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QUALITY OF SURFACE WATER IN THE SUWANNEE RIVER BASIN, FLORIDA, AUGUST 1968 THROUGH DECEMBER 1977

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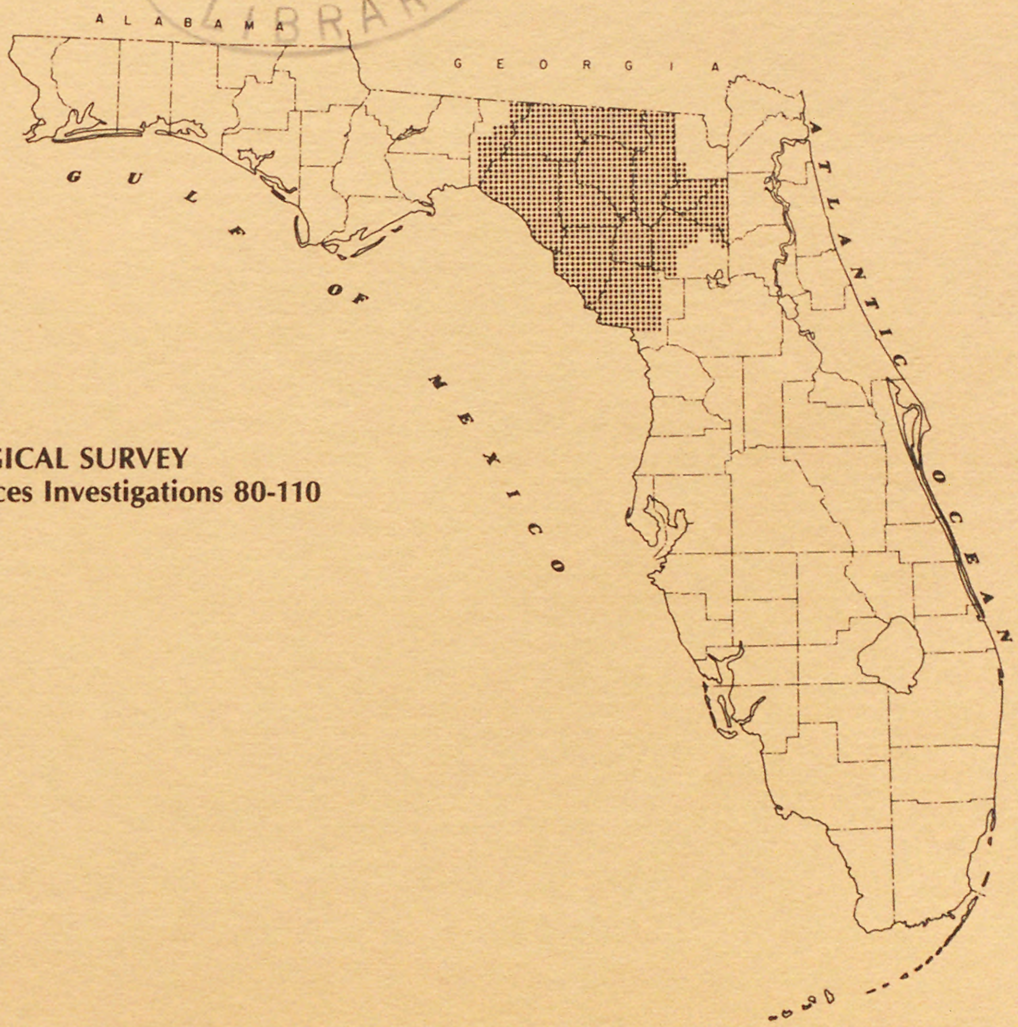

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 80-110

Prepared in cooperation with the
SUWANNEE RIVER AUTHORITY
and the
SUWANNEE RIVER WATER MANAGEMENT DISTRICT, FLORIDA

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1981

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

For use of those readers who may prefer to use SI (metric) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)

QUALITY OF SURFACE WATER IN THE SUWANNEE RIVER BASIN, FLORIDA, AUGUST 1968 THROUGH DECEMBER 1977

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ABSTRACT

In the 9,950-square mile area of the Suwannee River basin in Florida and Georgia, 17 surface-water stations on 9 streams and several springs were sampled for selected water-quality properties and constituents from August 1968 through December 1977. Analyses from these samples indicate that: (1) the water quality of tributary wetlands controls the water quality of the upper Suwannee River headwaters, (2) ground water substantially affects the water quality of the Suwannee River basin streams below these headwaters, (3) the water quality of the Suwannee River is variable and not solely related to discharge, and (4) development in the Suwannee River basin has had observable effects on the quality of surface waters.

INTRODUCTION

In the summer of 1968, the U.S. Geological Survey, in cooperation with the Suwannee River Authority, established a bimonthly sampling program to generate a data base for surface-water quality of streams in the Suwannee River basin. Since the inception of the program, some minor changes in sampling scope have been made to provide more definitive areal coverage or to suit fiscal limitations, but the program has maintained the same basic structure and intent.

The purpose of this report is to: (1) describe the quality of surface water, (2) identify potential impacts of development on the quality of surface water, and (3) assess the need for continued collection of surface-water quality data in the Suwannee River basin. This report was prepared in cooperation with the Suwannee River Authority and the Suwannee River Water Management District.

The scope of the investigation includes the collection and interpretation of physical, microbiological, and chemical data of streams in the Suwannee River basin, Florida, under varying hydrologic conditions. This report covers the period from August 1968 through December 1977, and includes hydrologic data from sites in the basin from the Florida-Georgia border area south to the Gulf of Mexico. The data base included in this report is not limited to stations monitored in the bimonthly sampling program.

DESCRIPTION OF STUDY AREA

Regional Setting

The Suwannee River basin encompasses an area of 9,950 mi^2 in the Atlantic Coastal Plain of Georgia and Florida (fig. 1). The northern part of the basin (5,720 mi^2) is in Georgia. The southern part of the basin (4,230 mi^2), which is in Florida, is marked with wetland and lowland topography that is karstic in places, a few small tributary streams, and by a dominance of spring discharge.

There are no significant urban centers within the Suwannee River basin in Florida. In the 1970 census, Columbia County (fig. 2) had a population of about 25,250, or about double that of 10 of the other 11 counties in part or fully within the basin (Morris, 1977, p. 510). The largest town in the Suwannee River basin, Florida, is Lake City in Columbia County, which has a population of 10,575 (Morris, 1977, p. 516).

The primary economy of the area is agriculture; however much of the labor force is employed in construction, mining, manufacturing, transportation, utilities, and wood industry (Florida Department of Environmental Regulation, 1975, p. II-13).

Climate

National Weather Service records (U.S. Department of Commerce, 1975) give the average annual rainfall at Lake City from 1941 to 1970 as 54.14 inches. This average is about equal to the regional average for a 19-county area surrounding Osceola National Forest (Miller and others, 1978, p. 15). The range for the period of record is from a low of 29.83 inches in 1908 to a high of 84.47 inches in 1964. Most Florida rainfall returns to the atmosphere by evapotranspiration, a term used to represent the loss of water by evaporation from soil and water surfaces and transpiration by plants. In Florida, average annual evapotranspiration is about 39 inches of the annual rainfall (Miller and others, 1978, p. 15), leaving approximately 15 inches in the Suwannee River basin for ground-water recharge and surface runoff.

Geology

Geologic formations affecting the quality of river water can be restricted to the rock formations that are either exposed in streambeds or provide source water for the streams. From oldest to youngest these are the Williston Formation (of local usage, Eocene age), Crystal River Formation (of local usage, Eocene age), Suwannee Limestone (Oligocene age), Hawthorn Formation (Miocene age), Alachua Formation (Miocene age, designated Pliocene by U.S. Geological Survey), and the terraces (Pleistocene and Holocene age) (fig. 3). Except for the Hawthorn and Alachua Formations, which are thin-bedded limestone, sandstone, and clay (phosphatic in places), and for the terraces, the formations are carbonate (James A. Miller, U.S. Geological Survey, oral commun., 1979). The karstic topography, which predominates in the Florida portion of the Suwannee River basin, facilitates the movement and exchange of waters from surface to subsurface.

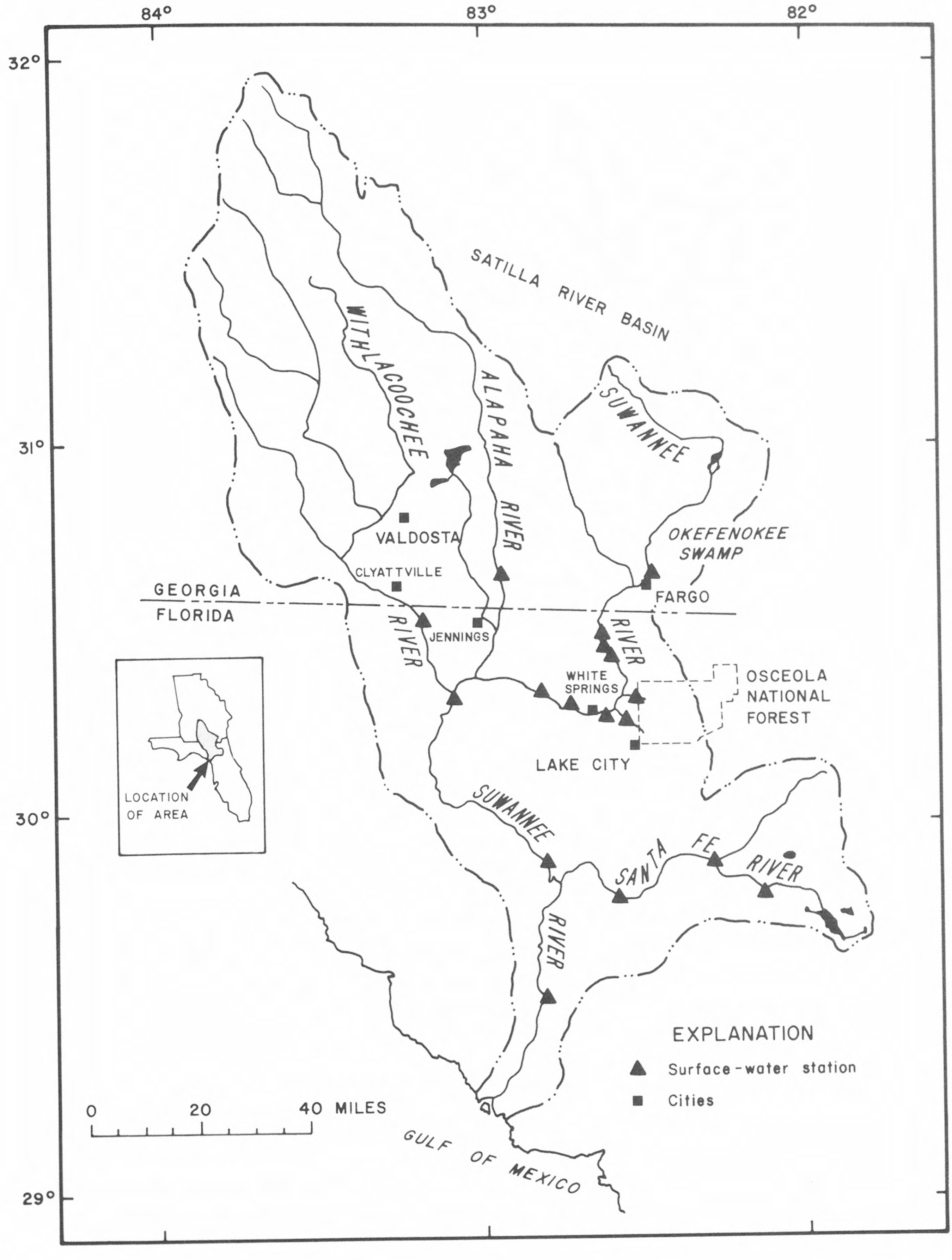


Figure 1.--Drainage basin of the Suwannee River in Georgia and Florida.

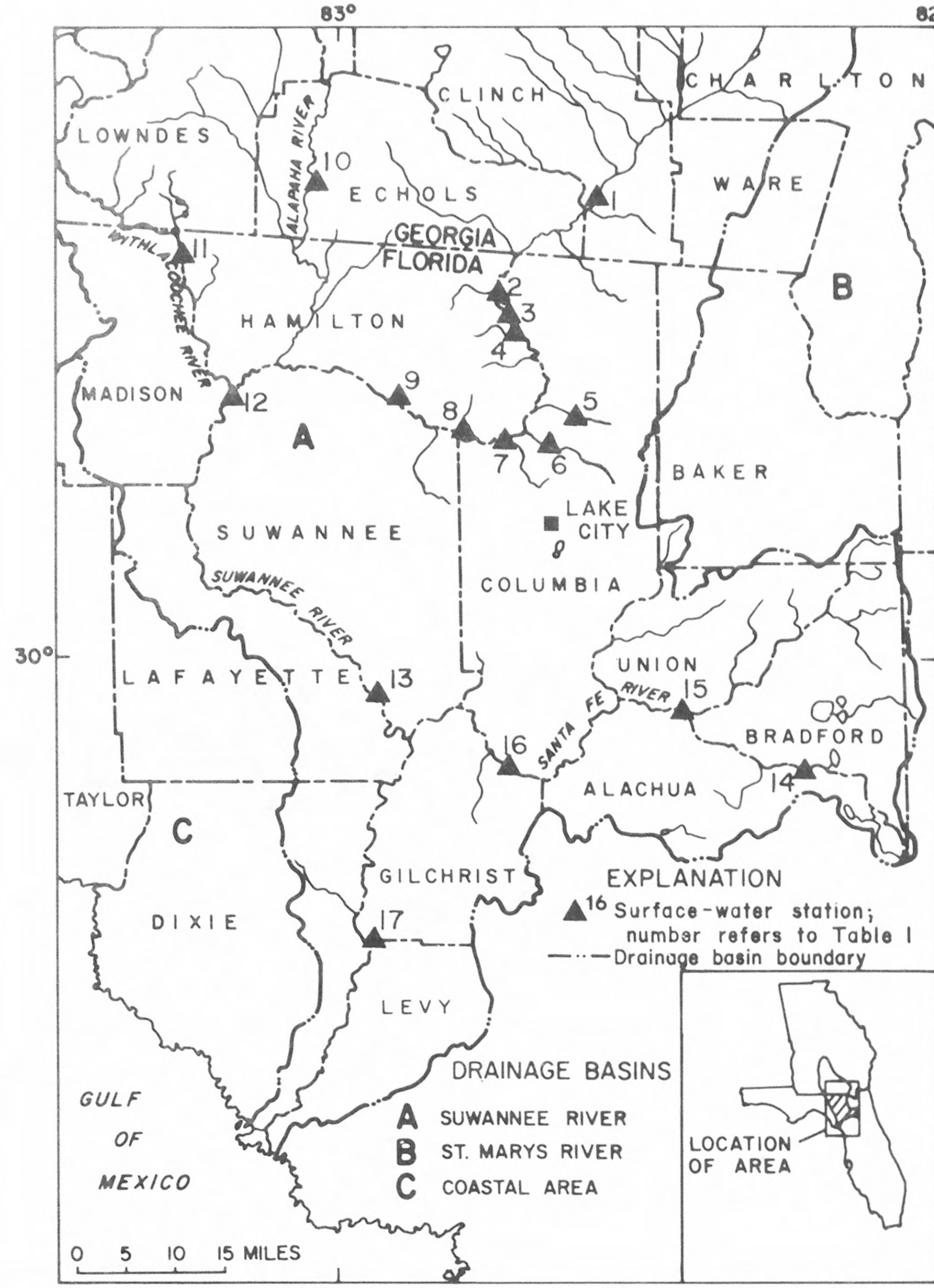
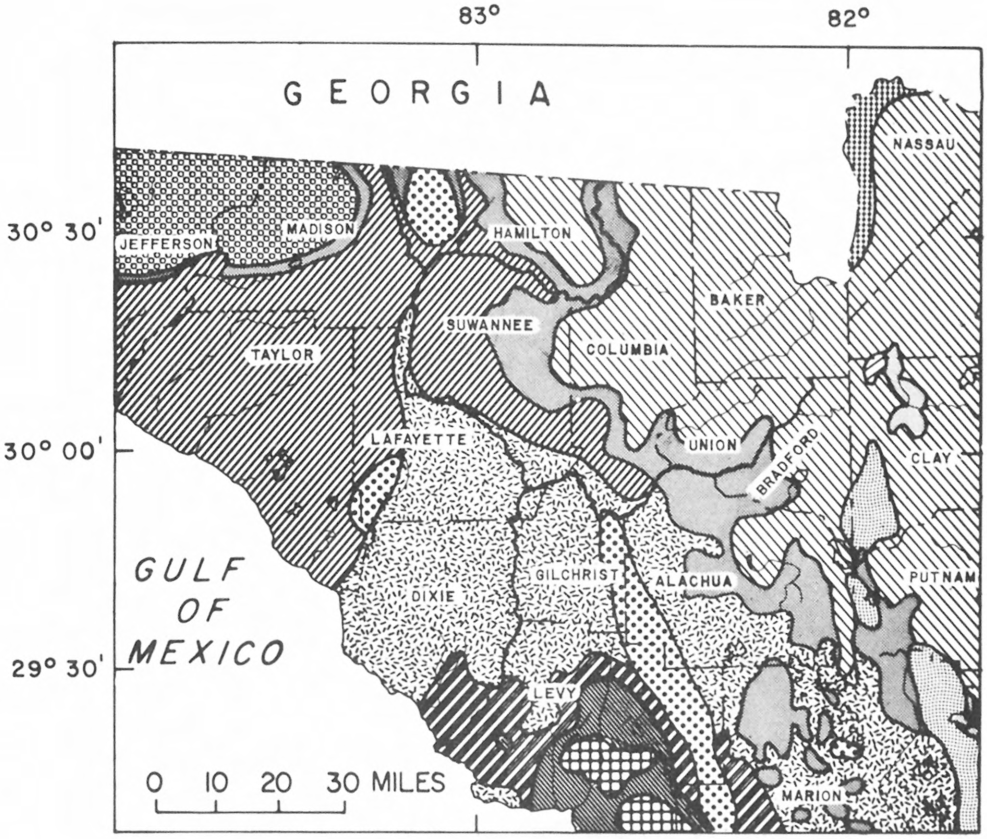


Figure 2.--Drainage basins in part of north Florida and south Georgia and surface-water stations for which records are used for this study.



EXPLANATION

SERIES	STAGE	FORMATION & MEMBER	
HOLOCENE AND PLEISTOCENE		Several lower marine and estuarine terrace deposits	
MIOCENE	CHOCTAWHATCHEE	Miccosukee Formation*	
		Charlton Formation*	
		Jackson Bluff Formation*	
		Yellow River Formation	
	?	Alachua Formation*	
	ALUM BLUFF	Fort Preston Formation	
		Hawthorn Formation*	
OLIGOCENE		Suwannee Limestone*	
EOCENE	JACKSONIAN*	Crystal River Formation	Equivalent to Ocala Limestone*
		Williston Formation	
		Inglis Formation	
	CLAIBORNIAN*	Avon Park Limestone*	

Stage, formation, and member terminology is that used by the Florida Bureau of Geology. The U.S. Geological Survey recognizes those units marked with an asterisk, but the Charlton, Jackson Bluff, and Alachua Formations are considered Pliocene age.

Figure 3.--Geologic map of northeast Florida (modified from Vernon and Puri, 1964).

Hydrology

A brief description of the Suwannee River basin sampling sites is given in table 1. Seventeen stations on nine streams were used with two stations in south Georgia and the remainder in Florida. Figures 1 and 2 show the locations of these stations. For purposes of brevity, the station names as used in the text are often shortened. For example, Suwannee River at Suwannee Springs would be Suwannee Springs, and Santa Fe River at Fort White would be Fort White.

The Suwannee River begins in the Okefenokee Swamp area of south Georgia and meanders south and westward through Florida to the Gulf of Mexico (fig. 1). Above the town of White Springs, in Hamilton County (map location number 7 on fig. 2 and table 1), the river flow consists of surface drainage from headwaters in wetland areas and ground-water discharge from the surficial aquifer (Miller and others, 1978, p. 23). Below White Springs the average annual flow of succeeding downstream stations for the respective periods of record increases (table 1) from 1,879 ft^3/s at White Springs to 6,580 ft^3/s at Ellaville (map location number 12 on fig. 2), to 6,994 ft^3/s at Branford (map location number 13 on fig. 2), and to 10,624 ft^3/s at Wilcox (map location number 17 on fig. 2). In the reach from White Springs to Branford in Suwannee County, the flow of the river increases primarily due to inflow from the Withlacoochee River (2,360 mi^2 drainage area at the mouth), and ground-water discharge from the thick and areally extensive sequence of interbedded limestones and dolomites of Paleocene to middle Miocene age known as the Floridan aquifer (Stringfield, 1966, p. 95). The Alapaha River (1,840 mi^2 drainage area at the mouth) adds little to the base flow of the Suwannee River, as explained in a later discussion. Analysis of flow records from these tributaries indicates that at periods of low flow they contribute about 16 percent of the Suwannee River flow at Ellaville (Miller and others, 1978, p. 23). The relatively high base flow observed at Ellaville is therefore credited to ground-water inflow from springs and seepage from the Floridan aquifer, which is exposed intermittently in the riverbed from White Springs southward, rather than from the increased drainage area.

The only major tributary to the Suwannee River downstream from the Withlacoochee River is the Santa Fe River (1,380 mi^2 drainage area at the mouth), which derives most of its base flow and much of its average flow from discharges from the Floridan aquifer (James D. Hunn, U.S. Geological Survey, oral commun., 1979).

Seepage studies (or runs) designed to identify loss or gain of streamflow in the Suwannee River between stations 3 at Benton and 9 at Suwannee Springs (fig. 2), were carried out during an investigation of the Osceola National Forest area (Miller and others, 1978). Results of these studies indicate that below map location number 7 at White Springs (fig. 2), stretches of the river may gain or lose streamflow depending on the degree of interconnection with the Floridan aquifer and recent hydrologic conditions. Figure 4 shows three of the seepage investigation sites on the Suwannee River and their respective discharge measurements for November 9, 1977, and April 25, 1978, (flow is from right to left).

