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FLORIDA GEOLOGICAL SURVEY
Robert O. Vernon, Director

REPORT OF INVESTIGATIONS NO. 28

WATER RESOURCES OF BREVARD COUNTY, FLORIDA

By

D. W. Brown, W. E. Kenner, J. W. Crooks, and J. B. Foster
U. S. Geological Survey

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
CENTRAL AND SOUTHERN FLORIDA FLOOD CONTROL DISTRICT
the
U. S. ARMY, CORPS OF ENGINEERS
and the
FLORIDA GEOLOGICAL SURVEY

TALLAHASSEE
1962

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Florida Geological Survey

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January 11, 1962

Honorable Farris Bryant, *Chairman*
Florida State Board of Conservation
Tallahassee, Florida

Dear Governor Bryant:

The Florida Geological Survey is pleased to publish as Report of Investigations No. 28, a comprehensive study of the water resources of Brevard County. This report was prepared by Messrs. D. W. Brown, W. E. Kenner, J. W. Crooks, and J. B. Foster, of the U. S. Geological Survey, in cooperation with the Central and Southern Florida Flood Control District; U. S. Army, Corps of Engineers; and the Florida Geological Survey.

This is a very timely study, since the development of adequate supplies of fresh water and the prevention and alleviation of flooding are the principal water problems in Brevard County. The rapid expansion of population and the development of new industries associated with the space effort have made large demands for increased supplies of fresh water, particularly in the Atlantic Coastal Ridge area on Merritt Island and in the barrier beach area. Flooding continues to be a problem in the St. Johns River Valley.

It would appear that nonartesian water is suitable for most demands, after it has been treated for the removal of iron color and for the reduction of hardness. For the most part, the mineralization of the artesian water in the area prevents its use as a public water supply in the area east of the St. Johns River, with the exception of the southeastern corner of the county and two small areas north and west of Titusville.

Respectfully submitted,
Robert O. Vernon, *Director*
Division of Geology

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WATER RESOURCES OF BREVARD COUNTY, FLORIDA

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ABSTRACT

Brevard County comprises an area of 1,298 square miles along the Atlantic Ocean in central Florida. Lying in bands roughly parallel to Indian River are three distinct landforms: the St. Johns River valley, which parallels the western border of the county; the Atlantic Coastal Ridge, which forms the eastern boundary of the mainland; and the barrier islands, which lie offshore and parallel to the mainland.

The county is underlain by a series of limestone formations having a total thickness of several thousand feet. The upper several hundred feet constitute the Floridan aquifer, which generally includes the Avon Park Limestone and the overlying Ocala Group of limestone formations, all of Eocene Age. Overlying the artesian aquifer are beds of sandy clay, shells, and clay of the Hawthorn Formation of Early and Middle Miocene Age and deposits of Late Miocene or Pliocene Age. These beds serve to confine water under pressure in the underlying artesian aquifer. The confining beds are overlain by unconsolidated deposits of sand and sandy coquina of Pleistocene and Recent Age which completely blanket the entire county.

The development of adequate supplies of fresh water and the alleviation of flooding are the principal water problems in Brevard County. Increased supplies are needed, particularly in the Atlantic Coastal Ridge area, on Merritt Island, and in the barrier beach area. Flooding is a major problem in the St. Johns River valley.

Lakes and streams occur throughout the county. The more important potential surface-water sources of supply are: (1) the St. Johns River; (2) the lakes and sloughs of the coastal ridge area; and (3) the streams flowing eastward into the Indian River. All the sources will provide water supplies, but the quality and quantity of water vary greatly.

Records from stream-gaging stations span from 1 to more than 24 years. The longer records, principally in the St. Johns River basin, enable fairly reliable estimates to be made of future flow. The shorter records, principally on streams in the coastal ridge area, do not provide enough data to project reliable estimates of future flow.

Ground water in Brevard County occurs under artesian and nonartesian conditions. Nonartesian water occurs in the sediments of Pleistocene and

Recent Age, whereas artesian water is in the underlying limestone formations of Eocene Age.

The piezometric surface of the artesian aquifer is higher than the land surface over most of Brevard County, and hence wells drilled into the aquifer will overflow at the surface. The top of the artesian aquifer is about 75 feet below sea level in the northwestern corner of the county and more than 300 feet below sea level in the southeastern corner. In Brevard County, the direction of movement of the artesian water is generally northeastward, except under the barrier islands. On the barrier islands north of Cocoa Beach, artesian water moves northwestwardly and south of Melbourne it moves directly eastward. The mineralization of the artesian water in the area under investigation does not meet the standards set by the U.S. Public Health Service for public drinking supplies except in the following areas: (1) west of the St. Johns River; (2) the southeastern corner of the county; and (3) two small areas north and west of Titusville.

The sediments of Pleistocene and Recent Age average about 50 feet in thickness in the coastal ridge area but are less than 20 feet thick in the vicinity of the St. Johns River. Nonartesian water saturates about 40 feet of these sediments in the coastal ridge area, and the zone of saturation thins toward the St. Johns and Indian rivers. The lower part of the sediments contains salty water in some places. Upward movement of salty water from the artesian aquifer can occur in areas where the water table is below the piezometric surface, including areas where the water table is, or in the future may be, lowered by large withdrawals of ground water from the nonartesian aquifer. Ground water in the nonartesian aquifer generally has a satisfactory color and is low in all chemical constituents except iron. In general, the nonartesian water is suitable for most purposes after it has been treated for the removal of iron and color and for the reduction of hardness.

INTRODUCTION

The development of water supplies of suitable quality and quantity for municipal, industrial, and agricultural purposes has long been a major problem in Brevard County. This problem has become acute in the past decade because of the rapid growth in population. The establishment of potable water supplies for the expanding population is of first importance in fostering the continued growth of the area, but the determination of potential sources of water for agricultural and industrial use is important also. In addition to local problems of water supply there are countywide and regional problems of flood control and drainage.

This report is a summary of the available information on the quantity, chemical quality, and availability of water in Brevard County. The report should be useful as a convenient reference for those charged with the responsibility of developing and protecting water supplies and for those who use or control water in significant quantities.

Brevard County lies within the boundaries of the Central and Southern Florida Flood Control District. The District has developed a comprehensive plan for control of floods and other water conditions in the basins of streams and lakes in southeastern Florida. The District's interest in Brevard County is twofold: (1) to collect basic hydrologic data that will provide a sound basis for the operation of its comprehensive plan, and (2) to obtain information on specific water problems. These interests spring from the District's fundamental aim—to promote the most beneficial use of the natural resources within the area under its jurisdiction. The present cooperative investigation, as a part of a systematic program of the U.S. Geological Survey to determine the water resources of the nation, provides information to aid the District in achieving this objective.

The water-resource problems in the area are of national importance because of public welfare and because of large federal investments in drainage and flood control works and in nearby military installations.

The following sources of water are described in this report:

1. The St. Johns River and associated lakes.
2. The tributaries to the St. Johns River.
3. The several small streams that flow eastward into the Indian River.
4. The shallow ponds along the coastal ridge.
5. The artesian aquifer.
6. The nonartesian aquifer.

Most of the data used in this report were collected by the U.S. Geological Survey in cooperation with the Central and Southern Florida Flood Control District, the Florida Geological Survey, and the Corps of Engineers, U.S. Army. In addition to data collected during this investigation, the report contains published and unpublished data collected by other agencies and individuals.

PREVIOUS INVESTIGATIONS

The water resources of Brevard County are described briefly in several reports published by state and federal agencies and unpublished reports by consultants and other interested parties.

Specific information on Brevard County is contained in published reports as follows: The geology and ground water are mentioned in a report by Matson and Sanford (1913, p. 273-277). Sellards and Gunter (1913, p. 232-245), in a report on the artesian water supply, give descriptions of wells, water-level measurements, and a few chemical analyses of water. Analyses of water from several wells in Brevard County are given in reports by Collins and Howard (1928) and Black and Brown (1951, p. 31-33). A report by Stringfield (1936) includes records of wells and artesian pressure in Brevard County and a piezometric map of the principal artesian aquifer in the Florida Peninsula. The U.S. Geological Survey has been gaging streams in Brevard County since 1933 and making water-level measurements in wells since 1946. These data are published in the regular series of annual water-supply papers of the Survey. The water-supply papers that contain records on surface-water supplies in Brevard County are nos. 757, 782, 802, 822, 852, 872, 892, 922, 952, 972, 1002, 1052, 1082 1112, 1142 ,1172, 1204, 1234, 1274, 1334, and 1384. Those that contain records on ground-water levels and artesian pressures in Brevard County are nos. 1072, 1097, 1127, 1157, 1166, 1192, 1222, 1266, 1322, and 1405. Cooke's "Geology of Florida" (1945, p. 47, 267, 301) describes some of the formations in Brevard County. Vernon (1951, figs. 11 and 33; pl. 2) has drawn geologic structure maps which include Brevard County.

In 1947-48, the U.S. Geological Survey, in cooperation with the Florida Geological Survey, conducted a ground-water reconnaissance of Brevard County which served as a basis for the present work. A table of well records and illustrations of the reconnaissance were released to the open file in a report by Neill (1955).

PRESENT INVESTIGATION

The present intensive investigation was made by the Water Resources Division of the U.S. Geological Survey in cooperation with the Central and Southern Florida Flood Control District. Other agencies supporting the investigation are the U.S. Army, Corps of Engineers and the Florida Geological Survey. The progress of the investigation and the information collected through 1955 are contained in the report entitled, "Interim Report on the Water Resources of Brevard County, Florida," Florida Geological Survey Information Circular no. 11. Records of streamflow, chemical analyses, ground-water levels, etc., of the water resources of Brevard County, Florida, are compiled in the report entitled "Water-Resource Records of Brevard County, Florida," by D. W. Brown, W. E. Kenner, J. W. Crooks, and J. B. Foster. This report is published as Florida Geological Survey Information Circular no. 32.

The surface-water work of the investigation consisted of collecting stage records on lakes, streams, and other water bodies and gaging the flow of the streams. Much reconnaissance work was done to define the limits of drainage areas, to determine flow patterns, and to select gaging sites.

The collection of ground-water information for this investigation began in the spring of 1954 and stopped in the spring of 1958, although water levels of five wells in Brevard County have been recorded since 1946. The major ground-water work of the current investigation included the following:

1. Inventory of wells to determine location, depth, distribution, diameter, yield, and other pertinent data.
2. Drilling of test wells in selected areas where information could not be obtained from existing wells.
3. Collection and study of water-level records to determine the seasonal fluctuations and progressive trends.
4. Collection of well logs and examination of well cuttings from test wells and privately owned wells to determine the thickness, lithologic character, and extent of the formations.
5. Conducting pump tests and analyzing the results to determine the water-transmitting and water-storing capacities of the different water-bearing formations.

The investigation of the quality of water in the upper St. Johns and Indian River basins, begun in the fall of 1953, was intensified during 1955 to meet the requirements of the study. Water-sampling stations for daily and periodic collection of water samples for chemical analyses were operated. Samples were collected periodically to detect progressive changes in the chemical quality of the water and to evaluate the effects of water use on the chemical quality of water. In general, the sampling stations were operated in conjunction with stream-gaging stations or ground-water recording gages.

ACKNOWLEDGMENTS

Thanks are extended to the municipalities of Cocoa, Cocoa Beach, Eau Gallie, Melbourne, Rockledge, and Titusville for their cooperation and help in the investigation. The commissioners of Brevard County kindly cooperated in various ways during the investigation. Mr. Jerry Sellars, water-plant superintendent of the Cocoa Water Department, kindly furnished data on Clear Lake.

Appreciation is expressed for the support and cooperation of the following well drillers who have aided the investigation by either furnishing file data or by collecting and saving rock cuttings from wells: Central Florida Well Drillers, Orlando; M. J. Heidekruger, Melbourne; Knight and King, Vero Beach; Layne-Atlantic, Orlando; Leon A. Merrow, Jr., Melbourne; and Adger Smith, Melbourne.

The following residents, consultants, and companies have contributed to the investigation: Roy Platt, Melbourne; Bert Thompson, Rockledge; Charles

Black, Black and Associates, Gainesville; W. M. Bostwick, Bostwick Inc., Daytona; A. B. DeWolf, Gee and Jensen, Consulting Engineers, West Palm Beach; Jerry Flipsie, A. Duda and Sons, Cocoa; Herbert Harrell, Nevins Fruit Co., Mims; Will Osteen, Norris Cattle Co., Mims; Leo Ellsworth, Orlando Livestock Co., Deerpark; Sottile, Micco Farms Division, Micco. Special thanks go to the many residents of the area who furnished water information and allowed access to their properties for the collection of geologic and hydrologic data.

WELL-NUMBERING SYSTEM

The Florida well-numbering system is based on a statewide grid of 1-minute parallels of latitude and 1-minute meridians of longitude. The wells in a 1-minute quadrangle are numbered consecutively in the order inventoried. In Florida, the latitude and longitude prefix north and west and the first digit of the degree number are not included in the well number.

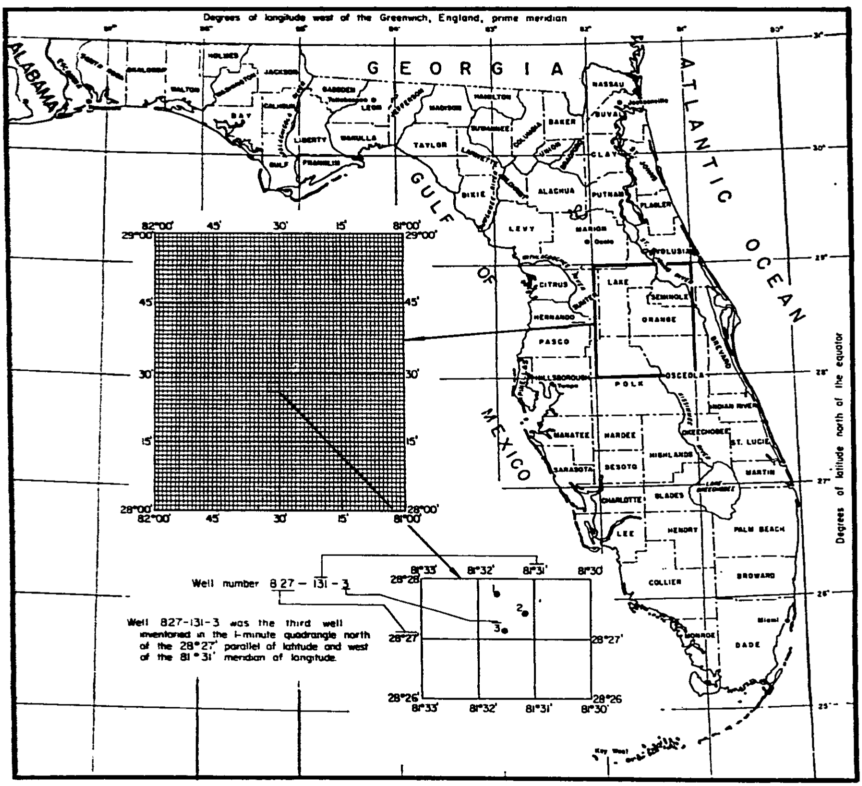


Figure 1. Well-numbering system.

The well number is a composite of three numbers separated by hyphens: The first number is composed of the last digit of the degree and the two digits of the minutes that define the latitude on the south side of a 1-minute quadrangle; and the second number is composed of the last digit of the degree and two digits of the minutes that define the longitude on the east side of a 1-minute quadrangle; and the third number gives the numerical order in which the well was inventoried in the 1-minute quadrangle (fig. 1).

GEOGRAPHY

LOCATION

Brevard County is on the Atlantic Coast near the middle of the Florida Peninsula (fig. 2). It is bordered on the north by Volusia County, on the west by Osceola, Orange, and Volusia counties, on the south by Indian River County, and on the east by the Atlantic Ocean. Cape Canaveral forms the central part of the Atlantic coastline of Brevard County. This cape is a conspicuous interruption in the relatively smooth line of Florida's east coast. The county has an area of 1,298 square miles. It has a north-south length of 66 miles and an east-west width of about 20 miles.

Most of Brevard County is served by good transportation facilities. Several state and federal highways, north-south and east-west, provide ready access between population centers within the county and the state. The Florida East Coast Railroad furnishes rail transportation. Airline service is available only at the city of Melbourne and bus service is available between most cities in the county. The Intracoastal Waterway provides a water route through the county via Indian River and Indian River Lagoon.

PHYSICAL FEATURES

Brevard County has been classified by Cooke (1939, p. 14-16) as part of the coastal lowlands physiographic unit. The principal physical features are the St. Johns River valley, the Atlantic Coastal Ridge, the barrier islands area and the coastal terraces (fig. 6).

ST. JOHNS RIVER VALLEY

In Brevard County, the St. Johns River valley includes all of the area west of the Atlantic Coastal Ridge. The source of the St. Johns River is the marsh area in the southern part of the county. The river forms a definite channel at Lake Hellen Blazes and passes through Sawgrass Lake, Lake Washington, Lake Winder, and Lake Poinsett. From Lake Poinsett the river flows along the western border of Brevard County until it reaches a point west of Titusville, where it flows out of the county and continues flowing northward until it discharges into the Atlantic Ocean near Jacksonville.

