

THE CHEMICAL TYPE OF WATER IN FLORIDA STREAMS

By
Matthew I. Kaufman
Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
FLORIDA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF INTERIOR RESOURCES
BUREAU OF GEOLOGY

Tallahassee, Florida
1972

INTRODUCTION

The chemical quality of surface water in Florida differs widely, both in composition and in concentration of major ions. The nature and concentration of ions in solution are influenced by many interrelated factors, including the chemical composition of rainfall and also the reaction of water with soils, bed materials, decomposing organic matter, and surficial rocks. In addition, variations in streamflow, activity of aquatic organisms, and the input from artesian springs, industrial and municipal waste-loadings, and agricultural runoff are also important factors.

Definition of the major ionic patterns, both under varying streamflow conditions and from place to place, provides insight into the impact of environment on the chemical quality of surface water in Florida.

This report (1) portrays inorganic chemical quality characteristics of Florida's streams and delineates broad regions of the State where stream waters are of similar chemical type (ionic composition) during low flow; and, (2) correlates chemical quality of surface waters with changes in streamflow and with certain natural and manmade environmental influences. Similarly, Rainwater (1962) in an earlier report presented a generalized map portraying the prevalent chemical type of water in major rivers of the United States.

The material presented herein should provide the reader with an understanding of some of the regional differences and dynamic aspects of surface water quality in Florida, useful for sound management of the State's water resources. In addition, the information should aid in determining area coverage, frequency, and required types of analyses for a Statewide chemical-quality-sampling network representative of the differing hydrogeochanical environments in Florida. This map report constitutes a phase in the portrayal of inorganic chemical quality information for Florida on a regional basis.

AREAL PATTERNS OF CHEMICAL QUALITY DURING LOW STREAMFLOW

Broad areas in Florida within which water in most of the streams are of similar chemical type during low flow are delineated on the large map. In this report the streams are divided into five chemical types, based on predominant cations and anions expressed in milliequivalents per liter. As discussed by Hem (1970), a classification of this nature is designed to convey general information and cannot be expected to be exact or precise. However, the classification provides a basis for the grouping of waters closely related chemically.

Once low-flow chemical type is established, it is possible to discuss environmental influences and variations in water quality with flow and, thus, develop an understanding of some of the dynamic aspects of inorganic surface water quality in Florida.

The analyses used in this report are of water samples collected from 1940 through 1967. Examination of long-term chemical data for selected streams indicates no significant changes in water-quality characteristics. Low-flow chemical analyses are plotted as percentages of indicated ions expressed in milliequivalents per liter. This figure illustrates the basis for the chemical typing used in this report and provides a means of indicating (1) similarities and differences in the composition of various waters and (2) mixtures of specific chemical types. As noted earlier, delineation of the five chemical types is based on predominant cations and anions, recognizing, however, that chemical types are gradational and classifications and boundary placements are somewhat arbitrary.

The five chemical types are described in terms of the dominant cations and anions, as follows: (A) calcium and magnesium bicarbonate type, (B) sodium bicarbonate and chloride type (C) mixed type, -no dominant cation or anion, (D) sodium chloride type, and (E) calcium and magnesium sulfate type.

For this report, more than 350 low-flow chemical analyses, supplemented by knowledge of the surficial geology (Vernon and Puri, 1964), drainage basin divides, areas of significant ground-water inflow, and areas of waste loading, were utilized in preparation of the large map and in the delineation of boundaries. The regional distribution patterns and placement of boundaries separating areas where water is of different chemical type are of necessity generalized. The differences in prevalent chemical type at low flow are related to environmental influences.