Table 1.--Station descriptions for the 17 U.S. Geological Survey Suwannee River basin surface-water stations

Map location number[1]	U.S. Geological Survey station number	Name and location	Drainage area (square miles)	Period of record (month and year)[2]	Frequency of record[3]	Discharge (ft^3/s): Average annual (number of years)[4] / mean annual[5]	Discharge (ft^3/s): Range for period of record: Minimum	Discharge (ft^3/s): Range for period of record: Maximum
1	023145.00	Suwannee River at Fargo, GA	1,260	01/21-09/23 01/27-12/31 04/37-12/77	P P P	1,104(43) / [6]818	0	13,600
2	023149.86	Rocky Creek near Belmont, FL	50.0	08/70-03/76 03/76-12/77	P D	-- / 37.9	0	2,410
3	023150.00	Suwannee River near Benton, FL	2,090	10/75-12/77	D	-- / 2,206	5.0	27,700
4	023150.05	Hunter Creek near Belmont, FL	25.4	05/65-08/71 08/71-12/77	P	-- / [7]22.4	1.0	425
5	023152.00	Deep Creek near Suwannee Valley, FL	88.6	04/76-12/77	D	-- / 51.3	0.19	675

[1]Refer to figure 2 for locations.
[2]Data continue to be collected (as of Nov. 1978) at those stations with a December 1977 date.
[3]Frequency of record: P, periodic; D, daily.
[4]Number of years for which annual discharge computed.
[5]Mean annual discharge for water year 1977 (October 1, 1976, through September 31, 1977).
[6]Mean annual discharge for water year 1976 (October 1, 1975, through September 31, 1976).
[7]Average of 9 instantaneous discharge measurements for water year 1977.

Table 1.--Station descriptions for the 17 U.S. Geological Survey Suwannee River basin surface-water stations--Continued

Map location number[1]	U.S. Geological Survey station number	Name and location	Drainage area (square miles)	Period of record (month and year)[2]	Frequency of record[3]	Discharge (ft^3/s): Average annual (number of years)[4] / mean annual[5]	Discharge (ft^3/s): Range for period of record, Minimum	Discharge (ft^3/s): Range for period of record, Maximum
6	023153.92	Robinson Creek near	27.4	03/76-12/77	D	--	0	330
		Suwannee Valley, FL				22.2		
7	023155.00	Suwannee River at	2,430	05/06-12/08	D	1,879(52)	4.8	38,100
		White Springs, FL		02/27-12/77	D	2,383		
8	023155.20	Swift Creek	65.3	08/69-04/76	P	--	1.6	1,180
		at Facil, FL		04/76-12/77	D	68.5		
9	023155.50	Suwannee River at	2,630	11/60-09/74	P	--	101	30,100
		Suwannee Springs, FL		10/74-12/77	D	2,440		
10	023175.00	Alapaha River at	1,400	01/21-06/21	P	1,032(45)	16	27,300
		Statenville, GA		10/31-12/77	D	[6] 924		

[1]Refer to figure 2 for locations.
[2]Data continue to be collected (as of Nov. 1978) at those stations with a December 1977 date.
[3]Frequency of record: P, periodic; D, daily.
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11	023190.00	Withlacoochee River near Pinetta, FL	2,120	10/31-12/77	D	1,674(46) 2,276	70	79,400
12	023195.00	Suwannee River at Ellaville, FL	6,970	01/27-12/77	D	6,580(50) 8,176	882	95,300
13	023205.00	Suwannee River at Branford, FL	7,880	07.31-12/77	D	6,994(46) 8,782	1,530	83,900
14	023207.00	Santa Fe River at Graham, FL	94.9	08/57-12/77	D	61.3(20) 8.48	0.04	2,360
15	023215.00	Santa Fe River at Worthington Springs, FL	575	10/31-12/77	D	442(46) 260	0.50	20,000

[1]Refer to figure 2 for locations.
[2]Data continue to be collected (as of Nov. 1978) at those stations with a December 1977 date.
[3]Frequency of record: P, periodic; D, daily.
[4]Number of years for which annual discharge computed.
[5]Mean annual discharge for water year 1977 (October 1, 1976, through September 31, 1977).

Table 1.--Station descriptions for the 17 U.S. Geological Survey Suwannee River basin surface-water stations--Continued

Map location number[1]	U.S. Geological Survey station number	Name and location	Drainage area (square miles)	Period of record (month and year)[2]	Frequency of record[3]	Discharge (ft^3/s): Average annual (number of years)[4] / mean annual[5]	Discharge (ft^3/s): Range for period of record, Minimum	Discharge (ft^3/s): Range for period of record, Maximum
16	023225.00	Santa Fe River near Fort White, FL	1,017	10/27-01/30 06/32-12/77	D	1,631(37) 1,100	609	17,000
17	023235.00	Suwannee River near Wilcox, FL	9,640	10/30-09/31 10/41-12/77	D D	10,624(37) 12,060	3,270	84,700

[1]Refer to figure 2 for locations.
[2]Data continue to be collected (as of Nov. 1978) at those stations with a December 1977 date.
[3]Frequency of record: P, periodic; D, daily.
[4]Number of years for which annual discharge computed.
[5]Mean annual discharge for water year 1977 (October 1, 1976, through September 31, 1977).

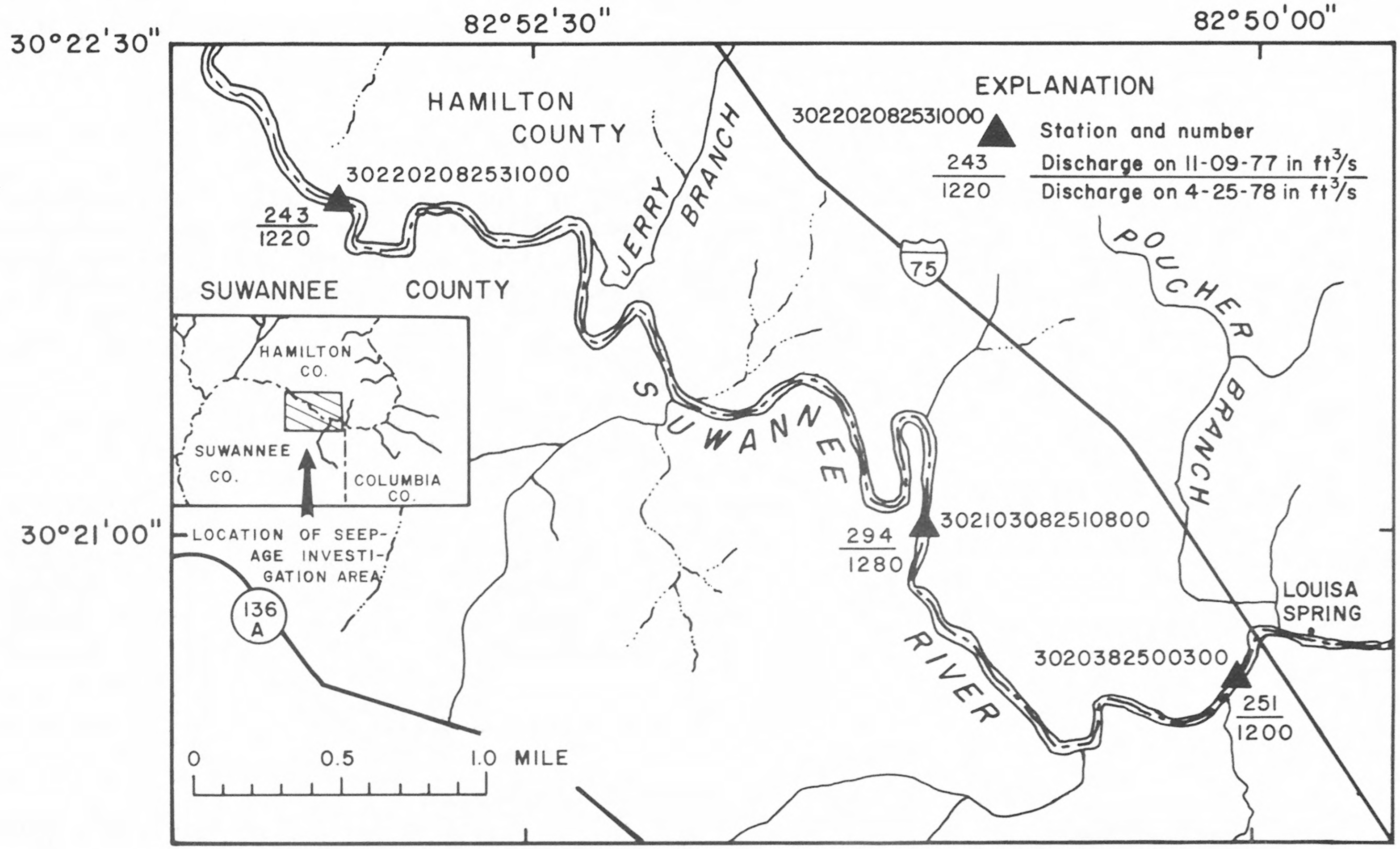


Figure 4.--Location of seepage investigation stations for runs during November 9, 1977 and April 25, 1978.

The November run was made after one week of relatively stable low-flow while the April run was made during a falling stage at lower than average flow with the most recent major peak flow occurring one month previous (both based on streamflow records for the Suwannee River at Suwannee Springs and at White Springs). For the November 1977 low-flow run, streamflow increased 43 ft^3/s from the first to second site (from right to left) and decreased 51 ft^3/s from the second to the third site. For the April 1978 falling stage (or recession) run, streamflow increased 80 ft^3/s from the first to second site, and decreased 60 ft^3/s from the second to the third site. No measurable flow was supplied by the tributary streams during the November run, and less than 5 ft^3/s total was attributed to surface inflow in this reach during the April run.

Shown below are selected water-quality determinations for two samples collected during the November low-flow run at the first and third sites. Constituents are dissolved and in mg/L. Properties are as noted.

Constituent or property	First site [1] 3020382500300	Third site [1] 302202082531000
Calcium (Ca)	13	16
Magnesium (Mg)	4.4	4.4
Potassium (K)	.6	.7
Sodium (Na)	7.3	7.0
Bicarbonate (HCO_3)	12	14
Chloride (Cl)	7.5	7.5
Fluoride (F)	.9	1.0
Sulfate (SO_4)	30	29
Dissolved solids sum, calculated	76	80
Dissolved solids residue, at 180°C	129	134
pH (in units)	6.8	6.9

These sample analyses indicate that for the November low-flow these sites have water of comparable quality, and that water picked up in the first stretch is of the same quality as that from the upstream sources. No samples were collected at these sites during the April investigation.

Field observations of the stream channel between these three sites suggest a more substantial connection with the Floridan aquifer between the second and third sites. The loss of flow in this latter reach under the two hydrologic conditions tends to corroborate this.

It would therefore be expected that fluctuating river stage, stage duration, and associated potentiometric levels of the aquifers (mainly the water table and Floridan) would be of significant importance in determining the water quality of both river and aquifer. This would result from bank storage (Clark, 1965, p. D211) or aquifer storage of river water; suspended, decreased, or increased discharge of springs; and discharge of stored river water or longer residence ground water.

[1] U.S. Geological Survey station number, note figure 4.

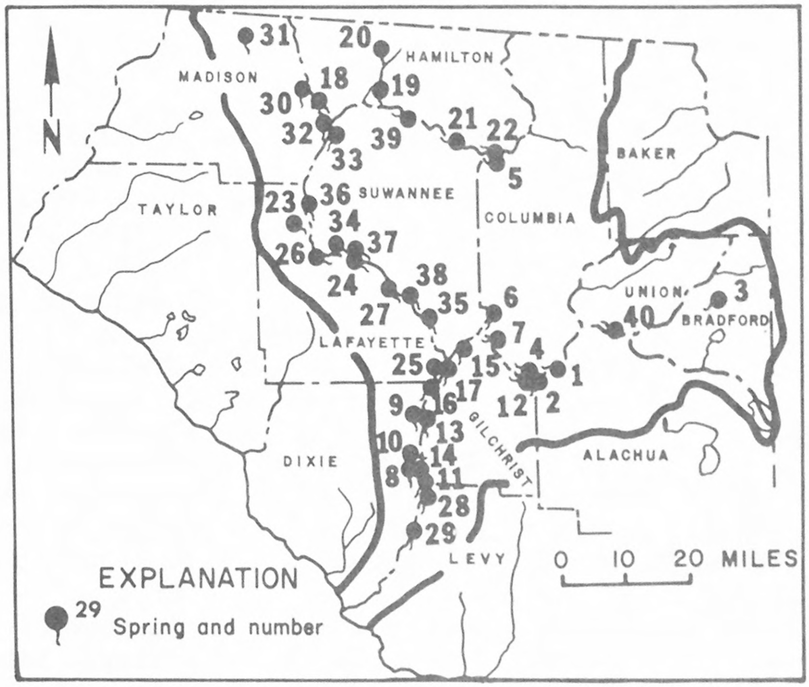
Much of the interconnection between the Suwannee River and the Floridan aquifer is revealed by numerous springs (fig. 5). Some 71 of these were described in a report by Rosenau and others (1977) which gave flow and water-quality data. Of the 27 first-magnitude springs they described in Florida--those with an average flow of 100 ft^3/s or more, 9 are in the Suwannee River basin. From instantaneous discharge measurements (Rosenau and others, 1977), these 9 account for a flow of about 2,100 ft^3/s (assuming continuous flow) while an additional 63 second-magnitude springs--those with an average flow of 10 to 100 ft^3/s, contribute another 1,900 ft^3/s to the Suwannee River for a total of 4,000 ft^3/s. Some of the first-magnitude springs and most of the second-magnitude springs backflow at times because the river stage exceeds the aquifer head at that point and their discharges vary correspondingly with changes in river stage (Rosenau and others, 1977). However, as found in the seepage investigations mentioned earlier, gains and losses from the river can be simultaneous in adjoining reaches, depending upon recent local hydrologic conditions relating to river stage and pressure head in the aquifer.

Given that: (1) Springflow is not continuous but may increase, stop, or reverse; (2) some springs can discharge while others reverse even in adjoining river reaches; and, (3) the basin is sufficiently large to permit extremes of hydrologic conditions to occur simultaneously; it is difficult to quantify the total or combined effects of spring discharge on the water quality and quantity of the Suwannee River basin as a whole. It can be stated, qualitatively, that any effects would be pronounced at lower river stages and in river reaches with the greatest degree of aquifer-river interconnection (spring density) where there is comparatively little tributary inflow. On the contrary, effects would be minimized at flood stages and where tributary input is most significant (except for the Santa Fe River which is discussed later).

The flow of the Suwannee River is unregulated except for Mixons Ferry Damsite located about 12 miles upstream from the Fargo, Ga., gaging station (map location number 1 on fig. 2); and an H-pile dam with removable boards located approximately 500 feet downstream from the Suwannee Springs gaging station (map location number 9 on fig. 2). On March 6, 1963, the H-pile dam was partially washed out, posing a hazard for boaters. It was subsequently removed in the fall of 1978.

Point-Discharge Facilities

Domestic and industrial facilities within the basin directly and indirectly discharge wastewaters to the Suwannee River. Wasteload allocations for 25 permitted point-source dischargers amount to about 229 Mgal/d or 14.4 ft^3/s in design capacity. These include powerplant cooling water, domestic sewage, and phosphate mining-processing effluent. Table 2 lists the operations as given in the Suwannee River Basin Water Quality Management Plan (Florida Department of Environmental Regulation, 1975).



ALACHUA COUNTY

1. Darby Springs
   Hornsby Spring
2. High Springs
   Poe Springs

BRADFORD COUNTY

3. Heilbronn Spring

COLUMBIA COUNTY

4. Allen Spring
   Columbia Spring
   July Spring
   Jonathan Spring
   Rum Island Spring
5. Bell Springs
6. Ichetucknee Group
   - Ichetucknee Spring
   - Cedar Head Spring
   - Blue Hole Spring
   - Roaring Springs
   - Singing Springs
   - Boiling Spring
   - Grassy Hole Spring
   - Mill Pond Spring
   - Coffee Spring
7. Jamison Spring
   Northbank Spring
   Wilson Spring

DIXIE COUNTY

8. Copper Spring
   Little Copper Spring
9. Guaranto Spring
10. McCrabb Spring

GILCHRIST COUNTY

11. Bell Springs
12. Blue Springs
    Devil's Eye Springs
    Ginnie Spring
    Lilly Springs
13. Hart Springs
    Lumber Camp Springs
    Sun Springs
14. Otter Springs
15. Pleasant Grove Springs
16. Rock Bluff Springs
17. Townsand Spring

HAMILTON COUNTY

18. Adams Spring
    Morgans Spring
19. Alapaha Rise
    Holton Spring
20. Bluff Cemetery Spring
21. Louisa Spring
    Wesson's Iron Spring
22. White Springs

LAFAYETTE COUNTY

23. Allen Mill Pond Spring
    Blue Spring
24. Convict Spring
    Mearson Spring
    Owens Spring
25. Fletcher Spring
    Turtle Spring
26. Perry Spring
27. Ruth Spring
    Troy Spring

LEVY COUNTY

28. Blue Spring
29. Fannin Springs

MADISON COUNTY

30. Blue Spring
31. Cherry Lake Spring
32. Suwanacoochee Spring

SUWANNEE COUNTY

33. Anderson Spring
    Ellaville Spring
    Falmouth Spring
    Lime Spring
34. Baptizing Spring
    Bonnet Spring
    Luraville Springs
    Peacock Springs
    Pump Spring
    Telford Springs
    Walker Spring
35. Branford Springs
36. Charles Springs
    Thomas Spring
37. Cow Spring
    Royal Spring
    Running Spring
    Suwannee Blue Spring
38. Little River Springs
39. Suwannee Springs

UNION COUNTY

40. Worthington Spring

Figure 5.--Selected springs in the Suwannee River basin, Florida.

Table 2.--Permitted wastewater dischargers to surface waters of the Suwannee River, Florida, and their respective wasteload allocations[1]

Index number[2]	Plant name	Receiving waters	Design capacity in Mgal/d
1	Occidental Chemical	Swift Creek	6.11
2	Occidental Chemical	Hunter Creek	3.0
3	Amoco Truck Stop	Alapaha River	.0075
4	Florida Sheriffs Boy's Ranch	Suwannee River	.02
5	Ocean Pond Recreation	Ocean Pond	--.008
6	Holiday Inn	Cypress Swamp	.045
7	City of White Springs	Suwannee River	.15
8	Owens-Illinois Co.	Jumping Gully Creek	12.7
9	City of Jasper	Swamp	.40
10	Gold Kist Poultry	Suwannee River	.70
11	Florida Power Corp.	Suwannee River	175.6
12	Advent Christian Home	Suwannee River	.04
13	Florida Motor Inn	Cannon Creek	.025
14	Ramada Inn	Cannon Creek	.013
15	Arrowhead Campground	Cannon Creek	.01
16	American Motor Lodge	Cannon Creek	.03
17	General Electric	Unnamed stream	1.0
18	E. I. Dupont	Alligator Creek	23.8
19	Dubois Fence & Garden	Price Creek - Alligator Lake	.001
20	Florida State Prison	New River	2.0
21	City of Lake Butler	Alligator Lake	1.05
22	Lake Butler	Richards Creek	1.0
23	City of Starke	Alligator Creek	1.0
24	General Electric	Unnamed stream	0.06
25	Progress Mobile Home Park	Turkey Creek	.013
26	Hills Mobile Home Park	Alligator Lake	.009

[1] Modified from Florida Department of Environmental Regulation, 1975.
[2] See figure 7 for location.

Water Classifications

All waters within the Suwannee River basin, Florida, were designated by the State of Florida as Class III Waters in Chapter 17-3 of the Florida Administrative Code, (Florida Department of State, 1978, Chapter 17-3.161). Class III waters provide for Recreation and Propagation and Management of Fish and Wildlife. Three exceptions are given: (1) "Tidal creeks within USGS Sub-basin 09J5 (Suwannee River below the confluence with the Withlacoochee River of the north) north of, but excluding the mouth of, the Suwannee River from Suwannee River or Gulf of Mexico to source," (2) "Tidal creeks within USGS Sub-basin 09J5 south of, but excluding the mouth of, the Suwannee River from Suwannee River or Gulf of Mexico to source," and (3) Jumping Gully Creek in Hamilton County. The tidal creeks are included under Class II waters: for Shellfish Harvesting-Surface Waters, while Jumping Gully Creek is unclassified. The Suwannee River has been given the additional protection of the Outstanding Florida Water status which prohibits degradation from the ambient conditions existing in 1978.

Compliance or non-compliance with the State water-quality standards, specifically those for the Outstanding Florida Waters classification, are to be determined by the State in river-quality assessment studies. The study done for Canoe Creek in extreme western Florida is a good example (Florida Department of Environmental Regulation, 1978).

Data included in this report, on the quality of surface water in the Suwannee River basin, covers the period from August 1968 through December 1977, and is prior to the implementation of the State standards.

METHODS AND PROCEDURES

Analytical Methods

The analytical methods used by the U.S. Geological Survey for the chemical analysis of water through 1970 were those described by Rainwater and Thatcher (1960). The methods used from 1971 through 1977 are given in Brown and others, (1970). Chemical analysis of "major inorganic constituents," (specifically: calcium, magnesium, sodium, potassium, bicarbonate, chloride, sulfate, and fluoride); dissolved solids; and "nutrients," (specifically: organic carbon, ammonia, nitrate, nitrite, organic nitrogen, orthophosphate, and total phosphorus) were done at the Florida District Quality of Water Service Unit in Ocala, Fla., through August 1973. From September 1973 through December 1977, nutrients were analyzed by the Ocala Service Unit, all other analyses were performed by the U.S. Geological Survey Central Water Quality Laboratory, Doraville, Ga. All analyses of trace elements were done at the Central Water Quality Laboratory. Microbiological samples were processed in the field and enumerated later.

Procedures for Sample Collection and Preservation

Sample preservation techniques described by Brown and others (1970) or similar procedures were not used as standard practice during the early part of the sampling period. Samples were customarily sent to the laboratory untreated, however, beginning in 1971 samples collected for nitrogen, phosphorus, total organic carbon, and trace element determinations were treated in the field as follows. Samples collected for nitrite, nitrate, and orthophosphate were filtered through a 0.45 micrometer (μm) filter in the field, and were treated with 1.0 milliliter (mL) of mercuric chloride yielding 40 milligrams (mg) of mercury per liter of sample. Samples were then chilled to about 4 degrees Celsius (°C). The use of mercuric chloride as a preservative in that type of sample was discontinued about January 1972, and subsequent samples were filtered and chilled only.

