

SPECIFIC CONDUCTANCE OF WATER IN
FLORIDA STREAMS AND CANALSBy
Larry J. Slack and Matthew I. KaufmanPrepared by
U.S. GEOLOGICAL SURVEY
in cooperation with
FLORIDA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF INTERIOR RESOURCES
BUREAU OF GEOLOGYTallahassee
1973

INTRODUCTION

This report presents in concise form, information on the nature and significance of the specific conductance of water and its areal distributions and variations with time and discharge. Specific conductance is frequently used as an indicator of inorganic chemical quality of a particular water body, and is useful for rapid estimation of chloride and/or dissolved solids content.

Changes in environmental quality with time, pollution and/or environmental degradation problems, and definition of the origin and history of waters may be evaluated through the application of specific conductance information.

NATURE AND SIGNIFICANCE OF SPECIFIC CONDUCTANCE

Specific conductance or "electric conductance," as it is sometimes called, is a measure of the ability of a water to conduct an electrical current. It is the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution and is often expressed in micromhos per centimeter at 25 degrees C (umhos/cm). (For background discussions, see Hem, 1970, pp. 96-102.)

The ability of water to conduct an electrical current depends upon the presence of ionic species (charged particles) in solution. As ionic concentration increases, conductance of the solution increases. Because of this relation and the fact that specific conductance determinations are relatively inexpensive and can be quickly made, they are widely used as an index of inorganic water quality. A common example of this important relationship is a plot of specific conductance versus chloride concentration. Often this curve is so well defined for a given stream that chloride concentrations can be estimated accurately from conductance data alone, as shown in figure 1.

The relation between ionic concentration and specific conductance is linear in dilute solution. As a solution becomes more concentrated, the relation deviates from a straight line as further increases in concentration cause progressively smaller increases in specific conductance. The slope of the straight-line part of the curve depends on the dominant salts present in the solution and differs for natural waters of different chemical type, as shown in figure 2. Since changes in concentrations of the dominant ions would obscure changes in concentrations of minor ions (such as fluoride), the specific conductance versus minor ion relationship is unreliable and highly variable.

The dissolved solids content of natural waters is commonly estimated by multiplying the specific conductance by a factor ranging from 0.55 to 0.75. This factor is equivalent to the dissolved solids/ specific conductance ratio. However, for Florida streams, this factor ranges from 0.28 to 0.75. Because the relation between dissolved solids and specific conductance is affected by the nature of the solids in solution, this factor must be determined separately for each set of stream conditions. For example, as shown in table 1, the Sopchoppy River near Sopchoppy during high flow is mostly acidic swamp drainage and has a dissolved solids/specific conductance ratio of 0.28. During low flow the stream is predominantly alkaline ground water and has a dissolved solids/specific conductance ratio of 0.53.

The chemical composition of a water depends on the water's origin and history (Table 1). For many streams within the State, base flow is essentially alkaline ground water-alkaline because of its passage through a limestone aquifer. Industrial and municipal wastes, agricultural drainage, swamp drainage, and tides also influence the chemical composition and specific conductance of streams and canals.

TEMPORAL AND FLOW VARIATIONS OF
SPECIFIC CONDUCTANCE

In many instances the low specific conductance of water in a stream during high flow reflects a dilution of the low streamflow (ground water) by storm runoff that is relatively free of dissolved solids and therefore low in specific conductance. Figure 3 shows this effect for four streams for which long-term data are available. The dilution effect may be small for streams with regulated discharge. In other instances, the immediate effect of a storm is the transporting of soluble minerals to the stream, thereby simultaneously increasing the water's conductance and discharge. Later, when storm runoff has less soluble minerals available, the dilution effect appears.

Figure 4 shows the relation of specific conductance to discharge for two canals in southeast Florida. A dilution effect is indicated for the Hillsboro Canal discharging from Lake Okeechobee and for the Tamiami Canal, whereas an opposite effect is suggested for the Hillsboro Canal discharging to Lake Okeechobee (negative flow). This increased specific conductance with increased negative flow is associated with the backpumping of drainage and irrigation waters from agricultural lands into the canal, and then into Lake Okeechobee.

