34	12	21	26	18	29	41
2	17	29	63	23	40	67	21	33	75
1	13	22	85	17	30	96	15	24	98
0	8	14	98	1	2	98	-	-	
Max.		7			4			4	
Min.		0			0			1	
Avg.		2			2			2	
Total # of Occ.		58			56			62	

	April			May			June		
Daily Diff. °F	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
8	-	-	-	-	-	-	1	3	3
7	1	2	2	9	15	15	-	-	-
6	3	5	7	8	14	29	11	31	33
5	12	20	26	11	19	47	5	14	47
4	14	23	49	15	25	73	8	22	69
3	14	23	72	10	17	90	7	19	89
2	12	20	92	3	5	95	3	8	97
1	4	7	98	2	3	98	-	-	-
0	-	-		-	-	-	-	-	-
Max.		6			7			8	
Min.		7			1			2	
Avg.		4			5			5	
Total # of Occ.		60			58			35	

CLINCH Cont'd.

Da. Diff. °F	July # of Occ.	July % Prob. of Occ.	July % ≥	August # of Occ.	August % Prob. of Occ.	August % ≥	September # of Occ.	September % Prob. of Occ.	September % ≥
8	1	2	2	1	2	2	-	-	-
7	11	17	19	3	5	6	-	-	-
6	14	17	19	3	5	6	16	26	26
5	12	19	60	16	25	49	18	30	56
4	13	21	81	19	30	79	12	20	75
3	5	8	89	6	9	89	7	11	87
2	4	6	95	5	8	97	3	5	92
1	2	3	98	1	2	98	4	7	98
0	-	-	-	-	-	-	-	-	
Max.		8			8			6	
Min.		1			1			1	
								6	
Avg.		5			5			4	
Total # of Occ.		62			62			60	

Daily Diff. °F	October # of Occ.	October % Prob. of Occ.	October % ≥	November # of Occ.	November % Prob. of Occ.	November % ≥	December # of Occ.	December % Prob. of Occ.	December % ≥
8	-	-	-	1	2	2	-	-	-
7	-	-	-	-	-	-	-	-	-
6	1	2	2	-	-	-	1	2	2
5	20	31	33	1	2	3	-	-	-
4	13	20	53	16	26	29	2	4	6
3	12	19	72	25	40	69	8	16	22
2	11	17	89	8	13	82	20	41	63
1	5	8	97	9	15	97	10	20	84
0	1	2	98	1	2	98	7	14	98
Max.		6			8			6	
Min.		0			0			0	
Avg.		4			3			2	
Total # of Occ.		63			61			48	

CLINCH Cont'd.

Daily Diff.	Overal # of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
8	4	0.6	0.6						
7	25	4	4						
6	67	10	14						
5	95	14	28						
4	126	18	46						
3	138	20	66						
2	130	19	85						
1	82	12	97						
0	18	3	100						
Max.		8							
Min.		0							
Avg.		3							
Total # of Occ.		685							

Daily Diff.	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥	# of Occ.	% Prob. of Occ.	% ≥
Max.									
Min.									
Range									
Avg.									
Total # of Occ.									

Period of Record: Jan. 1954-Sept. 1956 - Jackson, Mississippi
Nov. 1965-Sept. 1966 - near Monticello, Miss.

D Diff.	January #of Occ.	% Prob. of Occ.	%	February # of Occ.	% Prob. of Occ.	%	March # of Occ.	% Prob. of Occ.	%
5	--	--	--	--	--	--	--	--	--
4	--	--	--	1	0.9	0.9	1	0.8	0.8
3	1	1	1	1	0.9	2	7	6	6
2	13	13	14	2	2	3	19	15	22
1	40	40	53	42	37	40	53	43	65
0	46	46	99	68	59	99	43	35	99
Max.		3			4			4	
Min.		0			0			0	
Avg.		0.7			0.5			0.9	
Total # of Occ.		100			114			123	

Daily Diff. OF	April # of Occ.	% Prob. of Occ.	%	May # of Occ.	% Prob. of Occ.	%	June # of Occ.	% Prob. of Occ.	%
5	--	--	--	--	--	--	--	--	--
4	--	--	--	1	0.8	0.8	3	2	2
3	2	2	2	3	2	3	7	6	8
2	9	7	9	8	6	10	25	21	29
1	52	43	52	49	39	49	48	40	69
0	57	47	99	63	50	99	37	31	99
Max.		4			4			4	
Min.		0			0			0	
Avg.		0.6			0.6			1	
Total # of Occ.		120			124			120	

	July			August			September		
De Diff.	# of Occ.	% Prob. of Occ.	%	# of Occ.	% Prob. of Occ.	%	# of Occ.	% Prob. of Occ.	%
14	--	--	--	--	--	--	1	0.8	0.8
13	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	1	0.8	1
11	--	--	--	--	--	--	1	0.8	2
10	--	--	--	--	--	--	6	5	7
9	--	--	--	--	--	--	2	2	9
8	--	--	--	--	--	--	5	4	13
7	--	--	--	--	--	--	1	0.8	14
6	--	--	--	--	--	--	1	0.8	15
5	3	2	2	--	--	--	3	2	17
4	11	8	10	4	4	4	6	5	22
3	13	9	19	3	3	7	10	8	30
2	48	34	52	16	16	23	22	18	48
1	45	31	84	44	45	68	43	35	84
0	22	15	99	30	31	99	19	16	99
x.		5			4			14	
Min.		0			0			0	
Avg.		2			1			3	
Total # of Occ.		142			97			121	

Da. Diff. °F	October # of Occ.	October % Prob. of Occ.	October %	November # of Occ.	November % Prob. of Occ.	November %	December # of Occ.	December % Prob. of Occ.	December %
12	1	2	2	--	--	--	--	--	--
11	2	3	5	--	--	--	--	--	--
10	3	5	10	--	--	--	--	--	--
9	1	2	11	1	1	1	--	--	--
8	4	6	17	--	--	--	--	--	--
7	3	5	22	1	1	2	--	--	--
6	2	3	25	3	3	6	--	--	--
5	5	8	33	3	3	9	--	--	--
4	11	17	51	4	4	13	1	1	1
3	17	27	78	10	11	25	8	9	10
2	9	14	92	22	25	49	16	17	27
1	2	3	95	26	29	79	46	49	76
0	2	3	98	18	20	99	22	23	99
Max.		12			9			4	
Min.		0			0			0	
Avg.		4			2			1	
Total # of Occ.		62			88			93	

	Overall		
D Diff.	# of Occ.	% Prob. of Occ.	%
14	1	0.08	0.08
13	--	--	--
12	2	0.2	0.2
11	3	0.2	0.5
10	9	0.7	1
9	4	0.3	1
8	9	0.7	2
7	5	0.4	3
6	6	0.5	3
5	14	1	4
4	43	3	7
3	82	6	14
2	209	16	30
1	490	38	67
0	427	33	100
x.		14	
Min.		0	
Avg.		1	
Total # of Occ.		1,304	

May 12, 1970

Mr. Joe Crockett
Technical Director
Alabama Water Improvement
Commission
State Office Building
Montgomery 4, Alabama 36104

Dear Mr. Crockett:

We are transmitting with this letter an assemblage of historical temperature information for the State of Alabama. This information can be used for your consideration of and for subsequent discussions with this agency on changes in temperature criteria for the Alabama Water Quality Standards.

A note of explanation on each of the attachments is in order. The computer printout is a summary of all the temperature records for the State. As you know, these records were obtained from many different agencies. The printout contains a statistical breakdown by river basin and waterbody type within a basin. River temperatures are separated from lake and reservoir, coastal from river, etc. Each basin summary is a numbered four-page section:

- Page 1 - number of observations of each temperature by month
- Page 2 - percent frequency of occurrence of each temperature by month
- Page 3 - percent of time a given temperature value equalled or exceeded for a given month
- Page 4 - miscellaneous statistical data (self-explanatory)

A second attachment is an analysis of daily water temperature maxima for selected continuous recording sites in the Southeast. I think that this is also self-explanatory. I should note perhaps that the column entitled "mean" is the mean of the daily maximum values for the given month and for the year in which the greatest range occurred.

Finally, the third enclosure is an analysis of daily temperature extremes, also at selected continuous recording sites.

If you have any questions whatsoever, please let us know. We will be able to perform additional analysis with the data on tape should the need arise.

Sincerely,

Paul J. Traina, Director
Technical Services Program

Enclosures (3)

cc: Howard D. Zeller
John A. Little
Dennis T. Cafaro

JALittle:ec 5/12/70

June 4, 1970

Mr. Joe L. Crockett, Jr.
Director, Technical Staff
Water Improvement Commission
Rooms 324-326, State Office Building
Montgomery 4, Alabama 36104

Dear Mr. Crockett:

At Mr. Zeller's request we are providing you with some additional information on the recent computer printout for historical temperature records in the state of Alabama. The following references were used to obtain the temperature data which is summarized in the printout.

1. Temperature of Alabama Streams, by James R. Avrett and Lamar E. Carron, Geological Survey of Alabama - Information Series 35.

   This reference contained the largest amount of temperature information for Alabama. Data from as far back as the 1940's and from over 100 sites in the state were available in this publication.

2. Water Quality Records in Alabama, Louisiana, and Mississippi, USGS-1964.

   This publication lists temperature records for a number of stream gage sites in the state of Alabama.

3. Selected Field Studies Performed by the Alabama Water Improvement Commission (Warrior-Tombigbee River Study, 1966, Warrior Study August-September 1964, Upper Tombigbee 1965, Tombigbee River Study, 1964).

4. Data donated from American Can Company, 1963 - Tombigbee River Study, July 21-August 7, 1964.

5. Federal Water Quality Administration, Pollution Affecting Shellfish Harvesting in Mobile Bay, Alabama.

6. Water Temperatures of Streams and Reservoirs in the Tennessee River Basin, Tennessee Valley Authority, Knoxville, Tennessee, September 1966.

   This reference contains an extensive compilation of temperature data in the TVA system. The period of record extended back into the 1940's.

7. Reservoir Temperatures in North-Central Alabama, USGS, 1964.

   Temperature data in this report were for the years 1959 and 1960. Only surface temperatures were used in our historical review.

Not all of the data found in these selected references were incorporated into the printout. Temperature readings in the vicinity of and/or influenced by artificial heat sources were eliminated. Some of these elimination areas were as follows:

(1) Tuscaloosa, Alabama (Oliver Pool).

(2) A stream reach extending 10 miles below the American Can Company outfall.

(3) Downstream from the Chickasaw steam plant near Mobile, Alabama.

(4) Records obtained at the USGS stream gage site on Talladega Creek near Talladega, Alabama.

(5) Big Sandy Creek at Duncanville, Alabama.

(6) Tennessee River at Widows Bar, Alabama.

(7) Etc.

If further information is needed concerning the historical temperature printout, please contact us.

Sincerely yours,

John A. Little
Chief, Impoundment Studies

cc: Mr. Howard Zeller
    Mr. Dennis Cafaro

rnb

Howard Zeller

May 12, 1970

Dennis Cafaro

Analysis of Historical Temperature Records

Attached you will find two copies of the Alabama temperature printout, and a table containing a frequency distribution of all the temperature records above 87°F. We have also mailed a copy of the printout to Mr. Joe Crockett as your requested. Hopefully, barring any future crises, we will complete Florida around May 22, 1970.

ATTACHMENT

DTCafaro:ec 5/12/70

ALABAMA (River Basins)

°F	Lower Chatta-hoochee-west pt to Ga-Fla line	Tenn. Main Stem	Chocta-whatchee	Perdido-Escambia	Talla-poosa	Coosa	Cahaba	Ala.	Upper Tom-big-bee	Black Warrior	Lower Tombig-bee	Mobile Bay Coastal
94						1						
93						3				1		1
92		1				2	2	1		2		13
91		2				3			1	4	1	22
90	1	2			1	1	2			17	4	6
89	1	2				8	4	1		20		4
88		3				12	3	3	2	32	29	3
87		3	1		2	16	3	3	4	35		2
TOTAL	2	13	1	0	3	46	14	8	7	111	34	51

SUMMARY *

°F	Number of Total Observations	% Occurence
94	1	.01
93	5	.05
92	21	.24
91	33	.38
90	34	.39
89	40	.46
88	87	.99
87	69	.78
	290	3.30% TOTAL

* Total Number of Observations - 8781
3.30% of data ≳ to 87°F

Dennis
(mine)

March 18, 1971

Dennis Cafaro

Alabama Basin Temperatures

Howard Zeller

Attached are:

1. Table - Alabama Basin Temperatu
2. Graph I - Alabama Basin Temperatures
   Compared to your ~~predicted~~ proposed highs at approximately the 96.5% $\leq$ level.
3. Graph II - Alabama Basin Temperatures
   Compared to your ~~predicted~~ proposed highs at approximately 50% $\leq$ level.

The additional supplement requested for Graph I is:

	Tennessee River Basin % $\leq 55^{o}F$	Black Warrior Basin % $\leq 55^{o}F$	Coosa Basin % $\leq 55^{o}F$
JAN	86.2	91.8	83.4
FEB	87.3	86.2	73.9

Graph I looks very good except for January and February. The other basins were not plotted because sample populations less than 100/month tend to be misleading. I think we should stick with about the 97 or 98% $\leq$ level because 98.9% of the data in the Alabama printout is $\leq$ $90^{o}F$. This serves as a good rule of thumb.