Water samples analyzed for dissolved trace elements were filtered in the field with a 0.45 μm filter, and preserved with 3 mL of concentrated nitric acid for each 1,000 mL of sample. Analyses for total concentrations were made on an unfiltered sample treated with 3 mL of concentrated nitric acid for each 1,000 mL of sample.

Frequency of Sample Collection

Sample collection for the major dissolved inorganic chemical constituents for most of the stations in the Suwannee River basin, Florida, was twice each year, usually in May and November. By design, this was to account for the high- and low-flow conditions of the river, respectively. These samples were analyzed for the major dissolved inorganic chemical constituents, dissolved nutrients, and field parameters, such as pH, specific conductance, temperature, dissolved oxygen, and occasionally alkalinity.

Additional stations were later established to accommodate other programs such as those of the Osceola National Forest investigation and the National Stream Quality Accounting Network (NASQAN). The frequency or sampling parameters for these stations were designed to accommodate the needs of the current programs. Sampling at additional stations was commonly monthly or bimonthly consisting of the same analyses as above or simply dissolved nutrients and field parameters. The frequency of sampling at any of these stations was not always "regular" due to occasional early or late sampling intended to include a hydrologic event.

DESCRIPTION OF THE WATER-QUALITY VARIABLES AND RESULTS

This section describes most of the water-quality variables and the results of the data collected for the Suwannee River basin in a downstream or downbasin order. For brevity, the emphasis is on the major river-station water quality, however, emphasis on the tributaries is made when significant or necessary to highlight a situation. Specific discussions about water quality at a station, river reach, or tributary are covered mainly in the following section or discussion of results.

Selected Water-Quality Properties and Constituents

The properties and constituents routinely determined for the most part are those which reflect the overall water quality. Some are not necessarily a measurement of a concentration, but more a physical attribute of the sample water. These properties, attributes, and constituents are: pH (related to the hydrogen ion activity); alkalinity (capacity of a water to react with hydrogen ions to pH 4.5); hardness (the ability to precipitate soap up to the alkalinity concentration, expressed as calcium carbonate); noncarbonate hardness (the ability to precipitate soap over the alkalinity concentration, expressed as calcium carbonate); specific conductance (the ability of water to conduct an electric current); color (due basically to dissolved substances in the water); tannins and lignins (plant and animal residue concentrations); turbidity (reduction of transparency due to the presence of suspended particulate matter); water temperature; dissolved oxygen; biochemical oxygen demand (relative oxygen requirement due to biologically related systems); suspended solids and suspended sediment (both a quantitative measurement of the concentration of the suspended material); total and fecal coliform bacteria. A statistical summary of the results for these parameters is given in table 3 for August 1968 through December 1977.

The median pH increases downstream in the Suwannee River from 4.2 at Fargo, Ga., to 5.9 at Suwannee Springs, Fla., to 7.3 at Wilcox, Fla. (map location numbers 1, 9, and 17 respectively, on figs. 2 and 6 and tables 1 and 3). Tributary streams tend to have higher median pH than the nearest Suwannee River station with the exception of those of the Alapaha and upper Santa Fe Rivers. Samples collected from the two streams draining the phosphate mining areas in Hamilton County (Hunter and Swift Creeks), Fla., (map location numbers 4 and 8 on fig. 2 and table 1) have higher pH than other streams like Deep and Robinson Creeks in Columbia County, Fla., (map location numbers 5 and 6 on fig. 2 and table 1).

Mean and median values for alkalinity, hardness, and specific conductance also show an increasing trend downstream. Figure 7 illustrates this downstream increase in specific conductance. Mean alkalinity values for Fargo, Suwannee Springs, and Wilcox are 0, 26, and 122 mg/L, respectively. Mean hardness values for the same stations are 5, 46, and 132 mg/L. Mean noncarbonate hardness concentrations increase downstream from 7 mg/L at Benton (map location number 3 on fig. 2; Fargo had no measurements) to 23 mg/L at Suwannee Springs, but decrease to 13 mg/L at Wilcox (table 1). Mean specific conductance values remain nearly constant downstream to White Springs (map location number 7 on fig. 2) with 48 μmhos/cm (micromhos per centimeter), but increase to 99 μmhos/cm at Suwannee Springs and to 218 μmhos/cm at Wilcox. Except for noncarbonate hardness, concentrations of individual constituents tend to be higher in water from tributary streams than from the nearest Suwannee River stations. Streams draining the phosphate mining areas in Hamilton County tend to have individual constituent concentrations substantially different from their nearest Suwannee River station.

Mean and median values for color tend to decrease downstream in the Suwannee River. Mean values are over 200 platinum-cobalt units from Suwannee Springs upstream, while mean values downstream decrease to 100 platinum-cobalt units at Wilcox.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations

[In milligrams per liter (mg/L), except where noted]

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02314500 Suwannee River at Fargo, Ga., map location number 1					
pH, (standard units)	63	*	*	3.8-6.0	4.2
Alkalinity, total as $CaCO_3$	33	0	0	0-2	0
Hardness as $CaCO_3$ (Ca, Mg)	32	5	2	2-10	5
Noncarbonate hardness	0				
Specific conductance, (micromhos/cm at 25°C)	49	48	4	36-57	48
Color, (Platimum-cobalt scale)	48	225	53	140-325	225
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	48	5	12	1-68	2
Temperature, water, (°C)	104	20.0	6.2	4.0-29.5	20.5
Dissolved oxygen (DO)	47	7.5	2.3	3.9-13.0	7.5
Biochemical oxygen demand (BOD), 5-day at 20°C	43	1.1	1.1	0.1-7.6	0.8
Suspended solids, at 110°C	12	6	5	1-15	5
Sediment, suspended concentration	135	10	31	0-268	4
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	0				
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02314986 Rocky Creek near Belmont, Fla., map location number 2					
pH, (standard units)	46	*	*	3.1-7.4	4.0
Alkalinity, total as $CaCO_3$	16	4	10	0-39	0
Hardness as $CaCO_3$ (Ca, Mg)	16	19	12	8-49	12
Noncarbonate hardness	16	14	6	8-27	11
Specific conductance, (micromhos/cm at 25°C)	46	77	25	24-160	73
Color, (Platinum-cobalt scale)	20	472	181	80-800	480
Tannin and lignin	12	12	5	2.7-18	13
Turbidity, (Jackson turbidity units)	47	4	3	1-15	3
Temperature, water, (°C)	46	18.0	6.5	4.0-28.0	19.5
Dissolved oxygen (DO)	46	6.7	1.9	3.7-10.6	6.2
Biochemical oxygen demand (BOD), 5-day at 20°C	37	.8	.5	0.0-2.3	.8
Suspended solids, at 110°C	2	4	1	3-4	3
Sediment, suspended concentration	9	7	9	1-27	3
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	35	800	1,050	24-5,200	400
Coliform, fecal, membrane filtered (colonies/100 ml)	1	*	*	73	*

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315000 Suwannee River near Benton, Fla., map location number 3					
pH, (standard units)	20	*	*	3.8-6.2	4.1
Alkalinity, total as $CaCO_3$	8	0	1	0-2	0
Hardness as $CaCO_3$ (Ca, Mg)	8	7	4	0-12	6
Noncarbonate hardness	8	7	3	0-11	6
Specific conductance, (micromhos/cm at 25°C)	20	47	7	35-61	46
Color, (Platinum-cobalt scale)	9	272	52	200-360	260
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	16	4	2	1-8	3
Temperature, water, (°C)	20	20.0	7.0	5.5-30.5	21.0
Dissolved oxygen (DO)	16	7.9	1.8	5.2-12	7.2
Biochemical oxygen demand (BOD), 5-day at 20°C	15	.9	.5	0.1-1.7	.8
Suspended solids, at 110°C	2	10	9	3-16	3
Sediment, suspended concentration	1	*	*	16	*
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	10	300	400	50-1,400	200
Coliform, fecal, membrane filtered (colonies/100 ml)	1	*	*	30	*

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315005 Hunter Creek near Belmont, Fla., map location number 4					
pH, (standard units)	51	*	*	3.5-8.1	6.7
Alkalinity, total as $CaCO_3$	22	30	17	5-60	26
Hardness as $CaCO_3$ (Ca, Mg)	22	80	50	30-190	76
Noncarbonate hardness	22	50	47	12-160	25
Specific conductance, (micromhos/cm at 25°C)	51	212	135	34-630	200
Color, (Platinum-cobalt scale)	25	143	125	5-400	110
Tannin and lignin	14	3.3	2.8	0.8-8.3	1.2
Turbidity, (Jackson turbidity units)	48	17	30	3-190	10
Temperature, water, (°C)	51	19.0	6.0	7.0-28.0	20.0
Dissolved oxygen (DO)	45	6.5	1.8	2.6-11.4	6.3
Biochemical oxygen demand (BOD), 5-day at 20°C	38	2.3	1.9	0.0-8.1	1.6
Suspended solids, at 110°C	3	11	6	6-18	8
Sediment, suspended concentration	10	11	8	1-28	9
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	35	2,300	4,100	25-24,000	1,100
Coliform, fecal, membrane filtered (colonies/100 ml)	1	*	*	840	*

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315200 Deep Creek near Suwannee Valley, Fla., map location number 5					
pH, (standard units)	17	*	*	3.9-7.0	5.6
Alkalinity, total as $CaCO_3$	17	19	29	0-92	6
Hardness as $CaCO_3$ (Ca, Mg)	17	31	28	8-98	21
Noncarbonate hardness	17	12	5	6-25	10
Specific conductance, (micromhos/cm at 25°C)	17	83	55	42-225	61
Color, (Platinum-cobalt scale)	17	340	165	50-700	360
Tannin and lignin	12	8.5	2.9	1.3-12	8.9
Turbidity, (Jackson turbidity units)	12	2	1	1-5	2
Temperature, water, (°C)	17	18.4	7.0	7.0-27.0	20.5
Dissolved oxygen (DO)	14	8.0	1.9	5.5-12.3	7.0
Biochemical oxygen demand (BOD), 5-day at 20°C	0				
Suspended solids, at 110°C	0				
Sediment, suspended concentration	11	3	2	1-7	3
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	1	*	*	1,300	*
Coliform, fecal, membrane filtered (colonies/100 ml)	1	*	*	470	*

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315392 Robinson Crek near Suwannee Valley, Fla., map location number 6					
pH, (standard units)	18	*	*	3.9-7.8	5.7
Alkalinity, total as $CaCO_3$	18	27	35	0-94	0
Hardness as $CaCO_3$ (Ca, Mg)	18	38	33	9-98	18
Noncarbonate hardness	18	11	4	3-18	12
Specific conductance, (micromhos/cm at 25°C)	18	96	54	41-210	67
Color, (Platinum-cobalt scale)	18	260	150	20-480	240
Tannin and lignin	13	7.6	3.3	1.2-13	7.8
Turbidity, (Jackson turbidity units)	13	2	2	1-7	2
Temperature, water, (°C)	18	18.5	6.5	4.5-25.0	20.0
Dissolved oxygen (DO)	13	7.3	1.9	5.3-10.1	6.6
Biochemical oxygen demand (BOD), 5-day at 20°C	1	*	*	0.7	*
Suspended solids, at 110°C	0				
Sediment, suspended concentration	11	3	2	1-6	3
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	0				
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315500 Suwannee River at White Springs, Fla., map location number 7					
pH, (standard units)	40	*	*	3.9-7.2	4.6
Alkalinity, total as $CaCO_3$	19	3	7	0-28	0
Hardness as $CaCO_3$ (Ca, Mg)	21	12	7	6-38	10
Noncarbonate hardness	19	9	3	6-18	9
Specific conductance (micromhos/cm at 25°C)	39	48	13	31-84	45
Color, (Platinum-cobalt scale)	21	250	120	20-560	240
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	35	12	23	1-110	4
Temperature, water, (°C)	39	21.0	6.0	6.6-29.5	23.0
Dissolved oxygen (DO)	34	7.6	1.5	5.6-11.0	7.2
Biochemical oxygen demand (BOD), 5-day at 20°C	21	1.0	1.1	0.1-5.2	.6
Suspended solids, at 110°C	9	3	2	1-7	3
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	9	1,400	1,150	100-3,900	1,400
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315520 Swift Creek at Facil, Fla., map location number 8					
pH, (standard units)	62	*	*	3.7-7.1	6.3
Alkalinity, total as $CaCO_3$	30	11	14	0-69	6
Hardness as $CaCO_3$ (Ca, Mg)	31	172	50	79-290	168
Noncarbonate hardness	30	165	50	70-270	156
Specific conductance, (micromhos/cm at 25°C)	61	478	164	133-870	455
Color, (Platinum-cobalt scale)	31	130	85	10-400	115
Tannin and lignin	13	3.8	1.3	1.2-5.4	4.1
Turbidity, (Jackson turbidity units)	59	16	13	3-62	10
Temperature, water, (°C)	62	20.0	6.0	7.0-29.0	22.0
Dissolved oxygen (DO)	58	5.7	1.9	3.0-10.2	5.3
Biochemical oxygen demand (BOD), 5-day at 20°C	49	4.5	2.4	4-10.0	4.6
Suspended solids, at 110°C	8	10	4	4-13	10
Sediment, suspended concentration	11	22	22	5-83	15
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	39	7,300	27,000	100-170,000	1,200
Coliform, fecal, membrane filtered (colonies/100 ml)	2	20	0	20-20	20

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02315550 Suwannee River at Suwannee Springs, Fla., map location number 9					
pH, (standard units)	55	*	*	3.6-7.5	5.9
Alkalinity, total as $CaCO_3$	9	26	19	5-67	29
Hardness as $CaCO_3$ (Ca, Mg)	10	46	23	20-93	42
Noncarbonate hardness	9	23	11	14-47	18
Specific conductance, (micromhos/cm at 25°C)	55	99	71	39-370	67
Color, (Platinum-cobalt scale)	14	240	80	100-400	200
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	51	10	20	1-95	4
Temperature, water, (°C)	55	20.5	6.0	7.5-29.0	22.0
Dissolved oxygen (DO)	49	7.1	1.4	4.4-11.0	6.9
Biochemical oxygen demand (BOD), 5-day at 20°C	50	1.1	.8	0.2-5.5	.9
Suspended solids, at 110°C	2	4	0	4-4	4
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	43	830	1,500	28-9,200	380
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02317500 Alapaha River at Statenville, Ga., map location number 10					
pH, (standard units)	46	*	*	4.7-7.2	5.6
Alkalinity, total as $CaCO_3$	32	4	3	1-14	4
Hardness as $CaCO_3$ (Ca, Mg)	20	9	2	4-14	8
Noncarbonate hardness	0				
Specific conductance, (micromhos/cm at 25°C)	31	41	6	32-57	39
Color, (Platinum-cobalt scale)	32	120	50	30-200	115
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	32	7	6	2-30	6
Temperature, water, (°C)	76	19.0	6.0	4.0-29.0	20.0
Dissolved oxygen (DO)	30	8.7	2.0	5.2-13.0	8.4
Biochemical oxygen demand (BOD), 5-day at 20°C	31	1.0	.4	0.1-1.8	1.0
Suspended solids, at 110°C	12	8	6	1-19	6
Sediment, suspended concentration	143	8	5	1-50	7
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	0				
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02319000 Withlacoochee River near Pinetta, Fla., map location number 11					
pH, (standard units)	71	*	*	4.5-8.3	6.9
Alkalinity, total as $CaCO_3$	35	71	58	2-223	66
Hardness as $CaCO_3$ (Ca, Mg)	36	53	36	8-130	50
Noncarbonate hardness	35	1	3	0-11	0
Specific conductance, (micromhos/cm at 25°C)	86	171	121	25-510	138
Color, (Platinum-cobalt scale)	37	112	43	50-240	100
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	70	11	9	1-49	10
Temperature, water, (°C)	97	19.5	5.5	7.0-29.0	21.0
Dissolved oxygen (DO)	51	6.0	2.0	2.7-11.5	5.5
Biochemical oxygen demand (BOD), 5-day at 20°C	47	1.7	.8	0.3-4.2	1.5
Suspended solids, at 110°C	8	7	5	2-20	6
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	0				
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02319500 Suwannee River at Ellaville, Fla., map location number 12					
pH, (standard units)	4	*	*	6.4-7.2	6.6
Alkalinity, total as $CaCO_3$	2	79	18	66-92	66
Hardness as $CaCO_3$ (Ca, Mg)	2	100	21	85-115	85
Noncarbonate hardness	2	22	2	20-23	20
Specific conductance, (micromhos/cm at 25°C)	5	133	67	68-230	145
Color, (Platinum-cobalt scale)	2	120	30	100-140	100
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	5	7	2	5-10	6
Temperature, water, (°C)	14	22.5	3.5	16.5-28.0	22.0
Dissolved oxygen (DO)	5	5.2	1.0	3.8-6.1	5.4
Biochemical oxygen demand (BOD), 5-day at 20°C	0				
Suspended solids, at 110°C	0				
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	0				
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02320500 Suwannee River at Branford, Fla., map location number 13					
pH, (standard units)	87	*	*	5.1-8.2	7.3
Alkalinity, total as $CaCO_3$	73	78	43	0-155	87
Hardness as $CaCO_3$ (Ca, Mg)	73	93	46	14-178	100
Noncarbonate hardness	71	15	6	5-31	14
Specific conductance, (micromhos/cm at 25°C)	102	192	93	37-380	203
Color, (Platinum-cobalt scale)	52	120	80	10-320	120
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	85	6	4	1-20	5
Temperature, water, (°C)	109	20.5	5.0	9.0-28.0	22.0
Dissolved oxygen (DO)	67	6.5	1.4	3.5-9.8	6.2
Biochemical oxygen demand (BOD), 5-day at 20°C	55	.9	.7	0.0-3.1	.9
Suspended solids, at 110°C	4	9	8	2-20	6
Sediment, suspended concentration	30	8	6	1-34	6
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	38	480	700	25-3,800	240
Coliform, fecal, membrane filtered (colonies/100 ml)	26	70	100	10-330	30

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02320700 Santa Fe River at Graham, Fla., map location number 14					
pH, (standard units)	32	*	*	3.4-7.9	5.6
Alkalinity, total as $CaCO_3$	16	30	47	1-130	6
Hardness as $CaCO_3$ (Ca, Mg)	17	31	36	11-130	14
Noncarbonate hardness	15	10	4	3-19	10
Specific conductance, (micromhos/cm at 25°C)	37	87	68	29-260	55
Color, (Platinum-cobalt scale)	17	220	110	30-440	220
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	25	10	20	0-90	2
Temperature, water, (°C)	44	20.5	4.5	10.5-26.5	21.5
Dissolved oxygen (DO)	37	6.4	1.4	3.6-10.6	6.4
Biochemical oxygen demand (BOD), 5-day at 20°C	23	.7	.5	0.0-2.0	.7
Suspended solids, at 110°C	9	3	3	0-8	2
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	13	7,300	16,000	540-61,000	2,500
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02321500 Santa Fe River at Worthington Springs, Fla., map location number 15					
pH, (standard units)	47	*	*	5.2-8.0	6.0
Alkalinity, total as $CaCO_3$	36	17	12	5-66	13
Hardness as $CaCO_3$ (Ca, Mg)	37	30	11	12-59	26
Noncarbonate hardness	35	15	4	1-24	15
Specific conductance, (micromhos/cm at 25°C)	62	89	36	28-235	80
Color, (Platinum-cobalt scale)	37	180	80	30-400	160
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	42	9	11	1-50	5
Temperature, water, (°C)	78	21.0	5.5	7.0-29	22.0
Dissolved oxygen (DO)	30	6.2	1.2	3.2-8.0	5.6
Biochemical oxygen demand (BOD), 5-day at 20°C	20	1.2	1.7	0.0-8.0	.8
Suspended solids, at 110°C	9	5	2	1-7	6
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	3	18,000	20,000	1,400-40,000	12,000
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02322500 Santa Fe River near Fort White, Fla., map location number 16					
pH, (standard units)	17	*	*	6.6-8.4	7.5
Alkalinity, total as $CaCO_3$	5	144	9	135-157	141
Hardness as $CaCO_3$ (Ca, Mg)	5	162	18	130-174	170
Noncarbonate hardness	4	29	6	20-33	31
Specific conductance, (micromhos/cm at 25°C)	22	273	126	40-448	334
Color, (Platinum-cobalt scale)	5	40	70	0-160	20
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	12	16	27	0-98	4
Temperature, water, (°C)	29	22.0	3.0	12.0-25.5	22.5
Dissolved oxygen (DO)	20	5.6	1.0	4.2-8.4	5.8
Biochemical oxygen demand (BOD), 5-day at 20°C	10	.9	.4	0.2-1.3	1.0
Suspended solids, at 110°C	0				
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	10	1,400	1,200	340-4,200	900
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

Table 3.--Statistical summary of selected water-quality data for Suwannee River basin stations--Continued

Property or constituent	Number of samples	Mean	Standard deviation	Range	Median
02323500 Suwannee River near Wilcox, Fla., map location number 17					
pH, (standard units)	50	*	*	6.4-8.4	7.3
Alkalinity, total as $CaCO_3$	5	122	8	112-129	126
Hardness as $CaCO_3$ (Ca, Mg)	6	132	14	111-150	130
Noncarbonate hardness	5	13	8	0-21	14
Specific conductance, (micromhos/cm at 25°C)	47	218	91	56-360	237
Color, (Platinum-cobalt scale)	11	100	60	25-200	90
Tannin and lignin	0				
Turbidity, (Jackson turbidity units)	49	7	5	1-29	6
Temperature, water, (°C)	50	21.0	5.0	9.5-28.0	22.0
Dissolved oxygen (DO)	49	6.7	1.2	3.9-10.0	6.4
Biochemical oxygen demand (BOD), 5-day at 20°C	47	.8	.5	0.0-2.1	.8
Suspended solids, at 110°C	1	*	*	5	*
Sediment, suspended concentration	0				
Coliform, total membrane filtered, M-ENDO medium, (colonies/100 ml)	32	510	870	70-4,800	290
Coliform, fecal, membrane filtered (colonies/100 ml)	0				

*Cannot be computed.