Long-term specific conductance data are useful in assessments of changes in environmental quality with time and in providing needed perspective to short-term changes. Seasonal and long-term variation in specific conductance for selected Florida streams and canals are presented in figure 5A through 5C. Seasonal variations often relate to changes in discharge and are a recurring phenomenon. Little long-term change in water quality is evident for the Suwannee and Escambia Rivers in north Florida (fig. 5A) and for the Tamiami Canal in southeast Florida (fig. 5C). An upward trend in specific conductance is suggested for the St. Johns and Alafia Rivers in central Florida (fig. 5B) and the Hillsboro Canal in southeast Florida (fig. 5C). For the latter, this trend is suggested by the increasing minimum values.

AREAL DISTRIBUTION OF SPECIFIC CONDUCTANCE

According to Florida Statutes, 1969 (28-5.05), the specific conductance shall not be increased more than 100 percent above background levels or to a maximum level of 500 micromhos per centimeter for streams considered to be fresh-water streams.

Recognizing that certain waters of the State, due to natural causes, may not fall within desired or prescribed limitations, the Statutes provide for exceptions upon presentation of good and sufficient evidence.

The distribution of the maximum specific conductance observed in Florida streams and canals is shown on the large map. (Lake Okeechobee, the second largest fresh-water lake entirely within the United States, is also included.) The values tend to coincide with periods of low flow. The regional distribution patterns are generalized (based on all available data through 1968) and local variations may be expected to exist.

Water whose specific conductance is relatively low includes streams in the Florida panhandle and north-central and central peninsular Florida. Water exhibiting relatively high values includes streams in the St. Johns and Alafia River basins in northeast and west-central peninsular Florida, respectively, and most of southern peninsular Florida. The specific conductance of water from Lake Okeechobee falls between that of the relatively dilute inflow of the Kissimmee River and the relatively highly mineralized water characteristic of the agricultural areas immediately to the southeast.

SELECTED REFERENCES

- American Public Health Association and others
1971 *Standard methods for the examination of water and wastewater*. New York, Am. Public Health Assoc., Inc., 13 ed., p. 38-42, 323-327.
- Brown, Eugene
1970 (Skougstad, M.W., and Fishman, M.J.) *Methods for collection and analysis of water samples for dissolved minerals and gases*. U.S. Geol. Survey Techniques of Water Resources Invest., Book 5, Chap. A1, 160 p.
- Hem, J.D.
1970 *Study and interpretation of the chemical characteristics of natural water* (Rev. ed.): U.S. Geol. Survey Water-Supply Paper 1473, 363 p.
- King, E.J.
1959 *Qualitative analysis and electrolytic solutions*. New York, Harcourt, Brace and World, Inc., 641 p.
- Rainwater, F.H.
1960 (and Thatcher, L.L.) *Methods for collection and analysis of water samples*. U.S. Geol. Survey Water-Supply Paper 1454, 301 p.
- U.S. Geological Survey
Quality of surface waters of the United States, 1940-63. U.S. Geol. Survey Water-Supply Paper 942, 950, 970, 1022, 1030, 1050, 1132, 1162, 1186, 1197, 1250, 1290, 1350, 1400, 1450, 1520, 1571, 1641, 1741, 1881, 1941, 1947.
- U.S. Geological Survey
Water resources data for Florida, pt. 2, Water quality records 1964, 1965, 1966, 1967, 1968. Tallahassee, Florida.

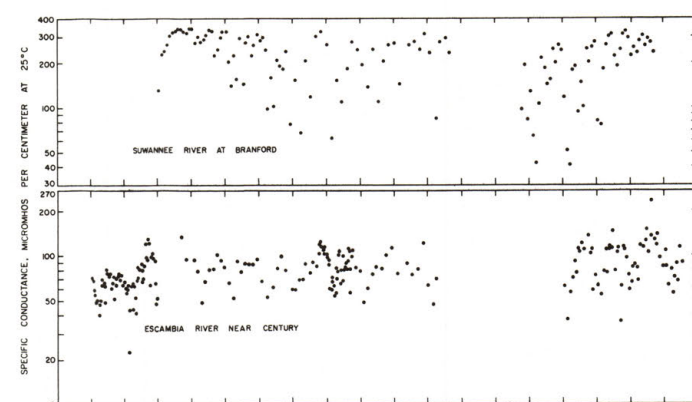


Figure 5A.—Long-term variations in specific conductance of two north Florida streams.