Sanitary Engineer

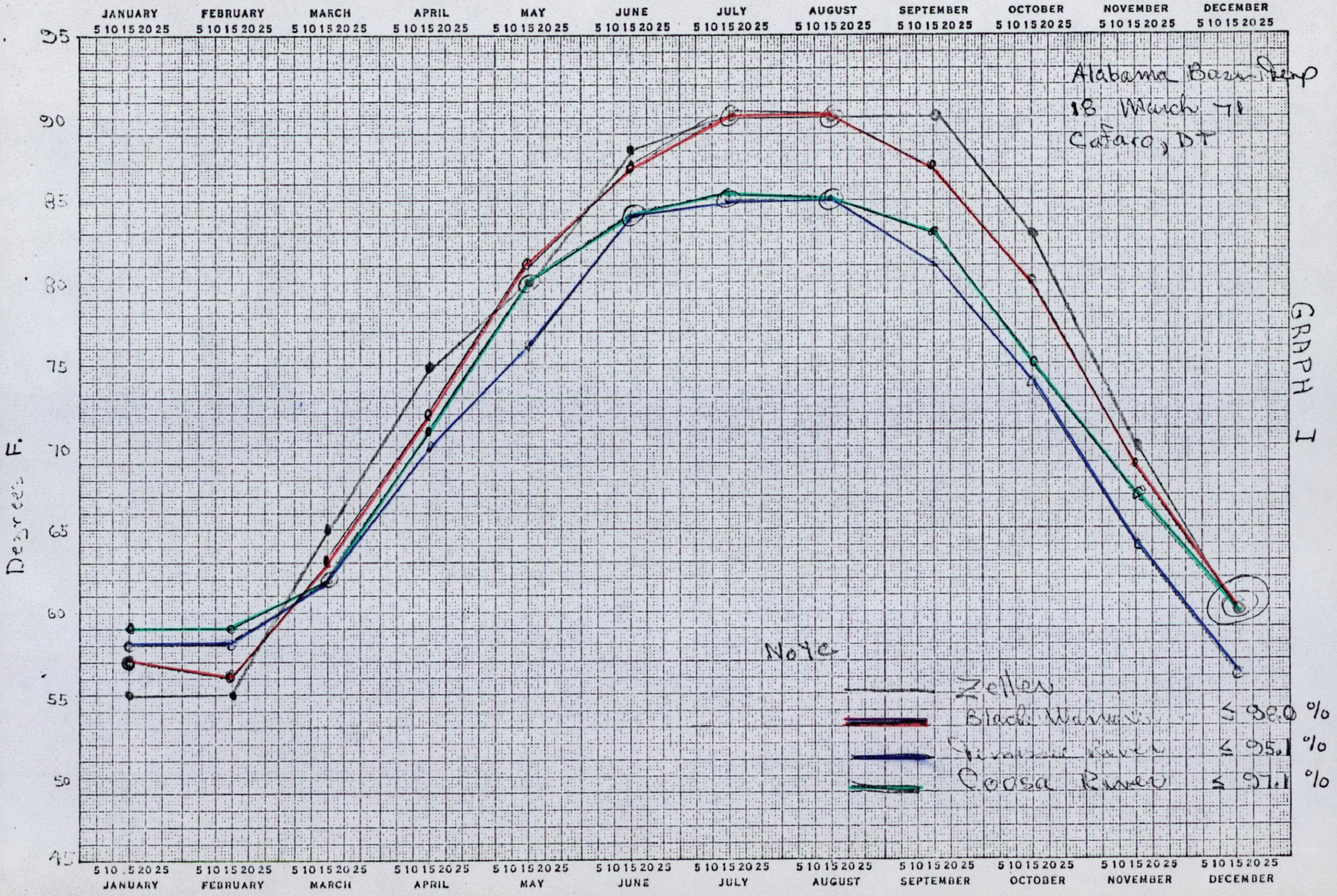
DTCafaro/tbw 3/18/71

ALABAMA BASIN TE[illegible]RATURES

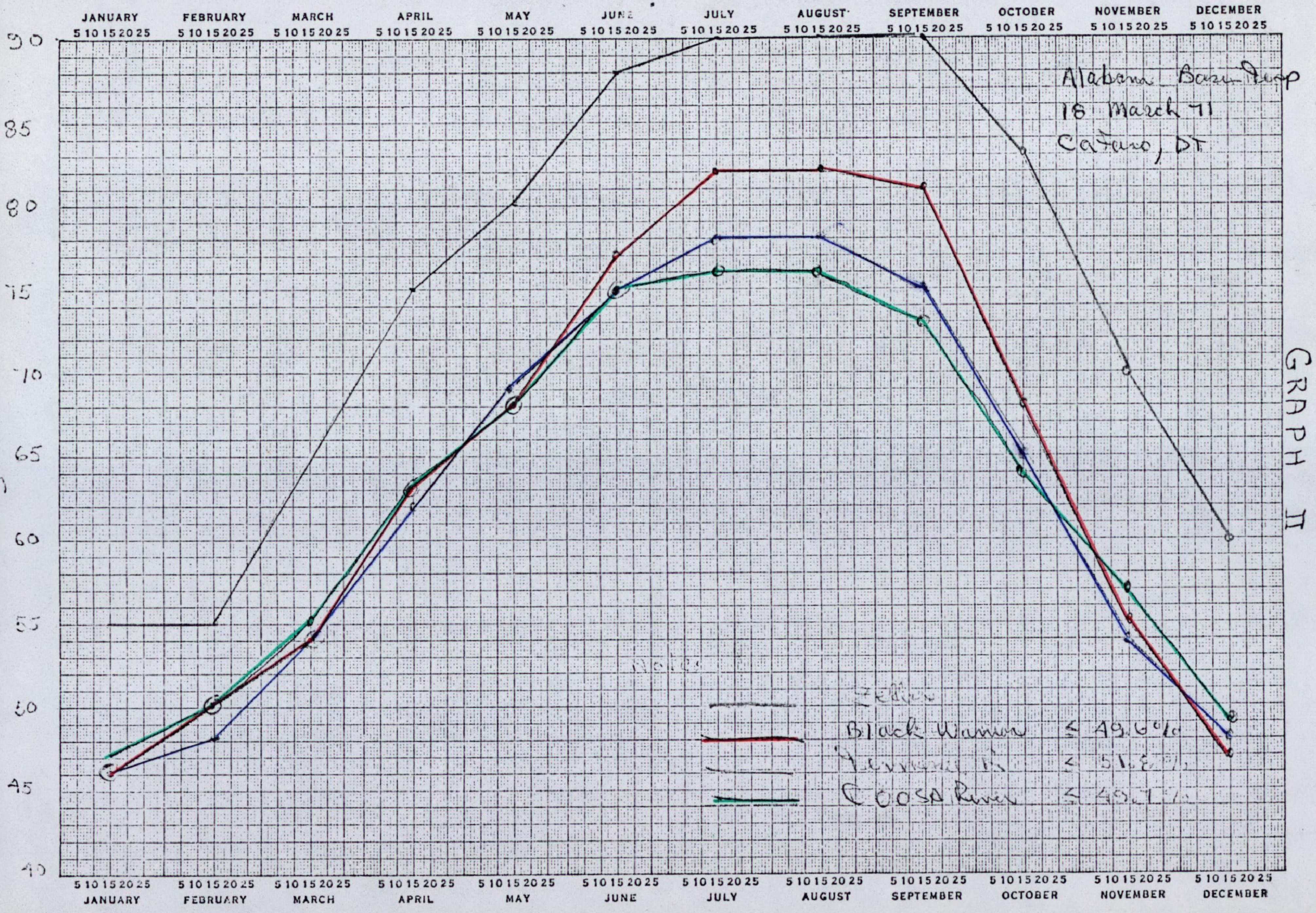
Months	Zeller °F	Tenn. River Basin Temp. °F	# of Occ.	% ≤	Perdido-Escambia Riv. B. Temp. °F	# of Occ.	% ≤	Coosa River Basin Temp. °F	# of Occ.	% ≤	Black Warrior Riv. B. Temp. °F	# of Occ.	% ≤
Jan.	55	58	130	94.7	58	31	93.6	59	120	95.0	57	133	94.8
Feb.	55	58	141	95.8	67	24	95.9	59	84	96.5	56	94	95.8
Mar.	65	62	132	94.7	66	52	98.1	62	89	95.6	63	86	98.9
Apr.	75	70	136	95.6	74	35	94.3	71	99	99.0	72	109	99.1
May	80	76	165	94.6	79	47	97.9	80	114	97.4	81	109	95.5
June	88	84	139	95.7	82	54	96.3	84	97	94.9	87	115	98.3
July	90	85	157	94.3	79	35	94.3	85	101	94.1	90	114	98.3
Aug.	90	85	172	96.6	80	50	94.0	85	121	98.4	90	153	99.4
Sept.	90	81	170	94.2	81	91	99.0	83	151	98.7	87	403	99.6
Oct.	83	74	142	94.4	73	36	97.3	75	103	98.1	80	176	98.9
Nov.	70	64	145	96.6	63	37	94.6	67	98	99.0	69	100	98.0
Dec.	60	56	154	94.2	58	20	95.0	60	94	99.0	60	102	99.1
			Ave.	95.1		Ave.	95.8		Ave.	97.1		Ave.	98.0

Months	Zeller °F	Tennessee River Basin Temp. °F	% ≤	Perdido-Escambia R. Basin Temp. °F	% ≤	Coosa River Basin Temp. °F	% ≤	Black Warrior R. Basin Temp. °F	% ≤
Jan.	55	46	55.4	48	38.8	47	52.5	46	48.9
Feb.	55	48	58.9	55	50.0	50	52.4	50	47.9
Mar.	65	54	53.8	61	53.9	55	48.4	54	52.4
April	75	62	47.8	65	54.3	63	43.5	63	50.5
May	80	69	52.8	70	49.0	68	47.4	68	51.4
June	88	75	51.1	75	55.6	75	49.5	77	50.5
July	90	78	52.9	77	42.9	76	47.6	82	50.0
Aug.	90	78	46.6	76	52.0	76	51.3	82	51.7
Sept.	90	75	50.6	77	49.5	73	52.4	81	41.0
Oct.	83	65	48.6	62	52.8	64	48.6	68	49.5
Nov.	70	54	51.8	55	48.7	57	50.0	55	52.0
Dec.	60	48	50.7	47	55.0	49	53.2	47	50.0
		Ave.	51.8	Ave.	50.2	Ave.	49.7	Ave.	49.6

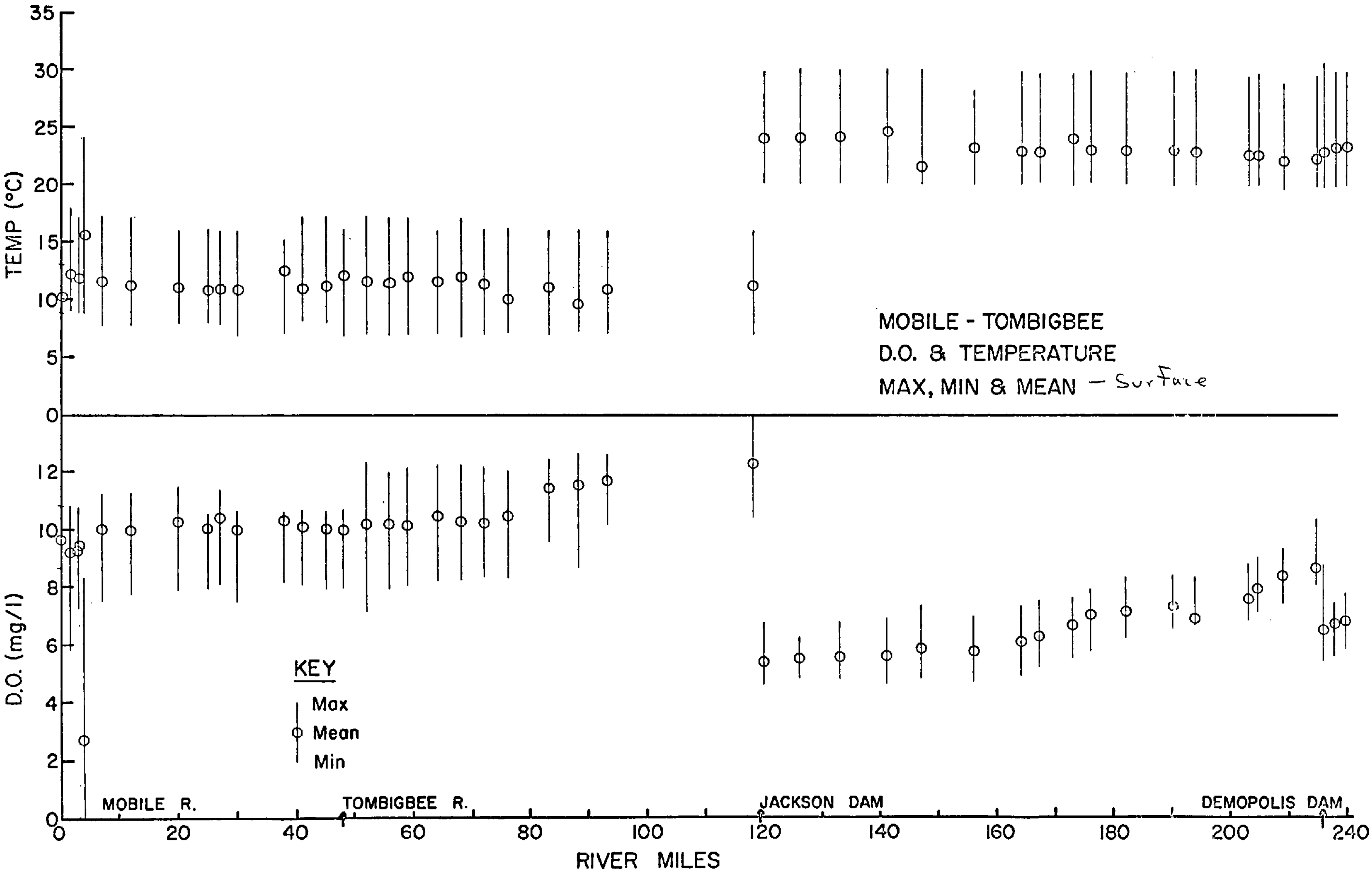
K+E 1 YEAR BY DAYS X 250 DIVISIONS 46 2893 MADE IN U.S.A. KEUFFEL & ESSER CO.



K+E 1 YEAR BY DAYS X 250 DIVISIONS 46 2893 MADE IN U.S.A.
KEUFFEL & ESSER CO.



GRAPH II



MOBILE - TOMBIGBEE
D.O. & TEMPERATURE
MAX, MIN & MEAN — Surface
TEMP (°C)
D.O. (mg/l)
KEY
Max
Mean
Min
MOBILE R.
TOMBIGBEE R.
JACKSON DAM
DEMOPOLIS DAM
RIVER MILES
0
5
10
15
20
25
30
35
2
4
6
8
12
20
40
60
80
100
120
140
160
180
200
240

April 15, 1970

Mr. Glen Wood
Acting Executive Secretary
Miss. Air and Water Pollution
Control Commission
P. O. Box 827
416 N. State Street
Jackson, Miss. 39205

Dear Mr. Wood:

As promised during our discussions in Atlanta last week, we are transmitting with this letter an assemblage of historical temperature information for the State of Mississippi. This information can be used for your consideration and for subsequent discussions with this office on changes in temperature criteria for the Mississippi Water Quality Standards.

A note of explanation on each of the attachments is in order. The computer printout is a summary of all the temperature records for the state. The first 18 pages or so contain computer language not entirely pertinent to your review but included for your information. The remaining portion of the printout contains a statistical breakdown by river basin and waterbody type within a basin. River temperatures are separated from lake and reservoir, coastal from river, etc. Each basin summary is a numbered four-page section:
Page 1 - number of observations of each temperature by month
Page 2 - percent frequency of occurrence of each temperature by month
Page 3 - percent of time a given temperature value equalled or exceeded for a given month
Page 4 - miscellaneous statistical data (self-explanatory)

A second attachment is an analysis of daily water temperature maxima for selected continuous recording sites in the Southeast. I think that this is also self-explanatory. I should note perhaps that the column entitled "mean" is the mean of the daily maximum values for the given month and for the year in which the greatest range occurred.

Finally, the third enclosure is an analysis of daily temperature extremes, also at selected continuous recording sites.

If you have any questions whatsoever, please let us know. We will be able to perform additional analyses with the data on tape should the need arise.