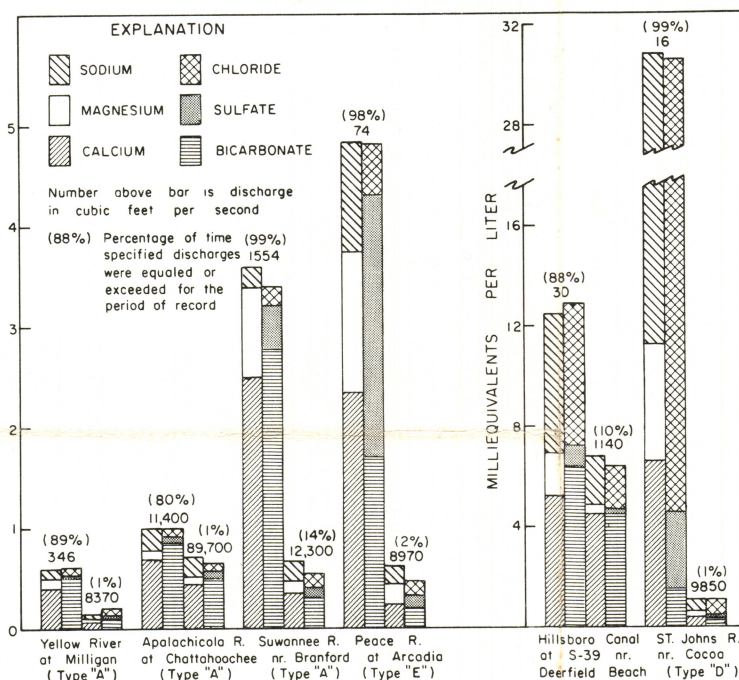


Figure 4. Relations among chemical composition, concentration, and discharge for six Florida streams and canals during low versus high streamflow.

RELATION OF ENVIRONMENTAL INFLUENCES TO CHEMICAL TYPE

A water-quality diagram portraying the chemical composition of water representative of several natural and manmade sources influencing chemical quality of water in Florida's streams is illustrated in figure 2. Limits are established from chemical analysis of water from specific source environments. Sources illustrated in figure 2 include fresh water from the Floridan and Biscayne carbonate aquifers (I); paper-mill effluent (II); municipal effluent (III); saline water from the Floridan aquifer (IV); phosphate industrial effluent, agricultural runoff, and water from gypsiferous aquifers (V); and bulk precipitation (rainfall plus dry fallout) at Ocala (VI). The precipitation composition represents that of the central Florida east region and should not be extended arbitrarily to other parts of the State.

The prevalent chemical type of water during low flow (as portrayed on the large map and in figure 1) may thus be related to the chemical composition of end-member sources or mixtures of water from several sources.

As noted by Stringfield (1964), surface water and ground water are closely interrelated in parts of Florida. The quality of surface water is influenced by the quality of ground water where the aquifers are at or near the land surface, where the sampled sites are downstream from first- and second-magnitude springs (large map, locations after Ferguson and others, 1947) or where streams are influenced by upward ground-water movement along fractures and fault-controlled spring lines. A first-magnitude spring has an average flow of 100 cubic feet per second or more; a second-magnitude spring has an average flow of 10 to 100 cubic feet per second. The chemical character of water in many streams in Florida during low flow approaches that of water in the contributing aquifers, of waste discharged to streams, or a combination of both.

Referring to the large map, water that is dominantly of the calcium and magnesium bicarbonate type (A) is associated with (1) Tertiary (Oocene through Miocene) carbonate terranes constituting the Floridan aquifer in central, north-central, and northwest Florida, (2) late Tertiary (upper Miocene) - Quaternary carbonate terranes constituting the Biscayne and shallow aquifers in south Florida, and (3) first- and second-magnitude springs having calcium and magnesium bicarbonate type waters derived from the Floridan aquifer. The water is generally alkaline and is moderate to high in mineralization and hardness.

Water that is dominantly of the sodium bicarbonate and chloride type (B) is of small areal extent and in several places contains paper-mill effluents. This water is generally alkaline, soft, and high in mineralization, color, and organic matter. Some soft natural sodium bicarbonate and chloride water, low in mineralization and color, occurs in the western Panhandle and in a small area of central peninsular Florida.