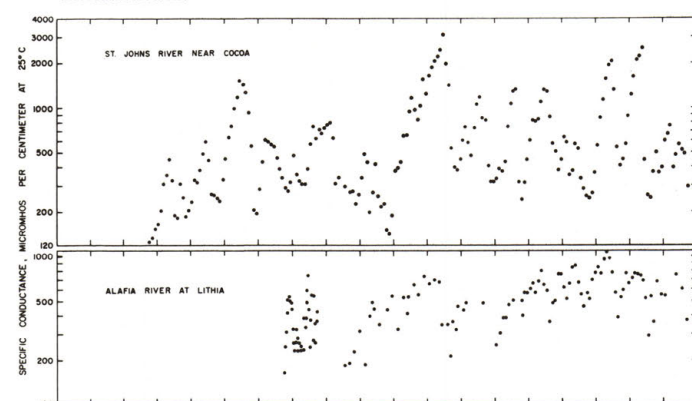


Figure 5B.—Long-term variations in specific conductance of two central Florida streams.

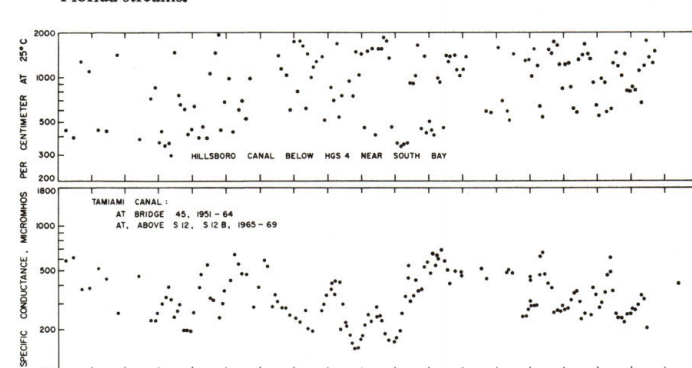


Figure 5C.—Long-term variations in specific conductance of two canals in southeast Florida.

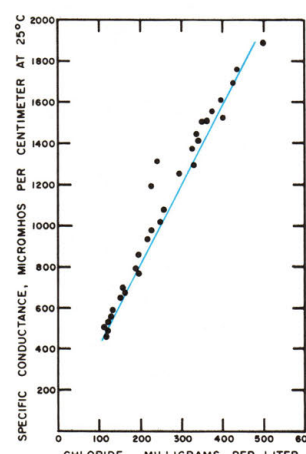


Figure 1.—Relation of chloride to specific conductance of composite samples of the St. Johns River near Deland, Florida, 1949.

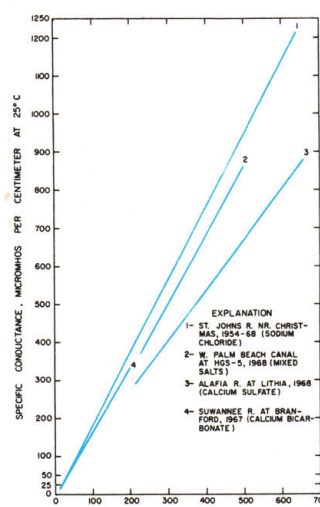


Figure 2.—Relation of dissolved solids to specific conductance of four Florida streams of different chemical type.

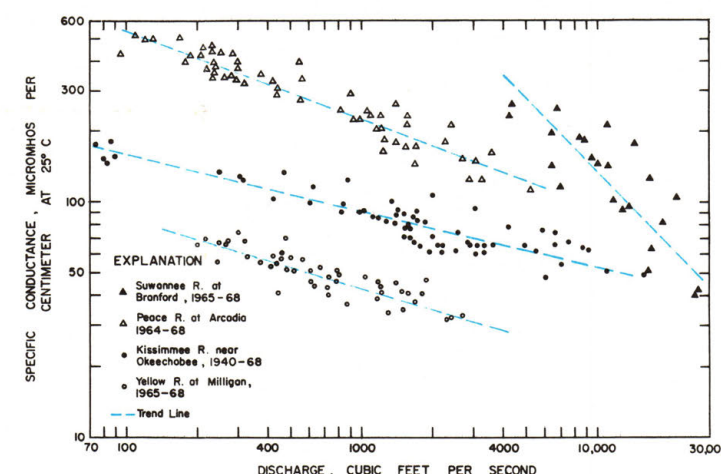


Figure 3.—Relation of specific conductance to discharge of four Florida streams.