Sincerely,

J. A. Little, Chief
Impoundment Studies

cc:
H. D. Zeller
Y. Barber
P. J. Traina

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Howard Zeller DATE: May 8, 1970

FROM : Dennis Cafaro
DTC

SUBJECT: Review of Historical Temperature Records

Attached you will find the frequency distributions which were tabulated for Mississippi, Georgia and Tennessee. Mississippi has been given more detailed attention since it was a matter of discussion with the Department of Fish and Wildlife. Good luck with your future negotiations.

sent via Magnafax 5/8/70

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

STATE OF MISSISSIPPI

Review of Historical Temperature Records (1943-1968)

River Basins

°F	Lower Mississippi -Yazoo R.	Lower Mississippi -Big Black R.	Lower Mississippi Natchez to Gulf	Mississippi Gulf Coast	Pascagoula	Pearl	Upper Tombigbee
99					1		
98	2	1	3				
97	3	1	1				1
96	1	4	2				1
95	2						
94	3		1	1	1		4
93	4	2	7	4		1	1
92	1	8	3	2	2	1	5
91	17	1	4	7		4	2
90	17	4	8	22	3	15	6

State Summary

°F	# of Total Observations	% of Occur. for 12 Mos.	# of Occur. June-Sept.	% of Occur. June-Sept.
99	1	.01	1	.03
98	6	.04	6	.15
97	6	.04	6	.15
96	8	.06	8	.20
95	2	.01	2	.05
94	10	.07	10	.25
93	19	.14	18	.45
92	22	.16	21	.53
91	35	.25	17	.43
90	75	.55	58	1.45
Total	184	1.33	147	3.69

Total number of measurements 13,681
Number of measurements June-Sept. 3,955

Little

May 5, 1970

Mr. S. Leary Jones
Executive Secretary
Stream Pollution Control Board
Tennessee State Dept. of Public Health
Cordell Hull Bldg.
Sixth Avenue North
Nashville, Tennessee 37219

Dear Mr. Jones:

We are transmitting with this letter an assemblage of historical temperature information for the State of Tennessee. This information can be used for your consideration of and for subsequent discussions with this agency on changes in temperature criteria for the Tennessee Water Quality Standards.

A note of explanation on each of the attachments is in order. The computer printout is a summary of all the temperature records for the State. As you know, these records were obtained from many different agencies. The printout contains a statistical breakdown by river basin and waterbody type within a basin. River temperatures are separated from lake and reservoir, coastal from river, etc. Each basin summary is a numbered four-page section:

- Page 1 - number of observations of each temperature by month
- Page 2 - percent frequency of occurrence of each temperature by month
- Page 3 - percent of time a given temperature value equalled or exceeded for a given month
- Page 4 - miscellaneous statistical data (self-explanatory)

A second attachment is an analysis of daily water temperature maxima for selected continuous recording sites in the Southeast. I think that this is also self-explanatory. I should note perhaps that the column entitled "mean" is the mean of the daily maximum values for the given month and for the year in which the greatest range occurred.

Finally, the third enclosure is an analysis of daily temperature extremes, also at selected continuous recording sites.

If you have any questions whatsoever, please let us know. We will be able to perform additional analysis with the data on tape should the need arise.

Sincerely,

Paul J. Traina
Director
Technical Services Program

Enclosures

cc: Howard D. Zeller
John A. Little

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

DIRECTOR
SOUTHEAST REGION
SUITE 300
1421 PEACHTREE STREET N.E.
ATLANTA, GEORGIA 30309

March 24, 1970

Mr. Milo Churchill
Chief, Water Quality Branch
Tennessee Valley Authority
715 Edney Building
Chattanooga, Tennessee 37401

Dear Milo:

Reference is made to our telephone conversation today concerning TVA data which has been included in our regional temperature study for the State of Tennessee.

The information we have from your agency is as follows:

1. Green River Survey, 1965, published by the Philadelphia Academy of Natural Science in April 1966.

2. Thermal and Biological Studies in the Vicinity of Widows Creek Steam Plant.

3. Thermal and Biological Studies in the Vicinity of Colbert Steam Plant.

4. Water Temperatures of Streams and Reservoirs of the Tennessee River Basin, 1966.

5. STORET Printouts, TVA Water Quality Sampling Stations.

In addition to the above, we also have Corps of Engineers data for the Cumberland River, 1960-69; printouts of temperature data 1968-69 from the Tennessee Game and Fish Commission; and other temperature data obtained from the Tennessee Department of Public Health and the Tennessee Stream Pollution Control Board.

If you have other significant temperature data which would be applical to our study and which is not previously covered above, we would appreciate receiving it from you at an early date. We would be particularly interested in a follow-up study on the Green River which I think was conducted after cooling towers were installed. If you have any questions or comments, please feel free to call me.

Very truly yours,

Howard D. Zeller
Chief, Water Quality Standards Branch

STATE OF TENNESSEE

River Basins

°F	Clinch	Holston	French Broad	Little Tennessee	Hiwassee	Elk	Duck	Cumberland	Tennessee R. Main Stream
94	1								
93									2
92						1			
91									2
90						1	1		3
89	2					1			3
88	2				1	2	6		9
87	1	2	1	2		3	7		9
86	10	2			1	2	15	7	8
tal	16	4	1	2	2	10	29	7	36

Total number of measurements 20,500
107 measurements $\gtrsim$ 86°F
.5% of the data $\gtrsim$ 86°F

Dennis
(mine)

March 16, 1971

Dennis Cafaro DTC

Regional Temperature Studies - Tennessee

Howard Zeller

Attached is the location of the data stations within the Tennessee Basins. A review of the data shows that:

- stream reaches receiving artificial heat have been successfully eliminated;

- there are 11 locations just below dams included in the data;

  Major Dams
  1. French Broad below Douglas Dam
  2. Little Tennessee below Fontana Dam
  3. Holston below Fort Patrick Henry Dam
  4. Clinch below Norris Dam
  5. Holston below Cherokee Dam

  Minor Dams
  6. Nolichucky below Nolichucky Dam
  7. Clinch River below Melton Hill Dam
  8. Little Tennessee below Chilhowee Dam
  9. South Fork of Holston below South Holston Dam
  10. Cheatam Dam, Tennessee River
  11. Old Hickory Dam, Tennessee River.

These stations were used because their elimination significantly reduces the statistical strength of the summary; and the Tennessee watersheds are a controlled system of dams and impoundments - the data should reflect this. Temperatures below the minor dams were very similar to the other stations within the basin. However, temperatures below the major dams were five to 15 deg. F. cooler in the summer months than the other stations within their basin.

Sanitary Engineer

Attachments

cc: J. A. Little

DTCafaro/tbw 3/16/71

CUMBERLAND RIVER BASIN

LOCATION OF TEMPERATURE INPUTS

Obey R. West Fk near Livingston
Obey R. East Fk, Fentress Co.
Obey R., Clay Co.
Cumberland R. near Gainesboro
Collins R. near McMinnville
Caney Fk R. near Spencer
Calfkiller R. near Sparta
Barton Cr. near Lebanon
Fall Cr. near Smithville
Pigeon Roost Cr. near Cookville
Red R. at Clarksville
Red R., Tennessee-Ky State Line
Town Cr. near Gallatin
Stones R. near Woodburg
Wolf R. near Byrdstown
Cheatam L., Cheatam Co.
Dale Hollow L., Clay Co.
Old Hickory L., Rome
Piney R., Dickson Co.
Cumberland R., Davidson Co.
Stones R. West near Murfreesboro
Stones R., I-40 Bridge
Obey R. near Crossville
New R. near Huntsville

ELK RIVER BASIN

LOCATION OF TEMPERATURE INPUTS

Elk River near Pelham
Elk River at Estill Springs
Bradley Creek near Prairie Plains
Elk River above Fayetteville
Elk River near Prospect
Richland Creek near Pulaski
Big Cr. near Altamont
Elk R., R.M. 166.3
Richland Cr. near Pulaski
Mulberry Cr. near Lynchburg

FRENCH BROAD RIVER BASIN

LOCATIONS OF TEMPERATURE INPUTS

French Broad River near Newport
Nolichucky River near Nolichucky Dam
Nolichucky River at Embreeville
French Broad River near Knoxville
French Broad River near Kodak
French Broad River below Douglas Dam
Sevierville, Little Pigeon River
Cocke County, French Broad River
Knox-Chapman Utility, French Broad River
Nolichucky River, R.M. 5.2
Pigeon River, R.M. 2.9
Pigeon River, R.M. 25.8
Turkey Cr. near Morristown
Clear Cr. near Chestnut Hill
Richland Cr., Greene Co.

DUCK RIVER BASIN

LOCATION OF TEMPERATURE INPUTS

Duck River near Shelbyville
Buffalo River near Lobelville
Buffalo River near Flat Woods
Piney River at Vernon
Duck River above Hurricane Mills
Duck River at Centerville
Duck River at Columbia
Shelbyville, Duck River
Bedford Lake, Bedford Co.
Duck River, R.M. 64.0
Duck River, R.M. 122.2
Duck River, R.M. 125.5
Duck River, R.M. 133.6
Duck River, R.M. 220.9
Green River near Waynesboro
Rock Cr. near Tulahma
Clear Cr. near Chestnut Hill

HOLSTON RIVER BASIN

LOCATION OF TEMPERATURE INPUTS

Mossy Spring near Jefferson City
Bristol, S. Holston River
Johnson City on N. Indian Creek
Holston River at Indian Cave Ferry
Holston River at Strawberry Plains
South Fork Holston River near Riverside
Watauga River above Elizabethton
Doe River at Elizabethton
Holston River near Jefferson City
Watauga River near Watauga Flats
Holston River at Surgoinsville
Holston River near Knoxville
Watauga River at Elizabethton
South Fork Holston River below South Holston Dam
Watauga R. near Johnson City
Watauga R., Hwy. 91
Beaver Cr., Knox Co.
Beaver Cr. near Bristol
Limestone Cr. near Jonesboro

CLINCH RIVER BASIN

LOCATION OF TEMPERATURE INPUTS

Clinch River below Norris Dam
Obed River near Lancing
Emory River at Oakdale
Clinch River at Clinton
Clinch River below Melton Hill Dam
Clinch River at Edgemoor
Poplar Creek near Oak Ridge
Powell River near Arthur
Clinch River above Tazewell
East Fork Poplar Creek near Oak Ridge
Harriman, Emory River
Clinch River near Medford
Emory R. near Harriman
Emory R. near Wartburg
Popular Cr., Anderson Co.

LITTLE TENNESSEE RIVER BASIN

LOCATION OF TEMPERATURE INPUTS

Little Tennessee River below Chilhowee Dam
Little Tennessee River near Lenoir City
Little Tennessee River below Fontana Dam, N. C.
Tellico River near Vonore
Tellico River at Tellico Plains
Little Tennessee River at McGhee

TENNESSEE RIVER BASIN
AND WESTERN SECTION OF TENNESSEE THAT DRAINS INTO MISSISSIPPI RIVER
LOCATION OF TEMPERATURE INPUTS

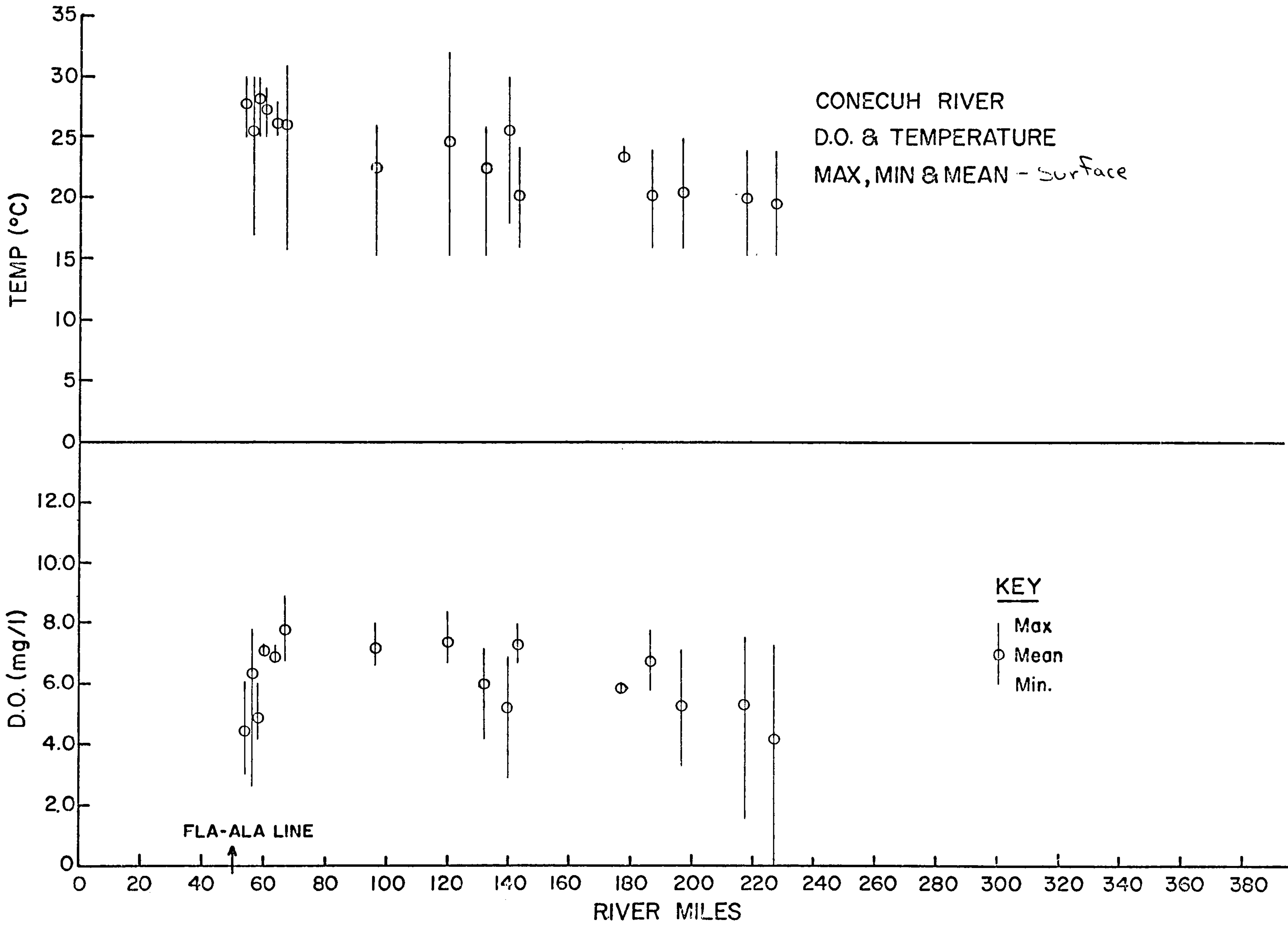
South Pittsburg, Tennessee River
Cheatham Reservoir
Dayton, Tennessee River
South Chickamauga Creek near Chickamauga
Sequatchie River near Whitwell
Tennessee River at Chattanooga
Horse Creek near Savannah, Tenn.
Indian Creek near Cerro Gordo
Little River above Townsend
Tennessee River at Knoxville
Big Sandy River at Bruceton
Tennessee River at Loudon
Little River near Maryville
White Creek near Glen Alice
Richland Creek near Dayton
South Chickamauga Creek below Georgia-Tennessee State Line
Sewee Creek near Decatur
Tennessee River near Loudon
Crab Orchard Creek near Deermont
East Fork Poplar Creek
Bullrun Creek near Halls
Beech Creek at Kepler
Clifton, Tennessee River
Cheatham Dam
Old Hickory Reservoir
Old Hickory Dam
Knoxville on Tennessee River
New Johnsonville, Tennessee River
Spring City, Tennessee River
Little River above Townsend
Tennessee River TVA at Chattanooga
Sequatchie R. near Pikeville
Sequatchie R. near Dunlap
Hatchie R. near Brownsville
Hatchie R. near Bolivar
Shoal Creek near Lwnsbg
Shoal Creek at Lwnsbg
Emory R. at Harriman
Emory R. at Wartburg
Forked Deer R. near Dyersburg
S. Fk Forded Deer R. at Jackson
S. Fk Forked Deer R. near Henderson
M. Fk Forked Deer R. near Humboldt
Green River near Waynesboro
Harris Fk Creek near Pierce Sta.
Herb Parsons L., Fayette Co.