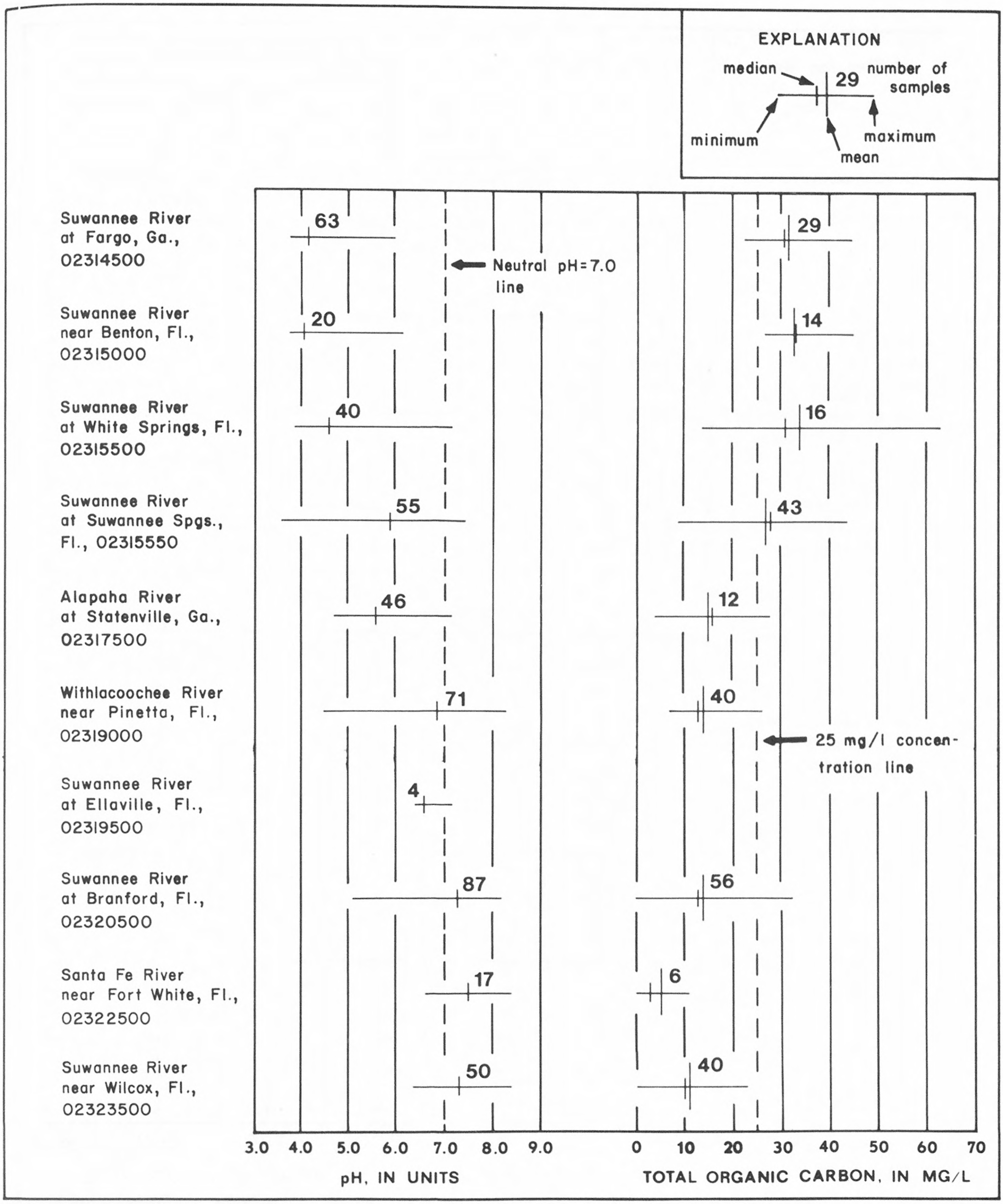


Figure 6.--Median and range of pH values, mean, median, and range of total organic carbon concentrations, and number of samples for selected Suwannee River basin stations in downstream order.

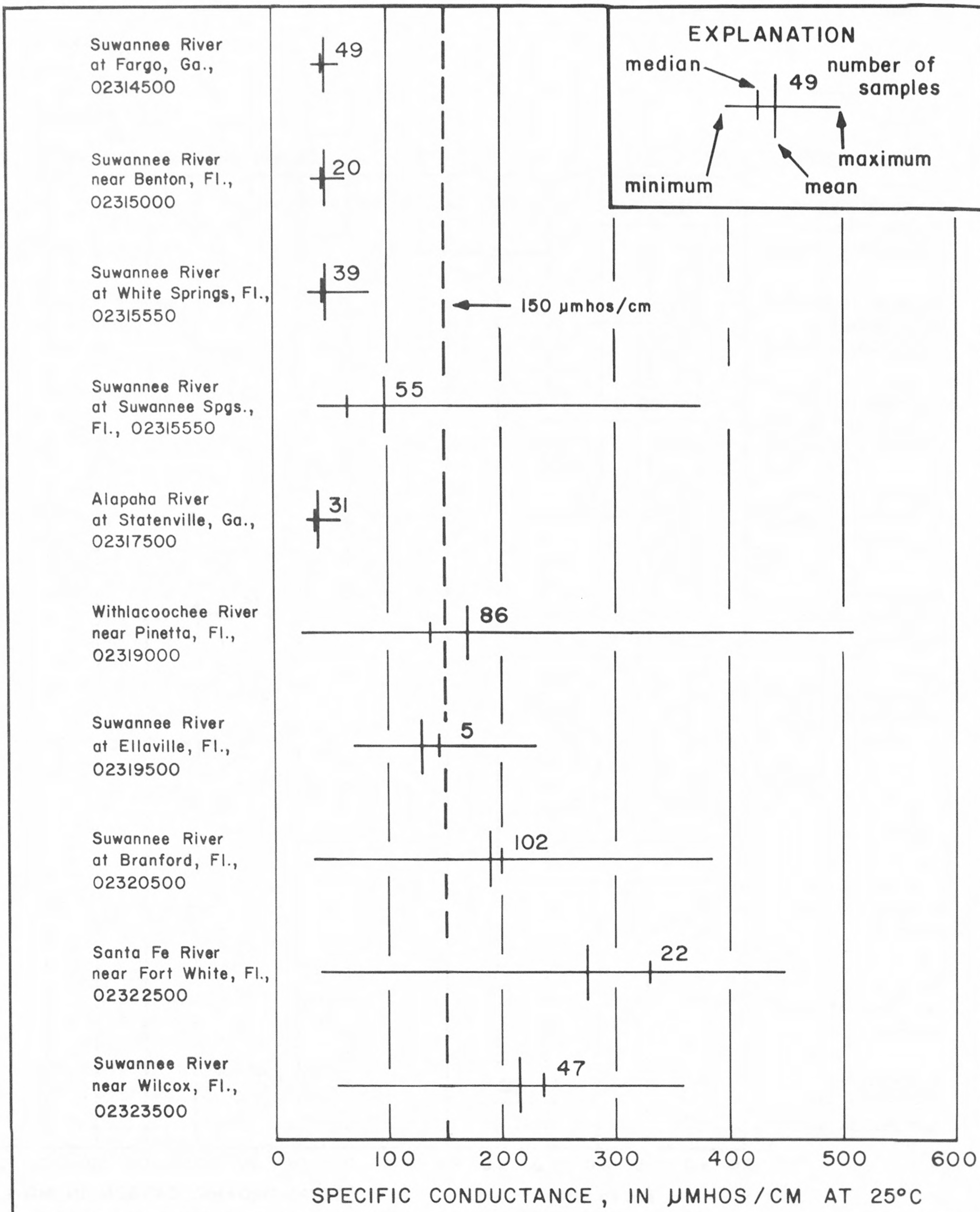


Figure 7.--Mean, median, and range of specific conductance values and number of samples for selected stations in the Suwannee River basin in downstream order.

Water-quality samples for tannins and lignins were only collected on the upper Suwannee River basin tributary streams above White Springs. Mean values ranged from 3.3 mg/L on Hunter Creek to 12 mg/L on Rocky Creek (map location number 2 on fig. 2). The lowest values were obtained for the streams in the phosphate mining areas.

Turbidity at the Suwannee River stations varies. The lowest mean value occurred at Benton with 4 Jackson Turbidity Units (JTU), and the highest mean value at White Springs with 12 JTU. Mean turbidity values on tributary streams ranged from 2 JTU at Deep and Robinson Creeks to 17 JTU at Hunter Creek.

Mean and median values for water temperature, dissolved oxygen (DO), and biochemical oxygen demand (BOD) do not show significant differences between stations or variation trends other than diurnal (day and night) and seasonal. Mean BOD values for Hunter and Swift Creeks were about two and four times higher, respectively, than for any of the other stations.

Mean suspended solids and sediment values were below 10 mg/L except suspended sediment at Swift Creek with 22 mg/L and Branford with 45 mg/L.

Coliform bacteria samples were collected at a few stations. Only Swift Creek and Branford (map location number 13 in fig. 2) had enough fecal coliform samples to average, with means of 20 and 70 colonies per 100 mL, respectively. For 26 samples, the values at Branford ranged from 10 to 330 colonies per 100 mL. Total coliform bacteria samples were collected at 12 of 17 stations. Mean total coliform bacteria concentrations ranged from 300 colonies per 100 mL at Benton to 18,000 colonies per 100 mL at the Santa Fe River at Worthington Springs (map location number 15 in fig. 2 and table 1).

Dissolved Major Inorganic Chemical Constituents

The term "major inorganic chemical constituents" here refers to the primary nonbiological components in the water which comprise the major portion of the dissolved constituents. These are calcium, magnesium, bicarbonate, sulfate, sodium, chloride, potassium, and fluoride. Statistical summaries of these data are given in table 4, which include associated correlation and regression summaries of individual constituents with specific conductance.

Mean concentrations of most dissolved major inorganic chemical constituents at the Suwannee River stations increased downstream. Tributary stream stations, although for the most part not treated here individually, have concentrations which vary from the Suwannee River stations at times. These will be covered in the following section where they have impact on the main river quality. For the Suwannee River stations (fig. 2) mean calcium concentrations ranged from 1.6 mg/L at Benton (no data for Fargo) to 42 mg/L at Wilcox, while magnesium ranged from 0.8 mg/L to 6.2 mg/L, respectively. Mean sodium and potassium concentrations increased only slightly with means of 3.5 and 0.3 mg/L, respectively, at Benton; 4.7 and 0.6 mg/L at Branford; and 8.3 and 0.5 mg/L at Wilcox.

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
					Concentrations (mg/L)					
Mean	Standard deviation	Range		Constituent	Mean	Standard deviation	Range	Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
				02314500 Suwannee River at Fargo, Ga., map location number 1						
			0	Calcium (Ca)						
			0	Magnesium (Mg)						
			0	Sodium (Na)						
			0	Potassium (K)						
			0	Bicarbonate (HCO_3)						
48	4	41-55	23	Sulfate (SO_4)	2.1	0.4	2.0-4.0	SO_4=1.886+0.004SC	0.04	1.2
48	4	41-55	23	Chloride (Cl)	6.3	1.2	4.4-10	Cl=3.842+0.050SC	.15	3.5
			0	Fluoride (F)						
				Dissolved solids						
			0	Residue at 180°C						
			0	Calculated (sum of determined constituents)						

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
Mean	Standard deviation	Range		Constituent	Concentrations (mg/L) Mean	Standard deviation	Range	Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
				02314986 Rocky Creek near Belmont, Fla., map location number 2						
76	13	54-98	16	Calcium (Ca)	3.9	2.5	1.5-9.7	Ca=5.629+(-0.022SC)	-0.12	3.8
76	13	54-98	16	Magnesium (Mg)	2.1	1.4	0.9-6.0	Mg=1.945+0.002SC	.02	2.2
76	13	54-98	16	Sodium (Na)	4.7	1.2	3.0-7.9	Na=4.842+(-0.002SC)	-.03	1.9
76	13	54-98	16	Potassium (K)	.3	.2	0.1-0.9	K=0.257+0.001SC	.05	.4
76	13	54-98	16	Bicarbonate (HCO_3)	5	12	0-48	HCO_3=-10.15+0.205SC	.23	18
75	13	54-98	15	Sulfate (SO_4)	11	5.8	0.0-20	SO_4=6.059+0.068SC	.15	9.1
76	13	54-98	16	Chloride (Cl)	7.7	1.5	5.5-11	Cl=9.278+(-0.021SC)	-.18	2.3
78	24	38-160	45	Fluoride (F)	.3	.1	0.0-0.6	F=0.215+0.001SC	.28	.1
				Dissolved solids						
76	13	54-98	16	Residue at 180°C	135	28	81-178	DR=97.40+0.494SC	.24	41
76	13	54-98	16	Calculated (sum of determined constituents)	38	14	17-58	DC=33.38+0.068SC	.07	21

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
					Concentrations (mg/L)					
Mean	Standard deviation	Range		Constituent	Mean	Standard deviation	Range	Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
02315000 Suwannee River near Benton, Fla., map location number 3										
46	3	42-50	8	Calcium (Ca)	1.6	0.7	0.8-2.4	Ca=2.037+(-0.009SC)	-0.05	3.7
46	3	42-50	8	Magnesium (Mg)	.8	.4	0.3-1.4	Mg=1.130+(-0.007SC)	-.07	1.9
46	3	42-50	8	Sodium (Na)	3.5	.8	2.4-4.5	Na=3.840+0.160SC	.68	3.2
46	3	42-50	8	Potassium (K)	.3	.1	0.2-0.5	K=0.631+(-0.008SC)	-.26	.5
46	3	42-50	8	Bicarbonate (HCO_3)	1	1	0-3	HCO_3=8.718+(-0.180SC)	-.58	4.7
45	4	42-50	7	Sulfate (SO_4)	3.2	3.1	0.8-7.7	SO_4=-5.180+0.184SC	.22	17
46	3	42-50	8	Chloride (Cl)	6.5	1.8	4.1-9.8	Cl=12.20+(-0.125SC)	-.24	9.5
48	7	35-61	19	Fluoride (F)	.2	.1	0.0-0.4	F=0.250+(-0.002SC)	-.12	.2
				Dissolved solids						
46	3	42-50	8	Residue at 180°C	77	10	63-94	DR=50.69+0.578SC	.20	54
45	4	42-50	7	Calculated (sum of determined constituents)	20	4	13-26	DC=12.79+0.162SC	.15	22

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02315005 Hunter Creek near Belmont, Fla., map location number 4										
195	118	59-485	22	Calcium (Ca)	20	13	7.0-49	Ca=-2.078+0.112SC	0.98	1.1
195	118	59-485	22	Magnesium (Mg)	7.4	4.0	2.8-16	Mg=1.087+0.032SC	.96	.5
195	118	59-485	22	Sodium (Na)	9.1	4.2	4.4-20	Na=2.620+0.033SC	.94	.6
195	118	59-485	22	Potassium (K)	.8	.4	0.2-1.5	K=0.361+0.002SC	.67	.1
195	118	59-485	22	Bicarbonate (HCO_3)	37	21	6-73	HCO_3=26.17+0.054SC	.31	8.5
195	118	59-485	22	Sulfate (SO_4)	46	50	4.0-160	SO_4=-31.63+0.399SC	.95	6.5
195	118	59-485	22	Chloride (Cl)	8.4	1.6	5.0-12	Cl=6.905+0.008SC	.57	.6
212	135	34-630	51	Fluoride (F)	1.3	.6	0.2-2.8	F=0.572+0.004SC	.77	.1
				Dissolved solids						
195	118	59-485	22	Residue at 180°C	160	75	74-335	DR=44.53+0.592SC	.93	12
195	121	59-485	21	Calculated (sum of determined constituents)	119	79	46-291	DC=-4.764+0.637SC	.98	6.5

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02315200 Deep Creek near Suwannee Valley, Fla., map location number 5										
83	55	42-225	17	Calcium (Ca)	6.6	6.1	1.8-21	Ca=-2.137+0.105SC	0.94	0.9
83	55	42-225	17	Magnesium (Mg)	3.4	3.1	0.9-11	Mg=-1.033+0.054SC	.94	.5
83	55	42-225	17	Sodium (Na)	4.3	.6	3.6-5.7	Na=4.619+(-0.004SC)	-.34	.3
83	55	42-225	17	Potassium (K)	.3	.2	0.0-0.6	K=0.073+0.002SC	.75	.1
83	55	42-225	17	Bicarbonate (HCO_3)	23	35	0-112	HCO_3=-28.60+0.618SC	.95	4.9
83	55	42-225	17	Sulfate (SO_4)	7.4	5.1	0.0-20	SO_4=11.93+(-0.055SC)	-.59	1.9
83	55	42-225	17	Chloride (Cl)	7.8	2.1	3.8-13	Cl=8.693+(-0.011SC)	-.30	.9
83	55	42-225	17	Fluoride (F)	.2	.1	0.0-0.4	F=0.097+0.001SC	.65	.1
				Dissolved solids						
83	55	42-225	17	Residue at 180°C	110	24	86-175	DR=102.60+0.0861SC	.19	11
83	55	42-225	17	Calculated (sum of determined constituents)	48	24	24-102	DC=13.504+0.410SC	.94	3.8

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
				02315392 Robinson Creek near Suwannee Valley, Fla., map location number 6						
96	54	41-210	18	Calcium (Ca)	8.2	6.9	1.9-21	Ca=-3.470+0.121SC	0.95	1.1
96	54	41-210	18	Magnesium (Mg)	4.3	3.7	1.0-11	Mg=-1.937+0.065SC	.94	.6
96	54	41-210	18	Sodium (Na)	4.0	.9	2.5-6.4	Na=4.874+(-0.009SC)	-.53	.4
96	54	41-210	18	Potassium (K)	.4	.2	0.1-0.9	K=0.219+0.001SC	.40	.1
96	54	41-210	18	Bicarbonate (HCO_3)	33	43	0-115	HCO_3=-39.38+0.751SC	.95	6.8
96	54	41-210	18	Sulfate (SO_4)	7.3	3.4	2.4-14	SO_4=11.180+(-0.040SC)	-.65	1.3
96	54	41-210	18	Chloride (Cl)	8.4	1.5	6.3-12	Cl=8.947+(-0.006SC)	-.21	.8
96	54	41-210	18	Fluoride (F)	.3	.1	0.0-0.4	F=0.176+0.0008SC	.46	.1
				Dissolved solids						
96	54	41-210	18	Residue at 180°C	108	17	76-135	DR=95.381+0.135SC	.44	7.5
96	54	41-210	18	Calculated (sum of determined constituents)	55	30	26-112	DC=3.817+0.538SC	.96	4.0

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
Mean	Standard deviation	Range		Constituent	Concentrations (mg/L) Mean	Standard deviation	Range	Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
				02315500 Suwannee River at White Springs, Fla., map location number 7						
47	13	35-84	21	Calcium (Ca)	2.7	1.8	1.3-9.1	Ca=-3.212+0.127SC	0.92	0.6
47	13	35-84	21	Magnesium (Mg)	1.3	.7	0.6-3.6	Mg=-1.005+0.049SC	.89	.3
47	13	35-84	21	Sodium (Na)	3.2	.7	2.3-5.4	Na=2.249+0.019SC	.35	.6
47	13	35-84	21	Potassium (K)	.2	.1	0.1-0.5	K=-0.005+0.005SC	.56	.1
48	13	35-84	19	Bicarbonate (HCO_3)	4	9	0-34	HCO_3=-23.413+0.567SC	.89	3.5
48	13	35-84	19	Sulfate (SO_4)	4.1	3.6	0.0-10	SO_4=1.605+0.051SC	.19	3.1
48	13	35-84	19	Chloride (Cl)	6.3	1.3	4.3-10	Cl=4.827+0.030SC	.30	1.1
48	13	31-84	39	Fluoride (F)	.2	.1	0.0-0.5	F=0.187+0.0007SC	.09	.1
				Dissolved solids						
47	13	35-84	20	Residue at 180°C	85	36	48-217	DR=67.468+0.363SC	.13	31
48	13	36-84	18	Calculated (sum of determined constituents)	24	9	15-53	DC=-3.949+0.572SC	.85	4.4

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
				02315520 Swift Creek at Facil, Fla., map location number 8						
493	137	250-807	31	Calcium (Ca)	46	14	22-80	Ca=-0.963+0.095SC	0.93	3.5
493	137	250-807	31	Magnesium (Mg)	14	3.8	5.8-21	Mg=2.422+0.023SC	.84	1.5
493	137	250-807	31	Sodium (Na)	29	11	11-62	Na=-5.563+0.070SC	.85	4.1
493	137	250-807	31	Potassium (K)	1.8	.4	1.1-2.6	K=0.791+0.002SC	.66	.2
500	132	250-807	30	Bicarbonate (HCO_3)	12	17	0-84	HCO_3=3.200+0.017SC	.14	12
500	132	250-807	30	Sulfate (SO_4)	156	55	69-290	SO_4=-36.138+0.384SC	.92	16
500	132	250-807	30	Chloride (Cl)	17	7.1	4.0-32	Cl=2.114+0.030SC	.56	4.3
478	164	133-870	61	Fluoride (F)	6.8	4.5	2.0-29	F=2.238+0.010SC	.35	1.7
				Dissolved solids						
500	132	250-807	30	Residue at 180°C	379	99	214-618	DR=37.763+0.681SC	.91	31
504	133	250-807	29	Calculated (sum of determined constituents)	324	102	140-520	DC=-20.291+0.684SC	.89	34