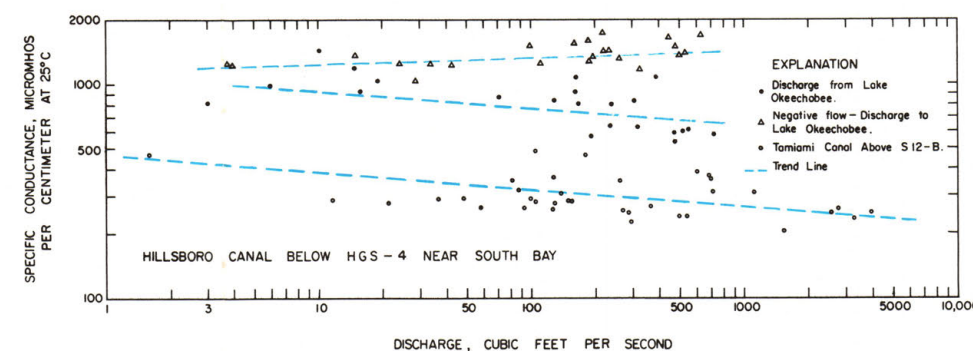


Figure 4.—Relation of specific conductance to discharge of two canals in southeast Florida, 1965-68.

Table 1.— Chemical composition of waters of different specific conductance.

Stream	Date	Spec. Cond. (umhos/cm)	Ratio ^a	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	HCO ₃ (mg/l)	SO ₄ (mg/l)	Cl (mg/l)	Chemical Type	Remarks
Sopchoppy River nr Sopchoppy	08-14-67	43	0.28	0.8	0.2	1.4	0	1.6	3.5	NaCl	Acidic swamp drainage, high flow
Sopchoppy River nr Sopchoppy	06-01-67	158	.53	26	2.7	2.3	86	0.4	4.0	CaHCO ₃	Base flow, predominantly alkaline ground water
Suwannee River at Branford	12-21-67	382	.45	44	8.9	5.4	154	18	7.0	CaHCO ₃	Base flow, predominantly alkaline ground water
Silver Springs nr Ocala	05-31-67	410	.57	66	8.6	5.6	206	30	10	CaHCO ₃	Floridan aquifer spring
Alafia River at Lithia	06-03-68	1,460	.40	84	14	56	4	180	78	CaSO ₄	Acidic industrial waste, high in phosphate
Hillsboro Canal below HGS-4 nr South Bay	07-02-68	1,720	.62	142	62	160	536	192	208	Mixed	Agricultural drainage
St. Johns River nr Cocoa	06-14-67	2,630	.54	117	39	343	130	141	700	NaCl	Base flow, predominantly alkaline, saline ground water
Everglades P-35 nr Homestead	04-18-68	17,000	.59	278	348	2,950	314	720	5,400	NaCl	Tidal

^aDissolved solids in milligrams per liter divided by specific conductance in micromhos per centimeter.DEPARTMENT OF NATURAL RESOURCES
BUREAU OF GEOLOGY

This public document was promulgated at a total cost of \$420.00 or a per copy cost of \$.28 for the purpose of disseminating hydrologic data.

WATER QUALITY DATA STATIONS,
FLORIDA STREAMS
U. S. GEOLOGICAL SURVEY 1940-68

- Minimum of 4 yrs. bimonthly or at least complete analyses, all flow conditions.
- Minimum of 2 yrs. semi-annual, or at least five complete analyses, all flow conditions.
- Annual, one to four complete analyses, generally represents low flow conditions.
- △ Daily specific conductance station, minimum record 1 yr., all flow conditions.

EXPLANATION

Generalized areal distribution of maximum specific conductance values of water in Florida streams and canals (in micromhos per centimeter at 25° Celsius).