Humboldt L., Crockett Co.
Kentucky L., Hymphreys Co.
Kentucky L., Hardin Co.
Kentucky L., Wayne Co.
Laurel Hill L., Lawrence Co.
Barkley L., Stewart Co.
Maples Creek L., Carroll Co.
Lake Carroll, Carroll Co.
Wolf R. near Rossville
Bailey Fork Cr. near Paris
Beasin Cr., Hardin Co.
Bear Cr., Parsons
Beech R. near S. Lexington
Big Sandy R., Henry Co.
Cane Cr. near Ripley
Cane Cr., Houston Co.
Chattanooga Cr. at Chattanooga
Cherry Cr., Carroll Co.
Cypress Cr. near Selmer
Crypress Cr., Benton Co.
Kentucky L., Savannah
Kentucky L., Tenn. River M. 95.0
Trace Cr. near Denver
Harris Fk Cr., Pierce Sta.
Forked Deer R. near Dyersburg
S. Fk Forked Deer R. near Roberts Sta.
Rutherford Fk near Milan
Nonconnah Cr., Shelby Co.
Wolf R. near Rossville
Richland Cr. at Dayton
Reelfoot Ditch, Lake Co.
OBED near Crossville
Loosahatchie R., Shelby Co.
Little R., Blount Co.
Spring Cr., Weakly Co.
Cypress Cr. near Selmer
Browns Cr., Henderson Co.
Pistol Cr., Rockford
Buffalo R., Perry Co.

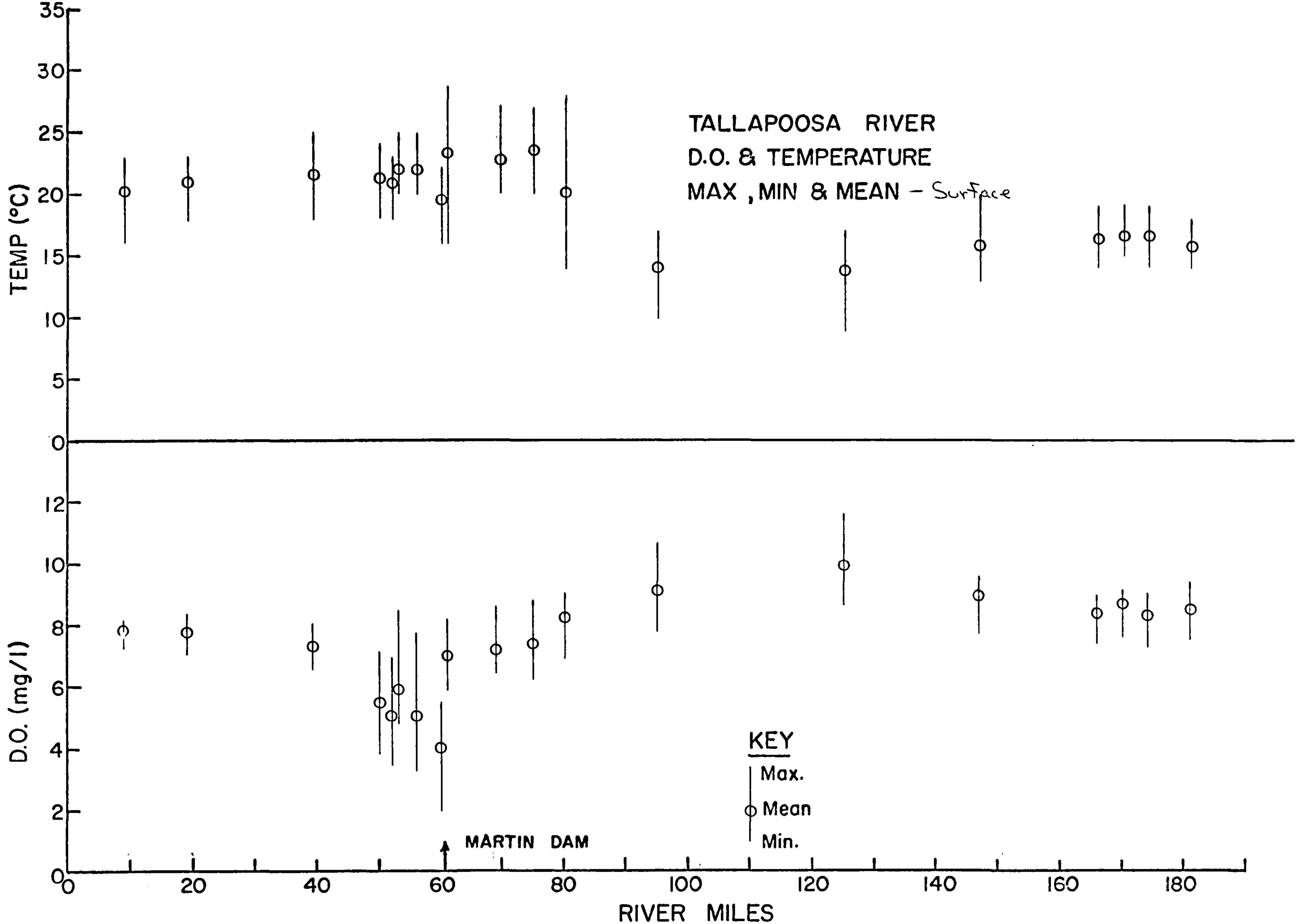
HIWASSEE RIVER BASIN

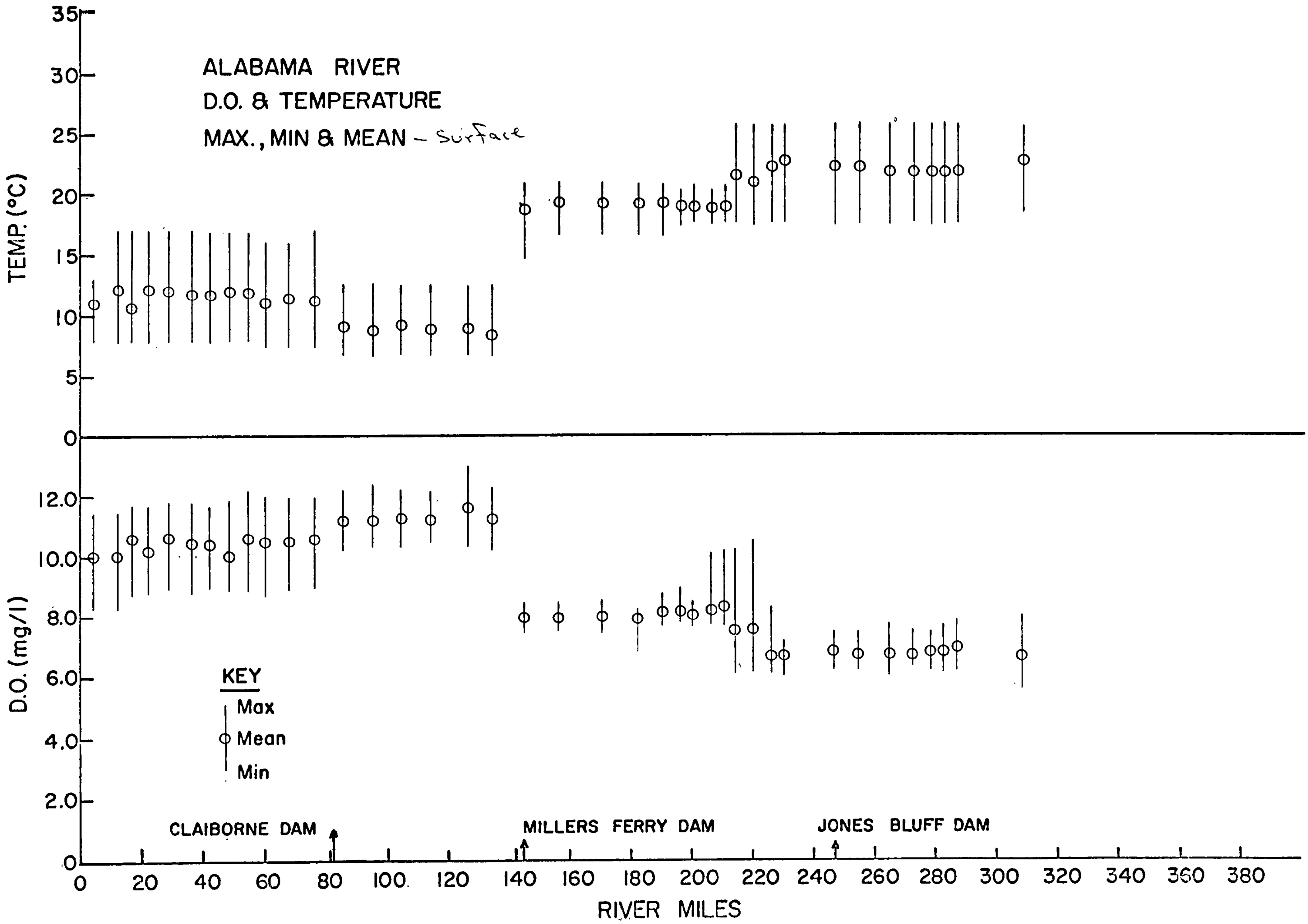
LOCATION OF TEMPERATURE INPUTS

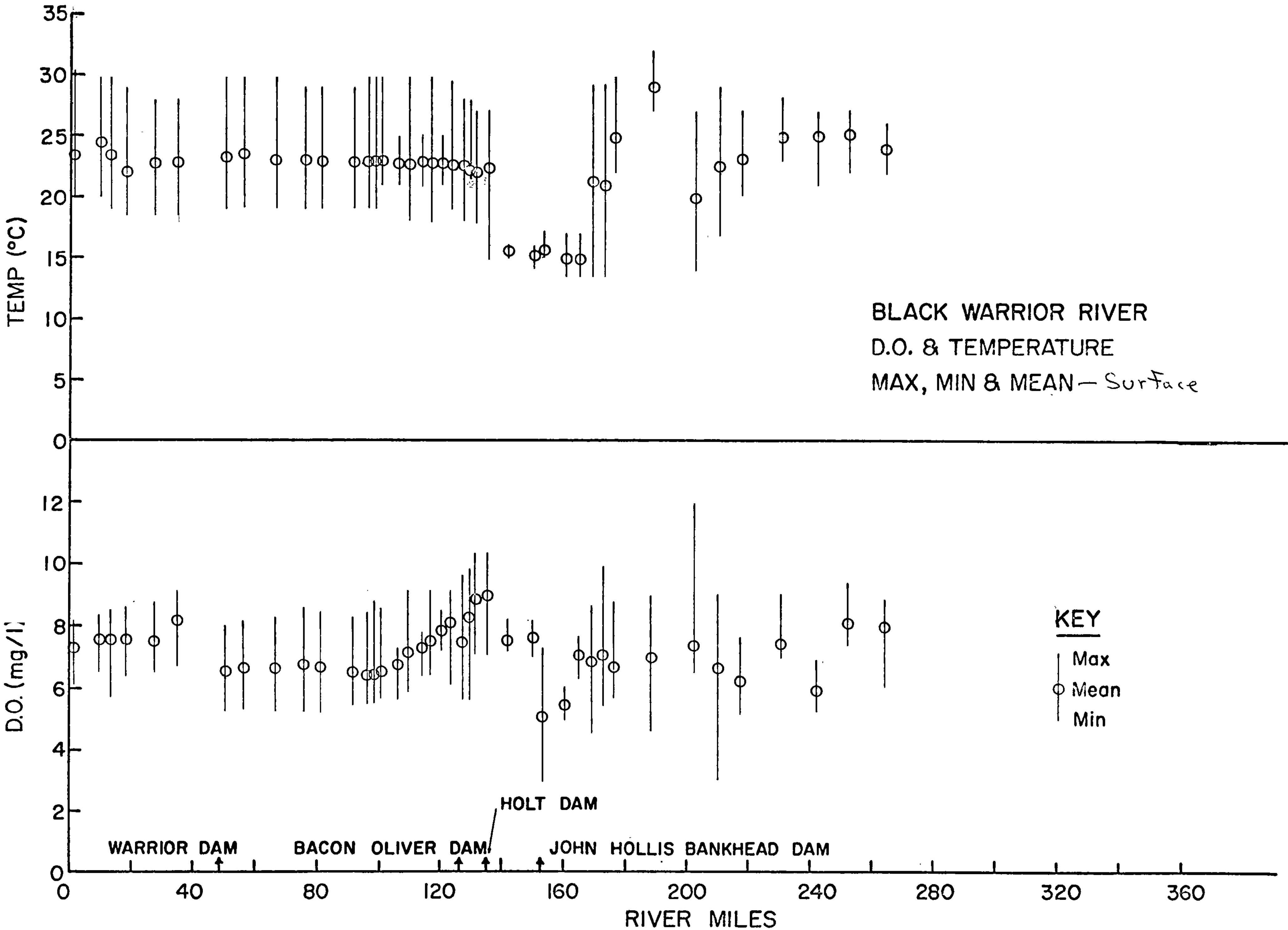
S. Mouse Cr., Bradley Co.
Ocoee R., Polk Co.
Hiwassee R. at Brittsville
Hiwassee R. at Cleveland
Hiwassee R. at Etowah
Ocoee River, Copperhill
Ocoee River at Parksville
Hiwassee River at Charleston
Hiwassee River near Witmore
Ooostanaula Cr. near Sanford
Hiwassee River near McFarland