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
Mean	Standard deviation	Range		Constituent	Concentrations (mg/L) Mean	Standard deviation	Range	Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
				02315550 Suwannee River at Suwannee Springs, Fla., map location number 9						
105	46	45-208	10	Calcium (Ca)	14	6.9	5.1-27	Ca=-1.594+0.146SC	0.98	1.2
105	46	45-208	10	Magnesium (Mg)	2.9	1.4	1.6-6.2	Mg=-0.157+0.029SC	.98	.2
105	46	45-208	10	Sodium (Na)	4.5	1.1	3.4-7.1	Na=2.260+0.021SC	.89	.4
105	46	45-208	10	Potassium (K)	.4	.2	0.2-1.1	K=0.487+(-0.0004SC)	-.08	.2
111	44	60-208	9	Bicarbonate (HCO_3)	32	23	6-81	HCO_3=-20.053+0.469SC	.88	11
111	44	60-208	9	Sulfate (SO_4)	9.3	6.8	1.2-21	SO_4=-6.860+0.145SC	.93	2.6
111	44	60-208	9	Chloride (Cl)	7.6	1.4	5.0-10	Cl=7.611+(-0.0003SC)	-.01	1.5
97	70	39-370	53	Fluoride (F)	.5	.3	0.0-2.0	F=0.265=0.002SC	.49	.1
				Dissolved solids						
111	44	60-208	9	Residue at 180°C	110	18	95-147	DR=72.182+0.343SC	.84	10
111	44	60-208	9	Calculated (sum of determined constituents)	63	28	31-125	DC=-7.405+0.634SC	.98	5.7

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02317500 Alapaha River at Statenville, Ga., map location number 10										
			0	Calcium (Ca)						
			0	Magnesium (Mg)						
			0	Sodium (Na)						
			0	Potassium (K)						
			0	Bicarbonate (HCO_3)						
41	6	32-56	23	Sulfate (SO_4)	2.7	1.7	2.0-8.0	SO_4=4.126+(-0.036SC)	-0.13	2.5
41	6	32-56	23	Chloride (Cl)	6.7	1.3	4.7-9.0	Cl=0.437+0.154SC	.71	1.4
			0	Fluoride (F)						
				Dissolved solids						
			0	Residue at 180°C						
			0	Calculated (sum of determined constituents)						

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02319000 Withlacoochee River near Pinetta, Fla., map location number 11										
190	116	35-460	36	Calcium (Ca)	17	11	2.1-39	Ca=-1.162+0.093SC	0.96	1.1
190	116	35-460	36	Magnesium (Mg)	3.1	1.8	0.7-8.0	Mg=0.090+0.016SC	.99	.1
190	116	35-460	36	Sodium (Na)	20	15	2.5-62	Na=-3.153+0.121SC	.95	1.5
190	116	35-460	36	Potassium (K)	1.6	.4	1.0-2.5	K=1.293+0.002SC	.49	.1
190	118	35-460	35	Bicarbonate (HCO_3)	86	71	2-272	HCO_3=-27.209+0.598SC	.99	3.8
190	118	35-460	35	Sulfate (SO_4)	11	6.9	0.6-26	SO_4=0.704+0.055SC	.94	.8
190	118	35-460	35	Chloride (Cl)	9.3	2.7	5.0-15	Cl=7.404+0.010SC	.43	.8
170	114	32-460	68	Fluoride (F)	.4	.3	0.0-1.9	F=0.253+0.0007SC	.26	.1
				Dissolved solids						
190	118	35-460	35	Residue at 180°C	141	75	39-328	DR=25.177+0.613SC	.97	6.3
190	118	35-460	35	Calculated (sum of determined constituents)	115	73	19-295	DC=-2.935+0.621SC	.995	2.4

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
				02319500 Suwannee River at Ellaville, Fla., map location number 12						
230			1	Calcium (Ca)			38			
230			1	Magnesium (Mg)			4.8			
230			1	Sodium (Na)			3.6			
230			1	Potassium (K)			.5			
230			1	Bicarbonate (HCO_3)			112			
230			1	Sulfate (SO_4)			16			
230			1	Chloride (Cl)			6.0			
230			1	Fluoride (F)			.4			
				Dissolved solids						
230			1	Residue at 180°C			161			
230			1	Calculated (sum of determined constituents)			134			

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02320500 Suwannee River at Branford, Fla., map location number 13										
189	93	38-380	72	Calcium (Ca)	28	14	4.3-55	Ca=0.888+0.146SC	0.95	1.2
191	92	38-380	71	Magnesium (Mg)	5.2	2.6	0.9-9.9	Mg=0.029+0.027SC	.96	.2
188	93	38-380	71	Sodium (Na)	4.7	1.1	2.3-7.3	Na=3.810+0.005SC	.39	.3
189	93	38-380	72	Potassium (K)	.6	.2	0.3-1.2	K=0.885+(-0.001SC)	-.58	.1
189	93	38-380	72	Bicarbonate (HCO_3)	95	53	0-189	HCO_3=-9.186+0.548SC	.97	3.5
189	94	38-380	71	Sulfate (SO_4)	12	5.4	0.0-24	SO_4=2.515+0.050SC	.86	.7
189	93	38-380	72	Chloride (Cl)	6.0	1.0	4.0-8.8	Cl=6.855+(-0.005SC)	-.44	.2
191	95	37-380	86	Fluoride (F)	.3	.1	0.0-0.7	F=0.288+(-0.0001SC)	-.11	.1
				Dissolved solids						
189	93	38-380	72	Residue at 180°C	135	44	24-222	DR=54.949+0.423SC	.90	5.0
192	91	38-380	69	Calculated (sum of determined constituents)	113	48	24-199	DC=16.608+0.501SC	.96	3.6

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02320700 Santa Fe River at Graham, Fla., map location number 14										
92	74	44-260	17	Calcium (Ca)	8.4	9.8	2.5-30	Ca=-3.620+0.131SC	0.98	0.8
82	62	44-239	16	Magnesium (Mg)	3.3	3.7	1.1-13	Mg=-1.488+0.059SC	.97	.4
82	62	44-239	16	Sodium (Na)	5.2	.9	2.5-6.6	Na=5.000+0.003SC	.19	.4
82	62	44-239	16	Potassium (K)	.5	.2	0.1-1.0	K=0.434+0.0003SC	.07	.1
95	75	45-260	16	Bicarbonate (HCO_3)	36	58	1-159	HCO_3=-35.655+0.755SC	.98	4.5
95	75	45-260	16	Sulfate (SO_4)	3.1	3.2	0.0-13	SO_4=3.786+(-0.007SC)	-.17	1.3
98	77	45-260	15	Chloride (Cl)	10	2.2	8.4-17	Cl=10.263+0.001SC	.05	1.0
85	64	37-260	24	Fluoride (F)	.3	.1	0.0-0.4	F=0.224+0.0003SC	.20	.1
				Dissolved solids						
82	62	44-239	16	Residue at 180°C	92	28	41-150	DR=66.065+0.315SC	.68	9.2
87	64	45-239	14	Calculated (sum of determined constituents)	48	40	19-145	DC=-4.723+0.613SC	.98	3.7

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
				02321500 Santa Fe River at Worthington Springs, Fla., map location number 15						
96	37	42-235	37	Calcium (Ca)	7.7	3.1	3.2-16	Ca=0.223+0.078SC	0.93	0.5
92	29	42-160	36	Magnesium (Mg)	2.7	1.1	1.1-5.7	Mg=-0.585+0.036SC	.93	.2
92	29	42-160	36	Sodium (Na)	6.4	1.7	3.3-11	Na=1.855+0.049SC	.84	.5
92	29	42-160	36	Potassium (K)	1.0	.4	0.4-2.5	K=0.926+0.0007SC	.05	.2
96	37	42-235	36	Bicarbonate (HCO_3)	21	15	6-81	HCO_3=-16.153+0.385SC	.94	2.5
96	37	42-235	36	Sulfate (SO_4)	9.8	5.0	0.0-23	SO_4=3.330+0.067SC	.50	2.1
96	37	42-235	36	Chloride (Cl)	11	3.1	6.2-23	Cl=4.213+0.067SC	.81	.9
88	29	42-160	40	Fluoride (F)	.3	.1	0.2-0.8	F=0.212+0.001SC	.30	.1
				Dissolved solids						
92	29	42-160	36	Residue at 180°C	91	17	58-138	DR=72.867+0.197SC	.33	9.2
92	29	42-160	35	Calculated (sum of determined constituents)	53	16	24-87	DC=2.189+0.552SC	.97	2.3

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C)			Number of samples	Dissolved chemical constituents				Regression summary		
				Constituent	Concentrations (mg/L)			Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
Mean	Standard deviation	Range			Mean	Standard deviation	Range			
02322500 Santa Fe River near Fort White, Fla., map location number 16										
352	17	336-380	5	Calcium (Ca)	55	2.7	51-58	Ca=97.895+(-0.121SC)	-0.77	20
345	9	336-355	4	Magnesium (Mg)	6.9	.2	6.7-7.1	Mg=3.396+0.010SC	.43	5.2
345	9	336-355	4	Sodium (Na)	5.9	.6	5.2-6.6	Na=0.900+0.014SC	.21	17
345	9	336-355	4	Potassium (K)	.5	.0	0.5-0.5	K=0.500+(-0.00000001SC)	-.40	.0
352	17	336-380	5	Bicarbonate (HCO_3)	176	11	164-192	HCO_3=-19.333+0.553SC	.89	59
352	17	336-380	5	Sulfate (SO_4)	29	2.2	26-31	SO_4=4.244+0.071SC	.57	21
352	17	336-380	5	Chloride (Cl)	9.0	1.2	8.0-11	Cl=13.833+(-0.014SC)	-.19	14
278	112	52-369	12	Fluoride (F)	.2	.1	0.0-0.3	F=0.218+0.00003SC	.03	.1
				Dissolved solids						
345	9	336-355	4	Residue at 180°C	219	6.6	210-225	DR=44.190+0.505SC	.68	135
345	9	336-355	4	Calculated (sum of determined constituents)	203	7.4	193-211	DC=120.08+0.239SC	.28	198

Table 4.--Statistical summary of dissolved major inorganic chemical-constituent data for the Suwannee River basin stations, August 1968 through December 1977--Continued

Specific conductance (micromhos/cm at 25°C): Mean	Specific conductance: Standard deviation	Specific conductance: Range	Number of samples	Dissolved chemical constituents: Constituent	Concentrations (mg/L): Mean	Concentrations (mg/L): Standard deviation	Concentrations (mg/L): Range	Regression summary: Regression equation	Correlation coefficient	Standard error of estimate (mg/L)
				02323500 Suwannee River near Wilcox, Fla., map location number 17						
275	23	237-300	6	Calcium (Ca)	42	5.1	33-47	Ca=45.698+(-0.013SC)	-0.06	31
275	23	237-300	6	Magnesium (Mg)	6.2	0.7	5.2-7.0	Mg=0.144+0.022SC	.70	3.1
275	23	237-300	6	Sodium (Na)	8.3	9.6	3.8-28	Na=-55.540+0.232SC	.54	50
275	23	237-300	6	Potassium (K)	.5	.1	0.4-0.6	K=0.428+0.00008SC	.02	.5
283	14	268-300	5	Bicarbonate (HCO_3)	149	9	136-157	HCO_3=-20.705+0.599SC	.89	50
283	14	268-300	5	Sulfate (SO_4)	17	1.9	14-19	SO_4=-7.352+0.085SC	.60	18
283	14	268-300	5	Chloride (Cl)	7.4	2.0	5.9-10	Cl=-2.974+0.037SC	.26	22
221	94	56-360	41	Fluoride (F)	.2	.1	0.0-0.5	F=0.267+(-0.0001SC)	-.09	.1
				Dissolved solids						
283	14	268-300	5	Residue at 180°C	175	18	156-196	DR=-167.16+1.208SC	.91	89
283	14	268-300	5	Calculated (sum of determined constituents)	164	13	153-184	DC=-79.539+0.862SC	.95	45

Bicarbonate had the same increasing downstream trend as calcium and magnesium, with mean concentrations of 1 mg/L at Benton to 149 mg/L at Wilcox. Sulfate also increased downstream, with mean concentrations of 2.1 mg/L at Fargo to 17 mg/L at Wilcox. Mean concentrations of chloride and fluoride show little change from station to station, most within one standard deviation and with mean values around 6.5 and 0.3 mg/L, respectively. Mean concentrations of dissolved-solids residue and calculated sum of constituents increased steadily downstream from 77 and 20 mg/L respectively at Benton, to 175 and 164 mg/L respectively at Wilcox.

Mean concentrations of individual constituents for most of the ten tributary stream stations do not show a trend or differ greatly from those of the Suwannee River. Hunter and Swift Creeks, the Withlacoochee River (map location number 11 on fig. 2), and the Santa Fe River at Fort White (map location number 16 on fig. 2) had mean dissolved major inorganic chemical concentrations that are substantially different from the nearest Suwannee River stations. Reasons for this are discussed later.

Regression and correlation analysis of specific conductance with the dissolved major inorganic chemical constituents (table 4) indicates some statistically significant relations. From the headwaters downstream to White Springs, correlation coefficients show significance only for sodium at Benton (map location number 3 in fig. 2) at the 5-percent probability level of determination (Snedecor and Cochran, 1967). From White Springs to Branford, however, most all of the correlations are significant at the 1-percent probability level. Potassium and chloride at Suwannee Springs (map location number 9 in fig. 2) and fluoride at Branford are not significant at even the 5-percent probability level. At Wilcox (map location number 17 in fig. 2) only dissolved-solids calculated sum of constituents at the 1-percent probability level and bicarbonate and dissolved-solids residue at the 5-percent probability level show statistical significance.

The standard error of estimate, given in milligrams per liter on table 4, can be expressed as a percentage of the mean constituent concentration for the linear regressions. These follow much the same trend as the correlations. The headwaters downstream to White Springs yield percentage standard errors for major constituents which are greater than 50 percent the standard errors in milligrams per liter are on the order of the standard deviation or larger. From White Springs to Branford, however, percentage standard errors are almost exclusively from 2 to 25 percent, and the standard errors in milligrams per liter are on the order of the standard deviation but generally less. At Wilcox the percentage standard error is greater than 50 percent except that for the dissolved solids calculated sum which is 27 percent. Standard errors here are generally much greater than the standard deviation.

Organic Carbon, Nitrogen, and Phosphorus

Carbon, nitrogen, and phosphorus are essential nutrients for plant production. Total organic carbon (TOC) in particular can be used as an index of the quantity of carbonaceous organic matter present in water. The

type and amount of organic matter in the aquatic environment can be influential in the dissolved-oxygen balance by controlling bacterial oxidation, but photosynthesis and reaeration usually balance these effects. Where loading of organic material is excessive, however, oxygen depletion may occur causing adverse effects on aquatic life dependent on the oxygen supply. Statistical summaries of the carbon, nitrogen and phosphorus data are given in table 5.

Mean concentrations of TOC for the Suwannee River stations from Fargo to Suwannee Springs (map location numbers 1 and 9, respectively, in fig. 2) show a slight decrease downstream from 32 to 27 mg/L but decrease more down to Branford and Wilcox with 14 and 11 mg/L (map location numbers 13 and 17, respectively, in fig. 2). The general downbasin decreasing trend of total organic carbon concentration is shown in figure 5. For the tributary streams, Rocky Creek (map location number 2 in fig. 2) had the highest mean TOC concentration at 52 mg/L while the Santa Fe River at Fort White (map location number 16 in fig. 2) had the lowest with a mean of 4.7 mg/L.

Many water samples were analyzed for ammonia, nitrate, nitrite, organic nitrogen, orthophosphate, and total phosphorus; and in a few instances both dissolved and total concentrations were determined. Only the total concentrations are given in table 5.

Mean concentrations for nitrite on the Suwannee River remain about the same between upstream and downstream stations with values around 0.01 to 0.02 mg/L. Mean concentrations for nitrate, however, increase downstream with values of 0.01 mg/L at Benton, 0.03 mg/L at White Springs, and 0.18 mg/L at Suwannee Springs to a high of 0.33 mg/L at Branford. Mean concentrations of ammonia range from 0.04 to 0.08 mg/L for the Suwannee River stations except for Fargo and Suwannee Springs which had means of 0.16 and 0.18 mg/L, respectively. Mean concentrations of total Kjeldahl and organic nitrogen at the Suwannee River stations are higher upstream from Suwannee Springs (0.73 to 0.95 mg/L and 0.68 to 0.73 mg/L, respectively), and decrease downstream to 0.39 and 0.36 mg/L, respectively, at Wilcox. Mean concentrations of total nitrogen increase downstream from 0.75 mg/L at Benton to 1.2 mg/L at Suwannee Springs, and decrease to 0.72 mg/L at Wilcox.

Mean concentrations of orthophosphate at the Suwannee River stations increase downstream from 0.04 mg/L at Fargo to 0.88 mg/L at Suwannee Springs, and decrease to 0.16 mg/L at Wilcox. Similarly, mean concentrations of total phosphorus generally increase from 0.03 mg/L at Fargo to 1.0 mg/L at Suwannee Springs and decrease to 0.18 mg/L at Wilcox. Mean total phosphorus values tend to be higher than the median values, indicating skewness or nonnormal distribution. This is most pronounced at Suwannee Springs where the median is 0.71 mg/L. A few inordinately high values here are responsible for the higher mean value.

Nutrient concentrations on tributary streams upstream of White Springs, that are not affected by mining, indicate organic carbon and organic nitrogen are the most dominant species. Nitrate, ammonia, and orthophosphate are the dominant species in streams affected by mining (Hunter and Swift Creeks).

Table 5.--Statistical summary of organic carbon, nitrogen, and phosphorus data for the Suwannee River basin stations

[Concentrations expressed in milligrams per liter (mg/L)]

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02314500 Suwannee River at Fargo, Ga., map location number 1					
Carbon, organic total as C	29	32	4	23-45	31
Nitrite, total as N	0				
Nitrate, total as N	0				
Nitrogen, ammonia, total as N	38	.16	.43	0.02-2.0	.02
Nitrogen, total Kjeldahl as N	0				
Nitrogen, total organic as N	0				
Nitrogen, total as N	0				
Phosphorus, total ortho as P	17	.04	.03	0.02-0.12	.03
Phosphorus, total as P	32	.03	.01	0.02-0.06	.02
02314986 Rocky Creek near Belmont, Fl., map location number 2					
Carbon, organic total as C	42	52	22	4.0 -97	56
Nitrite, total as N	42	.02	.01	0.00-0.06	.02
Nitrate, total as N	42	.01	.01	0.00-0.03	.00
Nitrogen, ammonia, total as N	43	.05	.03	0.01-0.16	.05
Nitrogen, total Kjeldahl as N	25	1.2	.4	0.33-1.9	1.2
Nitrogen, total organic as N	47	1.2	.6	0.26-4.3	1.2
Nitrogen, total as N	28	1.2	.4	0.34-1.9	1.3
Phosphorus, total ortho as P	44	.10	.07	0.02-0.27	.08
Phosphorus, total as P	44	.11	.08	0.02-0.30	.07
02315000 Suwannee River near Benton, Fl., map location number 3					
Carbon, organic total as C	14	33	5	27-45	33
Nitrite, total as N	15	.01	.00	0.01-0.02	.01
Nitrate, total as N	15	.01	.01	0.00-0.04	.00
Nitrogen, ammonia, total as N	15	.05	.04	0.02-0.19	.04
Nitrogen, total Kjeldahl as N	15	.73	.15	0.40-0.99	.71
Nitrogen, total organic as N	16	.68	.15	0.37-0.94	.68
Nitrogen, total as N	15	.75	.14	0.42-1.0	.73
Phosphorus, total ortho as P	15	.05	.05	0.02-0.22	.04
Phosphorus, total as P	15	.06	.06	0.02-0.25	.04

Table 5.--Statistical summary of organic carbon, nitrogen, and phosphorus data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02315005 Hunter Creek near Belmont, Fl., map location number 4					
Carbon, organic total as C	45	18	10	6.0 -45	15
Nitrite, total as N	46	.05	.04	0.01-0.18	.03
Nitrate, total as N	46	.66	.86	0.00-3.6	.34
Nitrogen, ammonia, total as N	46	2.1	3.4	0.01-15	.20
Nitrogen, total Kjeldahl as N	29	2.5	3.6	0.45-16	1.1
Nitrogen, total organic as N	48	.93	.50	0.26-2.5	.87
Nitrogen, total as N	32	3.9	4.2	0.60-16	1.8
Phosphorus, total ortho as P	47	1.2	1.2	0.02-6.0	.68
Phosphorus, total as P	47	1.3	1.2	0.30-6.2	.78
02315200 Deep Creek near Suwannee Valley, Fl., map location number 5					
Carbon, organic total as C	12	37	8	22-50	36
Nitrite, total as N	12	.02	.01	0.01-0.03	.02
Nitrate, total as N	12	.02	.03	0.00-0.10	.00
Nitrogen, ammonia, total as N	12	.05	.02	0.02-0.07	.05
Nitrogen, total Kjeldahl as N	12	.76	.14	0.54-1.1	.75
Nitrogen, total organic as N	12	.72	.13	0.51-1.0	.70
Nitrogen, total as N	12	.81	.15	0.60-1.1	.77
Phosphorus, total ortho as P	12	.09	.04	0.05-0.17	.08
Phosphorus, total as P	12	.10	.05	0.05-0.19	.10
02315392 Robinson Creek near Suwannee Valley, Fl., map location number 6					
Carbon, organic total as C	13	37	12	16-50	40
Nitrite, total as N	13	.02	.01	0.01-0.02	.02
Nitrate, total as N	13	.03	.03	0.00-0.10	.02
Nitrogen, ammonia, total as N	13	.05	.02	0.02-0.10	.05
Nitrogen, total Kjeldahl as N	13	.83	.21	0.53-1.2	.77
Nitrogen, total organic as N	13	.78	.19	0.50-1.1	.73
Nitrogen, total as N	13	.88	.20	0.65-1.3	.82
Phosphorus, total ortho as P	13	.11	.05	0.05-0.26	.10
Phosphorus, total as P	13	.14	.08	0.05-0.33	.11