- Less than 250
- 250 - 499
- 500 - 749
- 750 - 1500
- More than 1500

0 10 20 30 40 50 MILES

SPECIFIC CONDUCTANCE OF WATER IN FLORIDA STREAMS AND CANALS

By
Larry J. Slack and Matthew I. Kaufman

Prepared by
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
BUREAU OF GEOLOGY
FLORIDA DEPARTMENT OF NATURAL RESOURCES
TALLAHASSEE, FLORIDA

1973
Revised 1975

INTRODUCTION

This report presents in concise form, information on the nature and significance of the specific conductance of water and its areal distribution and variations with time and discharge. Specific conductance is frequently used as an indicator of inorganic chemical quality of a particular water body, and is useful for rapid estimation of chloride and/or dissolved solids content.

Changes in environmental quality with time, pollution and/or environmental degradation problems, and definition of the origin and history of waters may be evaluated through the application of specific conductance information.

NATURE AND SIGNIFICANCE OF SPECIFIC CONDUCTANCE

Specific conductance or "electric conductance," as it is sometimes called, is a measure of the ability of a water to conduct an electrical current. It is the reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of an aqueous solution and is often expressed in micromhos per centimeter at 25 degrees C (umhos/cm). (For background discussions, see Hem, 1970, pp. 96-102.)

The ability of water to conduct an electrical current depends upon the presence of ionic species (charged particles) in solution. As ionic concentration increases, conductance of the solution increases. Because of this relation and the fact that specific conductance determinations are relatively inexpensive and can be quickly made, they are widely used as an index of inorganic water quality. A common example of this important relationship is a plot of specific conductance versus chloride concentration. Often this curve is so well defined for a given stream that chloride concentrations can be estimated accurately from conductance data alone, as shown in figure 1.

The relation between ionic concentration and specific conductance is linear in dilute solution. As a solution becomes more concentrated, the relation deviates from a straight line as further increases in concentration cause progressively smaller increases in specific conductance. The slope of the straight-line part of the curve depends on the dominant salts present in the solution and differs for natural waters of different chemical type, as shown in figure 2. Since changes in concentrations of the dominant ions would obscure changes in concentrations of minor ions (such as fluoride), the specific conductance versus minor ion relationship is unreliable and highly variable.

The dissolved solids content of natural waters is commonly estimated by multiplying the specific conductance by a factor ranging from 0.55 to 0.75. This factor is equivalent to the dissolved solids/specific conductance ratio. However, for Florida streams, this factor ranges from 0.28 to 0.75. Because the relation between dissolved solids and specific conductance is affected by the nature of the solids in solution, this factor must be determined separately for each set of stream conditions. For example, as shown in table 1, the Sopchoppy River near Sopchoppy during high flow is mostly acidic swamp drainage and has a dissolved solids/specific conductance ratio of 0.28. During low flow the stream is predominantly alkaline ground water and has a dissolved solids/specific conductance ratio of 0.53.

The chemical composition of a water depends on the water's origin and history (Table 1). For many streams within the State, base flow is essentially alkaline ground water-alkaline because of its passage through a limestone aquifer. Industrial and municipal wastes, agricultural drainage, swamp drainage, and tides also influence the chemical composition and specific conductance of streams and canals.

TEMPORAL AND FLOW VARIATIONS OF SPECIFIC CONDUCTANCE

In many instances the low specific conductance of water in a stream during high flow reflects a dilution of the low streamflow (ground water) by storm runoff that is relatively free of dissolved solids and therefore low in specific conductance. Figure 3 shows this effect for four streams for which long-term data are available. The dilution effect may be small for streams with regulated discharge. In other instances, the immediate effect of a storm is the transporting of soluble minerals to the stream, thereby simultaneously increasing the water's conductance and discharge. Later, when storm runoff has less soluble minerals available, the dilution effect appears.

Figure 4 shows the relation of specific conductance to discharge for two canals in southeast Florida. A dilution effect is indicated for the Hillsboro Canal discharging from Lake Okeechobee and for the Tamiami Canal, whereas an opposite effect is suggested for the Hillsboro Canal discharging to Lake Okeechobee (negative flow). This increased specific conductance with increased negative flow is associated with the backpumpage of drainage and irrigation waters from agricultural lands into the canal, and then into Lake Okeechobee.