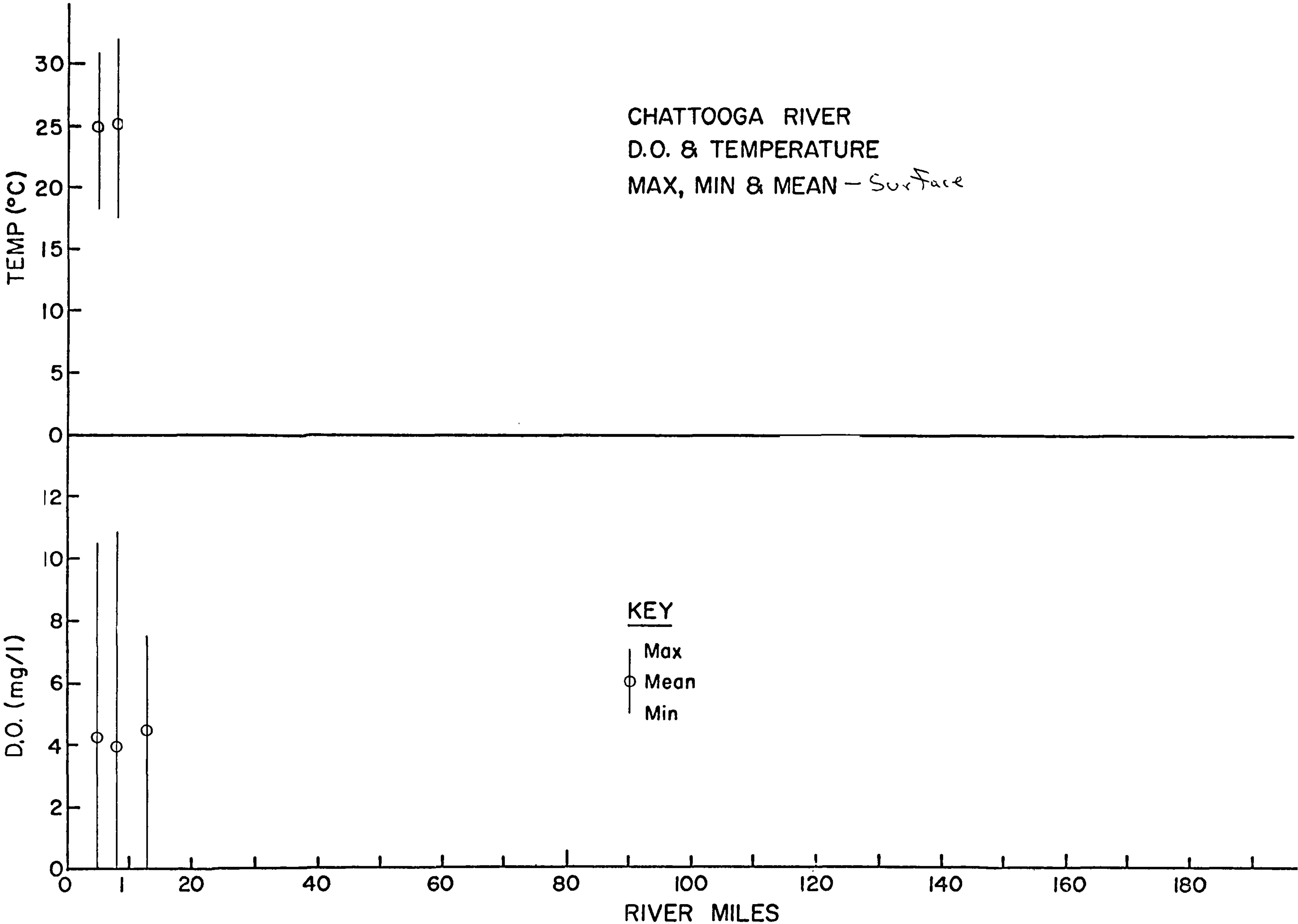
CONECUH RIVER
D.O. & TEMPERATURE
MAX, MIN & MEAN - Surface
TEMP (°C)
35
30
25
20
15
10
5
0
D.O. (mg/l)
12.0
10.0
8.0
6.0
4.0
2.0
0
KEY
Max
Mean
Min.
FLA-ALA LINE
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380
RIVER MILES


TALLAPOOSA RIVER
D.O. & TEMPERATURE
MAX , MIN & MEAN - Surface
TEMP (°C)
D.O. (mg/l)
KEY
Max.
Mean
Min.
MARTIN DAM
RIVER MILES
0
20
40
60
80
100
120
140
160
180
0
5
10
15
20
25
30
35
0
2
4
6
8
10
12

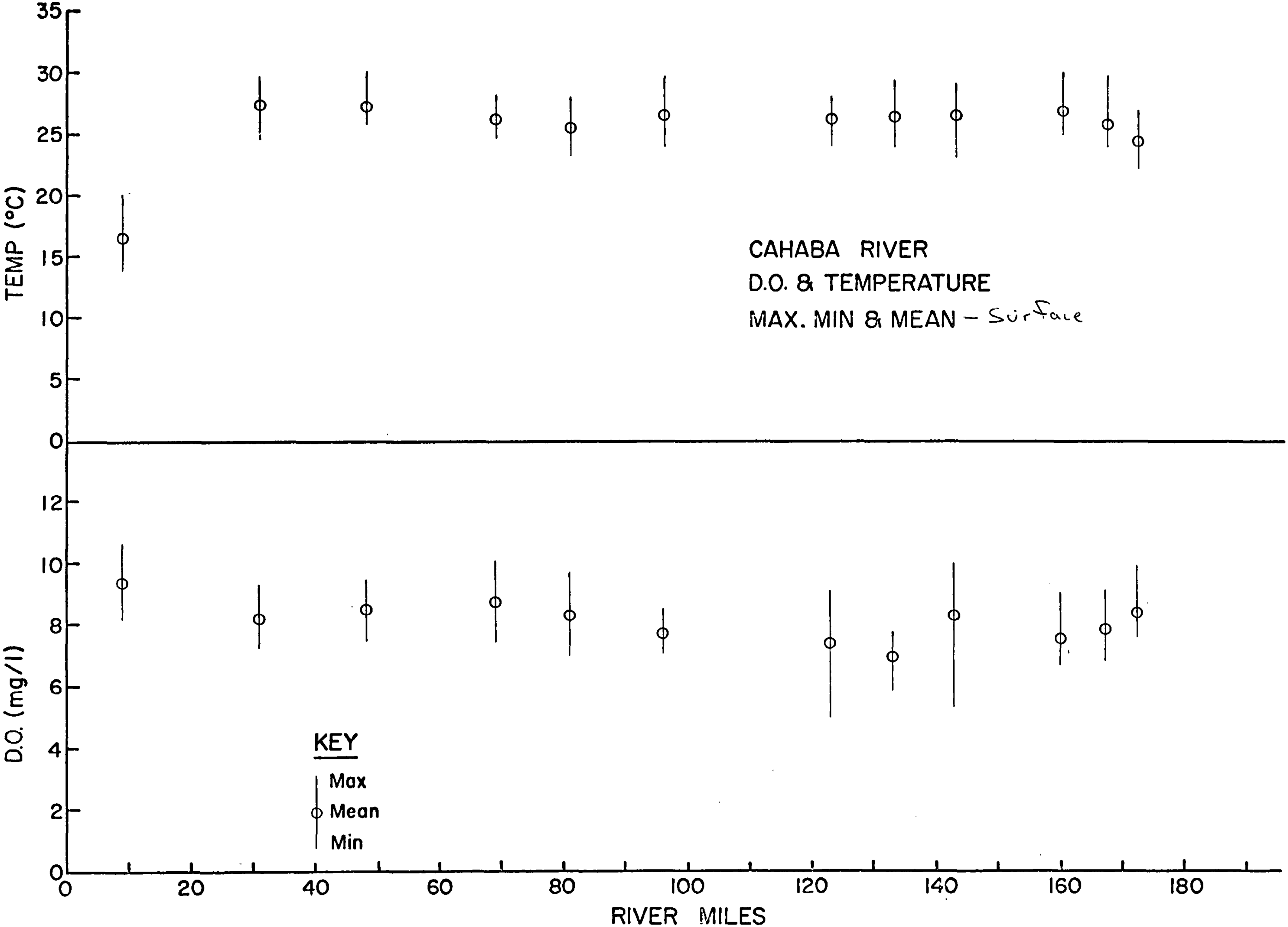

ALABAMA RIVER
D.O. & TEMPERATURE
MAX., MIN & MEAN – Surface
TEMP. (°C)
D.O. (mg/l)
KEY
Max
Mean
Min
CLAIBORNE DAM
MILLERS FERRY DAM
JONES BLUFF DAM
RIVER MILES



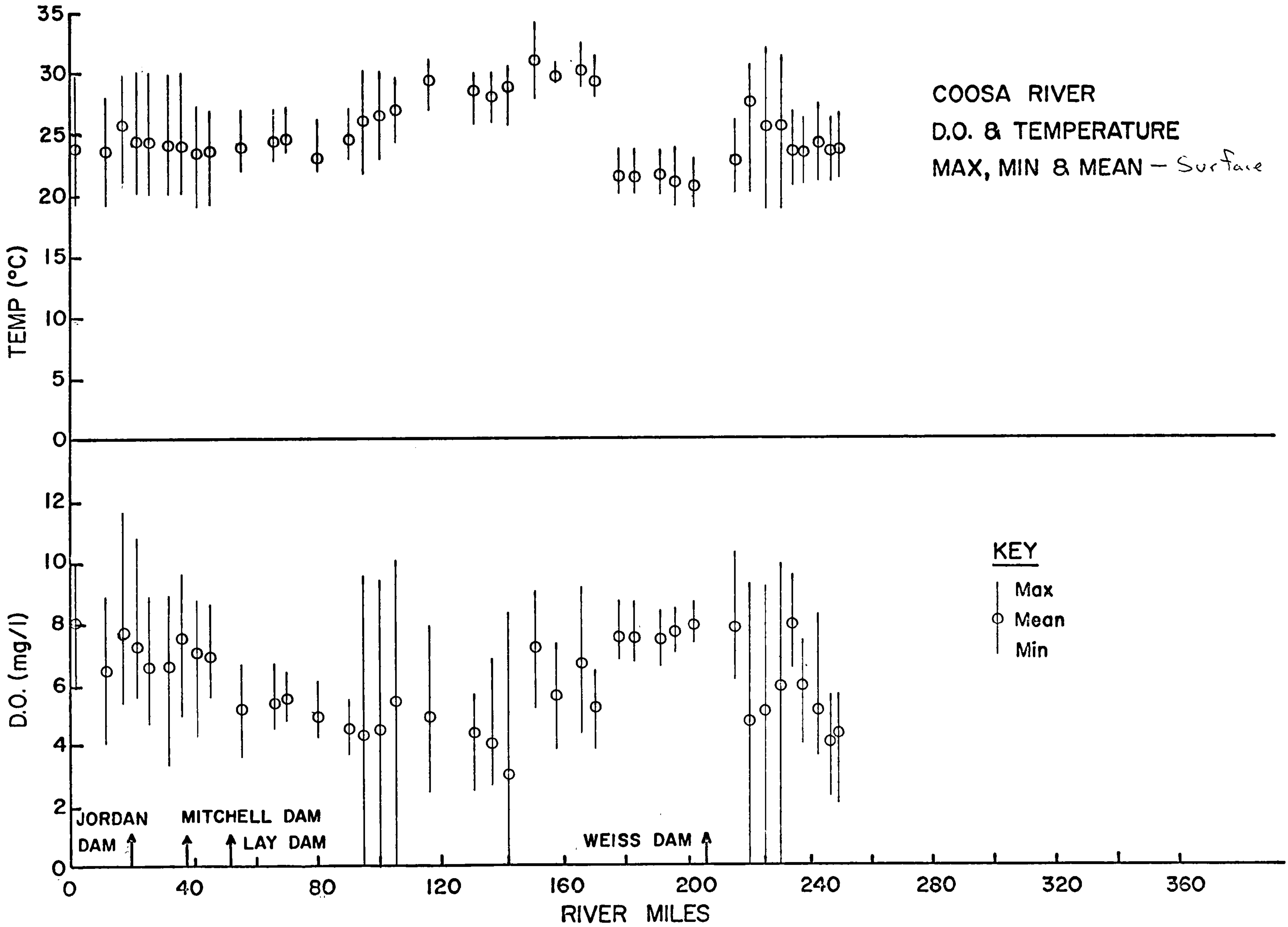
BLACK WARRIOR RIVER
D.O. & TEMPERATURE
MAX, MIN & MEAN — Surface
TEMP (°C)
D.O. (mg/l)
KEY
Max
Mean
Min
WARRIOR DAM
BACON OLIVER DAM
HOLT DAM
JOHN HOLLIS BANKHEAD DAM
RIVER MILES



CHATTOOGA RIVER
D.O. & TEMPERATURE
MAX, MIN & MEAN – Surface
TEMP (°C)
30
25
20
15
10
5
0
12
10
8
6
4
2
0
D.O. (mg/l)
KEY
Max
Mean
Min
0
1
20
40
60
80
100
120
140
160
180
RIVER MILES



CAHABA RIVER
D.O. & TEMPERATURE
MAX. MIN & MEAN – Surface
TEMP (°C)
D.O. (mg/l)
KEY
Max
Mean
Min
RIVER MILES
0
20
40
60
80
100
120
140
160
180
35
30
25
20
15
10
5
0
12
10
8
6
4
2
0



COOSA RIVER
D.O. & TEMPERATURE
MAX, MIN & MEAN — Surface
TEMP (°C)
35
30
25
20
15
10
5
0
D.O. (mg/l)
12
10
8
6
4
2
0
KEY
Max
Mean
Min
JORDAN DAM
MITCHELL DAM
LAY DAM
WEISS DAM
0
40
80
120
160
200
240
280
320
360
RIVER MILES

FLORIDA

August 11, 1970

Mr. Vincent D. Patton
Executive Director
Florida Department of Air
& Water Pollution Control
Suite 400, Tallahassee Bank Building
315 South Calhoun Street
Tallahassee, Florida 32301

Dear Mr. Patton:

As mentioned in earlier correspondence and recently with Mr. Zeller, we are transmitting with this letter an assemblage of historical temperature information for the State of Florida. This information can be used for your consideration of and for subsequent discussions with this office on changes in temperature criteria for the Florida Water Quality Standards.

A note of explanation on each of the attachments is in order. The computer printout is a summary of all the temperature records for the state. The records used were those provided by your office and by many other agencies, especially the U.S. Geological Survey who will also be provided a copy of the printout. Only naturally-occurring temperatures are summarized. The printout contains a statistical breakdown by river basin and waterbody type within a basin. River temperatures are separated from lake and reservoir, coastal from river, etc. Each basin summary is a numbered four-page section:

Page 1 - number of observations of each temperature by month.
Page 2 - percent frequency of occurrence of each temperature by month.
Page 3 - percent of time a given temperature value equalled or exceeded for a given month.
Page 4 - miscellaneous statistical data (self-explanatory).

See general file for copy of attachment

The second attachment is an analysis of daily water temperature maxima for selected continuous recording sites in the Southeast. I think that this is also self-explanatory. I should note perhaps that the column entitled "mean" is the mean of the daily maximum values for the given month and for the year in which the greatest range occurred.

If you have any questions on the temperature data, please let us know. We will be able to perform additional analyses with the data on magnetic tape should the need arise.

Sincerely yours,

John A. Little
Chief, Impoundment Studies

Enclosures - 2

cc: Mr. Howard Zeller (w/encl.)
Mr. Paul Traina

JALittle/jd 8/11/70

FLORIDA (Riv-- Basins)

°F	St. John's South of Lake George	St. John's North of Lake George	St. Mary's Nassaur	Suwanne	Ochlockonee St. Mary's	Withlacoochee	Tampa Bay Area
96							
95		1					1
94		3					-
93	3	3					-
92	1	2		1			-
91	4	8		-			2
90	12	32		-	1	1	3
89	7	29		1	-	-	2
88	32	113		5	-	1	9
87	45	108	2	7	1	6	14
TOTAL	104	299	2	14	2	8	31

°F	Kissimmee	Florida East Coastal Area	Lower Florida Area	Apalachicola	Choctawhatchee	Perdido-Escambia	Peace
96							2
95			5				1
94		1	1				-
93		-	2				2
92		1	6				-
91		-	6				2
90		3	11	1			7
89	1	2	22	1			8
88	1	3	49	1	2	5	15
87	3	4	44	1	-	7	17
TOTAL	5	14	146	4	2	12	54

FLORIDA (River Basins)

SUMMARY*

°F	Total Number of Observations	% Occurrence
96	1	.01
95	7	.04
94	2	.01
93	9	.05
92	11	.06
91	20	.12
90	81	.49
89	73	.44
88	236	1.43
87	255	1.54

* 16,536 Total Observations

4.19 Total %

695 Observations Between 87°F and 96°F

LOWER BISCAYNE BAY
DADE COUNTY, FLORIDA

Background temperatures prior to the installation of Florida Power and Lights nuclear facilities were obtained in Lower Biscayne Bay April through August 1968 (Temperature Studies, Lower Biscayne Bay, Florida, U. S. Dept. of Interior, FWPCA, Southeast Water Laboratory, October 1968). This study did not present any conclusions or suggestions but was prepared as a discussion basis among involved officials and concerned scientists. A more comprehensive report (Thermal Pollution of Intrastate Waters, Biscayne Bay, Florida, February 1970) was a follow-up report. This report on the present water quality and biological system of Biscayne Bay and Card Sound and the effect of Florida Power and Light's heated effluent on Biscayne Bay is based on previous reports, investigations of the University of Miami Institute of Marine Sciences, information and data furnished by the Florida Power and Light Company, and field investigations by the Environmental Protection Agency. Attached are the conclusions and recommendations. The Lower Florida Estuary Studies Project, Ft. Lauderdale, installed Ryan Thermographs for continuous temperature monitoring in Card Sound and Lower Biscayne Bay, August 1969. These monitors are still functional and have been interfaced to a computer for data assemblage and interpretation.