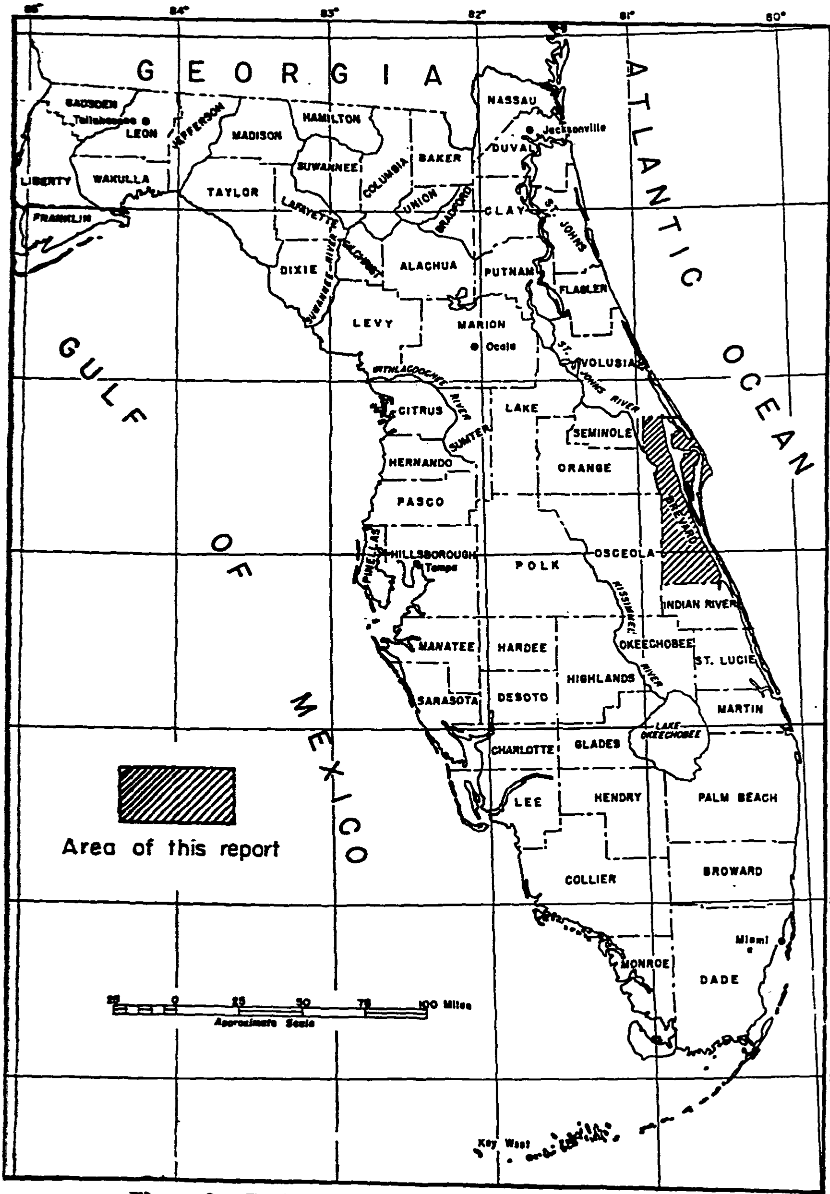


Figure 2. Peninsula of Florida showing Brevard County.

The St. Johns River channel at its source is approximately 20 feet above sea level (fig. 3). Along the river's 275-mile course to the ocean the fall in the water surface, when the river is at a low stage, is about 15 feet or about 0.05 foot per mile. The gradient of the St. Johns River between crest gages 1 and 19 (fig. 16, 18) is usually about 0.2 foot per mile during flood stage. The stream channel is tortuous and is interrupted by numerous lakes.

Much of the land immediately adjacent to the river is marshland and when the river is at flood stage this marshland functions as part of the river channel. During low stages, water from the marshland drains slowly back into the channel and helps to sustain flow. The width of the marshland ranges from less than 1 mile to more than 7 miles. In Brevard County the marshland adjacent to the river is not generally present in areas higher than 20 feet above sea level. The vegetation in the marshland consists primarily of marsh grasses and occasional hammocks or clusters of cypress trees.

A sandy prairie zone or dry prairie zone (Davis, 1943, p. 152) forms the upland border of the marshland. It is several miles wide in some areas and completely absent in others. The prairie zone is part of the flood plain of the St. Johns River and is flooded frequently. The vegetation of the zone consists principally of grasses, saw palmetto, many other low shrubs, and occasional hammocks of cabbage palm trees.

A pine flatwoods forest (Davis, 1943, p. 147, 160-166) in Brevard County lies between the prairie zone and coastal ridge. The combined width of the prairie and forest areas ranges from less than 1 mile to more than 12 miles. Where the sandy prairie zone is absent, the pine flatwoods forest borders the marshland. The forest area is relatively flat, poorly drained, and there are numerous scattered intermittent ponds, lakes, and sloughs. The altitude of the pine flatwoods forest ranges from a few feet above sea level along the marshland border to about 35 feet above sea level along the coastal ridge border. The vegetation consists mostly of pine, saw palmetto, and wire grasses. The area is suitable for lumbering and cattle grazing.

ATLANTIC COASTAL RIDGE

The Atlantic Coastal Ridge in Brevard County is bordered on the west by the pine flatwoods forest of the St. Johns River valley and on the east by the Indian River (fig. 6). The ridge ranges in east-west width from 1½ to 3 miles and is continuous along the full north-south length of Brevard County. The area has a mature dune-type topography with parallel north-south elongate ridges and intervening swales. The swales contain many shallow ponds, lakes, and long narrow sloughs. The coastal ridge ranges in altitude from sea level to 55 feet above sea level and it is the highest area east of the St. Johns River valley. The crest of the ridge forms the natural drainage divide between the St. Johns and Indian River basins. A series of small streams flow out of the coastal ridge and flow eastward into the Indian River. The western slope of the coastal ridge is drained by a series of small interconnecting depressions that channel water westward into the St. Johns River. The principal types of vegetation found on the coastal ridge are saw palmetto, sand pine, scrub oak, and shrubs.

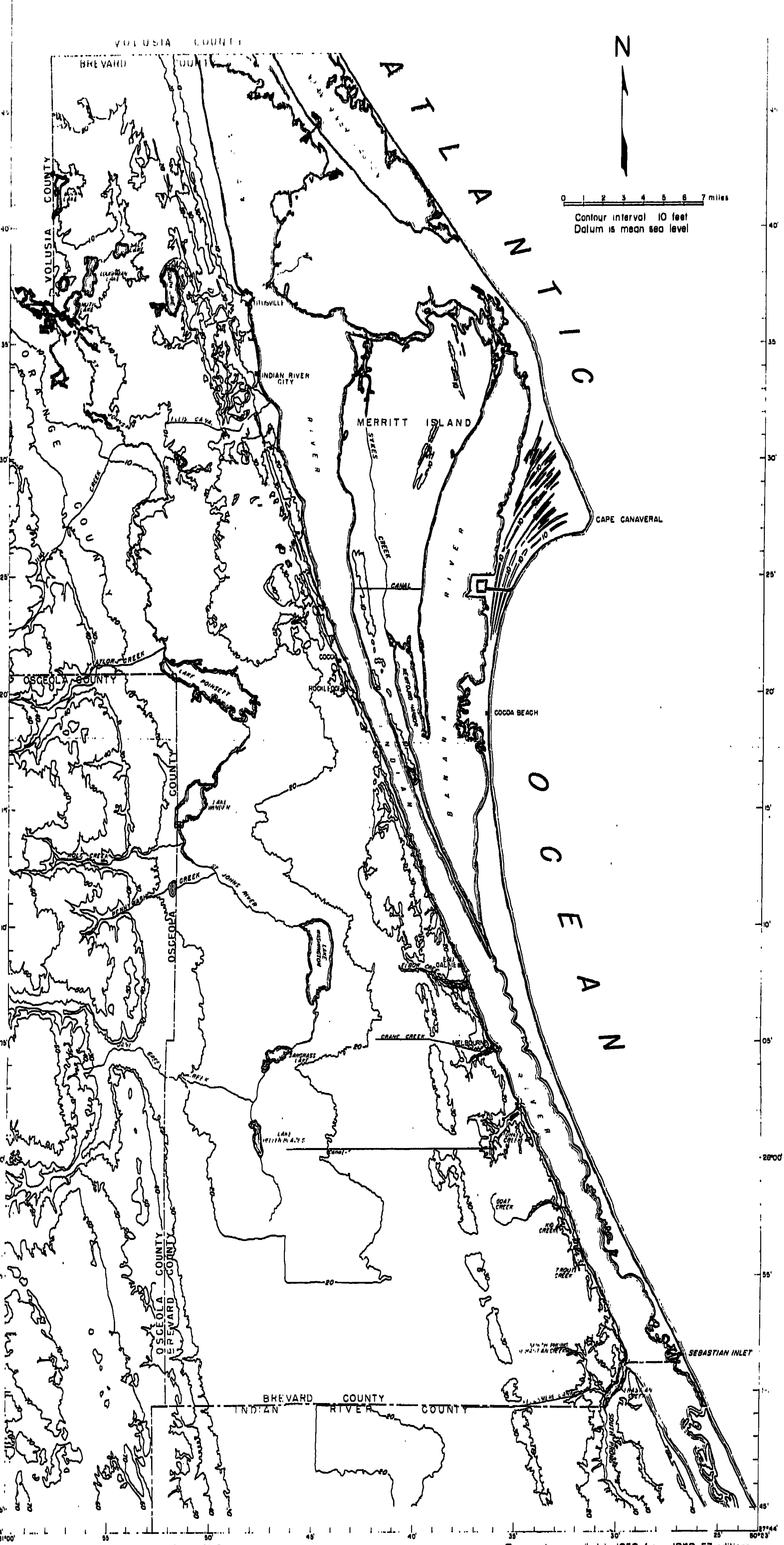
BARRIER ISLANDS AREA

In Brevard County the barrier islands area is separated from the mainland by the Indian River and is bordered on the east by the Atlantic Ocean. The similarity of landforms in the barrier island area indicates that their development was by similar depositional processes. The barrier islands are composed of relict beach ridges formed by the action of wind and waves of the ocean.

Merritt Island, one of the barrier islands, has a maximum east-west width of about 7 miles and a north-south length of about 31 miles. It is bordered on the west by the Indian River, on the southeast by the Banana River, and on the north by Banana Creek. The land surface is undulating, the troughs are near sea level, and the ridges generally are not more than 10 feet above sea level. The troughs and ridges, produced during deposition, generally parallel the present coastline.

The development of Merritt Island was rather complex but, in general, the deposition progressed from west to east. As Merritt Island formed, erosional forces tended to smooth out the ridges. Consequently, the original wavy surface of the western side has been reduced to a nearly level plain. The range in altitude between the crests and troughs of the land surface becomes greater from west to east. The surface drainage is primarily internal, being trapped in long, narrow lakes, ponds, and sloughs that have formed in the troughs. Some of these water bodies, however, have outlets to external drainage. The vegetation on Merritt Island is a mixture of the types found in the pine flatwoods forest and the coastal ridge of the mainland.

The barrier islands are a system of beach ridges that generally parallel the present shoreline. These islands separate the Atlantic Ocean from the Indian River, the Indian River Lagoon, and the Banana River. They are continuous along the full north-south length of Brevard County, and generally range in east-west width from a few hundred feet to a mile. However, at Cape Canaveral the barrier island is about 4½ miles wide. The land surface of these barrier islands ranges in altitude from sea level along the shoreline to 20 feet above sea level along the crest of the dune ridges.



Base and contour lines compiled from U.S. Geological Survey topographic quadrangles.

Topography compiled in 1958 from 1949-53 editions of Geological Survey topographic quadrangle.

Figure 3. Brevard County showing topographic contours.

Vegetation on these barrier islands consists only of plants that can grow in relatively saline soil and air. The most common of these are sea oats, saw palmettos, sea grapes, cocoa plums, wax myrtles, lantanas, and bay cedars.

TERRACES

The Pleistocene Epoch, or "Great Ice Age," was a time of alternate glaciation and deglaciation. The repeated retreat and growth of the glaciers caused sea level to rise and fall. Whenever the sea remained long enough at one level, a shoreline, marked by an escarpment, generally developed and the sea floor formed an essentially level surface, called a terrace. Several of these ancient shorelines and terraces, both above and below the present sea level, have been recognized. The higher shorelines are assumed to be older than the lower.

The Pleistocene history and terraces in Florida are included in reports by Cooke (1945, p. 245-312) and Parker (1955, p. 111-124, 135-147). The shorelines recognized by Cooke and the approximate altitude at which they stand are as follows:

Brandywine	270 feet
Coharie	215 feet
Sunderland	170 feet
Wicomico	100 feet
Penholoway	70 feet
Talbot	42 feet
Pamlico	25 feet
Silver Bluff	5-8 feet

The terraces that were formed by the Pamlico and Silver Bluff seas are shown in figure 4. The Pamlico and Silver Bluff terraces are at 25 to 35 feet and 5 to 8 feet above mean sea level, respectively, for which the closest available topographic contours are 30 feet and 10 feet. Topographic maps of the U.S. Geological Survey were used to delineate both terraces.

CLIMATE

The climate of Brevard County is humid subtropical. According to the U.S. Weather Bureau, the normal monthly temperature at the Merritt Island weather station ranges from 62.4°F. for January to 81.6°F. for August and the average temperature for this station is 72.6°F. The large bodies of water in and near Brevard County temper the climate, reduce the amplitude of the temperature range, and contribute to the generally high humidity of the area. Most of the rainfall occurs from May through October. The average annual precipitation is 51.70 inches at the Merritt Island weather station and 55.29 inches at the Titusville station based on intermittent records for the periods of 1878-1955 and 1888-1957, respectively. Summaries of the precipitation records for the stations at Merritt Island and Titusville are given graphically in figure 5. The collection of data at the Merritt Island weather station was discontinued in 1956; consequently, figure 5 shows 1955 as the last complete year of data for this station.

POPULATION

The U.S. Bureau of Census reported the 1950 population of Brevard County to be 23,653. Annual estimates of the population of Brevard County

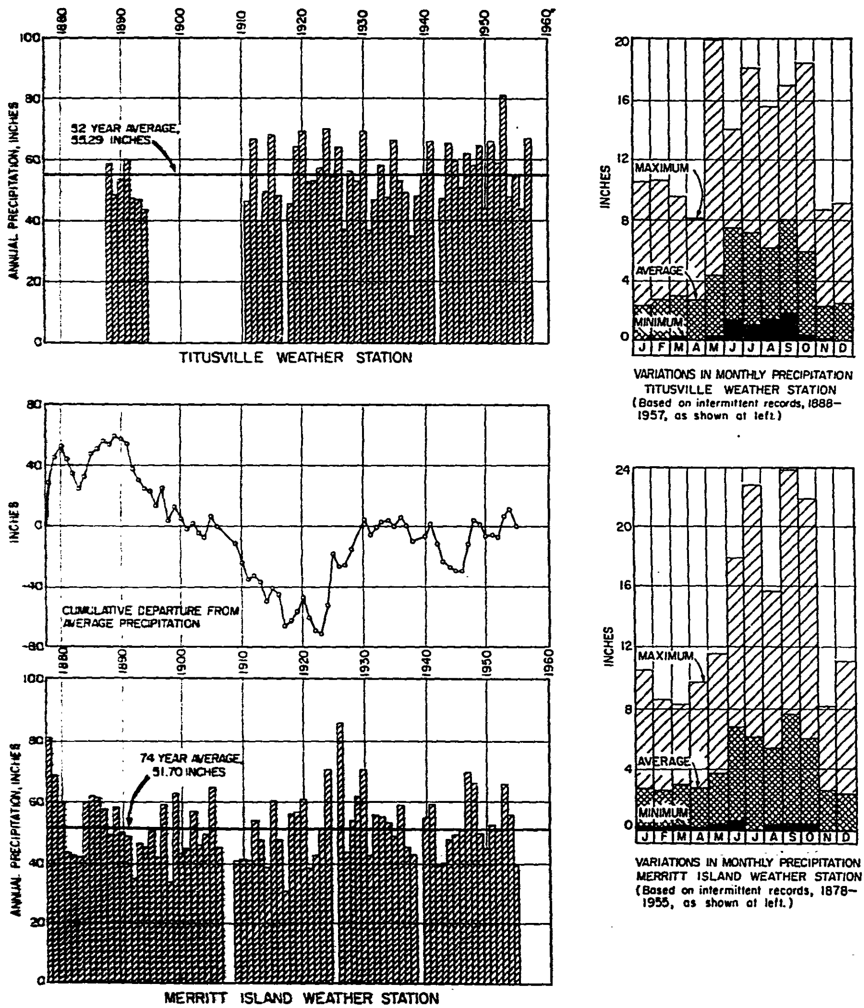


Figure 5. Precipitation records at Titusville and Merritt Island, Florida.