Long-term specific conductance data are useful in assessments of changes in environmental quality with time and in providing needed perspective to short-term changes. Seasonal and long-term variation in specific conductance for selected Florida streams and canals are presented in figure 5A through 5C. Seasonal variations often relate to changes in discharge and are a recurring phenomenon. Little long-term change in water quality is evident for the Suwannee and Escambia Rivers in north Florida (fig. 5A) and for the Tamiami Canal in southeast Florida (fig. 5C). An upward trend in specific conductance is suggested for the St. Johns and Alafia Rivers in central Florida (fig. 5B) and the Hillsboro Canal in southeast Florida (fig. 5C). For the latter, this trend is suggested by the increasing minimum values.

AREAL DISTRIBUTION OF SPECIFIC CONDUCTANCE

According to Florida Statutes, 1969 (28-5.05), the specific conductance shall not be increased more than 100 percent above background levels or to a maximum level of 500 micromhos per centimeter for streams considered to be fresh-water streams.

Recognizing that certain waters of the State, due to natural causes, may not fall within desired or prescribed limitations, the Statutes provide for exceptions upon presentation of good and sufficient evidence.

The distribution of the maximum specific conductance observed in Florida streams and canals is shown on the large map. (Lake Okeechobee, the second largest fresh-water lake entirely within the United States, is also included.) The values tend to coincide with periods of low flow. The regional distribution patterns are generalized (based on all available data through 1968) and local variations may be expected to exist.

Water whose specific conductance is relatively low includes streams in the Florida panhandle and north-central and central peninsular Florida. Water exhibiting relatively high values includes streams in the St. Johns and Alafia River basins in northeast and west-central peninsular Florida, respectively, and most of southern peninsular Florida. The specific conductance of water from Lake Okeechobee falls between that of the relatively dilute inflow of the Kissimmee River and the relatively highly mineralized water characteristic of the agricultural areas immediately to the southeast.

SELECTED REFERENCES

- American Public Health Association and others
1971 *Standard methods for the examination of water and wastewater*. New York, Am. Public Health Assoc., Inc., 13 ed., p. 38-42, 323-327.
- Brown, Eugene
1970 (Skougstad, M.W., and Fishman, M.J.) *Methods for collection and analysis of water samples for dissolved minerals and gases*. U.S. Geol. Survey Techniques of Water Resources Invest., Book 5, Chap. A1, 160 p.
- Hem, J.D.
1970 *Study and interpretation of the chemical characteristics of natural water* (Rev. ed.). U.S. Geol. Survey Water-Supply Paper 1473, 363 p.
- King, E.J.
1959 *Qualitative analysis and electrolytic solutions*. New York, Harcourt, Brace and World, Inc., 641 p.
- Rainwater, F.H.
1960 (and Thatcher, L.L.) *Methods for collection and analysis of water samples*. U.S. Geol. Survey Water-Supply Paper 1454, 301 p.
- U.S. Geological Survey
Quality of surface waters of the United States, 1940-63. U.S. Geol. Survey Water-Supply Paper 942, 950, 970, 1022, 1030, 1050, 1132, 1162, 1186, 1197, 1250, 1290, 1350, 1400, 1450, 1520, 1571, 1641, 1741, 1881, 1941, 1947.
- U.S. Geological Survey
Water resources data for Florida, pt. 2, Water quality records 1964, 1965, 1966, 1967, 1968. Tallahassee, Florida.

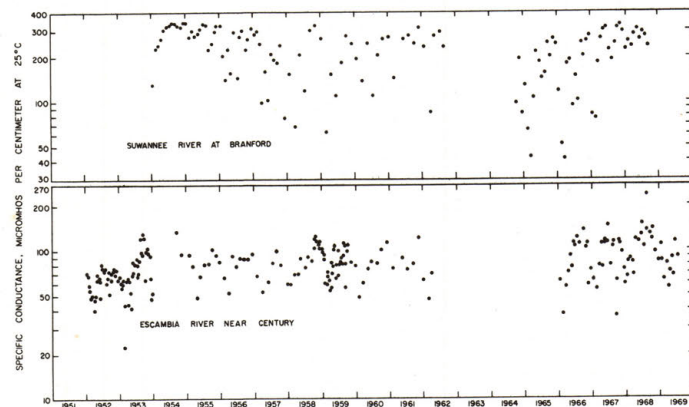


Figure 5A.—Long-term variations in specific conductance of two north Florida streams.

