

WATER QUALITY OF FLORIDA SPRINGS

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INTRODUCTION

Florida's vast ground water storage and circulation system discharges in part from the State's 300 or more springs. Their combined flow is about 12, 600 cubic feet per second or 8 billion gallons per day. By comparison, in 1975 fresh ground water pumped for all uses in Florida totaled 3.3 billion gallons per day, or about 40 percent of the water discharged each day from springs in Florida. The chemical quality of Florida's spring water, its origin, composition, and concentration of major ions in the water are presented in this atlas.

HOW SPRINGS ARE FORMED

A spring is a localized emergence of ground water at land surface. The source of Florida's ground water is rainfall that seeps into the ground and recharges aquifers throughout Florida and in southern Alabama and Georgia, especially where rocks of the Floridan aquifer are at or near land surface. The State is underlain by the Floridan aquifer, a thick sequence of south- and southwest-dipping limestone and dolomite beds that act essentially as a hydrologic unit. Figure 1 shows the aquifer to be near or at land surface in about a sixth of the State, northward along the Gulf of Mexico from Tampa Bay.

The solution of limestone (CaCO₃) or dolomite [CaMg(CO₃)₂] by natural waters in the presence of carbon dioxide (CO₂) is probably the largest single factor responsible for the existence of large springs in Florida. Limestone and dolomite are only slightly soluble in pure water, but their solubility increases in natural water that contains carbon dioxide. Carbon dioxide is gathered from the atmosphere by water falling as rain and from soil air (gas) as rainwater percolates through the soil and through the unsaturated zone to the water table. Concentrations of carbon dioxide in soil air are commonly several hundred times greater than in the atmosphere owing to plant respiration and decaying plant material in the soil layer. (Stumm and Morgan, 1970, p. 128.)

CHEMICAL TYPES OF SPRING WATER

Chemical constituents are normally reported in milligrams per liter (mg/L) or in micrograms per liter (µg/L), which is one-thousandth of a milligram per liter. Milliequivalents per liter may be calculated by multiplying the constituent ion in milligrams per liter by the reciprocal of the ion's gram-equivalent weight. The appropriate factors for the more common chemical constituents of Florida waters are:

Bicarbonate	(HCO ₃ ⁻¹)	0.01639
Calcium	(Ca ⁺²)	.04990
Carbonate	(CO ₃ ⁻²)	.03533
Chloride	(Cl ⁻¹)	.02821
Fluoride	(F ⁻¹)	.05264
Magnesium	(Mg ⁺²)	.08226
Sodium	(Na ⁺¹)	.04350
Sulfate	(SO ₄ ⁻²)	.02082

The prevalent chemical types of water from most of Florida's 100 first- and second-magnitude springs are illustrated on the adjacent map. First-magnitude springs have an average discharge of 100 cubic feet per second or greater, and second-magnitude springs discharge from 10 to 100 cubic feet per second. The large map shows the locations of these major springs for which water-quality data were available and chemical types of water they discharge. The chemical types indicate the predominant cations and anions (positive and negatively charged ions, respectively) present in the spring water, expressed in terms of equivalent weights or equivalent chemical reactivity measured in milliequivalents per liter (meq/L). The four chemical types considered are: (1) calcium-magnesium bicarbonate, (2) calcium sulfate, (3) mixed (no dominant cations or anions), and (4) sodium chloride.

The predominant spring-water type is calcium-magnesium bicarbonate (fig. 2), which is quite logical because the majority of Florida springs are formed by the solution of the carbonate rocks (limestones and dolomites) of the Floridan aquifer. The water from Wakulla Springs (table 1 and fig. 3) is a typical calcium-magnesium bicarbonate water.

The next most prevalent chemical type of spring water in Florida is sodium chloride (NaCl). Although water discharging from most springs in Florida contains relatively small amounts of chloride, a few springs have water that is moderately to strongly saline. These springs are generally in coastal areas where ground water quality is affected by saltwater intrusion or in areas where saline residues from earlier invasions of the sea still remain. Water discharging from Blue Spring in Volusia County (table 1 and fig. 3) is chemically typical of sodium chloride spring water.