Water containing no predominant cation or anion is considered to be a mixed type (C). Water of this type is associated with noncarbonate terranes and is generally upstream from springs and alkaline ground-water inflow. With some exceptions, this water reflects the chemical characteristics of rainfall, soils, and decomposed organic matter in natural swampland areas. In several areas, including parts of southeast Florida, the water is associated with municipal wastes high in mineralization, and may contain high concentrations of chloride, sulfate, and nitrate. Water of this type may also result from the mixing of calcium and magnesium bicarbonate water and sodium chloride water.

Water that is dominantly of the sodium chloride type (D) and also relatively highly mineralized is associated with (1) saline water in the low-lying coastal areas of tidal and estuarine environments (2) saline water that has moved upward from the Floridan aquifer along fracture and/or fault traces (note on large map the northwest-trending spring line that parallels the St. Johns River in east central Florida, with several springs having sodium chloride water), and (3) agricultural runoff and industrial and municipal effluents.

Sodium chloride type water that is low in mineralization is associated with upland swamp areas, and it also occurs in the western Florida Panhandle. Water in the Panhandle streams generally contains a relatively high percentage of silica, which in several places constitutes more than 40 percent of the dissolved solids.

Water that is dominantly of the calcium and magnesium sulfate type (E) is associated in several places with industrial effluents and agricultural runoff. The industrial wastes are generally highly mineralized, acidic, and contain a high concentration of phosphate, sulfate, fluoride, and nitrate. The Alafia and Peace Rivers, which drain phosphate-mining areas in west-central peninsular Florida, are prime examples. In addition, in water from several Florida streams the percentage of magnesium and sulfate exceeds that of a straight-line mixture of ground water from a limestone terrane and sea water. This magnesium and sulfate water may be derived from agricultural runoff, or it may result from discharge from gypsiferous aquifers.

CHANGES IN CHEMICAL QUALITY ACCOMPANYING CHANGES IN STREAMFLOW

Changes in chemical character of water from selected Florida streams and canals, as represented by high versus low flow chemical analyses, are presented in figures 3 and 4. In general, concentration decreases as streamflow increases. The individual analyses shown in figure 3 are considered to be representative of general and high-low flow conditions at the sampling site, on the basis of a detailed survey of data for 1940-67. These analyses reflect extreme chemical-quality conditions. Analogous to the definition of low flow given earlier, high flow refers to the upper 25 percent of flow based on the flow-duration data of Heath and Wimberly (1971).

As the flow increases from low to high, two distinct changes in ionic composition occur (fig. 3). These changes depend primarily on the chemical character of water during low flow and secondarily on the chemical character of surface runoff.

(1) Water in streams and canals of type "A", "B", and some mixed type "C" at low flow exhibits an increased percentage of "salinity" (it increases in percentage of dissolved ions such as sodium, magnesium, sulfate, and chloride) at high flow (fig. 3A).

(2) Water in streams and canals of type "D", "E", and locally of mixed type "C" at low flow exhibits an increased percentage of "alkalinity" (it increases in percentage of dissolved ions such as calcium, sodium, and bicarbonate) at high flow (fig. 3B).

The difference in composition between the high- and low-flow samples indicates that the direct-runoff fraction is quite different in chemical type from the base-flow fraction. The chemical response to increase in streamflow is indirectly a function of environmental influences governing the chemical nature of the water during low-flow discussed earlier. Water representative of the first group (types "A", "B", and, in part, "C") generally has low to moderate mineralization at low flow (relatively high percentage of bicarbonate) and, with some exceptions, reflects natural conditions. Water of the second group (types "D", "E", and, in part, "C") generally has moderate to high mineralization at low flow (relatively high percentage of sulfate and chloride) and, with some exceptions, reflects the influences of man.