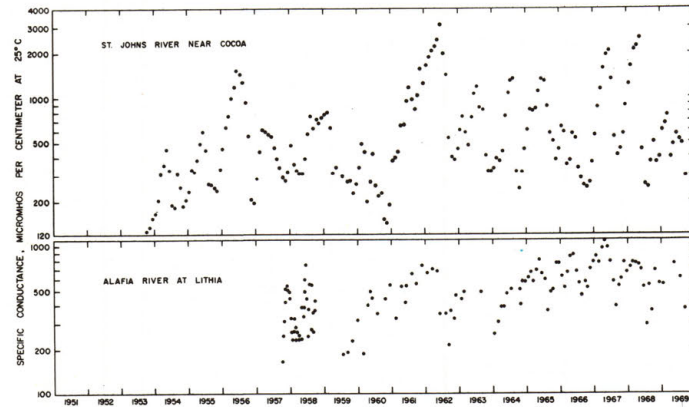


Figure 5B.—Long-term variations in specific conductance of two central Florida streams.

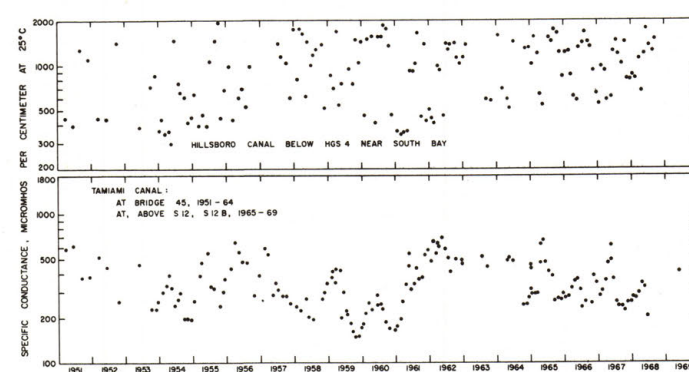


Figure 5C.—Long-term variations in specific conductance of two canals in southeast Florida.

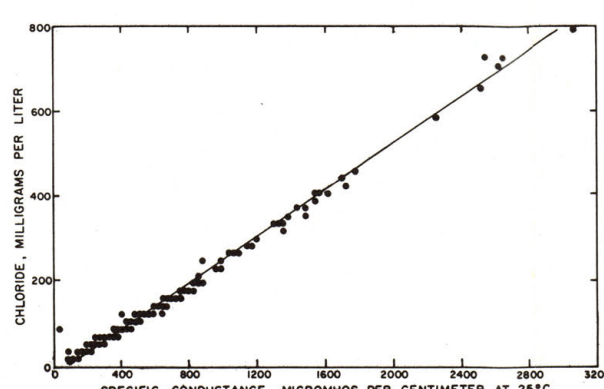


Figure 1.—Relation of chloride to specific conductance of composite samples of the St. Johns River near Cocoa, Florida, period of record to February 1973.

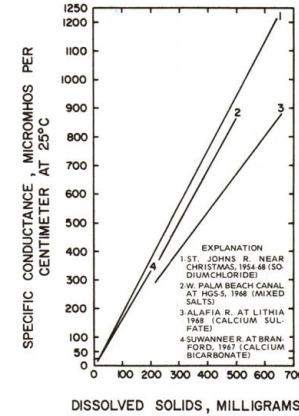


Figure 2.—Relation of dissolved solids to specific conductance of four Florida streams of different chemical type.

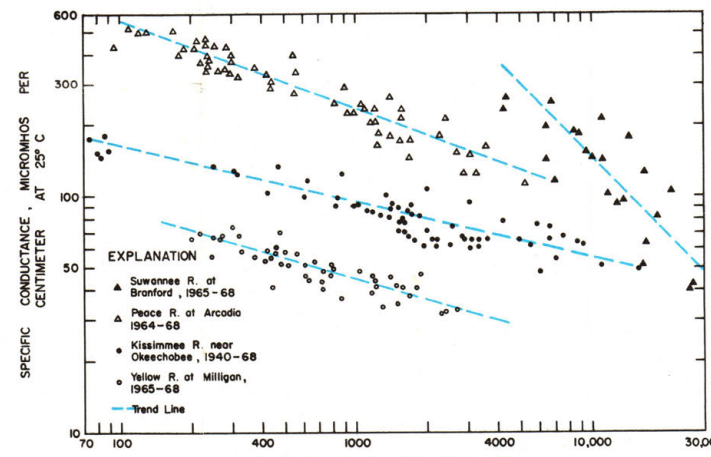


Figure 3.—Relation of specific conductance to discharge of four Florida streams.