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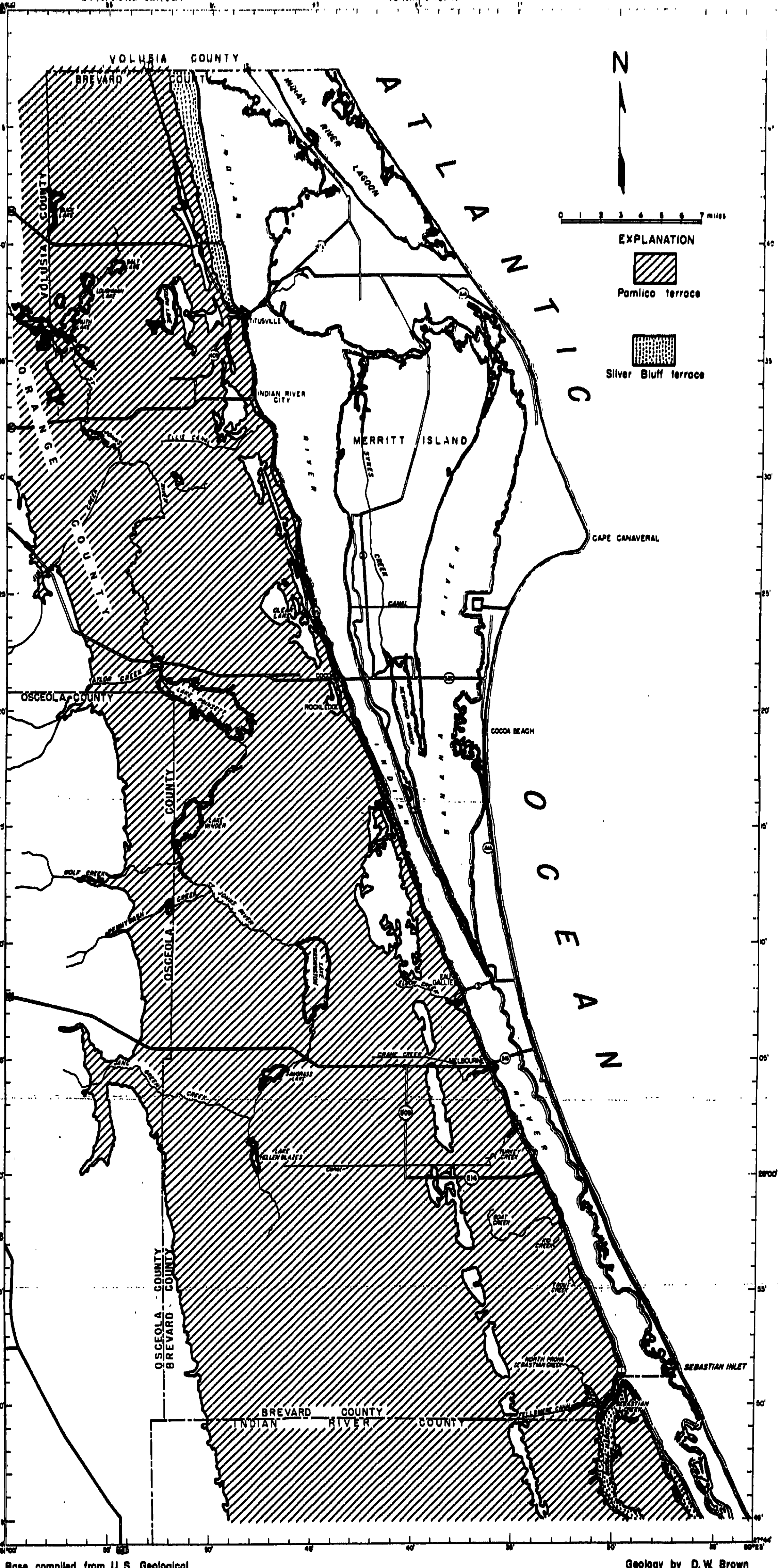
H O Vernon, Director



Base compiled from U. S. Geological Survey topographic quadrangles.

Geology by D. W. Brown in 1958

Figure 4. Brevard County showing the Pleistocene marine terraces.

prepared by Professor John N. Webb of the University of Florida indicate an increase of about 320 percent from 1950 to July 1, 1959. The main centers of population are on the Atlantic Coastal Ridge near Indian River. Population figures by decades from 1910 to 1950, and annually since 1950, are given in table 1.

TABLE 1. Population of Brevard County and Principal Municipalities in Brevard County, 1910-50.

(Source: Reports of U.S. Bureau of Census)

Population unit	1910	1920	1930	1940	1950
Brevard County	4,717	8,505	13,283	16,142	23,653
Titusville	868	1,361	2,089	2,220	2,604
Cocoa	613	1,445	2,164	3,098	4,245
Rockledge	——	453	551	725	1,347
Eau Gallie	329	507	871	873	1,554
Melbourne	157	533	2,677	2,622	4,223

(Source: Estimates by Dr. John N. Webb, University of Florida)

Brevard County

1950	23,700	1955	42,400
1951	24,720	1956	53,500
1952	25,570	1957	72,000
1953	26,430	1958	86,200
1954	38,650	July 1, 1959 (Provisional)	101,500

GEOLOGY

The occurrence, origin, quality, and availability of ground water in an area are dependent largely upon the geology of the aquifers. Therefore, a knowledge of the structure, stratigraphy, and lithology of the rock formations is essential in the evaluation of an aquifer as a source of water supply.

A simple interpretation of the geology, adequate to evaluate the aquifers, is presented in the following paragraphs. The classification and nomenclature of the rock units conform to the usage of the Florida Geological Survey and also, except for the Ocala Group and its subdivisions, with those of the U.S. Geological Survey. Where the use of a formation name is questionable, the geologic age of the deposit is used to denote the deposit.

The geology of Brevard County was studied from data collected on existing water wells and exploratory test wells. Rock samples were collected and described by U. S. Geological Survey personnel during the drilling of selected water wells and test holes. Detailed examinations of samples in the laboratory were made to determine the texture, lithology, and fauna.

This information was used to prepare maps and cross sections to illustrate graphically the thickness, general distribution, and structure of the subsurface formations.

The earth materials exposed at the surface in Brevard County are undifferentiated deposits of Pleistocene and Recent Age that form the reservoir rock for the nonartesian water. These surficial sediments are underlain by unconsolidated beds of Late Miocene or Pliocene Age, which, in turn are underlain by the Hawthorn Formation of Early and Middle Miocene Age. The deposits of Late Miocene or Pliocene Age and the Hawthorn Formation include beds for material of relatively low permeability which serve to confine water under pressure in the underlying limestone formations of Eocene Age. The limestone formations of Eocene Age are the major source of ground water in Brevard County and form part of the principal artesian aquifer in Florida and Georgia. In Florida, the principal artesian aquifer has been called the Floridan aquifer by Parker and others (1955, p. 189). The geologic formations generally penetrated by water wells in Brevard County are listed in table 2, which gives the thickness, lithologic character, and water-bearing properties of the formations.

TEST DRILLING

Most of the ground-water and geologic data in this report were obtained from existing water wells. Test wells were drilled in areas where adequate data could not be obtained from existing wells. Wells were drilled to obtain information on the Pleistocene and Recent deposits that form the nonartesian aquifer, and to obtain information on Miocene or Pliocene deposits that form the confining beds for the Floridan aquifer and the limestone formations of Eocene Age of the Floridan aquifer. During the investigation, 67 test wells were drilled into the Pleistocene and Recent deposits and 8 test wells were drilled into the Floridan aquifer. Of the 75 test wells installed, 13 were installed by cable-tool method and 62 by power auger method.

Test drilling in the Pleistocene and Recent deposits was by power auger and cable-tool drilling machine. The power auger was used to drill shallow test holes and to construct shallow wells. These wells, 1¼ inches in diameter, were used to observe changes in water level and chemical quality of the nonartesian water (fig. 6). A cable-tool drilling machine was used to drill 4-inch diameter test wells from which rock cuttings were obtained at 5-foot intervals, water samples for chemical analysis were collected from the bailer at various depths, drilling time was recorded, and water levels were measured. Water samples for chemical analysis were pumped from isolated sections of the well at selected depths.

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FLORIDA GEOLOGICAL SURVEY
R. O. Vernon, Director

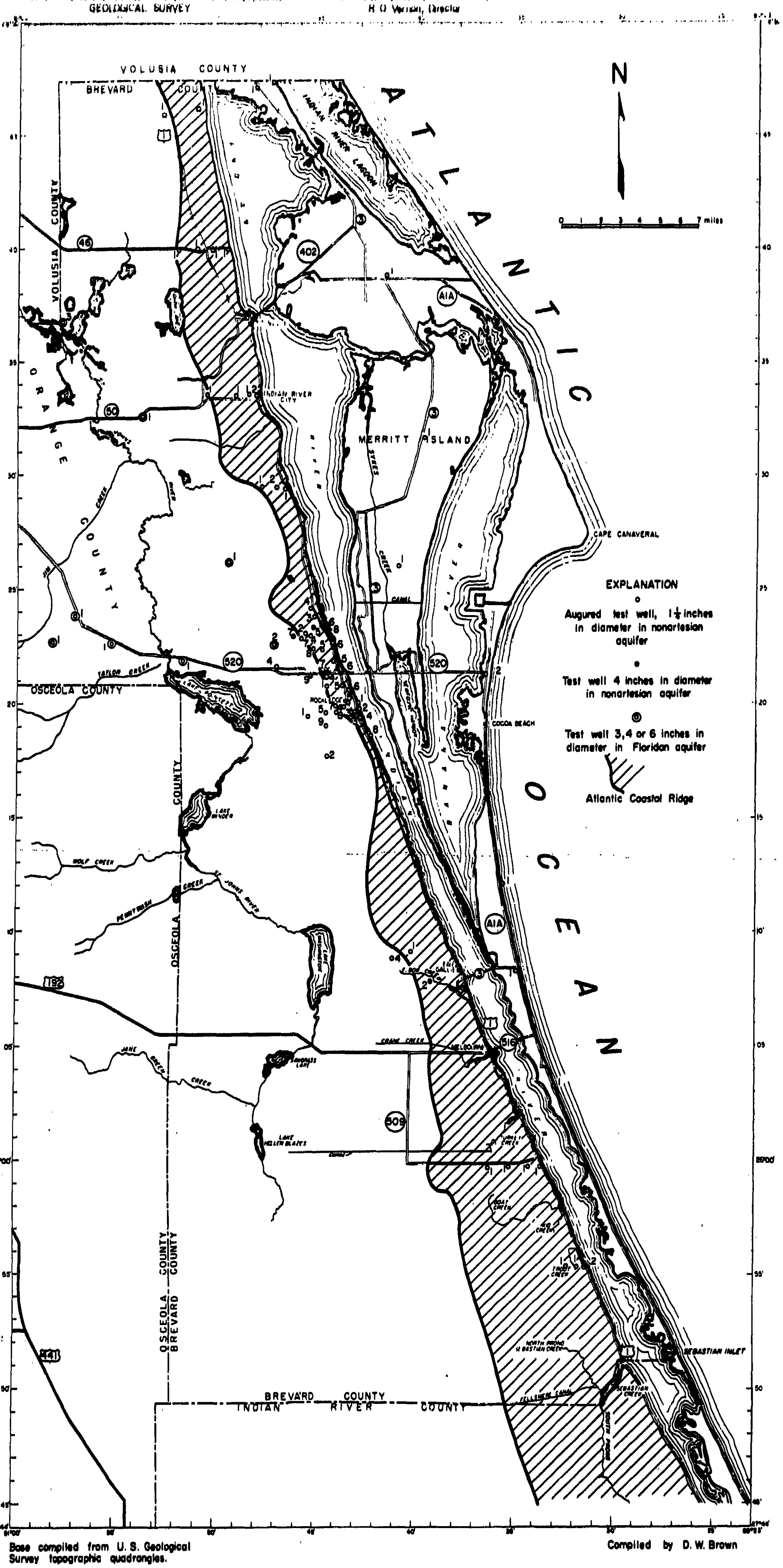

Figure 6. Brevard County showing the locations of test wells and Atlantic Coastal Ridge.

TABLE 2. Stratigraphic Units of Brevard County, Florida

Geologic age	Stratigraphic unit		Approximate thickness (feet)	General lithologic character	Water-bearing properties
Recent Pleistocene	Pleistocene and Recent deposits		0-110	Fine to medium sand, coquina and sandy shell marl.	Permeability low due to small grain size, yields small quantities of water to shallow wells, principal source of water for domestic uses not supplied by municipal water systems.
Pliocene Miocene	Upper Miocene or Pliocene deposits		20-90	Gray to greenish gray sandy shell marl, green clay, fine sand, and silty shell.	Permeability very low, acts as confining bed to artesian aquifer, produces small amount of water to wells tapping shell beds.
Miocene	Hawthorn Formation		10-300	Light green to greenish gray sandy marl, streaks of greenish clay, phosphatic radiolarian clay, black and brown phosphorite, thin beds of phosphatic sandy limestone.	Permeability generally low, may yield small quantities of fresh water in recharge areas, generally permeated with water from the artesian zone. Contains relatively impermeable beds, that prevent or retard upward movement of water from the underlying artesian aquifer. Basal permeable beds are considered part of the Floridan aquifer.
Eocene	Ocala Group	Crystal River Formation	0-100	White to cream, friable, porous coquina in a soft, chalky, marine limestone.	Floridan aquifer: Permeability generally very high, yields large quantities of artesian water. Chemical quality of the water varies from one area to another and is the dominant factor controlling utilization. A large percentage of the ground water used in Brevard County is from the artesian aquifer. The Crystal River Formation will produce large quantities of artesian water. The Inglis Formation is expected to yield more than the Williston Formation. Local dense, indurated zones in the lower part of the Avon Park Limestone restrict permeability but in general the formation will yield large quantities of water.
	Ocala Group	Williston Formation	10-50	Light cream, soft, granular marine limestone, generally finer grained than the Inglis Formation, highly fossiliferous.	
	Ocala Group	Inglis Formation	70+	Cream to creamy white, coarse granular limestone, contains abundant echinoid fragments.	
	Avon Park Limestone		285+	White to cream, purple tinted, soft, dense chalky limestone. Localized zones altered to light brown or ashen gray, hard, porous, crystalline dolomite.	

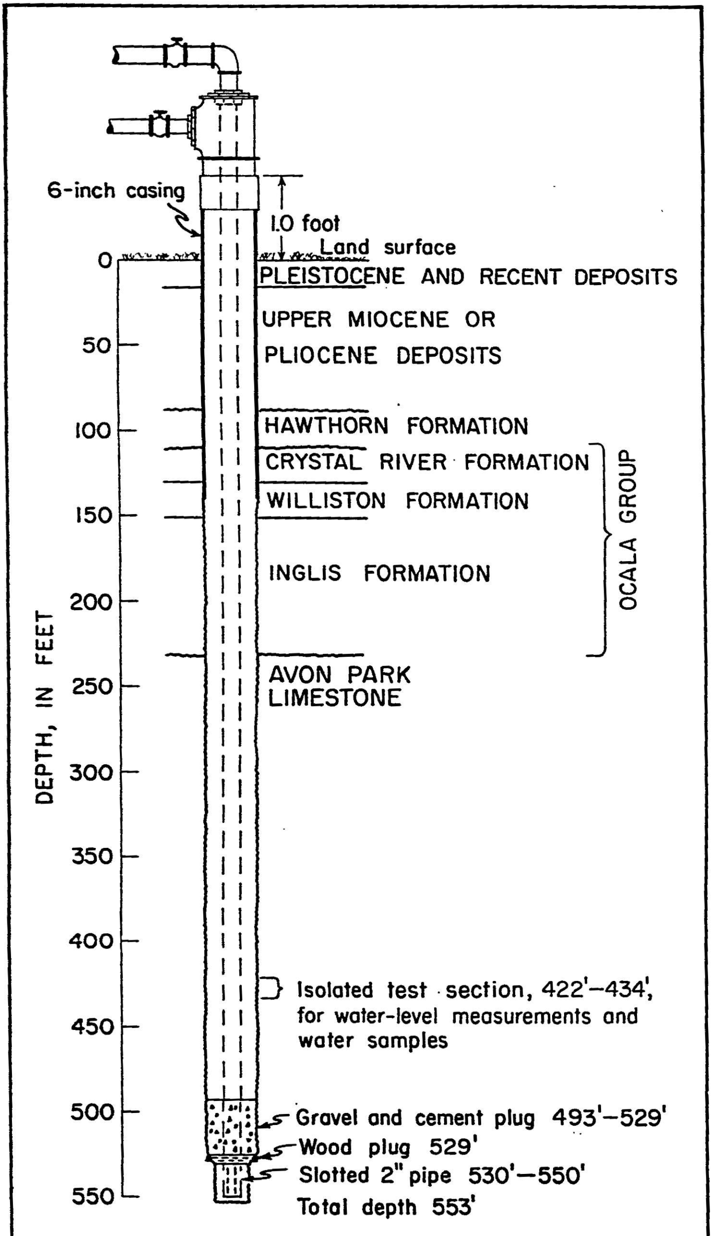

Figure 7. Sketch showing construction of and geologic formations penetrated by observation well 822-051-1.

Test wells in the artesian aquifer and the confining beds overlying the artesian aquifer were drilled by the cable-tool method. These wells were drilled to determine the chemical quality of the water at different depths, to determine the westward limits of the saline artesian water, and to obtain geologic and hydrologic data in areas where such data could not be obtained from existing wells.

Well 822-051-1, on the right-of-way of State Highway 520 about 1 mile east of the St. Johns River bridge and 8 miles west of Cocoa, was drilled to a depth of 553 feet to test deep zones in the artesian aquifer. Special sampling methods were used during the construction of this well to collect water samples and measure water levels in two isolated sections of the well. The isolated sections were at depths of 422-434 feet and 530-553 feet. Sections of the well were isolated by removing the 6-inch drilling bit from the open hole and inserting inside the well a 4-inch diameter unperforated casing that was driven 5 feet below the bottom of the 6-inch diameter open hole. A 4-inch bit was then used to drill a 10-foot section of open hole below the bottom of the 4-inch diameter casing. Then water-level measurements were made and water samples were collected from the isolated 10-foot section of the 4-inch diameter open hole. When the testing of the isolated section had been completed, the 4-inch diameter casing was removed from the well and the 4-inch diameter open hole was reamed to 6 inches in diameter.

When the well was completed a current-meter traverse was made to locate the water-producing zones and to determine the rate of flow in the well. Upon completion of construction and testing, the well was altered, as shown in figure 7, so that water levels could be measured in sections of the aquifer from 140-493 feet and 530-553 feet below land surface. A summary of the pertinent data collected during and after construction of this well is shown diagrammatically in figure 8.