Federal agencies have performed numerous biological studies throughout the Lower Biscayne Bay and Card Sound to date. Some of these are referenced in the bibliography section.

II. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. Severe damage has occurred to the aquatic plant and animal population of Lower Biscayne Bay due to the present heated effluent from the Turkey Point plant of the Florida Power and Light Company.

2. No man-made pollution or any physical condition other than elevated temperature is present which could account for the observed biological damage in Lower Biscayne Bay.

3. Under the most conservative present operating conditions, the temperature rise of the cooling water, across the condensers, will exceed 10^{o}F at least 16% of the time.

4. The cooling water effluent discharged from Grand Canal moves in a northeasterly direction around Turkey Point. This path coincides with the zone of biological degradation.

5. The biological degradation zone covers about 670 acres of Lower Biscayne Bay as observed during the summer of 1969.

6. A wide variety of both aquatic plants and animals were killed in late June 1969. This damage to aquatic life and vegetation is directly attributable to the discharge of heated effluent from the Turkey Point facility of Florida Power and Light Company.

7. The monthly mean of the maximum daily temperatures in areas of Lower Biscayne Bay outside the influence of artificially elevated temperatures resulting from waste cooling water is 83^{o}F in June, 85.6^{o}F in July and 87.3^{o}F in August. (1968)

8. The additional operation of two nuclear powered generating units at the Turkey Point plant will increase the waste heat load by four times over that presently discharged (without proper thermal control). This increased heat load will intensify the present damage in extent, severity and frequency.

9. If waste heat from the Turkey Point facility is discharged to Card Sound, as presently proposed by the Florida Power and Light Company, temperatures in excess of 95°F can be expected in at least 35% of Card Sound, five percent of the time.

B. Recommendations

1. The Florida Power and Light Company shall abate the excessive waste heat load being discharged from its Turkey Point power plant to the levels recommended by the National Technical Advisory Committee to the Secretary of the Interior for estuarine waters. The Committee has recommended that the monthly mean of the maximum daily temperatures should not be raised more than 4°F during the fall, winter and spring (September through May) or by more than 1.5°F during the summer (June through August).

2. The Federal Water Pollution Control Administration in cooperation with the State of Florida and the Florida Power and Light Company establish a temperature monitoring program to determine compliance with the recommended temperature requirements as above.

GEORGIA

April 20, 1970

Mr. R. S. Howard, Executive Secretary
Georgia Water Quality Control Board
47 Trinity Street, S. W.
Atlanta, Georgia 30334

Dear Mr. Howard:

Two copies of various analyses of historical temperature records for the State of Georgia were forwarded to Mr. Ledbetter on April 18. An explanation of these records was also included. I would add one further note that artificially heated areas were selectively removed from the analyses.

Our Atlanta office should be in contact with you soon concerning a suitable time to discuss our studies with you in greater detail.

Sincerely yours,

John A. Little
Chief, Impoundment Studies

cc: Paul J. Traina
Howard Zeller (w/2 printouts)

JALittle:rnb 4/20/70

STATE OF GEORGIA

Geographic Regions

°F	Coastal	Piedmont	Mountain
99			
98			
97			
96			
95			
94	1		
93	3	1	
92	6	9	
91	5	8	
90	14	10	
Total	29	28	

Total records 13835

57 $\geq$ 90°F

.04% of the data $\geq$ 90°F

SELECTED TEMPERATURE EVALUATION
FOR GEORGIA WATERS

Including a Historical Temperature Review
at Three Stream Sites -
Mountain, Piedmont, Coastal
&
Stream Temperature Elevations
at Existing Steam Power Plants

Federal Water Pollution Control Administration
April 1970

HIWASSEE RIVER BASIN (Blue Ridge Zone)
Random Sampling 1949-1965 Hiwassee River, Toccoa River, Nottely River
Continuous Daily Sampling 1964 and 1965 Dail, Georgia - Toccoa River

SUMMARY OF ALL DATA

Temp. °F	% Prob. of Occurrence	% ≥	Temp. °F	% Prob. of Occurrence	% ≥
86	0.07	.07	59	2.30	50.82
85	0.07	.15	58	2.53	53.34
84			57	2.01	55.35
83			56	1.18	56.54
82	0.07	.22	55	2.97	59.51
81	0.07	.30	54	2.75	62.26
80			53	2.53	64.78
79	0.07	.37	52	2.45	67.23
78	0.22	.59	51	2.01	69.24
77	0.44	1.04	50	2.90	72.14
76	0.59	1.63	49	2.74	74.89
75	1.63	3.27	48	2.45	77.34
74	2.38	5.64	47	3.04	80.38
73	2.67	8.32	46	3.27	83.65
72	4.16	12.48	45	2.30	85.97
71	3.05	15.52	44	2.97	88.93
70	3.34	18.87	43	1.86	90.78
69	2.97	21.84	42	1.41	92.20
68	3.79	25.63	41	1.63	93.83
67	3.94	29.57	40	2.23	96.06
66	2.15	31.72	39	0.96	97.02
65	4.23	35.96	38	0.86	97.92
64	3.42	39.37	37	0.44	98.36
63	2.22	41.60	36	0.59	98.96
62	2.00	43.61	35	0.22	99.18
61	2.45	46.06	34	0.29	99.48
60	2.45	48.51	33	0.30	99.77
			32	0.15	99.97

Max. 86°F
Min. 32°F
Range 54°F
Ave. 58°F
Total # of measurements 1345

12-383

	JANUARY	%		FEBRUARY	%		MARCH	%	
	Temp. °F	Prob. of Occurrence	% ≥	Temp. °F	Prob. of Occurrence	% ≥	Temp. °F	Prob. of Occurrence	% ≥
	54	1.02	1.02	57	1.20	1.20	55	2.68	2.68
	53	2.04	3.06	56	1.20	2.40	54	4.46	7.14
	52	2.04	5.10	55	3.61	6.02	53	5.36	12.50
	51	4.08	9.18	54	1.20	7.23	52	4.46	16.96
	50	5.10	14.28	53	6.02	13.25	51	4.46	21.43
	49	2.04	16.32	52	1.20	14.45	50	8.93	30.36
	48	4.08	20.41	51	4.81	19.27	49	8.03	38.35
	47	5.10	25.51	50	1.20	20.48	48	8.93	47.32
	46	6.12	31.63	49	4.82	25.30	47	9.82	57.14
	45	12.24	43.88	48	3.61	28.91	46	11.61	68.75
	44	12.24	56.12	47	9.64	38.55	45	4.46	73.21
	43	7.14	63.26	46	9.63	48.20	44	7.14	80.35
	42	7.14	70.40	45	10.84	59.02	43	8.04	88.39
	41	4.08	74.48	44	7.22	66.26	42	0.89	89.30
	40	5.10	79.58	43			41	2.67	91.96
	39	4.08	83.67	42	4.82	71.08	40	2.68	94.64
	38	3.06	86.73	41	4.82	75.90	39	1.78	96.42
	37	2.04	88.77	40	12.05	87.94	38		
	36	3.06	91.83	39			37		
	35	2.04	93.87	38	4.82	92.76	36	0.89	97.31
	34	1.02	94.89	37	3.61	96.38	35	0.89	98.20
	33	4.08	99.00	36	2.41	98.78	34	0.89	99.10
Max.	54			57			55		
Min.	33			36			34		
Range	21			21			21		
Ave.	44			45			47		
Total # of measurements	97			82			111		

	APRIL	%		MAY	%		JUNE	%	
	Temp. °F	Prob. of Occurrence	% ≥	Temp. °F	Prob. of Occurrence	% ≥	Temp. °F	Prob. of Occurrence	% ≥
	66	1.02	1.02	81	0.92	0.92	85	1.04	1.04
	65	2.04	3.06	72	0.92	1.85	74	2.08	3.12
	64	5.10	8.16	71			73	1.04	4.17
	63	2.04	10.20	70	2.78	4.63	72	8.33	12.50
	62	1.02	11.22	69	3.70	8.33	71	5.20	17.70
	61	4.08	15.30	68	0.92	9.26	70	5.21	22.91
	60	6.12	21.42	67	7.41	16.66	69	6.25	29.16
	59	12.24	33.67	66	4.63	21.30	68	11.46	40.62
	58	9.18	42.85	65	12.96	34.25	67	12.50	53.12
	57	6.12	48.97	64	7.41	41.66	66	3.12	56.25
	56	3.06	52.04	63	8.33	49.99	65	4.17	60.41
	55	4.08	56.12	62	11.11	61.10	64	8.33	68.75
	54	7.14	63.26	61	5.56	66.66	63	5.21	73.95
	53	5.10	68.36	60	6.48	73.14	62	2.08	76.04
	52	7.14	75.50	59	3.70	76.84	61	3.12	79.16
	51	4.08	79.58	58	1.85	78.69	60	2.08	81.24
	50	3.06	82.64	57	1.85	80.54	59	2.08	83.33
	49	5.10	87.75	56	0.92	81.47	58	4.17	87.50
	48	3.06	90.81	55	2.78	84.25	57	3.12	90.62
	47	2.04	92.85	54	0.92	85.17	56		
	46	2.04	94.89	53	0.92	86.09	55	1.04	91.66
	45	1.02	95.91	52	1.85	87.95	54		
	44	3.06	98.97	51	1.85	89.80	53	1.04	92.70
				50	1.85	91.65	52		
				49	1.85	93.50	51	3.12	
				48	1.85	95.35	50	3.12	98.95
				47	0.92	96.28			
				46					
				45					
				44	0.92	97.20			
				43	0.92	98.13			
Max.	66			81			85		
Min	44			43			50		
Range	22			38			35		
Ave.	56			62			65		
Total # of measurements	97			107			95		

NATIONAL 12-383 Made in U.S.A.

	JULY			AUGUST			SEPTEMBER		
	Temp. °F	% Prob. of Occurrence	% ≥	Temp. °F	% Prob. of Occurrence	% ≥	Temp. °F	% Prob. of Occurrence	% ≥
	79	0.70	0.70	82	0.68	0.68	86	0.69	0.69
	78	0.70	1.41	78	1.40	2.05	75	2.08	2.77
	77			77	4.11	6.16	74	1.39	4.16
	76	0.70	2.11	76	4.79	10.96	73	3.47	7.63
	75	6.34	8.45	75	6.85	17.80	72	9.03	16.66
	74	12.67	21.13	74	6.85	24.65	71	9.03	25.69
	73	9.86	30.98	73	10.96	35.61	70	11.80	37.50
	72	8.45	39.43	72	14.38	49.99	69	9.72	47.22
	71	7.74	47.18	71	7.53	57.53	68	9.72	56.94
	70	4.93	52.11	70	7.53	65.06	67	9.03	65.97
	69	3.52	55.63	69	5.48	70.54	66	4.17	70.14
	68	7.04	62.67	68	8.22	78.76	65	9.72	79.86
	67	4.22	66.90	67	7.53	86.30	64	7.64	87.49
	66	4.22	71.12	66	3.42	89.72	63	2.77	90.27
	65	9.86	80.98	65	2.05	91.77	62	2.08	92.36
	64	6.34	87.32	64	1.37	93.14	61	2.08	94.44
	63	1.41	88.73	63	0.68	93.83	60	0.69	95.14
	62	2.11	90.84	62	2.05	95.88	59	2.08	97.22
	61			61			58	1.38	98.61
	60	2.11	92.95	60	2.05	97.95	57	0.69	99.30
	59			59					
	58	0.70	93.66	58	1.37	99.32			
	57	2.11	95.77						
	56	0.70	96.47						
	55								
	54	2.11	98.58						
	53								
	52								
	51	0.70	99.30						
Max.	79			82			86		
Min.	51			58			57		
Range	28			24			29		
Ave	69			71			68		
Total # of measurements	141			145			143		

NATIONAL 12-383

	OCTOBER	%		NOVEMBER	%		DECEMBER	%
	Temp. °F	Prob. of Occurrence	% ≥	Temp. °F	Prob. of Occurrence	% ≥	Temp. °F	Prob. of Occurrence	% ≥
	72	0.92	0.92	63	1.00	1.00	54	4.67	4.67
	71	0.92	1.83	62			53	4.67	9.34
	70	1.83	3.67	61			52	2.80	12.15
	69	2.75	6.42	60	2.00	3.00	51	1.87	14.02
	68	2.75	9.17	59	4.00	7.00	50	3.74	17.75
	67	2.75	11.92	58	8.00	15.00	49	5.61	23.36
	66	2.75	14.68	57	1.00	16.00	48	7.47	30.84
	65	5.50	20.18	56	5.00	21.00	47	5.61	36.44
	64	2.75	22.93	55	12.00	33.00	46	9.34	45.79
	63	5.50	28.44	54	8.00	41.00	45	2.80	48.59
	62	2.75	31.19	53	5.00	46.00	44	7.48	56.07
	61	3.67	34.86	52	5.00	51.00	43	4.67	60.74
	60	8.26	43.11	51	1.00	52.00	42	5.61	66.35
	59	5.50	48.62	50	9.00	61.00	41	7.48	73.82
	58	5.50	54.12	59	8.00	69.00	40	9.34	83.17
	57	10.09	64.21	48	3.00	72.00	39	5.61	88.78
	56	4.59	68.80	47	8.00	80.00	38	3.74	92.51
	55	9.17	77.97	46	5.00	85.00	37	0.93	93.45
	54	5.50	83.48	45	1.00	86.00	36	1.87	95.32
	53	3.67	87.15	44	2.00	88.00	35		
	52	7.34	94.48	43	3.00	91.00	34	1.87	97.18
	51	1.83	96.32	42	1.00	92.00	33		
	50	1.83	98.15	41	3.00	95.00	32	1.87	99.05
	49	0.92	99.07	40	2.00	97.00			
				39	1.00	98.00			
				38	1.00	99.00			
Max.	72			63			54		
Min.	49			38			32		
Range	23			25			22		
Ave.	59			51			44		
Total # of measurements	108			99			106		