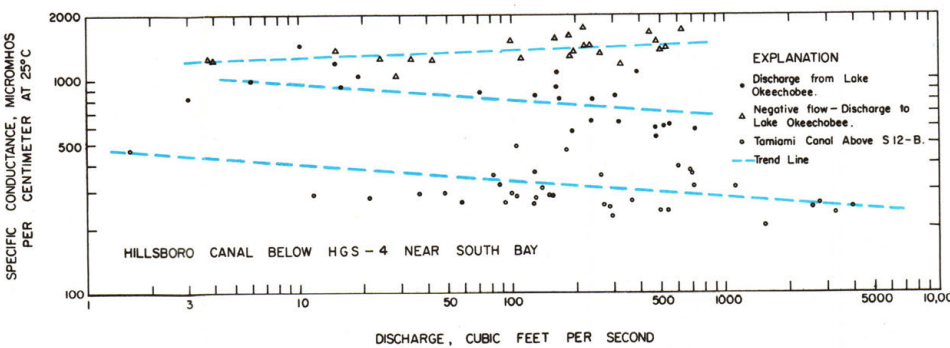


Figure 4.—Relation of specific conductance to discharge of two canals in southeast Florida, 1965-68.

Table 1.—Chemical composition of waters of different specific conductance.

Stream	Date	Spec. Cond. Ratio ^a (umhos/cm)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	HCO ₃ (mg/l)	SO ₄ (mg/l)	Cl (mg/l)	Chemical Type	Remarks
Sopchoppy River near Sopchoppy	08-14-67	43	0.28	0.8	0.2	1.4	0	3.5	NaCl	Acidic swamp drainage, high flow
Sopchoppy River near Sopchoppy	06-01-67	158	.53	26	2.7	2.3	86	0.4	CaHCO ₃	Base flow, predominantly alkaline ground water
Suwannee River at Branford	12-21-67	382	.45	44	8.9	5.4	154	18	CaHCO ₃	Base flow, predominantly alkaline ground water
Silver Springs near Ocala	05-31-67	410	.57	66	8.6	5.6	206	30	CaHCO ₃	Floridan aquifer spring
Alafia River at Lithia	06-03-68	1,460	.40	84	14	56	4	180	CaSO ₄	Acidic industrial waste, high in phosphate
Hillsboro Canal below HGS-4 near South Bay	07-02-68	1,720	.62	142	62	160	536	192	Mixed	Agricultural drainage
St. Johns River near Cocoa	06-14-67	2,630	.62	117	39	343	130	141	NaCl	Base flow, predominantly alkaline, saline ground water
Everglades P-35 near Homestead	04-18-68	17,000	.59	278	348	2,950	314	720	NaCl	Tidal
Tamiami Canal Outlets 40-mile Bend to Monroe	05-13-68	469	.55	74	3.4	17	236	4.9	CaHCO ₃	Base flow, predominantly Big Cypress Swamp drainage

^aDissolved solids in milligrams per liter divided by specific conductance in micromhos per centimeter.

FLORIDA DEPARTMENT OF NATURAL RESOURCES
BUREAU OF GEOLOGY
This public document was promulgated at a total cost of \$330.00 or a per copy cost of \$.13 for the purpose of disseminating hydrologic data.

WATER QUALITY DATA STATIONS, FLORIDA STREAMS U. S. GEOLOGICAL SURVEY 1940-68

- Minimum of 4 yrs. bimonthly or at least complete analyses, all flow conditions.
- Minimum of 2 yrs. semi-annual, or at least five complete analyses, all flow conditions.
- Annual, one to four complete analyses, generally represents low flow conditions.
- △ Daily specific conductance station, minimum record 1 yr., all flow conditions.

EXPLANATION

Generalized areal distribution of maximum specific conductance values of water in Florida streams and canals (in micromhos per centimeter at 25° Celsius).

- Less than 250
- 250 - 499
- 500 - 749
- 750 - 1500
- More than 1500

0 10 20 30 40 50 MILES