To locate the western limits of the salty water in the Floridan aquifer, wells 822-055-1, 822-058-1, and 823-056-1 were drilled in Orange County west of the State Highway 520 bridge over the St. Johns River. They were spaced about 2 miles apart in the east-west direction. These wells penetrated about 50 feet into the Eocene Limestone and provided stratigraphic data and water for chemical analysis.

FORMATIONS

Rocks older than the Avon Park Limestone are not described in this report because only a few water wells in Brevard County penetrate below the Avon Park Limestone. The Avon Park Limestone and younger rocks

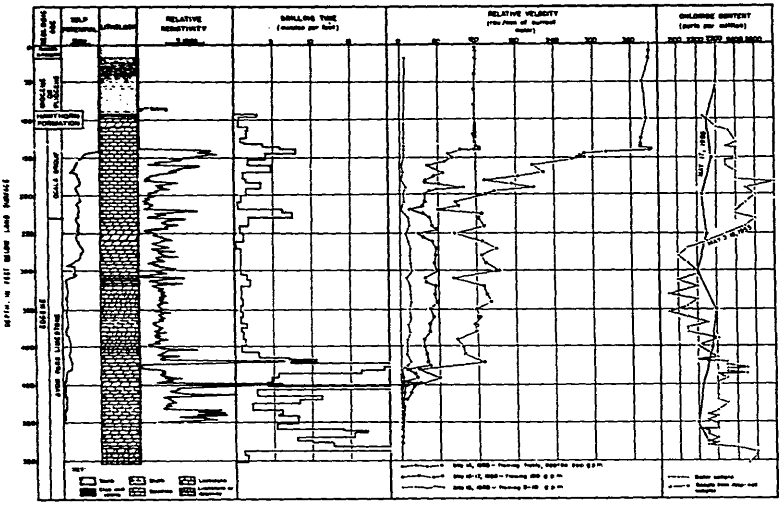

Figure 8. Graphs showing data obtained from test well 822-051-1.

are described in the order of their ages, from the oldest to the youngest—that is, from the deepest formation to the shallowest formation.

AVON PARK LIMESTONE

The Avon Park Limestone (Applin and Applin, 1944) of Late Middle Eocene Age is the deepest formation generally penetrated by water wells in Brevard County. The limestone is exposed at the surface in Citrus and Levy counties (Vernon, 1951, p. 95), and is the oldest rock cropping out in Florida. The thickness of the Avon Park Limestone ranges from 150 to 300 feet in the central part of the state (Applin and Applin, 1944, p. 1687) and exceeds 300 feet in Brevard County. The Avon Park is overlain by younger Eocene Limestones in all of Brevard County.

The Avon Park consists mostly of white to cream-colored soft, dense chalky limestone. It ranges in color from white to light brown or ashen gray and in composition from chalky limestone to a loose coquina of foraminifera, echinoids, and other marine shells. In places the Avon Park has been altered largely to dolomite (fig. 8). The graphs of drilling time and the resistivity curve of well 822-051-1 (fig. 8) indicate the presence of dense, highly resistant zones in the Avon Park and overlying limestones. These zones retarded the drilling rate and registered a relatively high electrical resistivity. They are most prominent below 420 feet, where several hard zones were encountered. Similar zones, encountered in test wells in Volusia County, were reported by Wyrick and Leutze (1955, p. 22) to be relatively impermeable; thus, vertical movement of water probably is retarded by these dense zones.

The Avon Park Limestone is an important unit of the Floridan aquifer and is the principal source of water for the deep artesian wells in Brevard County.

OCALA GROUP

The Ocala Group (Puri, 1957) is a series of limestone formations of Eocene Age that unconformably overlie the Avon Park Limestone and unconformably underlie the Hawthorn Formation of Miocene Age. The major subdivisions of the Ocala Group are, from the bottom upward, the Inglis, Williston, and Crystal River Formations. The formations are differentiated on the basis of fossil content and lithology. The limestone in the Ocala Group has been subdivided and renamed several times in recent years by different investigators, but the above nomenclature is currently being used by the Florida Geological Survey.

The Inglis Formation is a cream-colored to white marine fossiliferous granular limestone. Rock cuttings from wells in Brevard County show that the Inglis Formation ranges in thickness from 50 to 100 feet. The formation contains abundant fragments of the echinoid, *Periarchus lyelli floridanus,* which is the most readily identifiable fossil in the formation.

The Williston Formation is predominantly a cream-colored fossiliferous marine limestone. It is distinguished from the Inglis Formation by being somewhat finer grained and containing fewer echinoids. The Williston Formation underlies all of Brevard County and averages about 30 feet in thickness.

The Crystal River Formation is white to cream-colored. It is a soft massive friable fossiliferous limestone. The lower section is distinguished from the Williston on the basis of fauna and the fact that it is more granular than the Williston. The formation underlies the southern part of Brevard County but has been eroded away in the northern part (fig. 9). The thickness of the formation gradually increases to as much as 100 feet at the Indian River County line. In the southern part of the county the top of the Crystal River Formation represents the top of the limestone of Eocene Age.

The hydraulic properties of the Inglis, Williston, and Crystal River Formations are similar. These formations are hydrologically connected and function as a part of the Floridan aquifer.

The Ocala Group supplies copious quantities of water to wells penetrating the upper part of the Floridan aquifer. The Crystal River and Inglis Formations ordinarily will yield more water than the finer grained Williston Formation. Nevertheless, the Williston Formation is a productive part of the aquifer.

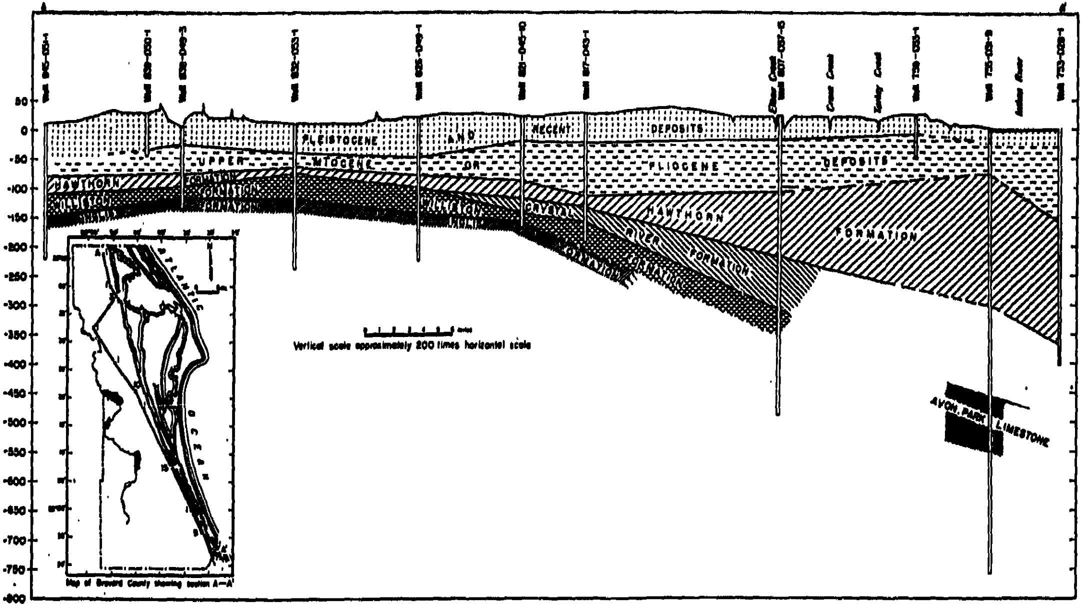

Figure 10. Geologic section A-A'.

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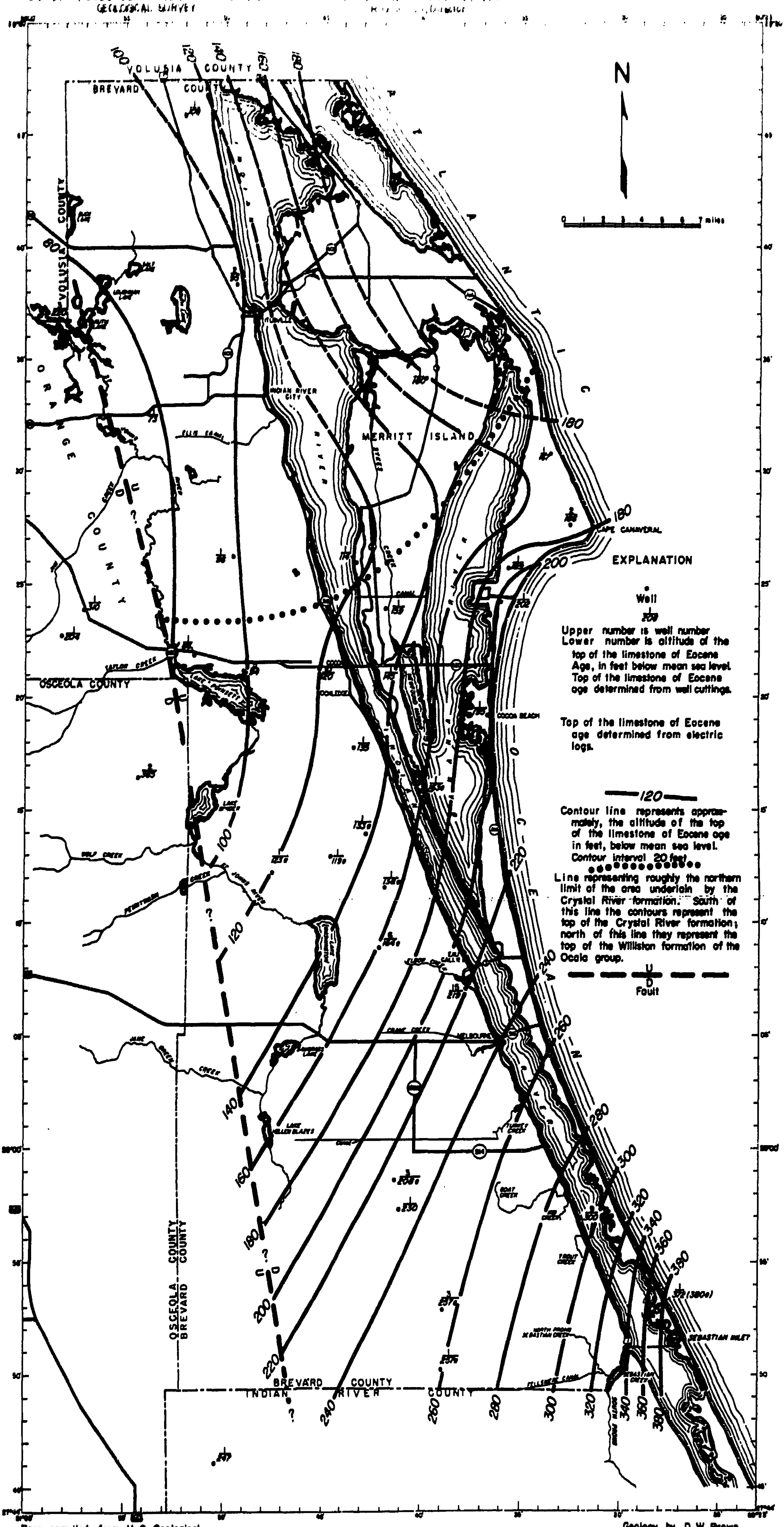

Base compiled from U. S. Geological Survey topographic quadrangles.

Geology by D. W. Brown in 1958

Figure 9. Brevard County showing contours on the surface of the limestone of Eocene Age.

HAWTHORN FORMATION

The Hawthorn Formation of Miocene Age underlies all of Brevard County and ranges in thickness from 10 feet in the northern part of the county to about 220 feet in the southern part (fig. 10). The formation is composed of greenish gray, calcareous clay; sandy, phosphatic limestone; black and brown phosphorite; and light green to white, phosphatic, radiolarian clay. It contains many layers of relatively impervious marl and clay which serve as confining beds to the water in the underlying artesian aquifer. In the formation the basal limestone beds that are permeable and connected hydraulically with the underlying artesian aquifer are considered to be part of the Floridan aquifer. Where the more permeable sands, shell marls, and limestones of the Hawthorn Formation contain relatively fresh water they constitute sources for domestic and public supplies.

UPPER MIOCENE OR PLIOCENE DEPOSITS

Unconsolidated beds of fine sand, shells, clay and calcareous clay of Late Miocene or Pliocene Age overlie the Hawthorn Formation and underlie the Pleistocene and Recent deposits. Similar material in surrounding counties has been classified as the Caloosahatchee Marl of Pliocene Age by Cooke (1945, p. 214, 226-227; pl. 1) and as beds of Late Miocene Age by Vernon (1951, fig. 13, 33). Until further investigation determines the correct age of these deposits in Brevard County, they will be referred to as deposits of Late Miocene or Pliocene Age. Their permeability is generally low, and hence, they retard upward leakage from the artesian aquifer. A few domestic supplies of water are obtained from zones of sand or shell in the deposits.

PLEISTOCENE AND RECENT DEPOSITS

The material exposed at the surface in Brevard County consists chiefly of unconsolidated, white to brown, medium to fine, quartz sand containing beds of sandy coquina of Pleistocene and Recent Age. The thickness of the deposits ranges from less than 20 feet in the St. Johns River valley to more than 100 feet in the coastal ridge area (fig. 11). The deposits constitute the principal source of relatively fresh ground water for hundreds of domestic wells in the county.

GEOLOGIC STRUCTURE

The configuration of the top of the limestone formations of Eocene Age is shown by a contour map (fig. 9). Profiles of the formations are shown by geologic cross sections (fig. 10, 11, 12).

The contours indicate the top surface of the Crystal River Formation in the southern part of the county and the top surface of the Williston Formation in the northern part of the county. The Crystal River Formation has

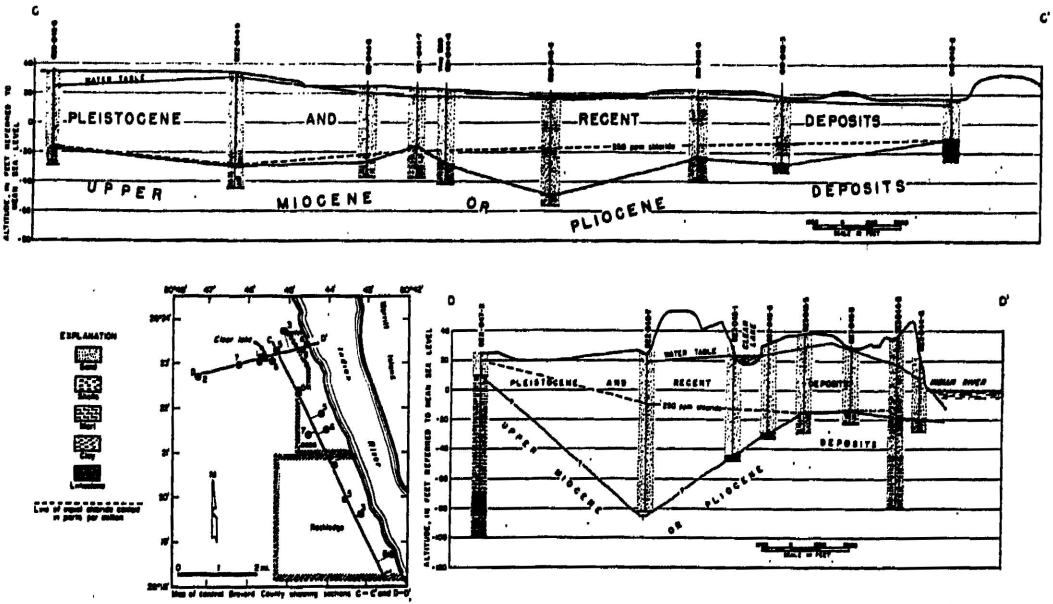

Figure 11. Geologic sections C-C' and D-D'.

been removed in the northern part of the county by post-Eocene erosion and the approximate northern limit of the formation is indicated on the map (fig. 9).

The surface of the limestone formations of Eocene Age in Brevard County generally slopes eastward in the northern and central part of the county and southeastward in the southern part of the county. The gradient of the surface ranges from about 3 to 17 feet per mile and averages about 9 feet per mile in most of the county.

The depth to the limestone formation of Eocene Age below land surface

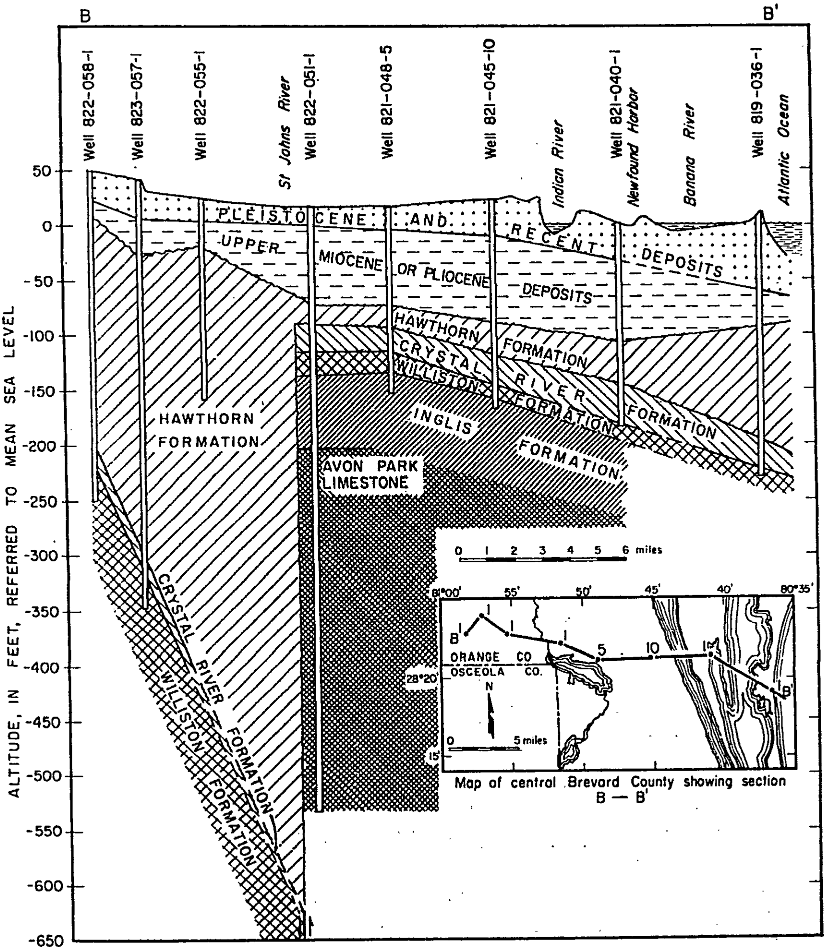

Figure 12. Geologic section B-B'.

may be obtained by adding the altitude of land surface (fig. 3) to the altitude of the surface of the limestone formations (fig. 9).