NATIONAL 12-383

FLINT RIVER NEAR CULLODEN, GEORGIA

Time of Record: June 1960-September 1964

SUMMARY OF ALL DATA

	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥
	88	1	1	59	3	68
	87	2	2	58	3	70
	86	3	5	57	2	73
	85	2	8	56	3	76
	84	3	11	55	1	77
	83	2	13	54	1	78
	82	5	19	53	2	80
	81	4	23	52	1	81
	80	4	27	51	1	82
	79	3	30	50	1	84
	78	3	33	49	1	85
	77	2	35	48	2	87
	76	2	37	47	2	89
	75	2	39	46	1	90
	74	2	41	45	2	92
	73	2	43	44	2	94
	72	2	45	43	2	95
	71	2	48	42	2	98
	70	2	49	41	1	98
	69	2	51	40	0.5	99
	68	1	52	39	0.5	99
	67	1	53	38	0.5	100
	66	2	55	37	0.2	100
	65	1	56			
	64	1	58			
	63	2	59			
	62	1	61			
	61	2	62			
	60	2	65			
Max.	88°F					
	37°F					
Range	51°F					
Avg.	67°F					
Total # Values	1,529					

FLINT RIVER NEAR CULLODEN, GEORGIA

Time of Record: June 1960-September 1964

	January			February			March		
	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥
	55	2	2	60	1	1	64	2	2
	54	1	3	59	3	3	63	6	8
	53	2	6	58	3	7	62	1	9
	52	1	7	57	3	9	61	2	11
	51	4	11	56	11	21	60	14	25
	50	4	15	55	3	23	59	15	40
	49	6	20	54	2	25	58	14	53
	48	7	28	53	3	28	57	9	62
	47	6	34	52	1	29	56	8	70
	46	6	39	51	4	34	55	2	73
	45	7	46	50	3	37	54	3	76
	44	12	58	49	1	38	53	7	83
	43	7	65	48	8	46	52	5	88
	42	17	82	47	17	63	51	3	91
	41	5	87	46	6	69	50	2	93
	40	3	90	45	7	76	49	3	95
	39	2	92	44	9	85	48	2	98
	38	6	98	43	9	93	47	2	99
	37	2	100	42	4	97	46	1	100
				41	3	100			
Max.	55°F			60°F			64°F		
Min.	37°F			41°F			46°F		
Range	18°F			19°F			18°F		
Avg.	45°F			49°F			57°F		
Total # of Values	122			116			124		

FLINT RIVER NEAR CULLODEN, GEORGIA

Time of Record: June 1960-September 1964

	April			May			June		
	T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥
	71	8	8	82	7	7	86	1	1
	70	3	11	81	3	10	85	4	4
	69	4	15	80	2	13	84	11	15
	68	3	18	79	2	15	83	7	22
	67	4	22	78	3	19	82	17	39
	66	12	35	77	6	24	81	12	51
	65	7	42	76	8	32	80	8	59
	64	8	50	75	4	37	79	8	67
	63	3	53	74	8	45	78	4	70
	62	9	62	73	4	49	77	1	72
	61	8	70	72	6	56	76	4	76
	60	7	77	71	11	70	75	6	82
	59	12	88	70	6	73	74	4	86
	58	5	93	69	5	77	73	5	91
	57	3	97	68	2	79	72	4	95
	56	3	100	67	4	83	71	4	99
				66	2	85	70	1	100
				65	7	92			
				64	2	94			
				63	3	97			
				62	2	99			
				61	1	100			
Max.	71^oF			82^oF			86^oF		
Min.	56^oF			61^oF			70^oF		
Range	15^oF			21^oF			16^oF		
Avg.	63^oF			73^oF			79^oF		
Total # es	120			124			142		

Time of Recrod: June 1960-September 1964

	July			August			September		
	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥
	88	3	3	88	3	3	87	4	4
	87	7	10	87	8	10	86	7	11
	86	8	18	86	12	22	85	3	14
	85	10	28	85	9	31	84	6	20
	84	8	36	84	11	42	83	7	27
	83	7	43	83	4	46	82	7	35
	82	9	52	82	13	59	81	7	42
	81	7	59	81	13	72	80	16	58
	80	5	63	80	13	85	79	6	64
	79	13	76	79	6	91	78	5	69
	78	11	87	78	4	95	77	5	74
	77	4	91	77	1	96	76	6	80
	76	4	95	76	1	96	75	2	82
	75	4	99	75	2	98	74	6	88
	74	--	--	74	--	--	73	2	90
	73	1	100	73	1	99	72	7	97
				72	1	99	71	--	--
				71	1	100	70	2	99
							69	1	100
Max.	88°F			88°F			87°F		
Min.	73°F			70°F			69°F		
Range	15°F			18°F			18°F		
Avg.	81°F			82°F			80°F		
Total # Values	150			160			136		

FLINT RIVER NEAR CULLODEN, GEORGIA

Time of Record: June 1960-September 1964

	October			November			December		
	T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥
	81	1	1	71	3	3	57	2	2
	80	2	2	70	1	3	56	2	4
	79	1	3	69	2	5	55	--	--
	78	3	6	68	2	7	54	1	5
	77	6	13	67	--	--	53	8	13
	76	2	15	66	2	8	52	8	21
	75	2	17	65	--	--	51	5	26
	74	1	18	64	1	9	50	9	35
	73	12	30	63	2	11	49	5	40
	72	6	36	62	2	13	48	8	48
	71	4	40	61	5	18	47	4	52
	70	10	50	60	8	25	46	5	58
	69	10	60	59	10	35	45	8	65
	68	4	64	58	11	46	44	3	68
	67	8	72	57	10	56	43	8	76
	66	7	78	56	17	73	42	11	87
	65	--	--	55	6	79	41	3	90
	64	5	83	54	9	88	40	3	93
	63	8	91	53	6	94	39	5	99
	62	3	94	52	2	97	38	1	100
	61	3	98	51	2	98			
	60	2	100	50	2	100			
Max.	81^oF			71^oF			57^oF		
Min.	60^oF			50^oF			38^oF		
Range	21^oF			21^oF			19^oF		
Avg.	70^oF			58^oF			47^oF		
Total # Values	124			119			92		

NATIONAL
12 383

ALAPAHA RIVER - SUWANNEE BASIN (SOUTHEAST GEORGIA)

Time of Record: March 1953-July 1957
July 1958-September 1960
January 1968-December 1968

SUMMARY OF ALL DATA

T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥
91	0.05	0.05	64	3	65
90	0.2	0.2	63	2	66
89	0.1	0.4	62	2	69
88	0.2	0.6	61	1	70
87	1	2	60	3	73
86	1	3	59	2	75
85	2	5	58	2	78
84	2	7	57	2	80
83	2	10	56	2	82
82	5	14	55	2	84
81	5	20	54	2	86
80	6	25	53	1	87
79	4	29	52	2	89
78	3	33	51	2	91
77	3	36	50	2	93
76	3	39	49	2	95
75	2	41	48	1	96
74	2	43	47	1	97
73	2	45	46	1	98
72	3	48	45	1	99
71	1	49	44	0.3	99.5
70	3	51	43	0.2	99.6
69	2	53	42	0.1	99.7
68	2	55	41	0.1	99.8
67	2	58			
66	2	59			
65	2	61			

Max.	91
Min.	41
ge	50
Avg.	69
Total # Values	2410

NATIONAL
12-383

ALAPAHA RIVER - SUWANNEE BASIN (SOUTH GEORGIA)

Time of Record: March 1953-July 1957
July 1958-September 1960
January 1968-December 1968

	January			February			March		
	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥
	64	1	1	68	2	2	74	2	2
	63	--	--	67	1	3	73	0.5	2
	62	1	2	66	4	6	72	1	3
	61	1	3	65	3	9	71	0.5	4
	60	1	4	64	4	13	70	0.5	4
	59	3	7	63	2	15	69	3	8
	58	4	12	62	2	17	68	2	10
	57	7	18	61	4	21	67	2	13
	56	4	23	60	8	29	66	1	14
	55	5	27	59	8	36	65	4	19
	54	7	34	58	7	44	64	7	26
	53	4	38	57	5	49	63	7	33
	52	6	44	56	12	61	62	5	38
	51	9	53	55	7	68	61	4	42
	50	12	65	54	6	74	60	6	48
	49	6	70	53	4	78	59	9	57
	48	6	76	52	3	81	57	6	63
	47	4	80	51	4	84	57	4	67
	46	7	88	50	3	87	56	5	72
	45	7	95	49	5	97	55	8	80
	44	2	97	48	3	95	54	3	83
	43	1	98	47	1	96	53	3	86
	42	0.5	99	46	1	98	52	4	90
	41	1	100	45	1	99	51	2	92
				44	1	100	50	2	95
							49	2	97
							48	1	98
							47	1	100
Max.	64°F			68°F			74°F		
Min.	41°F			44°F			47°F		
..ge	23°F			24°F			27°F		
Avg.	51°F			57°F			60°F		
Total # Values	216			139			204		

NATIONAL 12-383

ALAPAHA RIVER - SUWANNEE BASIN (SOUTH GEORGIA)

Time of Record: March 1953-July 1957
July 1958-September 1960
January 1968-December 1968

	April			May			June		
	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥
	77	1	1	82	3	3	91	0.5	0.5
	76	0.5	1	81	4	7	90	1	1
	75	--	--	80	3	9			
	74	3	4	79	5	14	88	1	3
	73	4	9	78	4	18	87	4	7
	72	10	18	77	8	25	86	1	8
	71	4	23	76	11	36	85	6	14
	70	12	35	75	10	45	84	4	18
	69	7	42	74	11	56	83	3	21
	68	6	48	73	10	66	82	9	31
	67	6	53	72	13	78	81	10	41
	66	7	60	71	6	84	80	11	52
	65	7	67	70	7	91	79	10	63
	64	13	81	69	3	94	78	9	71
	63	7	88	68	2	95	77	10	81
	62	8	96	67	2	97	76	10	90
	61	2	97	66	1	98	75	6	96
	60	1	98	65	1	99	74	2	98
	59	1	99				73	1	99
	58	0.5	100				72	0.5	100
Max.	77°F			82°F			91°F		
Min.	58°F			65°F			72°F		
Range	19°F			17°F			19°F		
Avg.	67°F			74°F			80°F		
Total # Values	221			198			210		

ALAPAHA RIVER - SUWANNEE BASIN (SOUTH GEORGIA)

Time of Record: March 1953-July 1957
July 1958-September 1960
January 1968-December 1968

	July			August			September		
	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥	T°F	% Prob. of Occur.	% ≥
	90	1	1	89	0.05	0.05	87	0.05	0.05
	89	1	2	88	0.05	1	86	2	3
	88	1	3	87	4	5	85	2	5
	87	5	8	86	4	9	84	6	12
	86	4	13	85	3	12	83	4	16
	85	9	22	84	7	19	82	6	22
	84	5	27	83	11	30	81	13	36
	83	6	33	82	18	48	80	13	49
	82	13	47	81	15	63	79	11	60
	81	15	62	80	15	78	78	11	71
	80	19	81	79	9	87	77	10	81
	79	8	89	78	3	90	76	4	86
	78	7	96	77	3	92	75	5	91
	77	3	100	76	1	94	74	3	94
				75	1	94	73	1	95
				74	2	97	72	2	97
				73	1	98	71	0.5	98
				72	1	99	70	--	--
				71	0.5	99	69	1	99
				70	0.05	100	68	1	100
Max.	90			89			87		
Min.	77			70			68		
Range	13			19			19		
Avg.	82			81			79		
Total # Values	239			243			200		

NATIONAL
12-383

ALAPAHA RIVER - SUWANNEE BASIN (SOUTH GEORGIA)

Time of Record: March 1953-July 1957
July 1958-September 1960
January 1968-December 1968

	October			November			December		
	T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥	T^oF	% Prob. of Occur.	% ≥
	86	0.5	0.5	69	1	1	64	3	3
	85	0.5	1	68	1	2	63	1	4
	84	0.5	2	67	6	8	62	3	6
	83	--	--	66	6	14	61	2	8
	82	0.5	2	65	6	20	60	3	11
	81	1	3	64	5	25	59	4	15
	80	--	--	63	2	27	58	7	22
	79	2	5	62	10	37	57	6	28
	78	5	10	61	5	42	56	4	32
	77	4	14	60	15	57	55	5	37
	76	6	20	59	8	65	54	6	43
	75	4	23	58	6	71	53	5	48
	74	1	24	57	6	77	52	6	54
	73	5	29	56	3	80	51	6	60
	72	7	36	55	4	84	50	11	71
	71	4	40	54	2	86	49	8	79
	70	10	50	53	3	88	48	7	86
	69	5	55	52	2	91	47	4	90
	68	6	61	51	3	94	46	4	94
	67	7	68	50	1	95	45	2	96
	66	12	80	49	1	97	44	1	97
	65	7	87	48	1	97	43	1	98
	64	6	93	47	2	100	42	1	99
	63	3	95				41	1	100
	62	1	96						
	61	1	97						
	60	1	98						
	59	2	100						
Max.	86^oF			69^oF			64^oF		
Min.	59^oF			47^oF			41^oF		
Range	25^oF			22^oF			23^oF		
Avg.	70^oF			60^oF			53^oF		
Total # Values	193			172			188		

EFFECTS OF STEAM POWER PLANTS IN GEORGIA ON STREAM TEMPERATURE INCREASE

As part of an overall evaluation of thermal pollution problems in the FWPCA, Southeast Region, stream temperature increases at several thermal power plant sites were studied. Water temperature data used for the study were obtained chiefly from the FWPCA's Southeast Comprehensive Water Quality Management Project (SECWQMP), which conducted field investigations in the middle and late 1960's. Power plant records and results of special FWPCA studies (also for middle and late 1960's) were also reviewed.

In Georgia, plant sites examined where cooling waters are discharged to streams were:

Plant	MW Capacity (as of June 1965)	Stream Location	Approximate Avg. Streamflow (from USGS records) (cfs)
Arkwright	181.3	Ocmulgee River at Macon, Ga.	2700
Atkinson	258.0	Chattahoochee River at Atlanta, Ga.	2500 (subject to upstream regulation)
McDonough	598.4		
Hammond	375.0	Coosa River at Rome, Ga.	6600 (subject to upstream regulation)
Mitchell	218.3	Flint River at Albany, Ga.	6300 (minor regulation effects)
Yates	680.0	Chattahoochee River in north Coweta Co., Georgia	3850 (some regulation)

Plant Arkwright

This steam plant is one of the smallest in the Georgia Power Company system. Plant records furnished by Georgia Power indicate that the degree rise of cooling water passing across the condensers is normally in the 10°F range, but has on occasion been as high as 19°F.

Temperature records for the Ocmulgee River upstream from the plant are poor, the closest SECWQMP sampling station (#126260) being 33 stream miles above the plant. Two water quality data stations were located immediately downstream from Plant Arkwright and above the influence of waste discharges from the Macon area. One of these stations was located one mile (#126210) and the other six miles (#126205) downstream from Arkwright.

Data available for the months of May and June 1967 indicated little effect of cooling water discharges on temperature increase in the Ocmulgee River. A 5°F difference between stations 126260 and 126210 was observed on May 29, 1967, but usually there was no significant temperature increase recorded. Temperatures up to 75°F were recorded below Arkwright during May and June.

Plants Atkinson and McDonough

These two plants are located near each other in the Atlanta area. Wastes from the large Clayton sewage treatment plant enter the Chattahoochee River immediately upstream from Plant Atkinson. At Atkinson, the temperature increase across the steam condenser averages approximately 20°F, but may rise as much as 35°F at times. No records were available for Plant McDonough. Cool waters released from Lake Lanier above Atlanta are beneficial to thermal power production.