Further, in much of Florida, maximum and minimum concentrations of dissolved solids in water at a specific location in a stream often differ widely, reflecting extreme differences in chemical quality during high and low streamflow. Figure 4 portrays the relations among chemical composition, concentration, and discharge for selected Florida streams and canals representative of some of the different chemical types and environmental conditions. The figure illustrates the ranges and variability in chemical composition that may be expected. The water samples from the Apalachicola River at Chattahoochee indicate relative stability of chemical quality from low to high flow, whereas water samples from the Suwannee River near Branford indicate relative instability of chemical quality from low to high flow. The cation-anion imbalances indicated by the bargraphs are caused by unreported minor concentrations of potassium, nitrate, fluoride, or phosphate.

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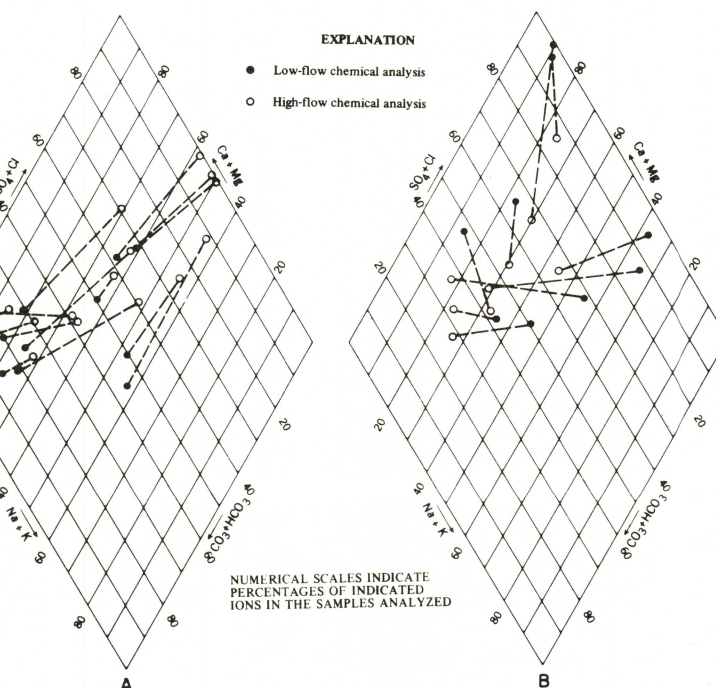


Figure 3. Changes in chemical character of water from selected Florida streams and canals, as represented by high- or low-flow chemical analyses.

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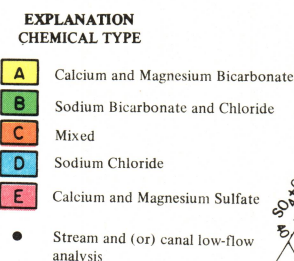
EXPLANATION

PREVALENT CHEMICAL TYPE OF WATER IN FLORIDA STREAMS AND CANALS DURING LOW FLOW

- A Calcium and Magnesium Bicarbonate
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- C Mixed
- D Sodium Chloride
- E Calcium and Magnesium Sulfate

FIRST AND SECOND MAGNITUDE SPRINGS

- Calcium and Magnesium Bicarbonate
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NUMERICAL SCALES INDICATE PERCENTAGES OF INDICATED IONS IN THE SAMPLES ANALYZED

Figure 1. Prevalent chemical type of water during low-flow in selected Florida streams and canals.

EXPLANATION

- I Fresh water from the Floridan and Biscayne carbonate aquifers.
- II Papermill effluent.
- III Municipal effluent.
- IV Saline water from the Floridan aquifer.
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- VI Median chemistry of bulk precipitation, Ocala, Florida, 1965 (78 uncovered samples).

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Figure 2. Water representative of several natural and manmade sources influencing chemical quality of streamflow in Florida.

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The difference in composition between the high- and low-flow samples indicates that the direct-runoff fraction is quite different in chemical type from the base-flow fraction. The chemical response to increase in streamflow is indirectly a function of environmental influences governing the chemical nature of the water during low-flow discussed earlier. Water representative of the first group (types "A", "B", and, in part, "C") generally has low to moderate mineralization at low flow (relatively high percentage of bicarbonate) and, with some exceptions, reflects natural conditions. Water of the second group (types "D", "E", and, in part, "C") generally has moderate to high mineralization at low flow (relatively high percentage of sulfate and chloride) and, with some exceptions, reflects the influence of man.