The configuration of the contours on the surface of the limestone formations in the vicinity of Cape Canaveral shows a ridge-like structure that roughly conforms to the shape of Cape Canaveral. The similarity of this feature to Cape Canaveral suggests that the present Cape Canaveral may have developed as an expression of this buried feature.

The Eocene Formations in the western part of the county have been offset by a north-south trending fault. This fault and related structures have been described by Vernon (1951, p. 57-58) and shown in Indian River County by Bermes (1958, fig. 4). The fault forms the eastern boundary of the Osceola low, which has been described by Vernon (1951, p. 57-58) as a wedge-shaped downthrown block bounded on the northwest and east by normal faults and open on the southwest.

Test wells 823-057-1 and 822-058-1 (fig. 12) show the Crystal River and Williston Formations at appreciably greater depths than would be expected from a western projection of the dip of these formations in the eastern part of the county. These two wells also show a somewhat steeper eastward component of dip of the Crystal River Formation. A third well would be needed to give the true amount and direction of dip. The two wells probably penetrated the Osceola low.

The downthrown block of the Osceola low has created a depression in the surface of the limestone formations of Eocene Age which was later filled with sediments of Miocene Age. The sediments of Miocene Age have a low permeability and probably influence the direction of ground-water movement in the upper part of the artesian aquifer in the local area. The effect of the Osceola low on the chemical quality of water in the Floridan aquifer is discussed in the section entitled "Chemical Quality of Artesian Ground Water."

GEOLOGIC HISTORY

During the Eocene Epoch the Florida Peninsula was inundated repeatedly by the sea. Between periods of inundation the formations were exposed to erosion. Missing sections in the limestone sequence are evidence of these erosional periods.

The oldest of the formations of Eocene Age was laid down in Early Eocene time. The deposition of the limestone was halted at the end of Early Eocene time by emergence, after which the limestone was eroded. The beginning of Middle Eocene time was marked by the return of the sea which inundated Brevard County and deposited the Avon Park Limestone.

The limestones of Middle Eocene Age were deposited on the eroded surface of the formations of Early Eocene Age. The contact between the

Avon Park Limestone and the underlying limestone is reported by Vernon (1951, p. 92) as being unconformable. The deposition of the limestones of Middle Eocene Age was followed by a period of erosion, so that an unconformity separates the Avon Park Limestone and the overlying formations of the Ocala Group. The formations of the Ocala Group were laid down with no apparent break in deposition during Late Eocene time.

The retreat of the seas from Brevard County at the end of the Eocene Epoch exposed the formations to erosion that reduced the thicknesses of these formations. The absence in Brevard County of the formations that were deposited elsewhere during Oligocene and Early Miocene time indicates that either the area remained above sea level during this time or that erosion before Middle Miocene time completely removed all vestiges of these sediments. The absence of deposits of Oligocene and Lower Miocene Age in Brevard County indicates that the area was structurally high in Early Miocene or later time.

The structural movement that resulted in the Ocala uplift, the Osceola low, and related flexures and faults was dated by Vernon (1951, p. 62) as post-Oligocene and pre-Miocene.

In Middle Miocene time the seas again invaded the Florida Peninsula, and the resulting sequence of beds progress by a series of overlaps that pinch out against the Ocala uplift. The gradual thinning of the Hawthorn Formation toward the north in Brevard County and the absence of the formation over the Sanford high (Vernon, 1951, fig. 33), in Volusia County, indicates that either the Sanford high was above sea level during Middle Miocene time or that the Hawthorn Formation was eroded after Middle Miocene time. In Late Miocene or Pliocene time the sea invaded Brevard County but not so extensively as in Middle Miocene time. The sediments deposited in Late Miocene or Pliocene time were not subsequently exposed to prolonged erosion; consequently, their upper surface is regular, and their thickness is generally greater than that of the sediments of Middle Miocene Age.

When the sea stood at higher levels during the interglacial periods of the Pleistocene Epoch the submerged areas were covered with a veneer of marine sands (fig. 4).

The sea has been approximately at its present level since the beginning of Recent time. During Recent time the major part of the windblown sand was deposited.

HYDROLOGY

Water sources utilized by man for water supplies are replenished through the hydrologic cycle—the endless circulation of water by evaporation, transportation through the atmosphere, precipitation, and transportation back to the ocean by surface and underground routes. Water that falls as precipitation and is not immediately evaporated or transpired begins to move toward the ocean above or beneath the ground. Water that remains above the ground may be stored temporarily in lakes, ponds, sloughs, etc., or may flow in streams toward the ocean. Water that filters into the ground and reaches the zone of saturation also begins a slow movement toward the ocean or other points of discharge. The amount of precipitation that runs off into the streams is dependent on the climate, geology, topography, and vegetal cover. Figure 13 is a generalized hydrologic cross section from the south-central

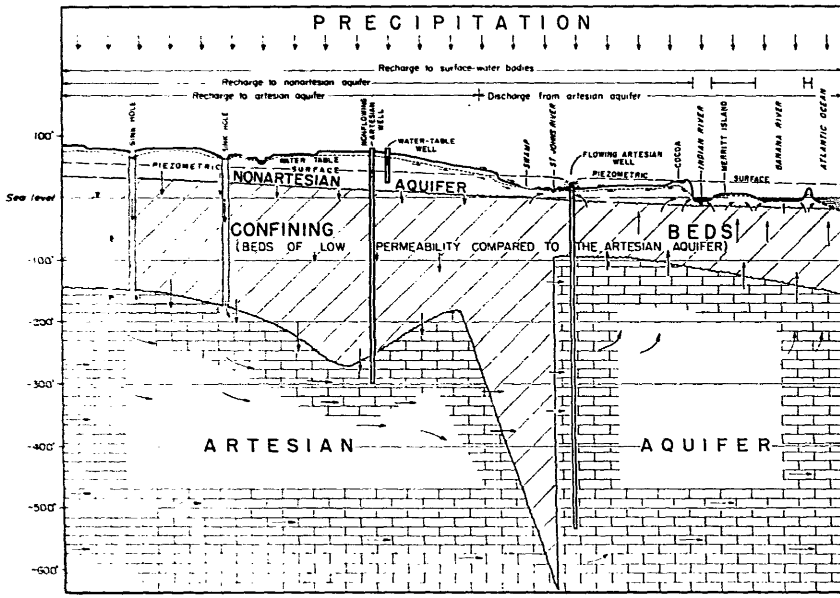

Figure 13. Diagram showing the generalized hydrologic conditions in east-central Florida.

part of Orange County to the Atlantic Ocean. The general direction of water movement is indicated by arrows in this figure.

Variations in annual stream runoff are closely associated with variations in weather, particularly precipitation and temperature. The flows of some streams increase quickly in response to changes in precipitation, whereas those of other streams change more slowly, lagging behind changes in precipitation by many weeks, months, or even years. Temperature is important because it affects the rate of evaporation and transpiration.

The type of soil mantle and underlying rocks has a pronounced influence on the amount of storm runoff in a given drainage basin. In areas of permeable soils, such as the Atlantic Coastal Ridge, rainfall is absorbed quickly and much of it infiltrates to the water table. In areas where the soil has poor absorptive qualities, rainfall tends to remain on the surface until it evaporates or flows off.

Most streams in Florida tend to be sluggish because of the comparatively flat topography. The St. Johns River—the longest river within the state—falls only 27 feet at high stage and 15 feet at low stage over the distance of 275 miles from its headwaters to the ocean.

The amount of water transpired by vegetation or evaporated reduces the total amount of water available for streamflow or ground-water recharge. In areas where the amount of water available is not adequate to meet the demand, the amount of water consumed by vegetation may be large enough to warrant an attempt to salvage a part of it.

Of the part of the rainfall that enters the soil, some is evaporated, some is retained in the soil until used by vegetation, and some seeps downward to the zone of saturation to become ground water. Once water reaches the zone of saturation it begins to move more or less laterally under the influence of gravity toward a place of discharge, such as a spring, a surface stream, or the ocean. Ground water moving toward a point of discharge may be, at a given moment, under either nonartesian conditions or artesian conditions.

Ground water in Brevard County occurs under both unconfined conditions (nonartesian aquifer) and confined conditions (artesian aquifer).

The nonartesian aquifer is composed of Pleistocene and Recent deposits and is exposed at the land surface. Water will enter the aquifer until it is filled, after which the water will either remain on the ground or run off as surface flow. In the sandy coastal ridge area, nearly all the rainfall will enter the soil during or immediately after dry seasons. During the wet seasons the rainfall rate exceeds the infiltration rate and the surplus water drains off. In the low-lying swampy areas very little rainfall enters the soil because the aquifer is nearly full. In the barrier islands area where the soil is very sandy, a large part of the rainfall soaks into the ground. Although part of this water is returned to the atmosphere by evaporation and transpiration, most of it seeps downward to the zone of saturation. Water in the zone of saturation moves laterally toward the ocean or river.

The Floridan aquifer in Brevard County consists of a series of limestone formations several thousand feet thick. The principal recharge area for this aquifer is in central and northern Florida, where the piezometric surface is high (fig. 14). West of the St. Johns River valley and in parts of the Atlantic Coastal Ridge the water table is higher than the piezometric surface and some water seeps down from the nonartesian aquifer into the artesian aquifer (fig. 13). In such areas the amount of water seeping down into the artesian aquifer is probably small, because of the low permeability of the confining beds through which the water must pass and the rather small water-level differential between the water table and piezometric surface.

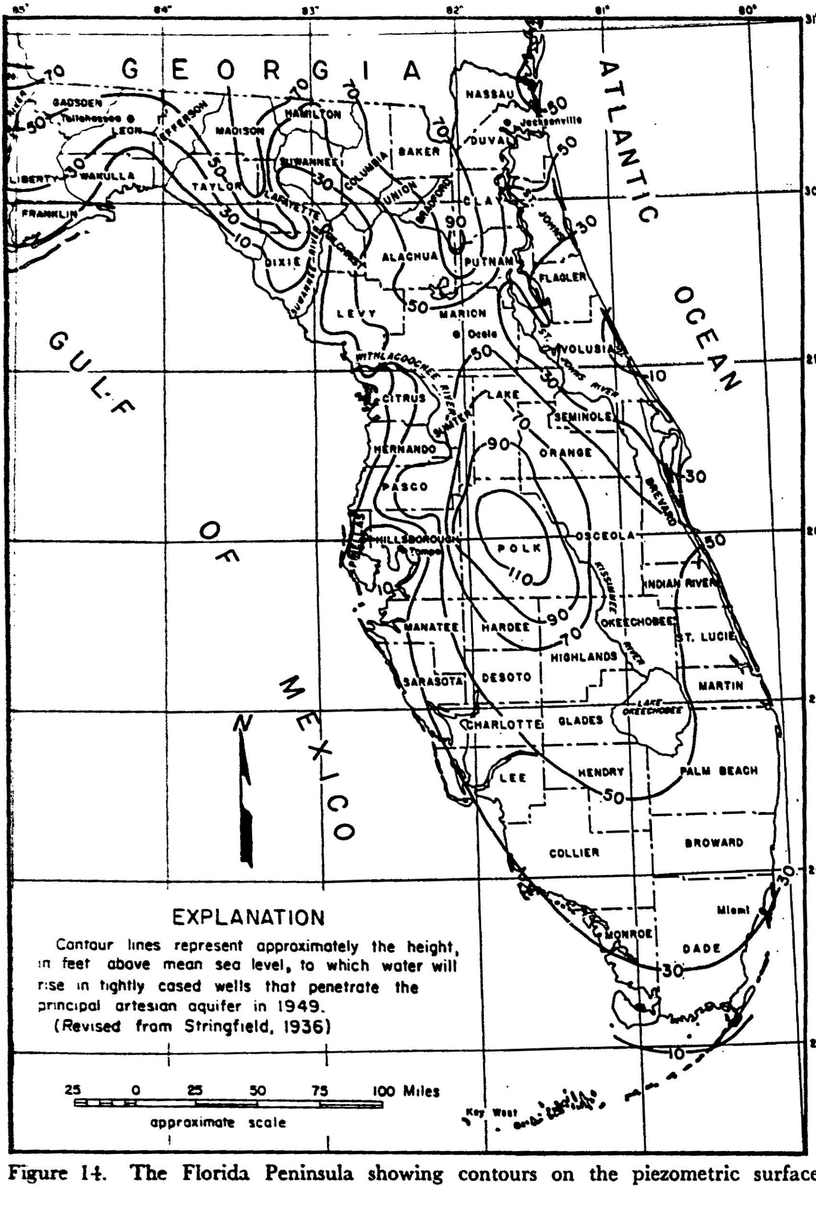

Figure 14. The Florida Peninsula showing contours on the piezometric surface.

The Floridan aquifer acts as a natural conduit through which water moves from areas of high artesian pressure to areas of lower artesian pressure. The artesian pressure of the water may be determined by measuring the height to which water will rise in tightly cased wells that penetrate the aquifer. The height is shown by means of contours that connect points of equal artesian pressure. In the center of the peninsula water stands at 110 feet above sea level, higher than any other place in the state. Ground water flows downgradient and perpendicular to contours.

The movement of water, both above and below ground, is extremely complex in Brevard County. It is important to understand the natural conditions that govern the occurrence of water when planning to make optimum use of local source of water.

CHEMICAL QUALITY OF NATURAL WATERS

Various materials, dissolved or otherwise picked up and retained by water, characterize the quality of water. Minerals from rocks, organic residues of plant, animal, and industrial wastes, and biological organisms contribute in varying degrees to the ultimate composition of water. Excessive amounts of any constituents decrease the value of water for municipal, agricultural or industrial purposes.

Water in nature is seldom found devoid of extraneous substances. Even as rain or atmospheric vapor, where purity is approached, minute particles of dust and molecules of gaseous elements are absorbed. Upon contact with the earth's crust following precipitation, additional materials are taken up to further change the characteristics of the water. The degree of change is dependent on many factors. Of these, geology, topography, water use, and the chemical composition of the water itself exert considerable influence. Carbon dioxide, absorbed by the water in the atmosphere and dissolved from decayed vegetal matter on the earth's surface, forms carbonic acid, which aids in the solution of minerals. Difference in composition and solubility of the rocks causes variations in the amount of minerals dissolved by the water. Where rocks are easily dissolved, water in contact with them becomes highly mineralized in a short time. This is particularly true in areas where limestones are predominant in the aquifer. Where granite, gneiss, or other hard rock comprises the geologic environment, solution activity proceeds at a much slower rate and usually has a low mineral content.

Topography is a factor that influences the rate of water movement. Where water movement is rapid the concentration of dissolved solids will be less than water in contact with similar materials under conditions of slower water movement. The contact time with soluble materials governs in part the mineralization of the water.

Man, in using water, causes additional changes in the quality of the water. Streams are used, often indiscriminately, for disposal of industrial and municipal wastes and agricultural drainage. Waste water introduced into underground formations may change the quality of the water as a result of direct contamination or by providing conditions by which chemical processes are stimulated.

Water movement in the ground is relatively slow. As a result, concentration of minerals in ground water is more uniform but often higher than in surface water in the same area. The concentration usually increases with depth or distance from the point where the water first enters the ground. Artesian water, for instance, is often highly mineralized at the point of discharge because of the time it has been in contact with minerals during its period of underground flow.

Surface water moves at a faster rate than ground water and is exposed to a larger number of influences that alter its quality. Usually the water responds quickly to these influences. For instance, water in the soils is often highly mineralized as a result of evaporation, transpiration, solution of the soils, and organic acids. When the mineralized water is flushed from the soils by rain and enters the streams, the concentration of chemicals in the streams may be greatly increased. The frequency and amount of rainfall, the types of soil, and the volume of the stream determine the magnitude of these increases in concentration. Once the water has been flushed out and the readily soluble materials leached from the soil, subsequent rains only serve to lower the concentration of the minerals in the stream.

A stream may receive considerable amounts of ground water. This water usually is more mineralized than surface water and increases the mineral content of the stream in proportion to the amount added and the volume of the stream. During periods of low streamflow ground-water inflow increases and the concentration of dissolved solids of the stream may become very high.

Losses of water by evaporation and transpiration cause some increase in the chemical concentration of a stream. When high losses are concurrent with low flow, the increases may be appreciable.

Each tributary of a river system influences, to some extent, the chemical characteristics of the major stream. Whether these added sources of water will cause dilution, increased concentrations, or change the chemical characteristic of the water in the major stream will depend on the amount or type of material contained in the tributary, the proportionate volume that it provides, and the chemical reaction that occurs when the two sources are combined.

Thus, it may be seen that water from any source, whether from a stream or underground formation, possesses an individual quality as a result of various influences by climate, geology, and other factors.