Table 5.--Statistical summary of organic carbon, nitrogen, and phosphorus data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02315500 Suwannee River at White Springs, Fl., map location number 7					
Carbon, organic total as C	16	34	11	14-63	31
Nitrite, total as N	37	.01	.01	0.00-0.03	.01
Nitrate, total as N	39	.03	.06	0.00-0.27	.00
Nitrogen, ammonia, total as N	30	.07	.05	0.00-0.23	.06
Nitrogen, total Kjeldahl as N	16	.76	.12	0.44-0.92	.77
Nitrogen, total organic as N	30	.73	.26	0.16-1.4	.73
Nitrogen, total as N	16	.78	.12	0.46-0.94	.79
Phosphorus, total ortho as P	38	.12	.06	0.05-0.31	.11
Phosphorus, total as P	36	.13	.06	0.05-0.31	.11
02315520 Swift Creek at Facil, Fl., map location number 8					
Carbon, organic total as C	54	20	10	0.0 -52	19
Nitrite, total as N	59	.11	.09	0.00-0.42	.07
Nitrate, total as N	59	1.7	1.3	0.01-5.8	1.5
Nitrogen, ammonia, total as N	53	5.8	4.7	0.04-23	4.8
Nitrogen, total Kjeldahl as N	30	8.4	4.8	2.3 -25	6.8
Nitrogen, total organic as N	54	1.1	1.2	0.00-7.9	.86
Nitrogen, total as N	31	10	5.1	4.7 -28	7.9
Phosphorus, total ortho as P	56	17	10	1.3 -42	16
Phosphorus, total as P	59	18	10	1.5 -42	17
02315550 Suwannee River at Suwannee Springs, Fl., map location number 9					
Carbon, organic total as C	43	27	8	9.0 -44	28
Nitrite, total as N	49	.02	.02	0.01-0.11	.02
Nitrate, total as N	49	.18	.26	0.00-1.5	.09
Nitrogen, ammonia, total as N	41	.18	.21	0.01-1.4	.13
Nitrogen, total Kjeldahl as N	21	.95	.29	0.57-1.8	.89
Nitrogen, total organic as N	46	.71	.30	0.11-1.5	.73
Nitrogen, total as N	24	1.2	.5	0.66-3.4	1.0
Phosphorus, total ortho as P	49	.88	1.1	0.12-6.9	.60
Phosphorus, total as P	41	1.0	1.2	0.12-6.9	.71

Table 5.--Statistical summary of organic carbon, nitrogen, and phosphorus data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02317500 Alapaha River at Statenville, Ga., map location number 10					
Carbon, organic total as C	12	15	7	4.0 -27	16
Nitrite, total as N	0				
Nitrate, total as N	0				
Nitrogen, ammonia, total as N	22	.08	.15	0.02-0.65	.02
Nitrogen, total Kjeldahl as N	0				
Nitrogen, total organic as N	0				
Nitrogen, total as N	0				
Phosphorus, total ortho as P	17	.14	.08	0.04-0.29	.09
Phosphorus, total as P	14	.14	.11	0.06-0.40	.10
02319000 Withlacoochee River near Pinetta, Fl., map location number 11					
Carbon, organic total as C	40	14	5	6.5 -26	13
Nitrite, total as N	50	.02	.01	0.01-0.04	.01
Nitrate, total as N	51	.19	.17	0.00-0.60	.15
Nitrogen, ammonia, total as N	53	.07	.06	0.01-0.44	.05
Nitrogen, total Kjeldahl as N	21	.59	.19	0.15-0.80	.64
Nitrogen, total organic as N	65	.65	.37	0.10-2.2	.59
Nitrogen, total as N	24	.82	.19	0.54-1.3	.80
Phosphorus, total ortho as P	87	.19	.13	0.05-0.78	.15
Phosphorus, total as P	0				
02319500 Suwannee River at Ellaville, Fl., map location number 12					
Carbon, organic total as C	0				
Nitrite, total as N	5	.02	.02	0.01-0.05	.01
Nitrate, total as N	6	.16	.13	0.02-0.35	.09
Nitrogen, ammonia, total as N	5	.08	.03	0.04-0.11	.09
Nitrogen, total Kjeldahl as N	3	.78	.13	0.63-0.86	.85
Nitrogen, total organic as N	5	.68	.25	0.32-1.0	.75
Nitrogen, total as N	3	.96	.03	0.94-0.99	.96
Phosphorus, total ortho as P	5	.21	.10	0.09-0.29	.27
Phosphorus, total as P	4	.21	.08	0.12-0.28	.17

Table 5.--Statistical summary of inorganic carbon, nitrogen, and phosphorus data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02320500 Suwannee River at Branford, Fl., map location number 13					
Carbon, organic total as C	56	14	8	0.0 -32	13
Nitrite, total as N	68	.02	.01	0.00-0.09	.01
Nitrate, total as N	73	.33	.22	0.00-0.75	.36
Nitrogen, ammonia, total as N	74	.04	.03	0.01-0.14	.04
Nitrogen, total Kjeldahl as N	42	.44	.23	0.00-1.2	.43
Nitrogen, total organic as N	83	.45	.26	0.00-1.4	.44
Nitrogen, total as N	44	.82	.25	0.55-2.2	.78
Phosphorus, total ortho as P	101	.20	.11	0.05-0.84	.17
Phosphorus, total as P	78	.23	.12	0.10-0.84	.21
02320700 Santa Fe River at Graham, Fl., map location number 14					
Carbon, organic total as C	16	30	17	5.0 -70	26
Nitrite, total as N	26	.01	.01	0.00-0.03	.02
Nitrate, total as N	27	.01	.02	0.00-0.07	.00
Nitrogen, ammonia, total as N	20	.05	.04	0.00-0.13	.03
Nitrogen, total Kjeldahl as N	7	.60	.32	0.18-0.90	.68
Nitrogen, total organic as N	20	.75	.79	0.15-3.8	.63
Nitrogen, total as N	8	.65	.32	0.18-0.98	.72
Phosphorus, total ortho as P	26	.06	.04	0.01-0.18	.05
Phosphorus, total as P	27	.08	.08	0.02-0.39	.05
02321500 Santa Fe River at Worthington Springs, Fl., map location number 15					
Carbon, organic total as C	13	20	7	8.0 -32	22
Nitrite, total as N	27	.01	.01	0.01-0.03	.01
Nitrate, total as N	28	.10	.10	0.00-0.43	.06
Nitrogen, ammonia, total as N	29	.05	.03	0.00-0.10	.04
Nitrogen, total Kjeldahl as N	7	.72	.18	0.46-0.92	.76
Nitrogen, total organic as N	37	.82	.36	0.27-2.1	.76
Nitrogen, total as N	9	.92	.15	0.73-1.3	.92
Phosphorus, total ortho as P	63	.19	.08	0.03-0.43	.17
Phosphorus, total as P	32	.26	.17	0.03-1.0	.21

Table 5.--Statistical summary of organic carbon, nitrogen, and phosphorus data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02322500 Santa Fe River near Fort White, Fl., map location number 16					
Carbon, organic total as C	6	4.7	4.1	0.0 -11	3.0
Nitrite, total as N	1	*	*	0.00	*
Nitrate, total as N	1	*	*	.29	*
Nitrogen, ammonia, total as N	0				
Nitrogen, total Kjeldahl as N	1	*	*	.13	*
Nitrogen, total organic as N	7	.15	.15	0.04-0.46	.09
Nitrogen, total as N	1	*	*	.42	*
Phosphorus, total ortho as P	10	.09	.03	0.05-0.13	.09
Phosphorus, total as P	4	.08	.01	0.07-0.10	.07
02323500 Suwannee River near Wilcox, Fl., map location number 17					
Carbon, organic total as C	40	11	7	0.0 -23	10
Nitrite, total as N	36	.01	.01	0.00-0.03	.01
Nitrate, total as N	36	.31	.17	0.00-0.59	.36
Nitrogen, ammonia, total as N	36	.04	.03	0.00-0.09	.02
Nitrogen, total Kjeldahl as N	21	.39	.18	0.02-0.74	.40
Nitrogen, total organic as N	44	.36	.21	0.01-0.93	.35
Nitrogen, total as N	23	.72	.10	0.50-0.88	.74
Phosphorus, total ortho as P	46	.16	.06	0.02-0.33	.14
Phosphorus, total as P	39	.18	.07	0.09-0.45	.16

*Cannot be computed.

Trace Elements

Element concentrations of less than 1 mg/L in water are considered minor or trace. Trace elements are sampled in many studies because they are considered potential hazards to the aquatic environment and to man. In the Suwannee River basin, concentration data on these constituents are sparse, but for many of the stations where data exist the analyses include: arsenic, chromium, copper, iron, lead, manganese, strontium, zinc, and aluminum. A few samples were also analyzed for boron, cadmium, cobalt, nickel, and mercury. A statistical data summary for these dissolved trace elements is given in table 6.

The concentrations of most dissolved trace elements were variable at each station and between stations. The mean iron concentrations tended to decrease in the downstream direction from 460 μg/L at Benton to 170 μg/L at Wilcox, while strontium tended to increase from 40 μg/L at Benton to 160 μg/L at Wilcox. Tributary streams tended to show much the same variability as the Suwannee River stations, but, as with other constituents, Hunter and Swift Creeks differed. Mean concentrations of iron in these streams were generally lower than for the nearest Suwannee River station, with 200 μg/L at Hunter Creek and 180 μg/L at Swift Creek. The lowest mean iron concentration was 30 μg/L occurring at the Santa Fe River at Fort White. Concentrations of strontium were generally higher in the phosphate mining area streams than for the Suwannee River stations with means of 50 μg/L at Hunter Creek and 120 μg/L at Swift Creek. The highest strontium concentration in the basin was 390 μg/L occurring at the Santa Fe River at Fort White.

DISCUSSION

Upper Suwannee River Basin to Suwannee Springs

The headwaters of the upper Suwannee River, including the tributary streams not affected by phosphate mining, are characteristically low in dissolved solids (calculated sum generally less than 100 mg/L), and high in organic materials (TOC generally greater than 25 mg/L) when compared to many natural waters. Concentration ratios of the mean organic content (expressed as TOC) to mean inorganic content (expressed as dissolved-solids calculated sum), are generally greater than 0.50 and qualitatively reflect their relative importance. Although these ratios of the means are for unmatched pairs of data, the sample distributions are normal and sufficient for the qualitative generalization. For the Suwannee River stations at Benton, White Springs, and Suwannee Springs (fig. 2 and table 1) the ratio of the means are: 1.65, 1.42, and 0.43, respectively. For the tributary stations on Rocky, Deep, and Robinson Creeks the ratios are: 1.37, 0.77, and 0.67, respectively. The highest ratios tend to occur during periods of high flow and lowest during low flow. Higher ratios result from the flushing of organic-laden, low dissolved-solids waters from swamps and wetlands during rain events. Low ratios reflect the low organic and high dissolved-solids input from ground-water sources during the dryer low- or base-flow stream conditions.

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations

[Concentrations expressed in micrograms per liter (ug/L)]

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02314500 Suwannee River at Fargo, Ga., map location number 1					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	0				
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	0				
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	0				
Copper, dissolved as Cu	0				
Iron, dissolved as Fe	0				
Lead, dissolved as Pb	0				
Manganese, dissolved as Mn	0				
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	0				
Zinc, dissolved as Zn	0				
02314986 Rocky Creek near Belmont, Fl., map location number 2					
Aluminum, dissolved as Al	5	430	210	100-640	450
Arsenic, dissolved as As	7	6	10	0-20	1
Boron, dissolved as B	4	250	110	80-320	300
Cadmium, dissolved as Cd	6	0	0	0-1	0
Chromium, dissolved as Cr	6	3	4	0-10	0
Cobalt, dissolved as Co	6	1	1	0-3	0
Copper, dissolved as Cu	12	3	4	0-10	1
Iron, dissolved as Fe	13	590	220	210-930	590
Lead, dissolved as Pb	13	6	4	0-12	6
Manganese, dissolved as Mn	12	27	12	6-50	30
Mercury, dissolved as Hg	5	.0	.0	0.0-0.1	.0
Nickel, dissolved as Ni	5	1	1	0-3	0
Strontium, dissolved as Sr	16	40	30	0-80	40
Zinc, dissolved as Zn	12	20	20	0-50	10

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02315000 Suwannee River near Benton, Fl., map location number 3					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	0				
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	0				
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	0				
Copper, dissolved as Cu	4	4	2	2-6	4
Iron, dissolved as Fe	5	460	130	280-630	450
Lead, dissolved as Pb	4	11	4	7-16	9
Manganese, dissolved as Mn	4	10	8	0-20	10
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	4	40	10	30-50	40
Zinc, dissolved as Zn	4	30	30	0-70	20
02315005 Hunter Creek near Belmont, Fl., map location number 4					
Aluminum, dissolved as Al	7	140	150	10-420	50
Arsenic, dissolved as As	8	2	3	0-10	1
Boron, dissolved as B	6	80	40	50-150	50
Cadmium, dissolved as Cd	7	0	0	0-0	0
Chromium, dissolved as Cr	7	3	4	0-8	0
Cobalt, dissolved as Co	7	0	0	0-0	0
Copper, dissolved as Cu	12	1	1	0-4	0
Iron, dissolved as Fe	16	200	180	10-560	110
Lead, dissolved as Pb	14	3	3	0-10	2
Manganese, dissolved as Mn	12	20	10	10-50	20
Mercury, dissolved as Hg	7	.1	.1	0.0-0.2	.0
Nickel, dissolved as Ni	7	1	2	0-4	0
Strontium, dissolved as Sr	18	50	20	10-100	50
Zinc, dissolved as Zn	12	9	10	0-30	4

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02315200 Deep Creek near Suwannee Valley, Fl., map location number 5					
Aluminum, dissolved as Al	7	300	90	180-460	290
Arsenic, dissolved as As	7	1	1	0-1	1
Boron, dissolved as B	6	260	70	190-370	230
Cadmium, dissolved as Cd	7	0	0	0-0	0
Chromium, dissolved as Cr	7	1	1	0-2	0
Cobalt, dissolved as Co	7	0	1	0-2	0
Copper, dissolved as Cu	7	1	2	0-6	0
Iron, dissolved as Fe	7	670	150	490-880	660
Lead, dissolved as Pb	7	6	3	3-12	5
Manganese, dissolved as Mn	7	20	10	10-40	20
Mercury, dissolved as Hg	7	.3	.3	0.1-0.9	.1
Nickel, dissolved as Ni	7	1	1	0-3	0
Strontium, dissolved as Sr	17	40	20	10-80	40
Zinc, dissolved as Zn	7	10	10	0-30	10
02315392 Robinson Creek near Suwannee Valley, Fl., map location number 6					
Alumiunum, dissolved as Al	7	350	120	130-480	400
Arsenic, dissolved as As	7	0	0	0-1	0
Boron, dissolved as B	6	250	70	160-370	210
Cadmium, dissolved as Cd	7	0	0	0-1	0
Chromium, dissolved as Cr	7	1	2	0-5	0
Cobalt, dissolved as Co	7	0	0	0-3	0
Copper, dissolved as Cu	7	1	2	0-5	0
Iron, dissolved as Fe	7	640	180	380-820	690
Lead, dissolved as Pb	7	9	4	3-16	9
Manganese, dissolved as Mn	7	20	10	0-40	20
Mercury, dissolved as Hg	7	.2	.2	0.0-0.5	.1
Nickel, dissolved as Ni	7	0	0	0-1	0
Strontium, dissolved as Sr	18	40	20	10-80	40
Zinc, dissolved as Zn	7	7	5	0-10	10

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02315500 Suwannee River at White Springs, Fl., map location number 7					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	4	10	14	0-30	5
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	2	0	0	0-0	0
Chromium, dissolved as Cr	1	*	*	0	*
Cobalt, dissolved as Co	2	0	0	0-0	0
Copper, dissolved as Cu	14	3	3	0-10	2
Iron, dissolved as Fe	18	460	140	230-810	440
Lead, dissolved as Pb	15	5	5	1-17	4
Manganese, dissolved as Mn	14	20	30	0-130	10
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	16	40	30	0-100	30
Zinc, dissolved as Zn	14	40	60	0-220	20
02315520 Swift Creek at Facil, Fl., map location number 8					
Aluminum, dissolved as Al	7	170	120	70-360	120
Arsenic, dissolved as As	11	4	3	0-10	3
Boron, dissolved as B	7	110	40	50-180	110
Cadmium, dissolved as Cd	10	1	1	0-2	0
Chromium, dissolved as Cr	8	1	1	0-3	0
Cobalt, dissolved as Co	10	1	1	0-4	0
Copper, dissolved as Cu	16	5	6	0-24	2
Iron, dissolved as Fe	21	180	120	10-440	140
Lead, dissolved as Pb	19	4	6	0-20	2
Manganese, dissolved as Mn	17	80	30	10-140	70
Mercury, dissolved as Hg	7	.1	.1	0.0-0.2	.1
Nickel, dissolved as Ni	7	7	5	0-16	6
Strontium, dissolved as Sr	26	120	130	10-720	100
Zinc, dissolved as Zn	17	50	110	0-460	10

*Cannot be computed.

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02315550 Suwannee River at Suwannee Springs, Fl., map location number 9					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	2	15	7	10-20	5
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	1	*	*	0	*
Chromium, dissolved as Cr	1	*	*	20	*
Cobalt, dissolved as Co	1	*	*	0	*
Copper, dissolved as Cu	7	4	4	0-10	2
Iron, dissolved as Fe	12	410	140	110-660	410
Lead, dissolved as Pb	10	2	2	0-6	0
Manganese, dissolved as Mn	8	20	8	7-30	20
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	5	40	10	30-50	50
Zinc, dissolved as An	8	20	20	0-50	10
02317500 Alapaha River at Statenville, Ga., map location number 10					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	0				
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	0				
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	0				
Copper, dissolved as Cu	0				
Iron, dissolved as Fe	0				
Lead, dissolved as Pb	0				
Manganese, dissolved as Mn	0				
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	0				
Zinc, dissolved as Zn	0				

*Cannot be computed.

Table 6.-Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
0231900 Withlacoochee River near Pinetta, Fl., map location number 11					
Aluminum, dissolved as Al	1	*	*	170	*
Arsenic, dissolved as As	4	5	6	0-10	0
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	2	1	1	0-1	0
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	2	1	1	0-1	0
Copper, dissolved as Cu	13	4	4	0-10	3
Iron, dissolved as Fe	21	294	192	30-770	350
Lead, dissolved as Pb	14	7	7	0-20	4
Manganese, dissolved as Mn	13	25	12	0-40	20
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	18	97	100	10-480	70
Zinc, dissolved as Zn	13	46	65	0-210	10
02319500 Suwannee River at Ellaville, Fl., map location number 12					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	0				
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	0				
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	0				
Copper, dissolved as Cu	0				
Iron, dissolved as Fe	1	*	*	150	*
Lead, dissolved as Pb	0				
Manganese, dissolved as Mn	0				
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	0				
Zinc, dissolved as Zn	0				

*Cannot be computed.

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02320500 Suwannee River at Branford, Fl., map location number 13					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	20	3	8	0-30	0
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	17	1	2	0-9	0
Chromium, dissolved as Cr	17	2	5	0-20	0
Cobalt, dissolved as Co	17	0	0	0-0	0
Copper, dissolved as Cu	20	4	4	0-12	2
Iron, dissolved as Fe	32	210	140	0-570	180
Lead, dissolved as Pb	22	6	7	0-27	4
Manganese, dissolved as Mn	20	20	20	0-70	10
Mercury, dissolved as Hg	15	.1	.2	0.0-0.5	.0
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	51	100	60	0-440	90
Zinc, dissolved as Zn	20	15	22	0-70	4
02320700 Santa Fe River at Graham, Fl., map location number 14					
Aluminum, dissolved as Al	1	*	*	230	*
Arsenic, dissolved as As	4	13	13	0-30	10
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	2	1	1	0-1	0
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	2	1	1	0-1	0
Copper, dissolved as Cu	12	6	7	0-23	2
Iron, dissolved as Fe	15	340	170	120-670	300
Lead, dissolved as Pb	13	6	6	0-20	4
Manganese, dissolved as Mn	12	13	7	0-25	10
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	14	40	20	10-70	40
Zinc, dissolved as Zn	12	40	50	5-160	10

*Cannot be computed.

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02321500 Santa Fe River at Worthington Springs, Fl., map location number 15					
Aluminum, dissolved as Al	1	*	*	230	*
Arsenic, dissolved as As	4	8	5	0-10	10
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	2	1	1	0-1	0
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	2	0	0	0-0	0
Copper, dissolved as Cu	12	2	2	0-8	0
Iron, dissolved as Fe	19	300	160	80-700	280
Lead, dissolved as Pb	14	6	8	0-24	2
Manganese, dissolved as Mn	12	19	11	0-40	17
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	18	60	30	10-100	60
Zinc, dissolved as Zn	12	30	50	0-150	10
02322500 Santa Fe River near Fort White, Fl., map location number 16					
Aluminum, dissolved as Al	0				
Arsenic, dissolved as As	2	15	7	10-20	15
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	1	*	*	0	*
Chromium, dissolved as Cr	0				
Cobalt, dissolved as Co	1	*	*	0	*
Copper, dissolved as Cu	3	0	0	0-0	0
Iron, dissolved as Fe	4	30	20	20-60	20
Lead, dissolved as Pb	3	1	1	0-2	1
Manganese, dissolved as Mn	3	7	6	0-10	10
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	3	390	30	360-420	390
Zinc, dissolved as Zn	3	50	10	40-60	40

*Cannot be computed.

Table 6.--Statistical summary of selected trace element data for the Suwannee River basin stations--Continued

Constituents	Number of samples	Mean	Standard deviation	Range	Median
02323500 Suwannee River near Wilcox, Fl., map location number 17					
Aluminum, dissolved as Al	1	*	*	70	*
Arsenic, dissolved as As	3	10	0	10-10	10
Boron, dissolved as B	0				
Cadmium, dissolved as Cd	1	*	*	0	*
Chromium, dissolved as Cr	2	0	0	0-0	0
Cobalt, dissolved as Co	1	*	*	0	*
Copper, dissolved as Cu	8	1	1	0-3	0
Iron, dissolved as Fe	11	170	120	0-350	140
Lead, dissolved as Pb	10	3	3	0-10	1
Manganese, dissolved as Mn	8	10	10	0-20	10
Mercury, dissolved as Hg	0				
Nickel, dissolved as Ni	0				
Strontium, dissolved as Sr	4	160	40	120-200	140
Zinc, dissolved as Zn	8	50	70	3-200	10

*Cannot be computed.

A predominance of either high- or low-flow conditions for the respective period of record at any station will somewhat skew the means and therefore the ratios. However, for the Suwannee River stations, the record is presumed to be of sufficient length to represent the probable range and therefore the ratios obtained should be characteristic. Based on these ratios, the headwater chemical character extends below White Springs but not as far as Suwannee Springs.