The third most prevalent chemical type of spring water in Florida lacks a dominant constituent. This type of water is normally a mixture of two or more of the chemical types of water discussed. Ground water that moves slowly through rocks of a given chemistry generally acquires the chemical characteristics of those rocks. Thus, waters from two or more sources that are mixing and discharging from a single spring vent reflect this mixing and might lack a single

chemical dominance. Beecher Springs in Putnam County, for example (table 1 and fig. 3), discharges water that is more than 99 percent (by volume) calcium-magnesium bicarbonate and less than 1 percent (by volume) seawater or its chemical equivalent (table 1).

Springs along the Suwannee River may discharge a chemically mixed water that is somewhat brown-colored by tannin. This occurs following a period of river flooding with subsequent inundation of the springs adjoining the Suwannee River. When the river is well above the potentiometric level of the Floridan aquifer, the spring outlets serve as points of massive recharge of river water to the aquifer. When the river declines, a mixture of river and ground water discharges from the springs. Scuba divers have reported seeing both clear and tannin-colored waters flowing concurrently through spring caves that adjoin Florida rivers. L.I. Briel (oral commun., February 24, 1978) has noted this condition while diving in the Suwannee and St. Marks Rivers.

The only large spring that discharges the fourth or calcium sulfate type water is Messant Spring in Lake County (table 1 and fig. 3). Many of the other springs contain significant amounts of sulfate, but not as the predominant anion. Sulfate is dissolved in large quantities from gypsum (CaSO₄) and from deposits of sodium sulfate. It may also be formed by the oxidation of sulfides of iron.

No herbicides, insecticides, or PCB (polychlorinated biphenyls) were detected in water sampled from eight of Florida's first-magnitude springs.

WATER-QUALITY VARIATIONS WITH TIME

The water quality of Florida springs is relatively constant. For example, the water quality of Wakulla Springs (table 1 and fig. 3) is essentially the same as it was a half-century ago. However, a few saline springs, such as Salt Springs in Marion County (table 3), have concentrations that fluctuate over a wide range. This is because of variations in the mixing of freshwater and saline water that contribute to the springs.

TURBIDITY AND COLOR

Water that issues from springs is usually free of color and turbidity because of the filtering and absorbing action of the soil and aquifer materials that the water passes through. Some springs, however, may have turbid or organic brown-colored water typical of many surface waters in Florida. Where turbid water, or the brown tannic acid water common in swamps, recharges an aquifer in proximity to a spring, the water may move quickly through solution channels in the aquifer to discharge at the spring vent little altered in quality. For this reason, it is not uncommon for Floridians to see "swamp water" discharging from some springs following heavy rainfall. A few springs—those with water having relatively high dissolved-solids concentrations—have a whitish cloudy appearance, possibly the result of the precipitation of calcium carbonate (CaCO₃) from rapid pressure or temperature changes on discharge. Examples are Blue Spring in Volusia County and Warm Mineral Springs in Sarasota County. Many Florida springs are bluish, carrying such names as Blue Spring or Blue Hole. The bluish appearance is characteristic of water in large volumes and is not necessarily caused by impurities.

AVAILABILITY OF SPRING WATER-QUALITY DATA

Lack of a state-wide spring water-quality network limits the Florida data base. The first state-wide spring-water data-collection effort was for a 1947 report by Ferguson, and the second was for the 1977 report "Springs of Florida" by Rosenau and others. Spring-water sampling has otherwise been spotty. This atlas is based on spring water-quality data from the computer files of the U.S. Geological Survey through 1977 and from published analyses that date back, in some cases, to 1924. Only 8 of the 27 known first-magnitude springs have been sampled more than 5 times. As springs are a surface manifestation of the quantity and quality of water in the aquifers, a consistent long-term measuring and sampling program of the major springs would provide an indication of the "health" of the aquifers.