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- Stream and (or) canal low-flow analysis

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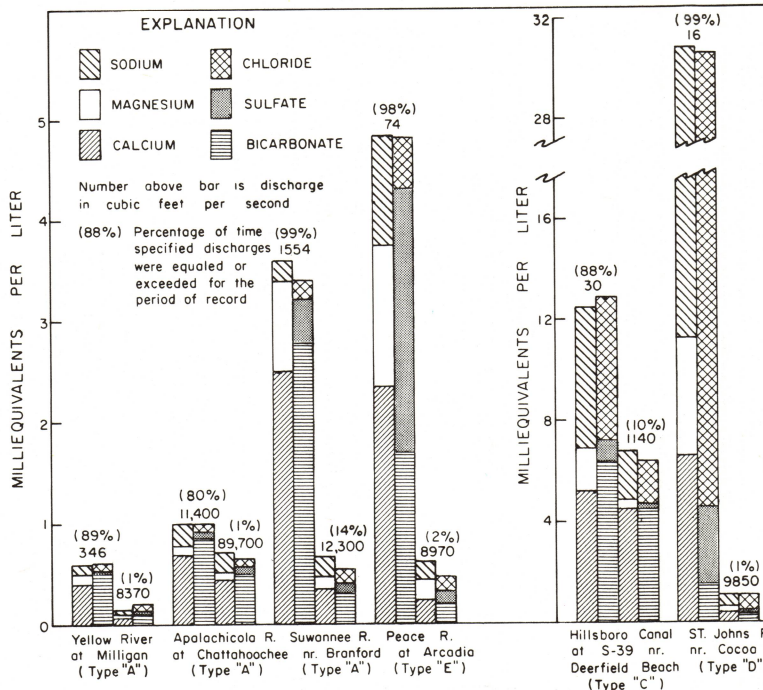


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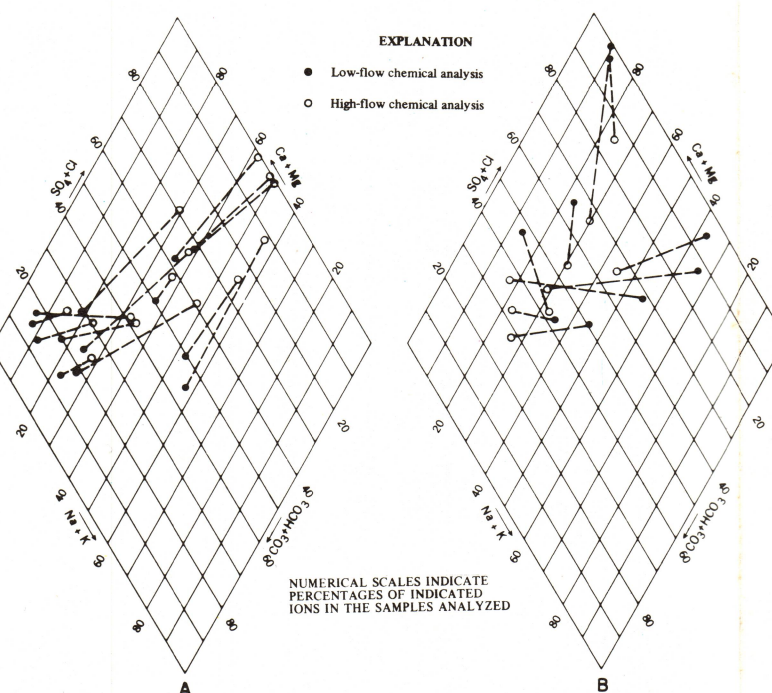


Figure 3. Changes in chemical character of water from selected Florida streams and canals, as represented by high- or low-flow chemical analyses.