The pH of the Suwannee River headwaters upstream of Suwannee Springs is acidic, usually around 4.0 to 4.5 pH units but ranging up to around 6.0 pH units. The low pH or high acidity of the river water down to Suwannee Springs is related to the presence of organic substances of a group known as humates which impart a yellowish-brown color to the water. The water-extractable fraction of this material is commonly referred to as fulvic acid while that which precipitates is referred to as humic acid (Gjessing, 1976). The significance of these acids and the quantity of organic material relative to the inorganic material to the chemistry of surface water has been studied for some southeastern United States coastal plain rivers in Georgia and Florida (Beck and others, 1974; Reuter and Purdue, 1977). These findings indicate that when the organic matter predominates over the inorganic, organic acids control the chemical environment by decreasing pH, removing free oxygen, and scavenging trace elements (by complexing--chelation and sorption).

The tributary streams of this headwater region represent surface water basins of less than 100 square miles (table 1). Because of their size they are more responsive to local conditions like rainfall and drought than the Suwannee River and are therefore more variable in their chemical character. The tributary streams, Hunter and Swift Creeks, are affected additionally by phosphate mining activities. Their general de-vegetated state (compared to other tributary stream basins), physical association with the mining product or matrix minerals, and input of Floridan aquifer water from the mining operations result in these creeks having an inorganic chemical character more like ground water than other tributary streams.

The water-quality type (Slack and Rosenau, 1979) of most streams (except those affected by mining) in the upper Suwannee River basin headwaters down to Suwannee Springs can be described as "mixed" or lacking a dominant inorganic constituent under average to high-flow conditions. Specific conductance of these waters is less than 100 µmhos/cm and is related to the low dissolved-solids concentration. Organic carbon and nitrogen here are dominant in concentration over the other nutrient forms determined for most of these waters. Aluminum, boron, and iron, associated with clay minerals in the surface and near subsurface environment, are commonly in the range from 100 to 300 µg/L in the water.

At Suwannee Springs the water-quality type is transitional between "mixed" at higher flows, and calcium-magnesium bicarbonate at average or lower flows. The mean specific conductance here is 99 µmhos/cm, ranging from 39 to 370 µmhos/cm. The higher values reflect the input of higher dissolved-solids water. The median pH is about 6.0 and ranges to over 7.0

as a result of calcium carbonate waters from the Floridan aquifer (Suwannee Springs, table 7) and effluent from Swift Creek (fig. 6; also Miller and others, 1978, p. 123). Other effects from Swift Creek are indicated at Suwannee Springs by almost an order of magnitude concentration increase in several nutrient forms found in substantially higher concentrations in Swift Creek (table 5). For example, median total phosphorus at White Springs is 0.11 mg/L, at Suwannee Springs is 0.71 mg/L, and at Swift Creek is 17 mg/L (median is used because of the skewed values mentioned earlier). Since the average annual discharges at White Springs and Suwannee Springs for the 1975, 1976, and 1977 water years (U.S. Geological Survey, 1975-1977) were within 10 percent of each other for each year a high concentration source with a small comparative discharge (high load) would be required to increase the mean concentration from 0.11 to 0.71 mg/L. No other source of total phosphorus has been identified in this reach of the Suwannee River to date (1979). It is possible, however, that agricultural fertilizer applications in the area could contribute, but overland runoff is almost nonexistent and spring data, although sparse, do not indicate springs as a source.

Fluoride also is found at Swift Creek in its highest concentrations in the basin with a mean of 6.8 mg/L, ranging from 2.0 to 29 mg/L. Hunter Creek is also high with a mean of 1.3 mg/L and a range of 0.2 to 2.8 mg/L. At Suwannee Springs, the next downstream Suwannee River station, fluoride concentrations range from 0.0 to 2.0 mg/L with a mean of 0.5 mg/L while the station upstream (White Springs) ranges from 0.0 to 0.5 mg/L with a mean of 0.2 mg/L. The source of the higher fluoride is likely Swift Creek since spring discharged concentrations and the upstream contributions from White Springs are lower. The fluoride is derived from the partial dissolution and ion exchange of the calcium fluoropatite mineral which is mined for phosphate.

Strontium and manganese concentrations in Swift Creek were higher than those at the Suwannee River stations. Strontium is derived from the dissolution of an accessory mineral called celestite (strontium sulfate) found in the limestone of the Floridan aquifer. Manganese is associated with the near-surface deposits in the form of a manganese oxide accessory mineral. The higher concentrations of manganese in Swift Creek are most likely a result of the presence of inorganic acids which, by causing a drop in pH, make the manganese a stronger oxidant and therefore more soluble (Ingols and Enginun, 1968, p. 147).

At Suwannee Springs the higher part of the ranges for pH, conductance, and other physical properties and inorganic constituents occurs at lower flows and approximate, at times, the concentrations found for the springs at Suwannee Springs (fig. 5 and table 7). Discharge from the mining-affected Swift Creek, is partly responsible for some of the higher concentrations, especially of nutrients, observed at Suwannee Springs. This is most evident when the discharge of Swift Creek is high with respect to the flow of the Suwannee River at their confluence. Although sparse, individual spring analyses do not indicate any substantial source of nutrients to the river by ground water in this reach (Rosenau and others, 1977).

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida

[Dissolved concentrations expressed in milligrams per liter (mg/L), except as noted]

[Data from Rosenau and others, 1977, and from U.S. Geological Survey files]

Constituents	Date of collection		
	February 26, 1924	May 11, 1966	November 19, 1973
Suwannee Springs, Columbia County, Florida			
Carbon dioxide (CO_2)	--	--	9.1
Calcium (Ca)	53	53	48
Magnesium (Mg)	12	7.2	11
Sodium (Na)	5.5	4.0	4.2
Potassium (K)	0.6	0.4	1.0
Silica (SiO_2)	14	11	12
Bicarbonate (HCO_3)	180	180	180
Carbonate (CO_3)	--	0	0
Sulfate (SO_4)	27	18	17
Chloride (Cl)	7.0	7.0	5.3
Fluoride (F)	--	.2	0.1
Dissolved oxygen (DO)	--	--	4.5
Dissolved solids			
Calculated	220	187	187
Residue on evaporation at 180°C	--	--	199
Hardness as $CaCO_3$	180	160	170
Noncarbonate hardness as $CaCO_3$	--	18	18
Alkalinity as $CaCO_3$	--	140	150
Specific conductance (micromhos/cm at 25°C)	--	330	333
pH (units)	--	7.5	7.5
Color (platinum-cobalt units)	--	15	10
Temperature (°C)	--	21.5	21.0
Strontium (Sr) (ug/L)	--	--	0

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection November 25, 1975
Alapaha Rise, Hamilton County, Florida	
Calcium (Ca)	33
Magnesium (Mg)	5.0
Sodium (Na)	4.2
Potassium (K)	0.7
Silica (SiO_2)	10
Bicarbonate (HCO_3)	100
Carbonate (CO_3)	.0
Sulfate (SO_4)	18
Chloride (Cl)	5.3
Fluoride (F)	.2
Nitrate (NO_3)	--
Dissolved oxygen (DO)	1.5
Dissolved solids	
Calculated	130
Residue on evaporation at 180°C	148
Hardness as $CaCO_3$	100
Noncarbonate hardness as $CaCO_3$	17
Alkalinity as $CaCO_3$	83
Specific conductance (micromhos/cm at 25°C)	225
pH (units)	7.6
Color (platinum-cobalt units)	60
Temperature (°C)	19.0
Strontium (Sr) (ug/L)	90

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection	
	November 22, 1960	October 16, 1973
Troy Spring, Lafayette County, Florida		
Carbon dioxide (CO_2)	4	23
Calcium (Ca)	54	56
Magnesium (Mg)	6.7	6.4
Sodium (Na)	2.4	2.6
Potassium (K)	0.2	1.3
Silica (SiO_2)	5.9	6.2
Bicarbonate (HCO_3)	180	180
Carbonate (CO_3)	0	0
Sulfate (SO_4)	6.0	5.6
Chloride (Cl)	3.0	4.0
Fluoride (F)	.1	.1
Dissolved solids		
Calculated	170	180
Residue on evaporation at 180°C	--	183
Hardness as $CaCO_3$	160	170
Noncarbonate hardness as $CaCO_3$	11	17
Alkalinity as $CaCO_3$	150	150
Specific conductance (micromhos/cm at 25°C)	307	358
pH (units)	7.8	7.1
Color (platinum-cobalt units)	5	0
Temperature (°C)	21.7	21.5
Turbidity (JTU)	--	1
Biochemical oxygen demand (BOD, 5-day)	--	.20
Dissolved oxygen (DO)	--	1.4
Total organic carbon (TOC)	--	.00
Total inorganic carbon (TIC)	--	37
Total carbon (TC)	--	37
Organic nitrogen (N)	--	.12

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection	
	November 22, 1960	October 16, 1973
Troy Spring, Lafayette County, Florida--Continued		
Ammonium (NH_3 as N)	--	0.00
Nitrite (NO_2 as N)	--	.01
Nitrate (NO_3 as N)	0.30	.95
Orthophosphate (PO_4 as P)	--	.02
Total phosphate (P)	--	.03
Cadmium (Cd) (ug/L)	--	.00
Chromium (Cr^6) (ug/L)	--	.00
Cobalt (CO) (ug/L)	--	.00
Copper (Cu) (ug/L)	--	10
Lead (Pb) (ug/L)	--	6
Strontium (Sr) (ug/L)	--	240

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection		
	Nov 7, 1924	Feb 29, 1972	Sept 15, 1976
Heilbronn Spring, Bradford County, Florida			
Nitrite (NO_2 as N)	--	0.00	0.00
Nitrate (NO_3 as N)	--	.60	1.0
Calcium (Ca)	38	31	36
Magnesium (Mg)	19	17	17
Sodium (Na)	8.7	9.1	9.5
Potassium (K)	8.7	.6	1.0
Silica (SiO_2)	23	18	6.2
Bicarbonate (HCO_3)	210	160	196
Carbonate (CO_3)	--	8	0
Sulfate (SO_4)	2.5	1.6	4.2
Chloride	14	13	14
Fluoride (F)	--	.4	.3
Dissolved solids			
Calculated	--	180	190
Residue on evaporation at 180°C	197	189	202
Hardness as $CaCO_3$	170	150	160
Noncarbonate hardness as $CaCO_3$	--	0	0
Alkalinity as $CaCO_3$	--	150	161
Specific conductance (micromhos/cm at 25°C)	--	340	340
pH (units)	--	8.5	7.6
Color (platinum-cobalt units)	--	5	5
Temperature (°C)	--	20.5	21.0
Iron (Fe) (ug/L)	30	--	--

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection	
	August 13, 1924	April 24, 1972
Worthington Spring, Union County, Florida		
Nitrite (NO_2 as N)	--	0.01
Nitrate (NO_3 as N)	--	.06
Calcium (Ca)	40	28
Magnesium (Mg)	7.9	9.2
Sodium (Na)	12	6.0
Potassium (K)		.7
Silica (SiO_2)	24	17
Bicarbonate (HCO_3)	170	130
Carbonate (CO_3)	--	0
Sulfate (SO_4)	8.8	4.4
Chloride (Cl)	10	9.0
Fluoride (F)	--	.4
Dissolved solids		
Calculated	--	140
Residue on evaporation at 180°C	189	167
Hardness as $CaCO_3$	130	110
Noncarbonate hardness as $CaCO_3$	--	7
Alkalinity as $CaCO_3$	--	100
Specific conductance (micromhos/cm at 25°C)	--	242
pH (units)	--	7.8
Color (platinum-cobalt units)	--	85
Temperature (°C)	--	20.0
Strontium (Sr) (ug/L)	--	1,900
Iron (Fe) (ug/L)	40	--

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection September 8, 1976
Hornsby Spring, Alachua County, Florida	
Nitrite (NO_2 as N)	0.01
Nitrate (NO_3 as N)	.27
Calcium (Ca)	69
Magnesium (Mg)	11
Sodium (Na)	13
Potassium (K)	1.3
Silica (SiO_2)	5.0
Bicarbonate (HCO_3)	192
Carbonate (CO_3)	.0
Sulfate (SO_4)	62
Chloride (Cl)	12
Fluoride (F)	.3
Dissolved solids	
Calculated	279
Residue on evaporation at 180°C	307
Hardness as $CaCO_3$	220
Noncarbonate hardness as $CaCO_3$	62
Alkalinity as $CaCO_3$	157
Specific conductance (micromhos/cm at 25°C)	457
pH (units)	7.4
Temperature (°C)	23.0

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection	
	May 17, 1946	April 2, 1975
Ichetucknee Springs, Columbia County, Florida		
Calcium (Ca)	58	52
Magnesium (Mg)	6.6	6.0
Sodium (Na)	3.1	3.4
Potassium (K)	0.3	0.3
Silica (SiO_2)	9.1	10
Bicarbonate (HCO_3)	200	170
Carbonate (CO_3)	0	0
Sulfate (SO_4)	8.4	6.9
Chloride (Cl)	3.6	4.4
Fluoride (F)	.1	.4
Dissolved solids		
Calculated	--	169
Residue on evaporation at 180°C	188	170
Hardness as $CaCO_3$	170	150
Noncarbonate hardness as $CaCO_3$	--	13
Alkalinity as $CaCO_3$	--	140
Specific conductance (micromhos/cm at 25°C)	329	290
pH (units)	7.7	7.6
Color (platinum-cobalt units)	0	1
Temperature (°C)	22.2	21.0
Turbidity (JTU)	--	1
Biochemical oxygen demand (BOD, 5-day)	--	2.0
Dissolved oxygen (DO)	--	4.5

Table 7.--Water-quality analyses for selected springs in the Suwannee River basin, Florida--Continued

Constituents	Date of collection	
	May 17, 1946	April 2, 1975
Ichetucknee Springs, Columbia County, Florida--Continued		
Total organic carbon (TOC)	--	0.0
Total inorganic carbon (TIC)	--	33
Total carbon (TC)	--	33
Organic nitrogen (N)	--	.04
Ammonium (NH_3 as N)	--	.01
Nitrite (NO_2 as N)	--	.01
Nitrate (NO_3 as N)	0.23	.43
Orthophosphate (PO_4 as P)	--	.05
Total phosphorus (P)	--	.05
Suspended solids	--	0
Strontium (Sr) (ug/L)	--	170
Arsenic (As) (ug/L)	--	1
Cadmium (Cd) (ug/L)	--	0
Copper (Cu) (ug/L)	--	3
Lead (Pb) (ug/L)	--	7
Zinc (Zn) (ug/L)	--	0
Manganese (Mn) (ug/L)	--	20
Nickel (Ni) (ug/L)	--	0
Aluminum (Al) (ug/L)	--	320
Mercury (Hg) (ug/L)	--	.0
Iron (Fe) (ug/L)	30	340

Alapaha-Withlacoochee Rivers and the Suwannee River from Suwannee Springs to Ellaville

Water-quality information on the Alapaha River at Statenville, Ga., is limited, but appears similar to that of the upper Suwannee River headwater stations, except that it is lower in organic material (expressed as TOC, 15 mg/L mean concentration). The Alapaha River has less direct influence on the Suwannee River than might be expected since much of its flow is captured by several sinkholes located about 2 miles south of Jennings in Hamilton County, Florida (fig. 1). The channel of the Alapaha River south of the sinkholes usually does not carry appreciable flow except during high stages of the river (Ronald Ceryak, Suwannee River Water Management District, oral commun., 1979).

A spring known as Alapaha Rise (Rosenau and others, 1977, p. 132) does, however, produce a substantial input to the Suwannee River in the range from 400 to 1000 ft^3/s (Suwannee River Water Management District, written commun., 1978). It may in part be a resurgence of the Alapaha River as indicated by its location about 0.5 mile upstream of the confluence of the Alapaha and the Suwannee Rivers. One analysis of water from this spring (table 7) indicates that at the time of collection in November 1975, a large part of the discharge was Floridan aquifer water; it was high in dissolved major inorganic constituents that are characteristic of the limestone aquifer (Rosenau and others, 1977).

The Alapaha Rise and numerous other springs along the Suwannee impart a ground-water character to the Suwannee River. This is especially true when the river is at low-flow and ground-water discharge constitutes most of the flow. Under high-flow or flood conditions many of these springs backflow because the river stage or pressure head of the river is higher than that of the aquifer at that point. This permits aquifer storage of surface water, which may be returned to the river when the conditions reverse and the aquifer head exceeds the stage of the river. This relation between river stage and the pressure head (or potentiometric level) of the aquifer therefore is instrumental in influencing the water quality of the river. For example, when river stage is high and the aquifer is storing water from backflowing springs, the river water will be higher in organic content and lower in dissolved-solids concentrations like the upper Suwannee River above Suwannnee Springs. Conversely, when the river stage is low and the aquifer is discharging through springs to the river, the river water will begin to take on the lower organic content and higher dissolved-solids character of Floridan aquifer water. For the large part of the year, the river is in between these extremes and the water quality is a mixture of the two conditions mentioned.

The water quality of the Withlacoochee River near Pinetta is similar to the Suwannee River at Suwannee Springs in its dissolved major inorganic chemical constituent and dissolved-solids concentrations. The only exceptions are sodium (mean of 20 mg/L) and potassium (mean of 1.6 mg/L) which are higher at Pinetta (table 4). Most nutrient concentrations, however, are about the same as at White Springs, except organic carbon, which is about half as high (a mean of 14 mg/L), and nitrate, which is about six times as high (a mean of 0.19 mg/L), and about equal to the mean at Suwannee Springs (table 5). The organic to inorganic means ratio is 0.12 implying a less significant role of organic with respect to inorganic materials in the Withlacoochee River water relative to the upper Suwannee River downstream to Suwannee Springs. Discharge from Jumping Gully Creek (also known as Running Gully Creek, fig. 8 and table 2) adds an average 11.72 Mgal/d (Florida Department of Environmental Regulation, 1975, p. III-13) to the flow of the Withlacoochee River from a pulp and paper mill in Clyattville, Ga. (fig. 1). Water from this tributary has color, organic nitrogen, chemical oxygen demand (COD), and specific conductance values which routinely exceed the natural Withlacoochee River water quality (Nadim Shamat, Florida Department of Environmental Regulation, oral commun., 1979). Variances in constituent-concentration levels at Pinetta do not reflect an obvious influence from Jumping Gully Creek from the data available in this report. If present, the greatest effects at Pinetta should be noted under low-flow conditions, by increased nutrient loading and depressed oxygen levels.

The Alapaha and Withlacoochee Rivers follow the downbasin trend of increasing pH, decreasing TOC, and increasing specific conductance (figs. 6 and 7) reflecting the increasing importance of ground water on the water quality. The higher median pH and mean specific conductance associated with low-flow conditions of the Withlacoochee River, with respect to the Alapaha or the upper Suwannee River, may be related to discharges from the surficial aquifer, Floridan aquifer, or Jumping Gully Creek effluent, or all of these.

Insufficient samples have been collected at the Suwannee River at Ellaville to make specific comparison statements about water-quality variability with respect to the other stations. However, the character of this water as expressed by pH, TOC, and specific conductance (fig. 6 and 7) indicates that the water quality is probably consistent with the previously mentioned downbasin trends. Nutrient concentrations in the few samples collected are lower than at Suwannee Springs. Whether this is due to an insufficient sample distribution or dilution from low nutrient concentration ground water, or for some other reason is inconclusive. Data for the dissolved major inorganic constituents and dissolved solids are lacking for Ellaville, but the one sample taken indicates that ground water was a significant part of the river flow when the sample was collected. There are a number of springs in the vicinity of Ellaville that are discharging to the Suwannee River (Rosenau and others, 1977).

Central Suwannee River Basin From Ellaville to Branford

In the reach of the Suwannee River from Ellaville to Branford (fig. 2 and table 1) the karstic topography produces an abundance of spring discharge with over 20 identified springs, and numerous unidentified or unnamed springs (fig. 4). Most tributary streams are few and small because of the karst underground drainage. They flow intermittently and derive most of their flow from a local surficial aquifer or the Floridan aquifer.

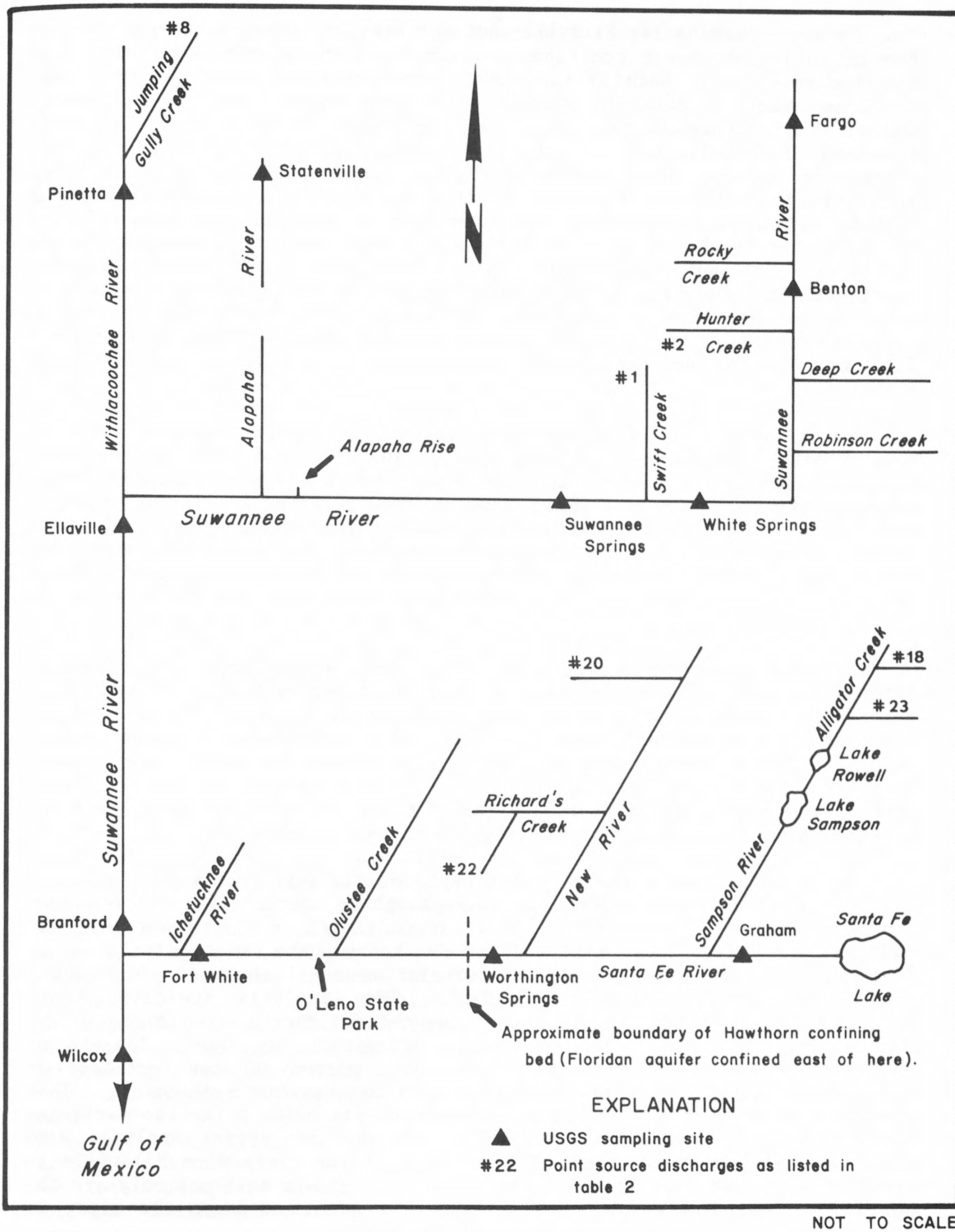


Figure 8.--Selected tributaries, wastewater dischargers, and surface-water flow path in the Suwannee River basin.