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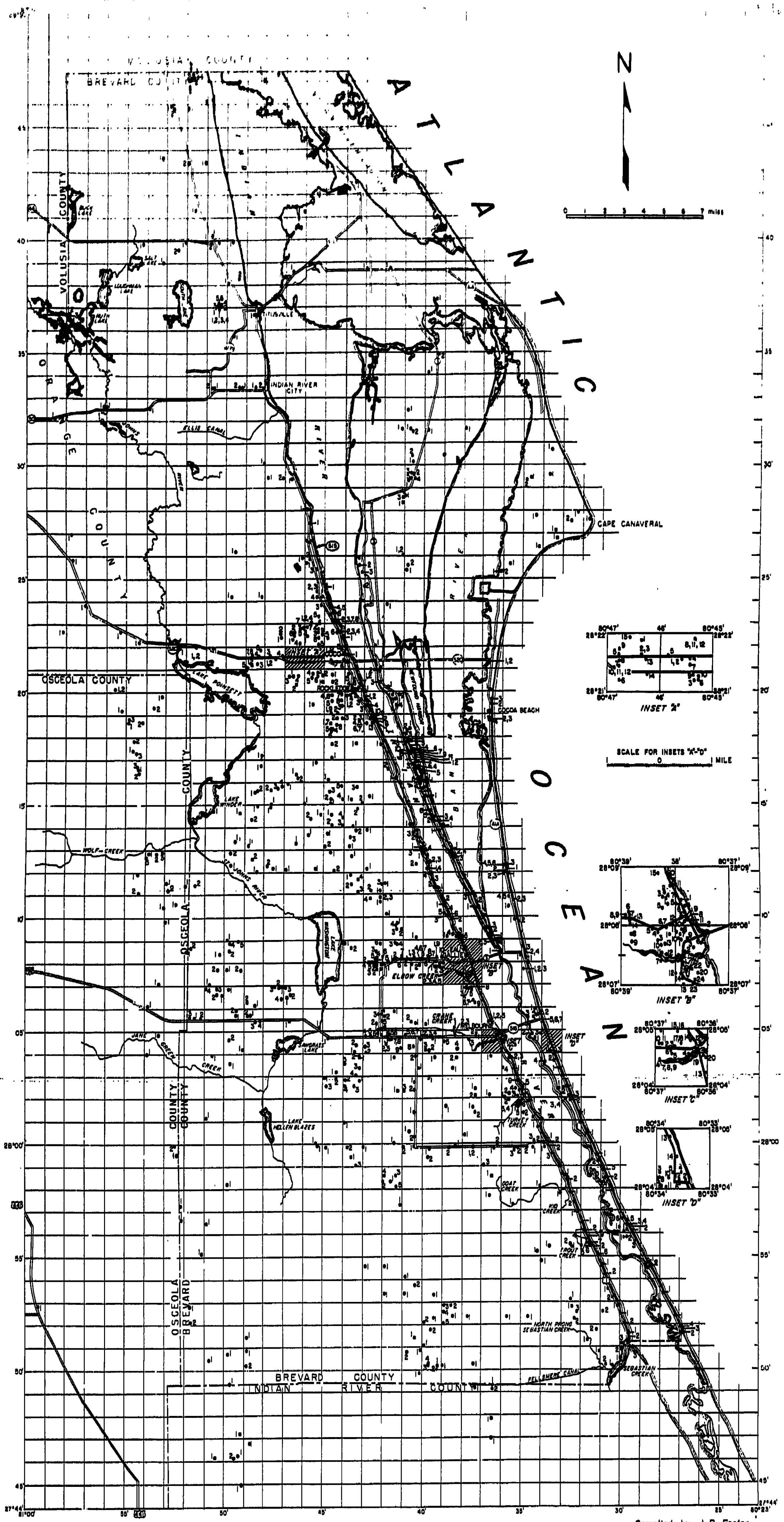

Base compiled from U. S. Geological Survey topographic quadrangles

Compiled by J. B. Foster in 1958

Figure 31. Brevard County showing the location of wells.

WATER-QUALITY CRITERIA

The value of water for a particular use depends on the types and amounts of materials it contains. Of the materials, those contributing to the chemical quality pose the greatest problems of water treatment. Pathogenic organisms and suspended particles are readily removed by treatment, but certain chemical constituents are difficult to remove and may require treatment that is so costly as to prohibit the utilization of the supply.

Minute quantities of some chemical ions influence considerably the value of water. In order that these quantities may be expressed in a usable manner, concentrations are reported in parts per million. Thus, the concentration of any determined constituent is reported on the basis of comparative weight with the water in which it is dissolved. A solution containing 1 ppm (parts per million) of calcium, for instance, would contain 1 pound of calcium dissolved in a sufficient quantity of water (approximately 120,000 gallons) to make a total weight of 1 million pounds. To illustrate unwieldiness of using percentage values this same concentration of calcium would be reported as 0.0001 percent. Table 3 shows the more common characteristics of water quality and their effects.

TABLE 3. Water-Quality Characteristics and Their Effects

Constituent	Effects
Dissolved solids	A measure of the total amount of dissolved matter, usually determined by evaporation. Excessive solids interfere in most processes and cause foaming in boilers.
Silica	Causes scale in boilers and deposits on turbine blades.
Sulfate	Excessive amounts are cathartic and unpleasant to taste. May cause scale.
Nitrate	High concentrations indicate pollution. Causes methemoglobinemia in infants. Helps to prevent intercrystalline cracking of boiler steel.
Fluoride	Excessive concentrations cause mottled tooth enamel, small amounts prevent tooth decay.
pH	Values below 7.0 indicate an acid water and a tendency for the water to be corrosive toward metal.
Iron and Manganese	On precipitation cause stains; unpleasant taste in drinking water; scale deposits in water lines and boilers; interferes in many processes such as dyeing and paper manufacture.
Calcium and Magnesium	The cause of hardness in water.
Chloride	Unpleasant taste in high concentrations. Increases corrosive nature of water.
Sodium	Large amounts injurious to humans with certain illnesses and to soils and crops.
Hardness	Due to calcium and magnesium salts causes excessive soap consumption, scale in heat exchangers, boilers, radiators, pipes, and interferes in dyeing, textiles, food, paper, and other manufacturing processes.
Alkalinity	Causes foaming in boilers and carryover of solids with steam, embrittlement of boiler steel.
Color	Stains products in process use. May cause foaming in boilers. Unsightly in drinking water.
Suspended solids	Unsightly appearance in water. Causes deposits in water lines, process equipment, and boilers.

To facilitate comparisons of different water in geochemical studies, parts per million may be converted to a form that shows the chemical equivalent weights of the ions or radicals in the water, e.g., equivalents per million. Parts per million may be converted to equivalents per million by multiplying the parts per million of the particular ion or radical by the reciprocal of the equivalent weight of the ion, as shown by the equation below:

$$\text{Equivalents per million} = \text{Parts per million} \times \frac{1}{\text{Equivalent weight of the ion or radical}}$$

For convenience in making this conversion the reciprocals of chemical equivalent weights (1 divided by the equivalent weight) of the most commonly reported constituents (ions) are given in the following table:

Constituent	Factor	Constituent	Factor
Iron (Fe^{++})	0.0358	Carbonate (CO_3^{--})	0.0333
Iron (Fe^{+++})	.0537	Bicarbonate (HCO_3^-)	.0164
Calcium (Ca^{++})	.0499	Sulfate (SO_4^{--})	.0208
Magnesium (Mg^{++})	.0822	Chloride (Cl^-)	.0282
Sodium (Na^+)	.0435	Fluoride (F^-)	.0526
Potassium (K^+)	.0256	Nitrate (NO_3^-)	.0161

The average person appraises water on the basis of the physical characteristics. If the water he uses is clear, odorless, colorless, and of pleasant taste. he is unconcerned about the various mineral constituents of the water. Not until the effects of these constituents become apparent does he become concerned. Iron and manganese, for instance, will stain plumbing fixtures, sidewalks, and house footings when present in concentrations of several parts per million. Excessive amounts of calcium and magnesium, the predominant ions causing hardness, require large amounts of soap in washing, and cause a reduced efficiency of hot-water heaters as a result of scale deposits. Conversely, when concentrations of these ions are low, the water may be so corrosive as to dissolve iron from pipes and containers.

Compounds of sulphur in water are objectionable. Hydrogen sulfide, a gas, has a disagreeable odor similar to rotten eggs and may tarnish metal surfaces. Sulfates produce a bitter taste and laxative effects when present in excessive amounts.

Chloride is one of the predominant ions found in many natural waters. As such, it is used often as an indication of the potability of a water because when present in moderate concentrations the water tastes salty.

Nitrate is a final oxidation product of animal and vegetable matter and when found in appreciable quantities in a water, is indicative of contamination. Methemoglobinemia or cyanosis in infants has been attributed to the ingestion of water containing nitrate of about 45 ppm or more.

The drinking of water containing fluoride by children during the period when their permanent teeth are being formed reduces the incidence of dental caries (Dean, 1936). Research has indicated that a fluoride concentration of about 1.0 ppm is optimum for the purpose, with mottling of the enamel occurring when water containing more than 1.5 ppm is used. While fluoride is a natural element found in various concentrations in the waters of Florida, it is often added at water treatment plants to bring the concentration to the optimum level.

Certain chemical ingredients in water cause undesirable effects when present in high concentrations. A water containing these substances may be satisfactorily used, however, provided the concentrations of the salts do not exceed certain limits. The U.S. Public Health Service has proposed certain standards for water supplies used on interstate carriers, which generally have been accepted for public water supplies. To be acceptable by these standards, the water shall not have objectionable turbidity, color, taste, or odor and must be essentially free of toxic salts. The maximum concentrations of the more common chemical substances taken from standards prescribed by the U.S. Public Health Service (1946) are as follows:

Constituent	Maximum concentration (parts per million)
Iron (Fe) and Manganese (Mn) together	0.3
Fluoride (F)	1.5
Magnesium (Mg)	125
Chloride (Cl)	250
Sulfate (SO_4)	250
Dissolved solids	500 (1,000 permitted when water of better quality is not available)

The requirements of industry are variable as to both quantity and chemical quality of water. The amount and type of water needed will depend on the size and type of industry and the manner in which the water is used. Where water is intended for washing or cooling, great quantities may be used with little concern as to the chemical quality of the water as long as there is little tendency on the part of the water to corrode pipes or form deposits. On the other hand, if the water is used in preparing a food or beverage and the water is incorporated in the product, it must, in addition to meeting prescribed health standards, be of such composition that it will not alter the flavor or otherwise diminish the value of the finished product. The limits imposed by some industries on the chemical constituents of a water supply are so critical that often times treatment is required in addition to that performed by municipal or other water-supply agencies.

Since the requirements of industry are so variable, standards of quantity and quality of water can be established as only general guides for determining the suitability of a supply for industrial purposes. Tables 4 and 5 illustrate the approximate quantity and quality of water needed by several specific industries.

TABLE 4. Industrial Requirements for Water[1]

Product	Unit	Water required, gal. to produce or process one unit
Alcohol	Gallon	100
Aluminum	Pound	160
Brewing (beer)	1 barrel	470
Butadiene	Pound	160
Canning	100 cases No. 2 cans	2,500 - 25,000
Cement	Ton	750
Coke	Ton	3,600
Distilling:		
Grain	1,000 bu. grain mashed	600,000
Molasses	1,000 gal., 100-proof	8,400
Cooling water	1,000 gal., 100-proof	120,000
Electric power	Kilowatt	80
Gasoline	Gallon	7 - 10
Iron ore (brown ore)	Ton	1,000
Meat, slaughterhouse and packing	100 hogs killed	550
Milk	1,000 raw pounds	100 - 300
Oil refining	Barrel	770
Paper	Ton	5,000 - 85,000
Rail freight	Ton/mile	0.1
Soap	Ton	500
Steam power	Ton of coal	60,000 - 120,000
Tanning	100 lbs. rawhide	800
Textiles	1,000 lbs. processed	1,000 - 20,000
Rayon	1,000 lbs. produced	135,000 - 160,000
Woolens	1,000 lbs. finished	70,000

[1]Data reported in Journal of American Water Works Association, vol. 38, no. 1, January 1946.

There are no steadfast rules by which water may be evaluated for agricultural uses. The chemical reactions that may result in the combination of soils, plants, and water are so complex that very few guidelines are available in predicting the applicability of any specific type of water to a single area or crop. Climate, soil characteristics, chemical quality of the water, and salt tolerance of the crops are a few of the factors that must be considered in such evaluations.

In general, where highly mineralized water is used for irrigation, crop losses may occur because of a buildup of salts in the soil. In sandy or other highly porous soils, irrigation waters percolate rapidly through the root zone leaving behind only minor amounts of salts. Continued application of water helps to flush these salts from the soils. If the soils are less permeable or react chemically with the irrigation water, the soil solutions may become extremely high in mineral content and deprive the plants or crops of moisture needed for continued growth. Often the salt content of an irrigation water supply may be well below the tolerance limits of the particular crop but, because of increased concentration caused by water losses through evaporation and transpiration or because of improper flushing, the concentration eventually exceeds the tolerance limits and injures the crop. Because the studies needed to determine these individual relationships are

TABLE 5. Suggested Water-Quality Tolerances‡
(Allowable limits in parts per million)

Industry or use	Turbidity	Color	Hardness as $CaCO_3$	Iron as Fe	Manganese as Mn	Total solids	Alkalinity as $CaCO_3$	Odor, Taste	Hydrogen sulfide	Other requirements†
Air conditioning	...	...	...	*0.5	0.5	...	...	low	1	No corrosiveness, slime formation.
Baking	10	10	...	* .2	.2	...	...	low	.2	P.
Brewing:										
Light beer	10	...	...	* .1	.1	500	75	low	.2	P. NaCl less than 275 ppm (pH 6.5-7.0).
Dark Beer	10	...	...	* .1	.1	1,000	150	low	.2	P. NaCl less than 275 ppm (pH 7.0 or more).
Canning:										
Legumes	10	...	25-75	* .2	.2	...	...	low	1	P.
General	10	...	...	* .2	.2	...	...	low	1	P.
Carbonated beverages	2	10	250	.2 * .3	.2	850	50-100	low	.2	P. Organic color plus oxygen consumed less than 10 ppm.
Confectionery	...	...	...	* .2	.2	100	...	low	.2	P. pH above 7.0 for hard candy.
Cooling	50	...	50	* .5	.5	...	...	...	5	No corrosiveness, slime formation.
Food: General	10	...	...	* .2	.2	...	...	low	...	P.
Ice	5	5	...	* .2	.2	...	...	low	...	P. SiO_2 less than 10 ppm.
Laundering	...	...	50	* .2	.2	...	...	...	...	
Plastics, clear, uncolored	2	2	...	* .02	.02	200	...	...	...	
Paper and pulp:										
Groundwood	50	20	180	*1.0	.5	...	...	...	...	No grit, corrosiveness.
Kraft pulp	25	15	100	* .2	.1	300	...	...	...	
Soda and sulfite	15	10	100	* .1	.05	200	...	...	...	
High-grade light papers	5	5	50	* .1	.05	200	...	...	...	
Rayon (viscose):										
Pulp production	5	5	8	* .05	.03	100	total 50; hydroxide 8	...	...	Al_2O_3 less than 8 ppm, SiO_2 less than 25 ppm, Cu less than 5 ppm.
Manufacture	.3	...	55	.0	.0	...	...	...	...	pH 7.8 to 8.3.
Tanning	20	10-100	50-135	* .2	.2	...	total 135; hydroxide 8	...	...	
Textiles: General	5	20	...	.25	.25	...	...	...	...	
Dyeing	5	5-20	...	* .25	.25	200	...	...	...	Constant composition. Residual alumina less than 0.5 ppm.
Wool scouring	...	70	...	*1.0	1.0	...	...	...	...	
Cotton bandage	5	5	...	* .2	.2	...	...	low	...	

‡ Moore, E. W., Progress report of the committee on quality tolerances of water for industrial uses: Jour. New England Water Works Assoc., vol. 54, p. 271, 1940.
† P indicates that potable water, conforming to U.S.P.H.S. standards, is necessary.
* Limit given applies to both iron alone and the sum of iron and manganese.

beyond the scope of this investigation, no effort has been made to classify types of water in Brevard County for irrigation.

SURFACE WATER

SCOPE OF STREAMFLOW RECORDS

Stream gaging by the U.S. Geological Survey was begun in Brevard County in 1933 with the establishment of a gaging station on the St. Johns River at State Highway 50 west of Indian River City. In 1939 another gaging station was installed on the St. Johns at the U.S. Highway 192 crossing west of Melbourne. In 1940 stage gages were installed on the Indian River at Melbourne and at Wabasso in Indian River County. The coverage was gradually increased to 15 gaging stations in 1953. During 1954, the number of stations was increased to 24 to provide the coverage required for a reasonably comprehensive study of the water resources. The duration of records at these stations is shown by graphs on figure 15, and the locations of surface-water gaging stations that have been operated in the area are shown on figure 16. The type of record collected at these stations in the Brevard County area is presented in table 6. In addition to the stage and flow data, reconnaissance-type information was collected to delineate drainage areas and determine flow patterns. The monthly and yearly mean discharge at gaging stations on the following streams for the period of record are presented in tabular form in Florida Geological Survey Information Circular no. 32: Crane Creek, Elbow Creek, Fellsmere Canal, Jane Green Creek, St. Johns River near Christmas and Melbourne, Turkey Creek, and Wolf Creek. The results of discharge measurements of small streams tributary to the Indian River are also presented in Information Circular no. 32.