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Table 1.—Comparison of chemical types of spring water to seawater

Parameter	Reporting units	Beecher Springs	Blue Spring	Messant Spring	Wakulla Springs	Seawater ¹
Specific conductance at 25°C	micromhos	446	1,800	650	279	—
pH	units	7.9	7.8	7.9	7.3	—
Calcium (Ca)	mg/L	33	30	94	39	400
Magnesium (Mg)	mg/L	1.0 ²	2.9	4.7 ²	1.9 ²	20
Sodium (Na)	mg/L	8.3	4.9	20	8.7	1,350
Bicarbonate (HCO ₃)	mg/L	7	2.4	1.6	7	111
Sulfate (SO ₄)	mg/L	41	4.5	7.4	3.7	10,500
Chloride (Cl)	mg/L	1.8 ²	11.3 ²	3	2	457
Total phosphorus (P)	mg/L	110	110	120	150	142
Strontium (Sr)	mg/L	1.8 ²	2.4	2	2.5 ²	2.3
Calcium (Ca)	mg/L	11	4.4	230	17	2,700
Sulfate (SO ₄)	mg/L	2	1.4	4.8 ²	4	56
Chloride (Cl)	mg/L	74	7	10	3.4	19,000
Total nitrogen (N)	mg/L	—	—	—	—	540
Total phosphorus (P)	mg/L	—	.07	—	.04	.07
Strontium (Sr)	µg/L	280	1,100	—	110	8,000
Arsenic (As)	µg/L	—	0	—	0	3
Cadmium (Cd)	µg/L	—	2	—	.00	.11
Copper (Cu)	µg/L	—	20	—	0	3
Lead (Pb)	µg/L	—	1	—	3	.03
Zinc (Zn)	µg/L	—	20	—	20	10
Iron (Fe)	µg/L	—	70	—	10	10
Mercury (Hg)	µg/L	—	—	—	.00	.03
PCB ³	µg/L	—	.00	—	.00	—
IAH ⁴	µg/L	—	.00	—	.00	—
Type of water	—	mixed	sodium chloride	calcium sulfate	calcium-magnesium bicarbonate	—
Date sampled	—	5-26-72	5-2-72	4-7-72	4-25-72	—

¹HEM, 1970.
²Predominant cations and anions in water type.
³Polychlorinated biphenyls.
⁴Insecticides and herbicides.

Table 2.—Variation of water quality of Wakulla Springs with time

Constituent	Feb. 28 1924	Date of Collection June 18 1946 Apr. 25 1972	Apr. 28 1977
(in milligrams per liter unless otherwise noted)			
Calcium (Ca)	38	38	38
Magnesium (Mg)	9.6	9.5	8.7
Sodium (Na)	5.7	4.0	3.7
Potassium (K)	—	.5	.3
Silica (SiO ₂)	16	12	10
Bicarbonate (HCO ₃)	150	150	150
Carbonate (CO ₃)	—	0	0
Sulfate (SO ₄)	11	9.5	17
Chloride (Cl)	8.0	5.1	3.4
Fluoride (F)	—	.1	.3
Dissolved solids, calculated	167	155	160
Hardness as CaCO ₃	140	130	130
Specific conductance (micromhos per centimeter at 25°C)	—	277	279
pH (units)	—	7.9	7.3
Color (platinum cobalt units)	—	0	0
Sodium and potassium	—	0	0

Table 3.—Variations of water quality of Salt Springs with time.

Constituent	Aug. 19 1924	Date of Collection Apr. 4 1946 Apr. 24 1969	May 31 1972
(in milligrams per liter unless otherwise noted)			
Calcium (Ca)	220	240	154
Magnesium (Mg)	140	170	98
Sodium (Na)	1,400	1,500	878
Potassium (K)	—	38	24
Silica (SiO ₂)	—	11	12
Bicarbonate (HCO ₃)	84	87	67
Carbonate (CO ₃)	—	0	0
Sulfate (SO ₄)	540	610	375
Chloride (Cl)	2,400	2,800	1,600
Fluoride (F)	—	.0	.1
Dissolved solids, residue on evaporation at 180°C	5,210	5,850	—
Hardness as CaCO ₃	1,100	1,300	787
Specific conductance (micromhos per centimeter at 25°C)	—	9,330	5,520
pH (units)	—	7.1	7.6
Color (platinum cobalt units)	—	0	5
Sodium and potassium	—	—	10