Data are lacking for Ellaville but for Branford the mean concentrations for the major inorganic constituents, specifically calcium, magnesium, and bicarbonate, are as much as two, two, and three times, respectively, over the mean values at Suwannee Springs. The mean dissolved-solids calculated sum of constituents is also about two times that of Suwannee Springs, but the mean dissolved-solids residue value, which includes both organics and inorganics, is only about one-fifth higher. The organic to inorganic ratio at Branford of 0.12 is the same as that for the Withlacoochee River near Pinetta and nearly four times less than at Suwannee Springs. This reflects the continued downbasin decrease of organics with respect to inorganics, and indicates a continued ground-water input with higher concentrations of major inorganic constituents. Water-quality analyses of a few springs discharging into the Suwannee River from Ellaville to Branford indicate that springflow is a most probable source of inorganics. The water-quality analyses for Troy Spring can be considered representative of springs in the area (table 7).

Spring water may also be an important source of certain nutrients. Water-quality analyses of spring waters in 1972 and 1973 in counties adjoining the Suwannee River in this reach (Rosenau and others, 1977) have nitrate-nitrogen concentrations ranging from 0.42 mg/L (Turtle Spring, Lafayette County) to 2.90 mg/L (Charles Spring, Suwannee County). These springs therefore are likely to provide at least one source of nitrate to the river, but the load they provide depends on the river to aquifer head relation. Their input is more observable at lower (or falling) river stages.

Nutrient-discharge correlation indicates a nonlinear relationship between the two variables in this reach of the Suwannee River. For example, correlation analysis of nitrate with discharge at Branford (73 data pairs) yields a correlation coefficient of -0.68 and a coefficient of determination of 0.47. These results indicate that: (1) nitrate tends to decrease with increased streamflow, (2) the relation is significant at the 1-percent probability level, but, (3) only 47-percent of the variation in nitrate can be statistically correlated (linearly) to change in discharge.

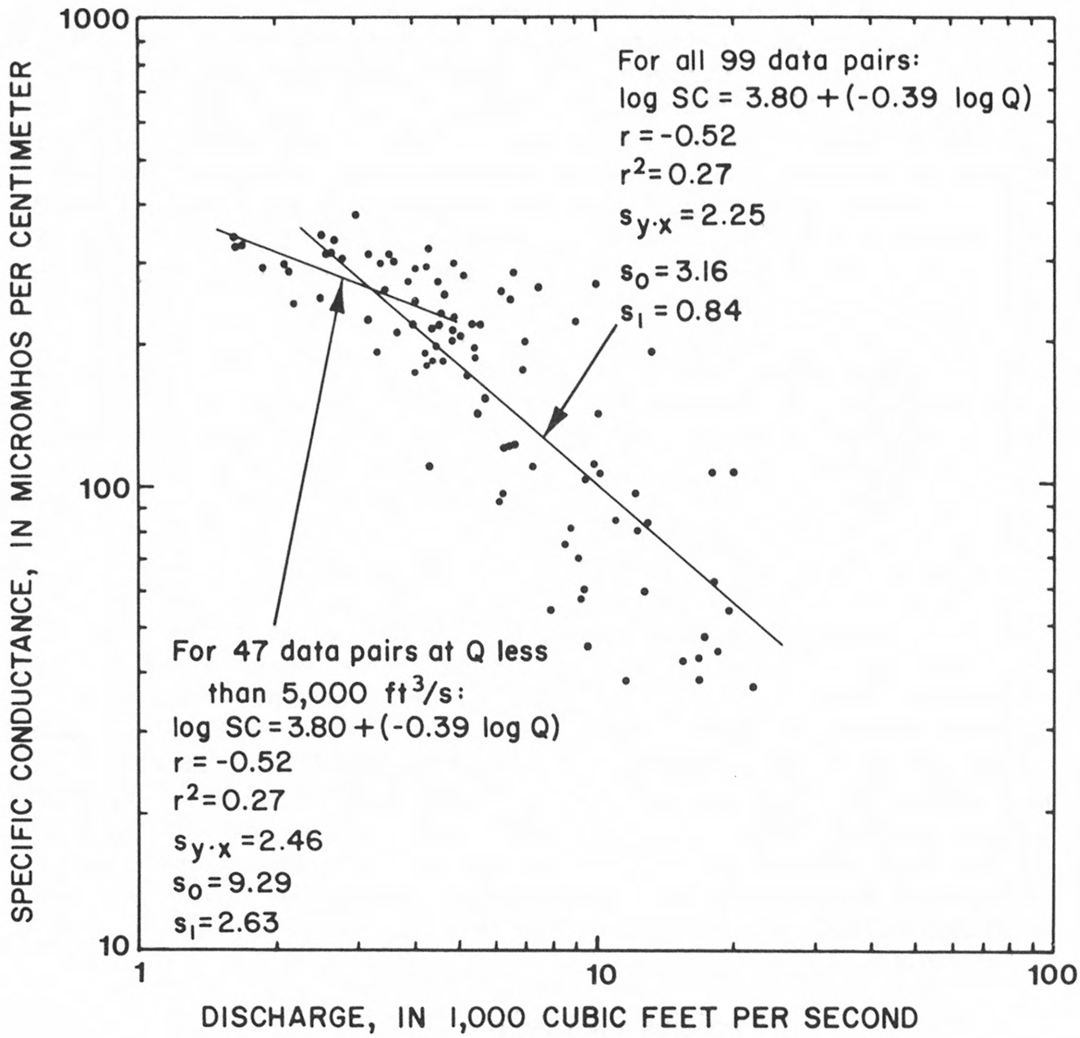
Other nutrients, such as orthophosphate, similarily show the lack of a simple linear relation. The mean orthophosphate concentration at Suwannee Springs is 0.88 mg/L, at Ellaville it is 0.21 mg/L, and at Branford it is 0.20 mg/L. Correlation analysis of orthophosphate with discharge at Branford (78 data pairs) yields a correlation coefficient of -0.16 and a coefficient of determination of 0.03. This analysis indicates that: (1) orthophosphate has a slight tendency to decrease with increased streamflow, (2) the relation is not significant at either the 1- or 5-percent probability level, and (3) only 3 percent of the variation in orthophosphate can be statistically related to changes in discharge. This in effect means that a poor linear relation exists between the two variables or that they are simply not related. Of the few spring analyses with orthophosphate determinations in the reach of the river from Ellaville to Branford, all are less than 0.04 mg/L. This suggests that not only are the springs a potentially weak source but they may even cause the river to become more dilute with respect to orthophosphate.

The nitrate found in the Floridan aquifer spring waters would likely come from agricultural area recharge since no natural source of nitrate exists within the basin. Nitrogen-rich fertilizer is widely used and nitrate is quite soluble. Phosphate, however, is probably not found together with the nitrate because it is one of the least mobile fertilizer constituents and is easily sorbed during ground-water transport (Kurtz and Melsted, 1973, p. 234). Potassium found in fertilizer is also not readily leached or mobilized under soil conditions (Kurtz and Melsted, 1973, p. 233) so it too would not be expected to be present in spring waters in high concentrations.

Figure 9 is a logarithmic plot of discharge versus specific conductance for the Suwannee River at Branford. The long line represents a linear regression using all available data pairs (99). The short line represents a linear regression using data pairs (47) for discharges less than 5,000 ft^3/s. Both sets of data yield correlation coefficients which are significant at the 1-percent probability level. Correlation using the 47 data pairs shows that only 27 percent of the variation in specific conductance can be explained by change in discharge. Correlation using 99 data pairs shows that 67 percent of the variation can be explained by the change in discharge. The show of statistical significance means only that the slope is non-zero. The fact that the explained variance is only about one-third and two-thirds, respectively, indicates that a substantial amount of the variation in specific conductance is not related in a linear fashion to discharge, and that for any given discharge many different values of conductance are possible (fig. 9). Regression of data pairs with discharge over 5,000 ft^3/s (not shown) would show a line of greater slope than that for all data pairs. Regression and correlation statistics for this set of data yield similar values. Standard errors for the regressions on figure 9 are shown in log units.

Santa Fe River

The Santa Fe River basin (fig. 2) is probably the most hydrologically complex part of the Suwannee River basin, Florida, because of the degree of interconnection between the river and different water producing and receiving zones in the aquifers of the area. The headwaters of this tributary begin east of the Suwannee River in an area where the Floridan aquifer is confined and discharge is from surface runoff and shallow ground water (J. Hunn and L. Slack, U.S. Geological Survey, written commun., 1979). The quality of water of the Santa Fe River at Graham is representative of the headwater area. It is similar in quality to that of the upper Suwannee River headwaters at White Springs although with a higher mean calcium (8.4 mg/L), magnesium (3.3 mg/L), and bicarbonate (36 mg/L) concentrations derived here from the surficial aquifer. Organics are also about the same, expressed as mean TOC concentration (30 mg/L), however, Graham has a wider range of 5 to 70 mg/L as compared to 14 to 63 mg/L for White Springs (fig. 6). The organic to inorganic mean concentration ratio is 0.63. Mean nutrient concentrations are also about the same as at White Springs, except for total phosphate which is about one half that of the river at White Springs. Sodium and chloride are slightly higher than at White Springs with mean concentrations of 5.2 and 10 mg/L, respectively.



EXPLANATION

Q	Discharge
SC	Specific conductance
r	Correlation coefficient
r^2	Coefficient of determination
$s_{y \cdot x}$	Standard error of estimate (of y of x)
s_0	Standard error of a_0 coefficient
s_1	Standard error of a_1 coefficient

Figure 9.--Relation between discharge and specific conductance, and regression analysis summaries for all data pairs and for data pairs below 5,000 ft^3/s for the Suwannee River at Branford (August 1968 through December 1977).

Between Graham and Worthington Springs, two tributaries enter the Santa Fe from the north. First is the Sampson River, which indirectly receives effluent from two permitted wastewater dischargers (fig. 8 and table 2), a heavy minerals processing plant and a municipal sewage-treatment plant. The second tributary, New River, causes the Santa Fe River to at least double its flow under normal conditions (James D. Hunn, U.S. Geological Survey, oral commun., 1979). New River receives effluent from two permitted wastewater dischargers (fig. 8 and table 2) which are municipal and prison sewage-treatment plants. Heilbronn Spring also discharges into New River (fig. 5 and table 7). Water-quality analyses of Heilbronn Spring water (table 7) suggest that individual constituent concentrations remain virtually constant with time, reflecting a consistent single source.

At the Santa Fe River at Worthington Springs the mean concentrations for the major inorganic constituents calcium (7.7 mg/L), magnesium (2.7 mg/L), and bicarbonate (21 mg/L), are lower than at Graham. Sodium (6.4 mg/L), potassium (1.0 mg/L), and sulfate (9.8 mg/L) are higher. The total phosphate concentration is about three times higher at 0.26 mg/L, TOC is one third lower at 20 mg/L, and nitrate is an order of magnitude greater at 0.10 mg/L. The organic to inorganic mean concentration ratio at 0.38 is lower than at Graham.

Less than a mile downstream from Worthington Springs is the spring of the same name (fig. 5 and table 7). Downstream from the spring, the river crosses into the area where the Floridan aquifer is unconfined (fig. 8), Olustee Creek flows into the Santa Fe River, and the Santa Fe is captured by a sinkhole at O'Leno State Park (fig. 8). The river resurges at a point about 3-1/4 miles southwest of O'Leno. From Worthington Spring to the sinkhole, spring flow has not been observed. Only the Worthington Spring analyses in table 7 indicate what the ground-water quality is like in this reach of the river.

Table 8 shows water-quality analyses for water collected on April 14 and 15, 1977, going into the sinkhole at O'Leno State Park, and at the point of resurgence. Discharge increases to 285 ft^3/s at the resurgence or more than double that going into the sink (128 ft^3/s) and sulfate concentrations more than double from 31 to 70 mg/L. If only one other source mixed with the Santa Fe River water, the stream discharges would be related as follows (Hem, 1959, p. 231):

$$q_1 + q_2 = q_3$$

or, rearranging:

$$q_2 = q_3 - q_1$$

where

q_1 is the Santa Fe River flow into the sink (128 ft^3/s)
q_2 is the added ground-water component (calculated to be 157 ft^3/s)
q_3 is the river flow at the point of resurgence (285 ft^3/s)

Also,

$$q_2c_2 = q_3c_3 - q_1c_1$$

where

c_1 and c_3 are respective concentrations going in and out
c_2 is the concentration of the unknown source

rearranging:

$$c_2 = \frac{q_3c_3 - q_1c_1}{q_2}$$

Table 8.--Water-quality analyses of water from the Santa Fe River going into the sinkhole at O'Leno State Park, and at the point of resurgence on April 14 and 15, 1977

[Dissolved concentrations expressed in milligrams per liter (mg/L), except as noted.]

	IN	OUT
Constituents	O'Leno State Park [1](02-321898)	Resurgence [1](02-321991)
Calcium (Ca)	43	57
Magnesium (Mg)	9.5	12
Sodium (Na)	6.7	9.1
Potassium (K)	1.0	1.0
Strontium (Sr)	.4	.8
Bicarbonate (HCO_3)	142	150
Sulfate (SO_4)	31	70
Chloride (Cl)	10	16
Fluoride (F)	.3	.3
Dissolved solids		
Calculated	180	250
Residue on evaporation at 180°C	194	281
Hardness as $CaCO_3$	150	190
Noncarbonate hardness as $CaCO_3$	33	67
Alkalinity as $CaCO_3$	117	123
pH (units)	7.6	7.4
Specific conductance (micromhos/cm at 25°C)	310	400
Color (platinum-cobalt units)	30	35
Silica (SiO_2)	12	13
Discharge in ft^3/s	128	285

[1]U.S. Geological Survey station number.

The mass balance calculated sulfate concentration of this other source (c_2) would be 102 mg/L. Ground water with concentrations equal to and exceeding this value has been identified at depths of 300 to 400 feet below land surface in this area (James D. Hunn, U.S. Geological Survey, oral commun., 1979), and is the probable source.

Between the Santa Fe River resurgence and the next station at Fort White, springflow activity has been noted (Rosenau and others, 1977). A water-quality analysis of water collected from Hornsby Spring, located a few miles downstream from the river's resurgence, indicates a high sulfate concentration (table 7), which is at variance with other springs in the area. This spring, like the river, is believed to obtain part of its water from the high sulfate zone 300 to 400 feet below land surface (James D. Hunn, U.S. Geological Survey, oral commun., 1979).

Mean concentrations of calcium, magnesium, bicarbonate, and sulfate increase by seven, three, eight, and three times, respectively, from Worthington Springs to Fort White. Mean sodium, chloride, and fluoride, on the other hand, are about the same at both stations, while potassium doubles. Mean dissolved-solids calculated sum of constituents is almost equal to the residue value and at 203 mg/L is about four times that at the Santa Fe River at Worthington Springs. The organic to inorganic ratio is 0.02, the lowest in the basin. The mean strontium concentration at Fort White of 390 µg/L is more than three times that of most of the other stations in the Suwannee River basin which range from 40 to 100 µg/L (except Wilcox and Swift Creek which are higher). Little nutrient data are available, but the mean total organic nitrogen concentration of 0.15 mg/L is about one fifth that at the Santa Fe River at Worthington Springs, while phosphate is about one half or less.

Downstream from Fort White, springflow activity is noted by the input from the springfed Ichetucknee River (fig. 5 and table 7). Water-quality analyses (table 7) indicate that the sources for these springs either are not the same as for Hornsby Spring, or they are mixed in different proportions. This is suggested by the sulfate concentration which is one seventh that of Hornsby Spring water.

The Lower Suwannee River at Wilcox

The Suwannee River at Wilcox is the last station downstream in the Suwannee River basin. It is located about 33 river miles above the mouth of the Suwannee River on the Gulf of Mexico, and 42 river miles below Branford. The drainage area represents 97 percent of the entire Suwannee River basin (Georgia and Florida). Wilcox has an average annual discharge for 37 years of record of 10,624 ft^3/s, or about 2,000 ft^3/s more than the combined discharges at Branford and Fort White (table 1).

In relation to water quality, this station represents the synthesis and summation of all the natural and man-induced influences in the basin (fig. 7). The water quality tends to have narrower ranges for constituent concentrations and less variability with flow than the other Suwannee River stations. The following tabulation comparing a few dissolved constituent ranges (in mg/L) at Branford and Wilcox illustrates this point:

	Calcium	Magnesium	Bicarbonate	Sulfate	Dissolved-solids calculated sum
Branford	4.3-55	0.9-9.9	0-189	0.0-24	24-199
Wilcox	33-47	5.2-7.0	136-157	14-19	153-184

TOC is about the same level at Wilcox (11 mg/L) as at Branford (14 mg/L), however, at Wilcox the organic to inorganic ratio is 0.07 compared to 0.12 at Branford. The only station sampled with a lower value is Fort White with a ratio of 0.02, which is strongly influenced by low organic concentration springflow. Mean nutrient concentration levels at Wilcox are about the same as at Branford although individual concentrations fall within a narrower range. Nitrate-nitrogen concentrations are still elevated as they are at Branford. The mean strontium concentration at Wilcox of 160 μg/L is more than one and a half times that at Branford, which has a mean of 100 μg/L.

The increased calcium, magnesium, bicarbonate, and strontium concentrations at Wilcox over Branford are derived from the Floridan aquifer through springs and seepage. Because of the greater interconnection between the surface and the Floridan aquifer in the lower Santa Fe River basin and the Suwannee River basin below Ellaville, tributaries to the river are fewer. This is evidenced by extensive spring-sink cave systems like that of Manatee Spring in Levy County which is known to traverse a distance of at least 2,000 feet (Rosenau and others, 1977, p. 248).

SUMMARY AND CONCLUSIONS

The water quality of streams in the Suwannee River basin is primarily determined by discharge from: swamps and wetlands, the surficial, Floridan, and other aquifers, and other point and non-point source waters. Summarizations and conclusions resulting from the evaluation of water-quality data collected in the basin from August 1968 through December 1977, plus limited spring and river-flow data collected after that period, are as follows:

1. The water quality of the Suwannee River and many of its tributaries at any particular site is related to: (1) river discharge; (2) relation between river stage and aquifer head in the locality (spring discharge); (3) antecedent conditions, such as bank storage, its extent and duration; and (4) mixing proportions from upstream sources, such as spring or seepage from ground water, runoff from agricultural or urban land, and wastewater input.

2. Source water from swamps and wetlands in headwater areas produce organic-acid water that is low in dissolved inorganic constituents, and contains high concentrations of organic material. The water-quality type of these waters is "mixed" lacking a dominant dissolved inorganic constituent.

3. Springs and seepage from the Floridan aquifer account for a substantial part of the increase in dissolved inorganic load to the Suwannee River and its tributaries downstream from White Springs. These waters are a calcium-magnesium bicarbonate type--near neutral pH character.

4. Considering all possible sources of water to the Suwannee River, water quality at times of high flow tends to approach the character of the high organic surface water of headwater areas, and low or base flow takes on ground-water characteristics at stations downstream of White Springs. These effects are most pronounced upstream and diminish downstream (note figs. 5 and 6).

5. Tributary streams in the headwater area above Suwannee Springs are small (less than 100 mi^2), exhibit greater chemical variability, and respond more quickly to local environmental stresses than the nearest associated Suwannee River station downstream.

6. Inflow from tributary streams receiving discharges from phosphate mining and processing at times may cause an increased concentration of some inorganic chemical constituents and nutrients in the Suwannee River. This would be especially noticeable when discharge from the tributary streams is large with respect to the flow of the Suwannee River at their confluence.

7. The Alapaha River has less direct effect upon the water quality of the Suwannee River than might be expected because much of the flow is captured by sinkholes. Alapaha Rise, on the other hand, has the potential to affect the water quality of the Suwannee River because of its substantial volumetric input, but the sparsity of data precludes a meaningful water-quality assessment.

8. The water quality of the Suwannee River at Wilcox has less variability than other stations because it is a summation of all the influences within the basin. Local influences upstream become diluted or moderated by discharges from other parts of the basin not similarly affected.

9. Elevated nitrate concentrations in the Suwannee River below Ellaville, in the Santa Fe River below Worthington Springs, in the Suwannee River at Wilcox, and in spring discharge in the associated areas suggest that local recharge and runoff from adjacent areas, specifically agricultural, might be affecting the water quality of both river and ground water from fertilizer use.

Water-quality data are insufficient to understand the causes and effects of the natural or man-induced conditions which might exist for much of the basin. This is especially true for the Alapaha River, Alapaha Rise, the Withlacoochee River, the Suwannee River at Ellaville, the lesser Santa Fe River tributaries, and for many springs in the immediate vicinity of the Suwannee River and its tributaries.

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