STREAM AND LAKE CHARACTERISTICS

ST. JOHNS RIVER BASIN

The St. Johns River, in Brevard County, flows northward through a wide shallow valley. Because the valley has nearly flat side slopes near its edges there are few well defined streams and practically all of the surface flow is overland. Near the middle of the basin the stream forms a definite channel and there are several well defined tributaries.

The important tributaries of the St. Johns that drain the western slope are Jane Green Creek, Pennywash Creek, Wolf Creek, Taylor Creek, and Jim Creek. There are no sizeable tributaries draining the eastern slopes.

The St. Johns River basin contains numerous lakes, of which several have a large storage capacity. The large storage capacity of these lakes could be of great value in the utilization of the water resources of the area.

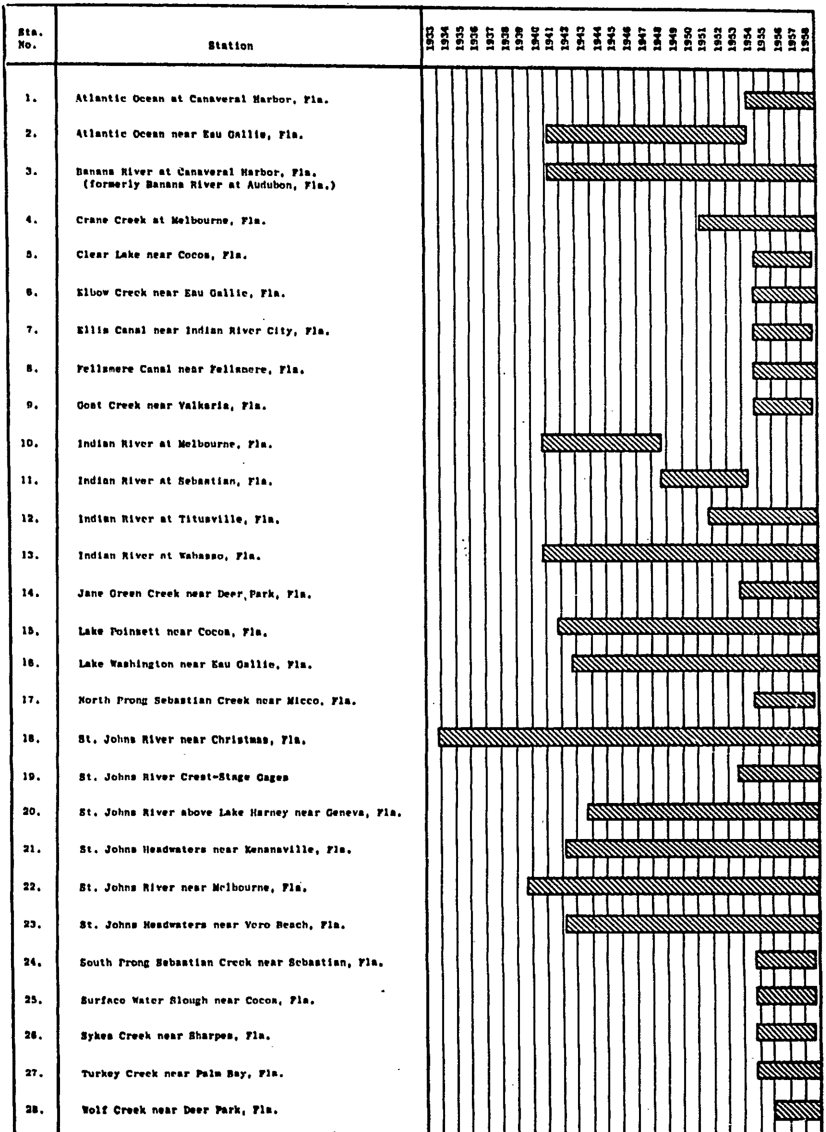

Figure 15. Duration of records at surface-water gaging stations.

TABLE 6. Location and Type of Record at Surface-Water Gaging Stations in the Brevard County Area

Station Name	Location	Type of Data	Established	Discontinued
Atlantic Ocean at Canaveral Harbor, Florida	at U.S.A.F. Crash Boat Headquarters in harbor entrance.......	Stage..............	June 24, 1954	
Atlantic Ocean near Eau Gallie, Florida.....	at Canova's pier, Canova Beach........	Stage..............	Feb. 18, 1941	June 24, 1954
Banana River at Canaveral Harbor, Florida. (Formerly Banana River at Audubon, Florida.)	on the east bank of Banana River ¼ mile north of harbor......	Stage..............	Feb. 17, 1941	
Crane Creek at Melbourne, Florida.........	at U. S. 192 crossing at Melbourne Country Club and 2¼ miles upstream from the Indian River......................	Stage and Discharge	Mar. 14, 1951	
Clear Lake near Cocoa, Florida............	2¾ miles northwest of Cocoa................................	Stage..............	Nov. 9, 1954	Sept. 12, 1958
Elbow Creek near Eau Gallie, Florida......	at north-south graded road crossing 1½ miles west of Eau Gallie and 2 miles upstream from the Indian River...............	Stage and Discharge	Sept. 28, 1954	
Ellis Canal near Indian River City, Florida..	at dirt road crossing 1½ miles south of Indian River City and 1 mile upstream from the Indian River....................	Stage and Discharge	Sept. 27, 1954	Oct. 29, 1958
Fellsmere Canal near Fellsmere, Florida.....	at State Highway 507 crossing 3.3 miles north of Fellsmere and 5½ miles upstream from the North Prong of Sebastian Creek.	Stage and Discharge	Oct. 1, 1954	
Goat Creek near Valkaria, Florida.........	at dirt road crossing 1½ miles west of Valkaria...............	Stage and Discharge	Oct. 1, 1954	Oct. 28, 1958
Indian River at Melbourne, Florida........	at U. S. Highway A1A crossing at Melbourne, Florida.........	Stage..............	Dec. 5, 1940	July 23, 1948
Indian River at Sebastian, Florida.........	on private dock 0.7 mile north of intersection of U.S. Highway 1 and Main Street in Sebastian...........................	Stage..............	July 29, 1948	July 8, 1954
Indian River at Titusville, Florida.........	at State Highway 402 crossing and 1 mile northeast of Titusville	Stage..............	Sept. 11, 1951	
Indian River at Wabasso, Florida..........	at crossing at Wabasso....................................	Stage..............	Nov. 5, 1940	
Jane Green Creek near Deer Park, Florida..	at graded road crossing 1½ miles southeast of Deer Park......	Stage and Discharge	Oct. 22, 1953	
Lake Poinsett near Cocoa, Florida.........	5½ miles west of Cocoa at Poinsett Lodge...................	Stage..............	Nov. 25, 1941	

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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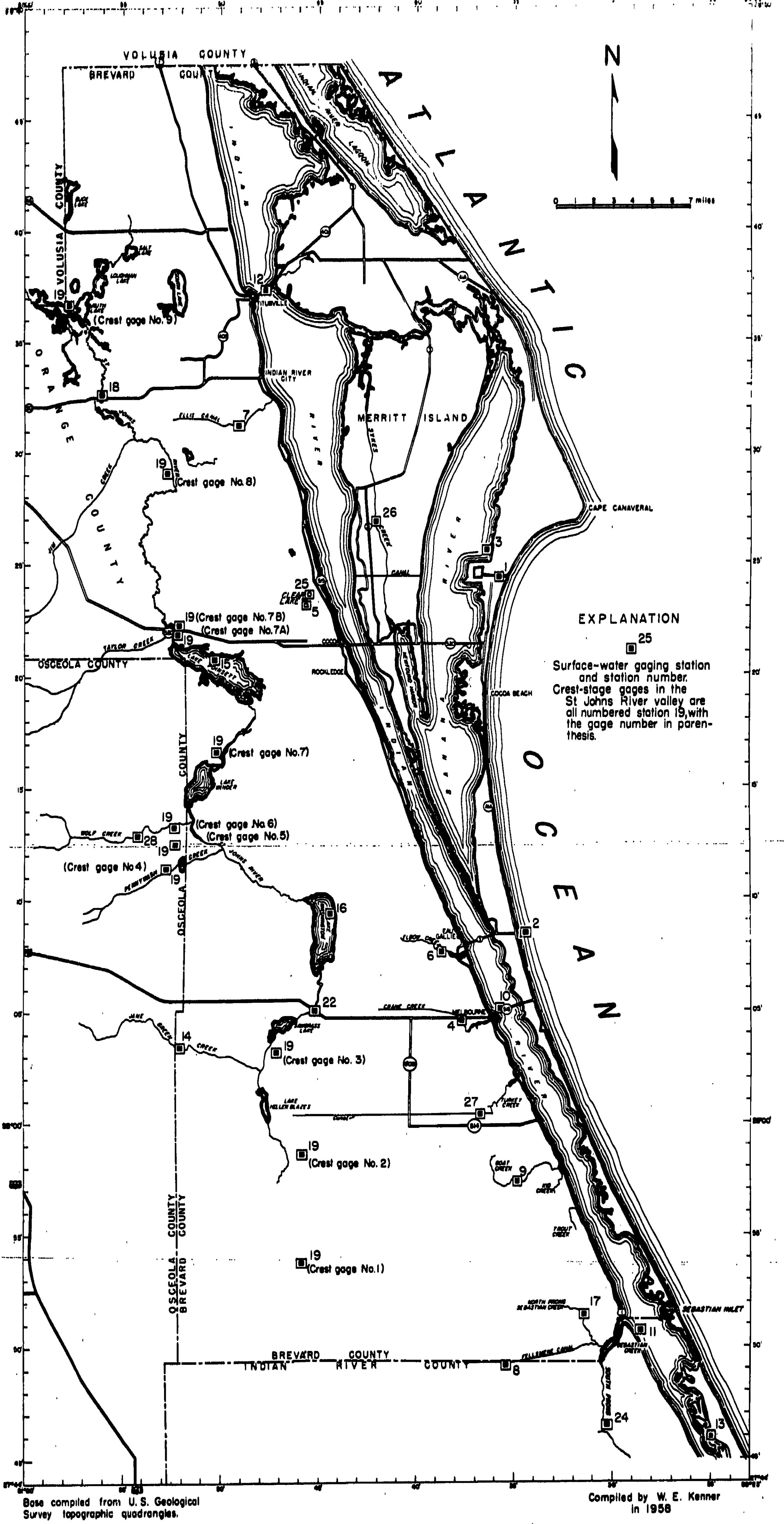

Base compiled from U.S. Geological Survey topographic quadrangles.

Compiled by W. E. Kenner in 1958

Figure 16. Brevard County showing the location of stream-gaging stations.

TABLE 6. (Continued)

Station Name	Location	Type of Data	Established	Discontinued
Lake Washington near Eau Gallie, Florida..	6½ miles west of Eau Gallie at Lake Washington Resort.......	Stage..............	July 24, 1942	
North Prong Sebastian Creek near Micco, Florida..............................	at dirt road crossing 2.2 miles southwest of Micco.............	Stage and Discharge	Oct. 1, 1954	Oct. 28, 1958
St. Johns River near Christmas, Florida....	at State Highway 50 crossing, 4 miles east of Christmas.......	Stage and Discharge	Dec. 14, 1933	
St. Johns River Crest-stage Gages..........	11 crest-stage gages distributed along the St. Johns River opposite Brevard County................................	Maximum Stage.....	Sept. 14, 1958	
St. Johns River above Lake Harney near Geneva, Florida.........................	at bridge at State Highway 46 crossing.......................	Stage and Discharge	Sept. 4, 1943	
St. Johns Headwaters near Kenansville, Florida..............................	on old county road 11½ miles east of Kenansville.............	Stage..............	Feb. 21, 1942	
St. Johns Headwaters near Vero Beach, Florida..............................	at bridge on State Highway 60, 16¾ miles west of Vero Beach..	Stage..............	Feb. 27, 1942	
St. Johns River near Melbourne, Florida....	at U. S. Highway 192 crossing, 9.2 miles west of Melbourne....	Stage and Discharge	Nov. 8, 1939	
South Prong Sebastian Creek near Sebastian, Florida..............................	at State Highway 512 crossing, 4 miles southwest of Sebastian..	Stage and Discharge	Oct. 1, 1954	Oct. 28, 1958
Surface Water Slough near Cocoa, Florida..	at culvert on graded road, 1.6 miles north of the Cocoa Water Plant...	Stage..............	Dec. 14, 1954	Oct. 31, 1958
Sykes Creek near Sharpes, Florida.........	on Merritt Island, at dirt road crossing of canalized portion of creek 1.1 miles southeast of Courtenay....................	Stage and Flow Estimates........	Dec. 13, 1954	Oct. 31, 1958
Turkey Creek near Palm Bay, Florida......	500 feet west of power line crossing, 2.2 miles southwest of Palm Bay and 2.6 miles upstream from the Indian River..........	Stage and Discharge	Oct. 2, 1954	
Wolf Creek near Deer Park, Florida........	at graded road crossing 8.5 miles north of Deer Park..........	Stage and Discharge	Jan. 10, 1956	

At the present time, flooding is a serious water problem in the St. Johns valley portion of Brevard County. In the early years when the area was used primarily for the seasonal pasturing of cattle, flooding did not constitute a serious problem. However, as the agricultural potentialities of the rich mucklands along the river became known, dikes were constructed to obtain the uninterrupted use of this land. At times high water has caused considerable damage to the dikes and resulted in the loss of livestock, truck crops, and improved pastures.

Flow and stage: Jane Green Creek drains an area of 248 square miles west and southwest of Deer Park. Its average flow from October 1953 to September 1957 was 370 cfs (cubic feet per second). However, there is considerable variation in the flow. The maximum flow recorded during this period was during the storm of October 1956 at which time the creek flowed at a rate of 18,400 cfs. In both 1955 and 1956 there were long periods when this creek ceased to flow. The longest period of no flow, which began in March 1956, lasted 116 days.

Wolf Creek, located about 12 miles north of Jane Green Creek, has more variation in its flow than does Jane Green Creek. Wolf Creek drains an area of only 26.3 square miles and had a peak discharge during the October 1956 storm of 7,700 cfs. Its average flow from January 1956, when the record began, to September 1957 was 36.0 cfs. It ceased to flow during the dry weather in the spring of 1956. Flow occurred on only 8 of the 99 days from March 15 to June 21 of that year.

Although the St. Johns River has no well defined channel south of Lake Hellen Blazes, the valley extends some 40 miles southward. In this section of the valley the water moves slowly northward through a wide, flat expanse of sawgrass and willows. Manmade canals aid the northward flow in some places. From Lake Hellen Blazes northward the river flows through fairly well defined channels at low and medium stages. At high stages the water spreads out and covers a strip of valley bottom 5 or 6 miles wide.

The St. Johns River flows through several lakes in the section bordering Brevard County. From south to north, the larger of these are: Lake Hellen Blazes, Sawgrass Lake, Lake Washington, Lake Winder, and Lake Poinsett. The estimated amount of water in the lakes at the lowest stage during the period of record is as follows: Lake Hellen Blazes, 650 million gallons; Sawgrass Lake, 650 million gallons; Lake Washington, 3,200 million gallons; Lake Winder, 1,080 million gallons; and Lake Poinsett, 1,660 million gallons. The percent of time during the period of record that Lake Poinsett contained various amounts of water is shown by a storage-duration curve (fig. 17). This curve indicates that all of the time there was a minimum of 1.6 billion gallons of water in the lake, that 50 percent of the time the lake contained at least 9.5 billion gallons of water.

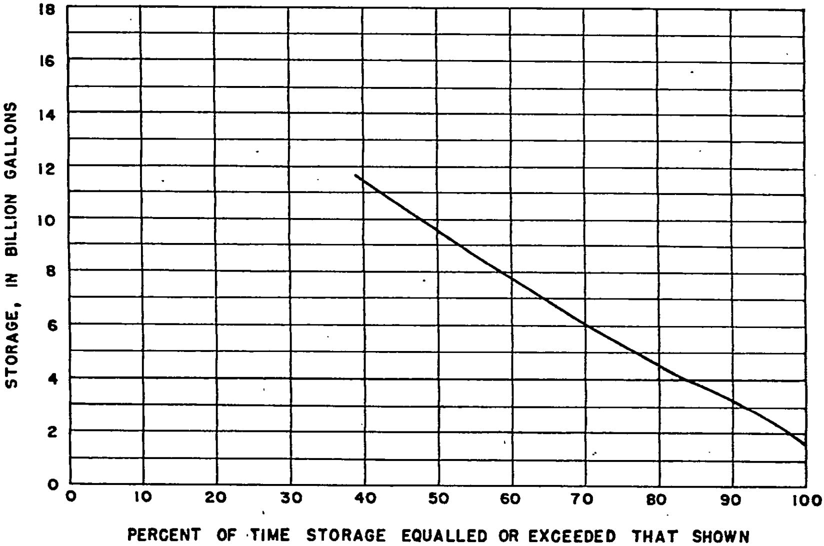

Figure 17. Storage-duration curve for Lake Poinsett, Florida, 1941-55.