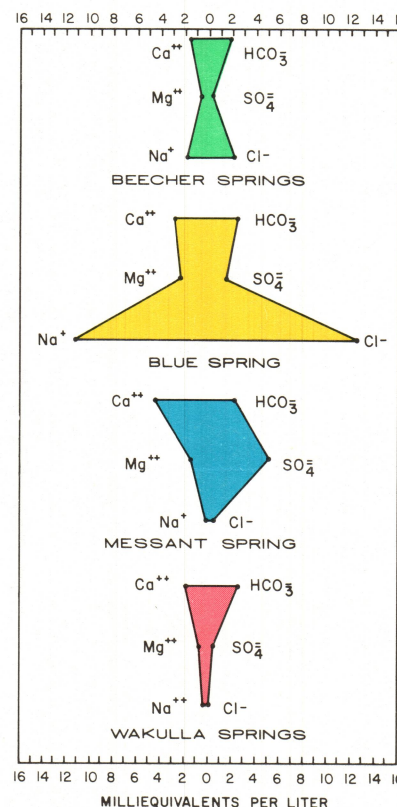


Figure 3.—Stiff diagrams for chemical types of spring water common to Florida.

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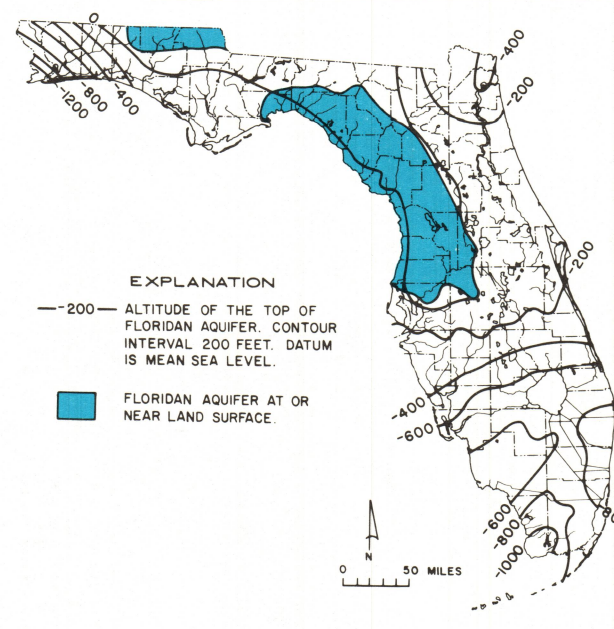


Figure 1.—The areal extent of the Floridan aquifer. (Modified from Vernon, 1973.)

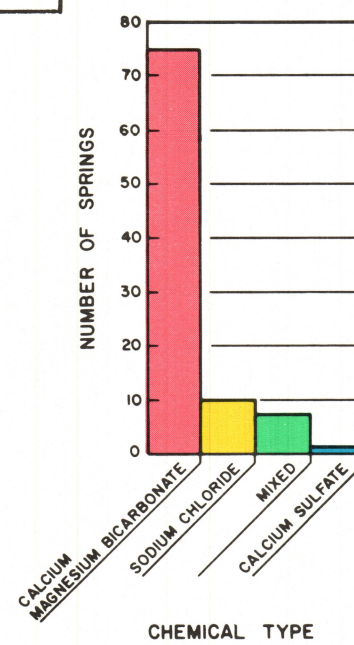


Figure 2.—Chemical types of water from first- and second-magnitude springs of Florida for which data were available.

EXPLANATION

FIRST MAGNITUDE SPRINGS.—Average flow greater than 100 cubic feet per second, 64.6 million gallons per day

- Calcium-magnesium bicarbonate
- Sodium chloride
- Mixed

SECOND MAGNITUDE SPRINGS.—Average flow 10 to 100 cubic feet per second.

- Calcium-magnesium bicarbonate
- Sodium chloride
- Mixed
- Calcium sulfate

Colors indicate prevalent chemical type of water discharged from the springs.

0 10 20 30 40 50 MILES