Water quality records for the Chattahoochee River are available for SECWQMP stations 122600 (four miles above Atkinson), 122460 (1½ miles below Atkinson), 122400 (6½ miles below Atkinson), and 122300 (14 miles below Atkinson). More temperature data are available for the downstream stations than for station 122600. The effect of flow regulation at Buford and Morgan Falls Dams above Atlanta and of the waste discharge from the Clayton treatment plant interferes to an extent with temperature increase evaluations.

The best interpretation of available data for May, June and July 1965 indicates that the two power plants cause a temperature increase in the Chattahoochee River consistently in the $10^{o}F$ range. The increased temperature is maintained at high levels for more than 10 miles below the power plant sites. The maximum recorded temperature at station 122400 for the period was $81^{o}F$.

Plant Hammond

This steam plant is situated about five miles downstream from Rome, Georgia, on the Coosa River. Treated effluent from the Rome Kraft paper mill enters the river immediately above Plant Hammond. The temperature increase across the condensers is recorded in power plant records as from 12^{o} to $16^{o}F$. Average flow of the Coosa River at the plant site is a sizeable 6600 cfs but is subject to some regulation from Allatoona Dam on the Etowah River tributary. A diffuser is used to return heated cooling water to the river.

The SECWQMP stations 120110 (1½ miles above Hammond and Rome Kraft), 120105 (1½ miles below Hammond), and 120100 (5½ miles below Hammond) were used to evaluate temperature data. Special studies conducted by FWPCA in August 1967 were made to determine the efficiency of the diffuser, and results of this study were also reviewed.

The SECWQMP data showed that average overall surface temperature for the same days in August and September 1966 was 4°F warmer at Station 120100 than at station 120110. Some effect of paper mill wastes should be considered. Maximum recorded surface temperature at station 120100 was 81°F.

The special diffuser study of 1967 showed that cooling water discharges from Plant Hammond caused a 2°F rise in river temperature in the immediate area of the diffuser. This rise did not persist for a great distance downstream.

Plant Mitchell

Large amounts of cool water from a large spring (Radium Springs) enters the Flint River upstream from Plant Mitchell. The plant itself is relatively small in comparison to streamflow available for heated cooling water dilution. Consequently, there is little if any effect of the plant on temperature increase.

Data from SECWQMP stations 123560 (one mile above Mitchell), 123540 (one mile below Mitchell), and 123520 (eight miles downstream of Mitchell) were reviewed for the months of June and July 1967. On most days, termperatures were the same above and below the plant. On July 20, 1967, a maximum was recorded for the period. This maximum was the same at stations 123560 and 123520, 82°F.

No degree rise, across-condenser data were available.

Plant Yates

This is one of the largest steam plants in the Georgia Power system, 680.0 MW in June 1965. Plant Yates is located on the Chattahoochee River some 50 stream miles below Atlanta. Plant records show that temperature increases across the steam condensers normally range from 15 to 20°F but may be as much as 30°F at times.

Stations 122000 (one mile above Plant Yates) and 121996 (13 miles below Plant Yates) were reviewed for temperature differences. No stations were located closer to Plant Yates than 121996.

Temperature differences during September 1965 were frequently in the 5°F range and on September 9, 1965, was 9°F. It is suspected that cooling water effects on river temperatures closer to the power plant are more severe than at station 121996. The maximum recorded temperature at 121996 was 81°F.

Plant Harlee Branch

Some information on this plant's effects on temperature increases in Lake Sinclair is available but was not included in this review. The plant has recently undergone expansion and is now the largest in the Georgia Power Company system. A new evaluation of existence of a thermal pollution problem needs to be made.

Summary

The effect of cooling water discharges on temperature increase in streams was evaluated at six thermal power plant sites in Georgia Waste discharges from nearby sources in two areas, Atlanta and Rome, interferred with the temperature increase review to a minor extent.

Highest temperature increases were observed below Plant Yates and Plants Atkinson and McDonough. Data indicated that the latter two plants increase Chattahoochee River temperatures consistently as much as 10°F and this increase persists several miles downstream. The closest data station to Plant Yates was 13 miles downstream. Even at this point a temperature increase of 5°F normally and 9°F on occasion was recorded.

At Plants Mitchell and Arkwright, the temperature data indicated insignificant effects of cooling water discharges. This was especially true at the former plant site. Plant capacity in relation to stream size obviously was related to the minimal thermal effects.

Plant Hammond near Rome, Georgia has installed a diffuser to reduce localization of stream temperature increase in the Coosa River. The effect of the diffuser has been to maintain surface temperature increases at about 2°F for the entire river cross-section at the discharge point.

Data used for this temperature review were generally representative of the warmer months, spring in some cases, summer and/or fall in others. In most cases, the temperature data obtained were incidental to other water quality studies and were not obtained specifically to document possible thermal pollution.

As thermal power production increases in Georgia, the potential for thermal pollution will also increase unless remedial measures are taken.

An Instance of Thermal Pollution and the Effect on Temperature And Oxygen Levels in a Middle Georgia Reservoir[1]

By

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Presented at the Twenty-Fourth Annual Conference
Southeastern Association of Game and Fish Commissioners
Atlanta, Georgia, September, 1970

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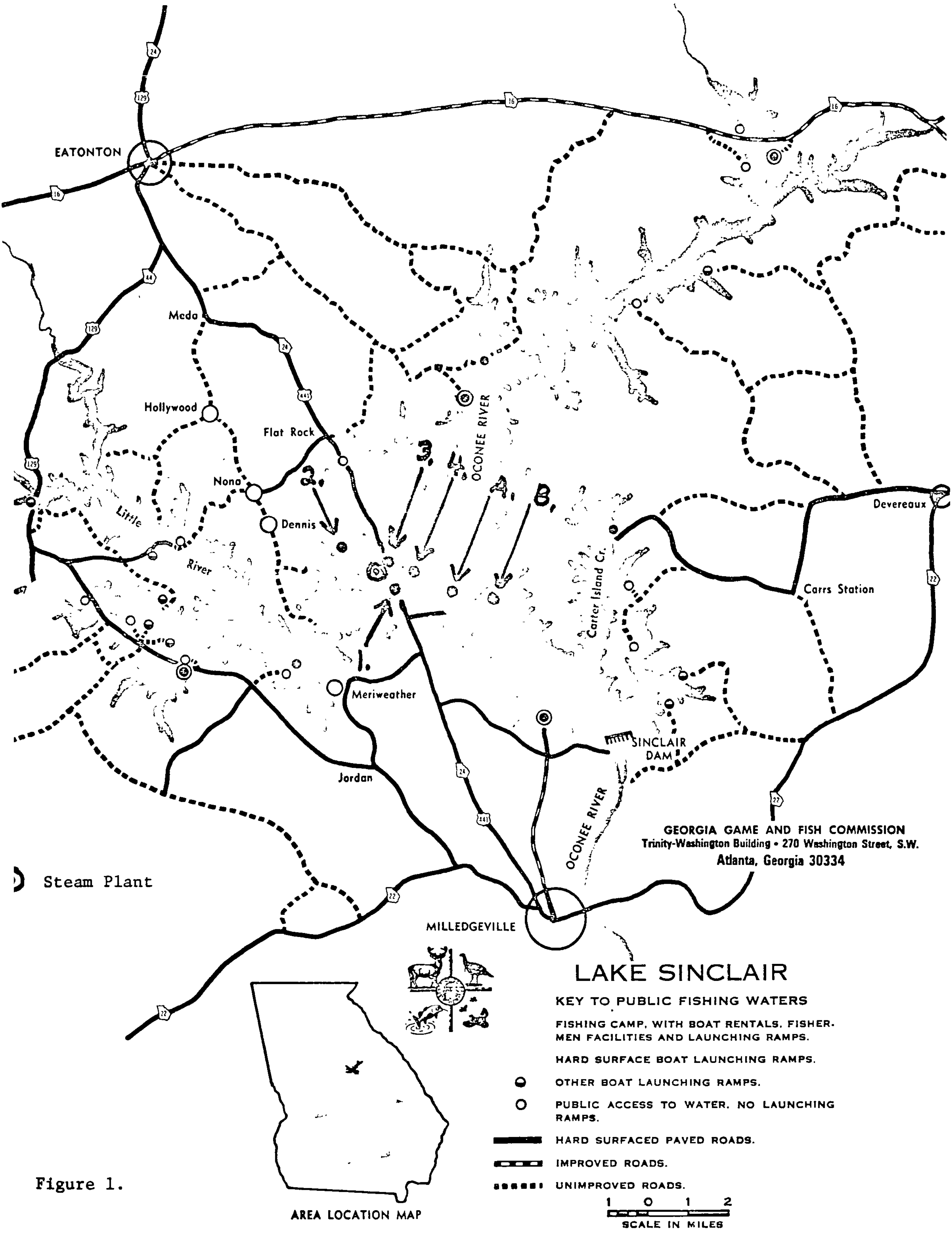
EATONTON
Meda
Hollywood
Flat Rock
Nona
Dennis
Little River
OCONEE RIVER
Carter Island Cr.
Devereaux
Carrs Station
Meriweather
SINCLAIR DAM
Jordan
OCONEE RIVER
MILLEDGEVILLE
GEORGIA GAME AND FISH COMMISSION
Trinity-Washington Building • 270 Washington Street, S.W.
Atlanta, Georgia 30334
Steam Plant
1.
2.
3.
4.
A.
B.
LAKE SINCLAIR
KEY TO PUBLIC FISHING WATERS
FISHING CAMP, WITH BOAT RENTALS, FISHERMEN FACILITIES AND LAUNCHING RAMPS.
HARD SURFACE BOAT LAUNCHING RAMPS.
OTHER BOAT LAUNCHING RAMPS.
PUBLIC ACCESS TO WATER, NO LAUNCHING RAMPS.
HARD SURFACED PAVED ROADS.
IMPROVED ROADS.
UNIMPROVED ROADS.
1 0 1 2
SCALE IN MILES
AREA LOCATION MAP

Figure 1.

collected during 1970 in June and July at this location. The maximum depth recorded at this station was 50 feet. During June and July, a thermocline was present at a depth of 25 feet. In July, water temperatures ranged from 91.4 F at the surface to 75.2 F on the bottom. Dissolved oxygen concentrations ranged from 5.2 ppm on the surface to 2.0 ppm at a depth of 25 feet during the same period. A 25 foot column of oxygen devoid water was present below the 25 foot level in July.

Figures 2, 3, 4, 5, 6 and 7 further summarize oxygen and temperature data collected at Lake Sinclair during this study.

Discussion and Conclusions

In comparing data collected in the Little River arm of Lake Sinclair with that recorded at the Beaverdam Creek stations, it is very evident that the aquatic environment has been drastically altered in Beaverdam Creek due to effluent from Plant Harllee Branch. Water of normal temperature and oxygen content is pumped from Little River, utilized as a coolant during steam plant operation, and discharged in large volumes into Beaverdam Creek in a hot, highly oxygenated state.[2] As a result the Beaverdam Creek arm of Lake Sinclair may now be considered a flowing stream. As estimated flow rate of 3 mph was observed at Station No. 3.

Average surface temperatures have exhibited a general increase since 1969 in Beaverdam Creek (See Figure 4). Water temperatures now average 15.8

2. Steam plant personnel can offer no explanation for this increase in dissolved oxygen.

degrees above normal in the vicinity of the steam plant. Temperatures as high as 25 degrees above normal have been recorded at Station No. 3. A high of 111.2 F was recorded during June, 1970 at Station No. 3. Surface temperatures during January in Beaverdam Creek now range from 59 F to 65 F (see Figure 5). In contrast, surface temperatures for Little River during the same period ranged from 45 F to 52 F. It should be noted that data collected during January, 1966 (see Figure 5) was during a period when the steam plant was not in operation for five days. Therefore, temperatures and dissolved oxygen were not influenced by steam plant effluent. Since the influence of hot water discharge was absent during this period, and temperatures and oxygen concentrations were comparable at all survey stations, it may be assumed that data recorded in Beaver Dam Creek during January 1966 reflects normal conditions for this area. Surface temperatures during August in Beaverdam Creek now range 90 F to 100 F, while surface temperatures in Little River range from 82 F to 86 F during this period. (see Figure 6).

Dissolved oxygen remains high throughout the year in Beaverdam Creek (see Figure 3). This has resulted from the continual discharge of water supersaturated with oxygen from the steam plant. Thus, the normal inverse relationship of temperature and oxygen is minimized or absent in Beaverdam Creek. For example, dissolved oxygen as high as 13.2 ppm at a temperature of 104 F in June, 1969 at Station No. 3 was recorded. The average dissolved oxygen was always higher at Beaverdam Creek stations than at Little River with the exception of January and February. During these months, temperatures were from 42 F to 45 F in Little River and a natural oxygen build-up occurred bringing oxygen levels above that in Beaverdam Creek for a short period.

Further analysis of data collected during this study reveals that approximately 3 percent of Lake Sinclair or approximately 470 surface acres are affected by hot, highly oxygenated water discharged by Plant Harllee Branch. The influence of this hot water discharge was found to extend 2.3 miles eastward from Station No. 3, beyond the mouth of Beaverdam Creek into the Oconee River arm of Lake Sinclair (see Figures 1 and 7). Both surface temperature and dissolved oxygen decreased sharply from Station No. 3 to Station No. 4, 1.1 miles due east. At this point, the surface temperature, during July, 1970 exhibited a decrease from 102.2 F to 95 degrees. Between these same stations during the above period, the oxygen concentration decreased from 5.6 ppm to a low of 4.4 at the surface. Surface temperatures continue to decrease for six tenths of a mile to Station A. Beyond this point, the temperature leveled off, at 91.4 degrees at Station B which is near the normal surface temperature (90.5 F) in Little River on this date. As water temperatures cooled between Station 4 and Station A, surface dissolved oxygen gradually increased to 5.2 ppm at Station B during the above period.

The increased water temperature and flow in Beaverdam Creek has resulted in a good winter fishery in this area. Creel census data and personal observations indicate a definite increase in catch of bass, crappie and white bass during winter months. Fish are attracted to this area during the winter by water temperatures ranging from 59 F to 71 F, while water temperatures in unaffected areas of Lake

Sinclair seldom rise above 45 F during the winter months. In addition, the current resulting from the large volume of water discharged at the steam plant into Beaverdam Creek encourages the upstream migration of fish into this arm of Lake Sinclair. However, in June, July and August, it has become apparent that fish move out of the Beaverdam Creek vicinity due to high water temperatures. During the summer months, water temperatures now remain above 90 F in Beaverdam Creek (see Figure 6) which is above the temperature tolerance of most warm water species.

He is speculating

Since the Beaverdam Creek arm of Lake Sinclair has been changed from a warm water reservoir habitat to a hot, highly oxygenated flowing stream it is obvious that these environmental conditions must affect aquatic organisms in this area. For example, increased spawning activity may be occurring and productivity of bottom organisms and plankton could also be altered. Certainly the increase in temperature and oxygen in this area has some effect on the bottom oxygen demand. There is also the possibility that the warm oxygenated water now present may serve as a reservoir for disease and parasite organisms which may over-winter in this area and increase in population, resulting in heavy infestation to the fish population at some later date. Since instances of thermal pollution will become more frequent due to the increase in demand for electric power and an increase in use of atomic power by industry, the author is of the opinion that further studies should be conducted to determine the effects of heated discharges on the aquatic ecosystem.

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