Some flooding takes place nearly every year in the St. Johns River basin, but extremely high water occurred in 1948, 1953, and again in 1956. The peak stages during the floods of October 1953 and October 1956 plotted on figure 18 show the effect of rainfall distribution on flooding on this

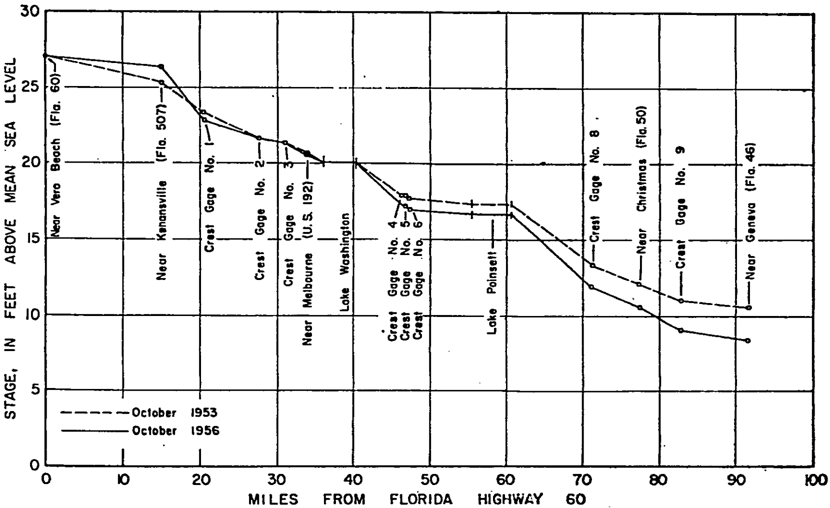

Figure 18. Profile of maximum stages on the St. Johns River, Florida, during floods of October 1953 and October 1956.

stream. In the 1953 storm the rainfall was widespread and of relatively low intensity. The result was fairly uniform flooding throughout the upper 100 miles of the basin. In contrast, in the 1956 storm the rainfall was short-lived but intense in the upper reaches and light to moderate in the lower reaches and produced extreme stages in the Kenansville area but practically no flooding in the lower sections.

The frequencies of floods of various magnitudes likely to occur on the St. Johns River are shown by profiles in figure 19. These profiles are based,

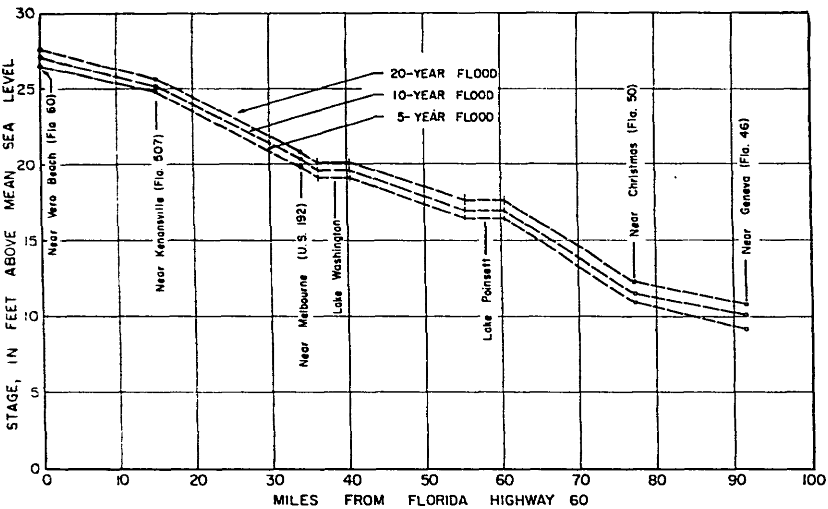

Figure 19. Flood-stage frequencies on the St. Johns River, Florida.

of course, on past records and apply only so long as the flow pattern is not altered by ditching, diking, or other control measures. A proposed dam, for example, to control the stage of Lake Washington would alter the profiles appreciably.

Damage to crops because of flooding is a function of the length of time that the root systems of the plants are under water. For this reason it is of value to know the probable length of time that a plot may be subject to inundation. Figure 20 shows inundation times in the vicinity of Lake Poinsett. This graph shows that, under the worst conditions that occurred between 1941 and 1955, the land would have been under water for 5 consecutive days if it was at an elevation of 17½ feet above sea level, for 14 consecutive days if it was 17 feet above sea level, and for almost 2 months if it was 16 feet above sea level.

The nearly flat prairie and flatwoods area which runs the length of the county between the flood plain of the St. Johns River and the coastal ridge

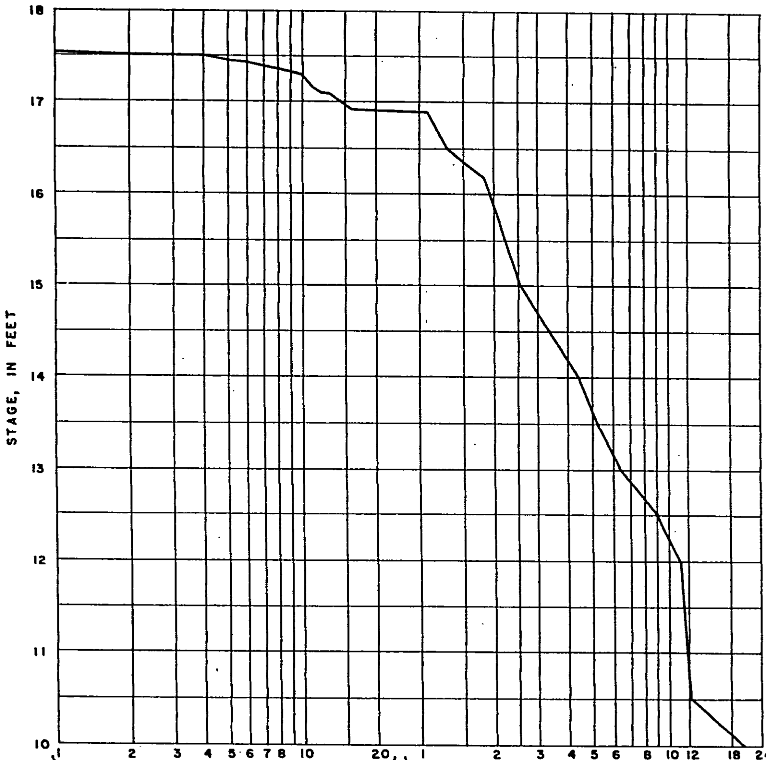

Figure 20. Maximum periods of high stages of Lake Poinsett near Cocoa, Florida, 1941-55.

is sparsely populated and is principally a cattle raising and citrus producing area. The recurring problem in this area is alternately too much water or too little water. These lands are frequently flooded, not because of high stages on the St. Johns River, but because water from rain drains away very slowly in such flat terrains. In order to remove excess water more quickly extensive ditching has been done. As an economic necessity the smaller landowners usually construct relatively small uncontrolled ditches to drain the water to the St. Johns River. However, many of the ditches are inefficient because only low gradients can be obtained. In dry seasons the lands are irrigated by using artesian wells. This water is high in chloride content and is usually applied indiscriminately, often from free-flowing wells. Any excess runs off via the ditches and considerable salt-water contamination of surface streams and lakes is caused by this practice. The chloride content of artesian water is discussed in the section entitled "Chemical Quality of Artesian Ground Water."

Efforts to control the water and thus allow more productive use of land on the eastern slope of the St. Johns River valley have resulted in the formation of several drainage districts within the county. These drainage districts are political and physical entities. They are created by Acts of the State Legislature, and are empowered to issue bonds, to collect taxes on lands within their designated boundaries, and to construct water-control facilities. In the Melbourne-Tillman Drainage District, the largest (80 square miles) in Brevard County, a perimeter dike, constructed along the District boundary, prevents the inflow of water from other areas. Within the diked area, surplus water flows by gravity through collecting ditches and canals to a "main" canal and thence to the Indian River. Pumps and control structures help to maintain near-optimum water levels.

There are a number of lakes and sloughs in the coastal ridge from which small supplies could possibly be developed. The determination of the potentialities of any one of these, or of a combination of several of them, would require intensive local investigation. However, some idea of the possibilities may be gained from the experience of the city of Cocoa, which developed Clear Lake as a municipal supply.

Clear Lake, 3 miles northwest of Cocoa, has a surface area of about 15 acres. No natural streams flow into or out of it. In 1937, when its use as a municipal supply began, its surface drainage area was 0.17 square mile (109 acres). In 1950 its drainage area was increased to 0.26 square mile (166 acres) and in 1951 it was increased to 4.94 square miles (3,162 acres), each time by connecting it to nearby sloughs.

From January 1951 to August 1957 rain falling on the Clear Lake drainage area amounted to an average of 11,850,000 gpd (gallons per day). During the same period the average pumpage, computed from records furnished by the city of Cocoa was 670,000 gpd. The yield, therefore, was 5.6 percent of the total input. The remainder was lost by evaporation, transpiration, and seepage. The record of stage, pumpage, and chloride content of Clear Lake is presented in hydrograph form (fig. 21).

Chemical quality: In order to ascertain the chemical quality of the surface water of the St. Johns River basin, samples were collected at 26 sites. The locations of these stations are shown on a map (fig. 22). Samples for comprehensive analysis were collected daily at station 18 and at approximately 6-week intervals at stations 4, 6, 20, 25, 26, 31, and 32. Samples for determination of chloride were collected daily for nearly 2 years at station 17 and at approximately 6-week intervals at station 12. Samples for comprehensive analysis were collected semi-annually from the other locations. The results of chemical analyses of these samples are presented in tabular form in Florida Geological Survey Information Circular 32.

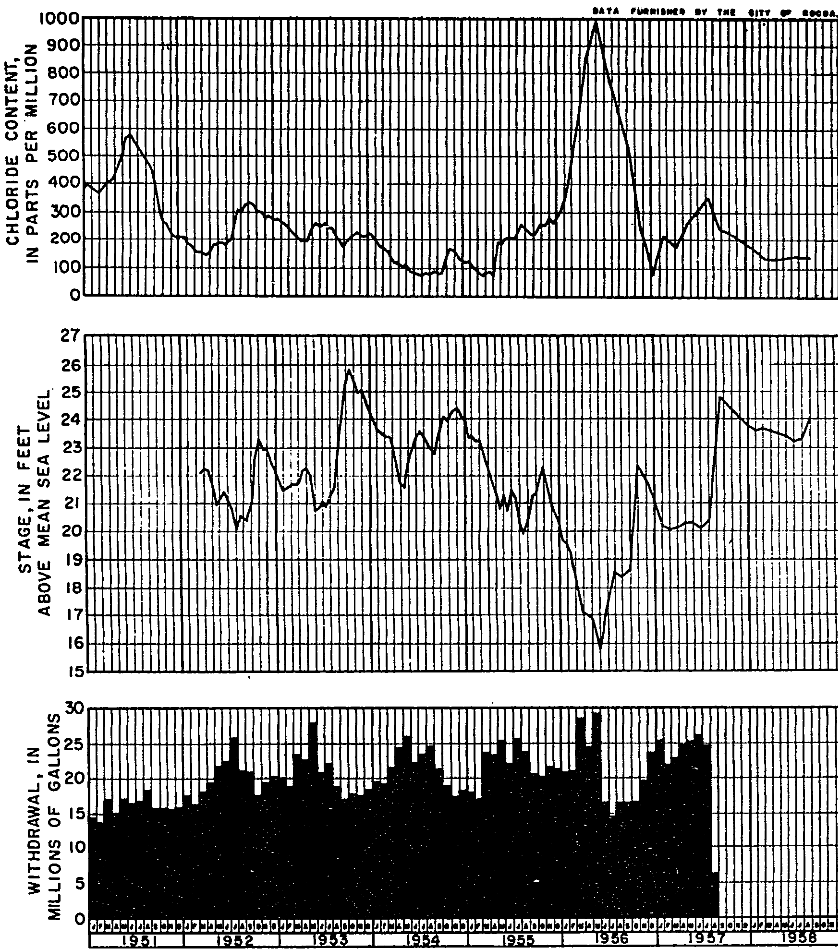

Figure 21. Chloride content, stage, and pumpage, Clear Lake, near Cocoa, Florida.

Measurements of temperature and specific conductance were made on samples collected daily from the St. Johns River near Cocoa and the samples composited at 10-day intervals for comprehensive chemical analysis. Specific conductance, an approximate measure of dissolved solids, provided a day-to-day record of the changes that occurred in the concentration of dissolved solids at this location during the period of study.

Analyses of the samples collected at 6-week intervals show the general chemical characteristics of the water and, over a long period of time, show the manner in which these characteristics respond to influences of climate

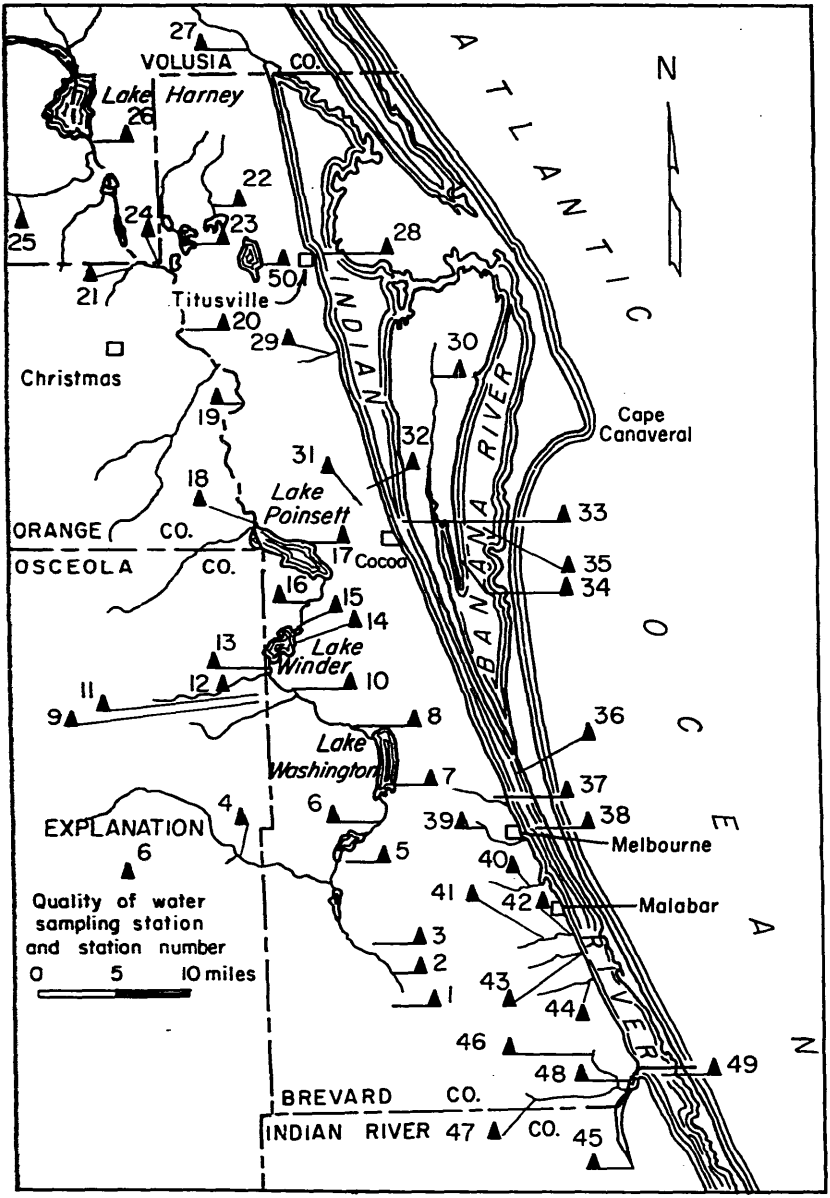

Figure 22. Brevard County showing the water-quality sampling stations on streams and lakes.

and other factors. They are used also to indicate relationships that exist between locations in the same basin. Table 7 shows maximum and minimum values of hardness, chloride, and color observed at these stations and other periodic stations in the county during the period of study.

The chemical composition of the water in the streams of Brevard County varies with changes in the amount of streamflow. Concentrations of constituents generally are high during periods of low flow and are low during periods of high flow. In order to define relationships, samples were collected during a dry period and again during a wet period in each year. Samples were collected from points throughout the basin in as short a time as possible in order to obtain a nearly instantaneous picture of the chemical composition of the streams in the county, to indicate the type and magnitude of changes that occur as the water moves downstream, and to establish approximate ranges in concentration of chemical constituents. The chemical composition of the St. Johns River at several locations during a period of relatively low flow is shown graphically (fig. 23). As shown by the bar graph, the concentration of chemical constituents increases progressively downstream but the greatest increase in concentration was downstream from Lake Poinsett. Maximum, minimum, and average values of chemical constituents are shown for samples obtained at the daily sampling station on the St. Johns River near Cocoa during the period October 1, 1953 to September 30, 1957.

The results of the investigation show that most of the surface waters of the St. Johns River basin in Brevard County would be suitable for most

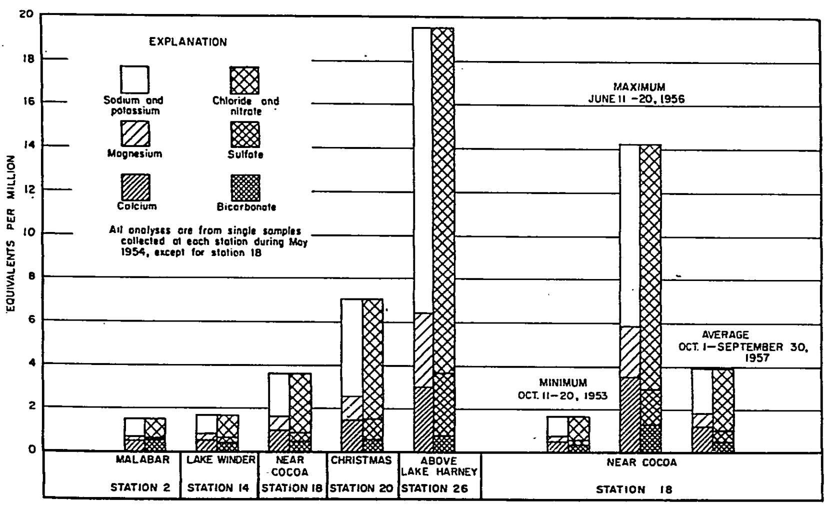

Figure 23. Graph showing analysis of water from the St. Johns River.

TABLE 7. Partial Chemical Analyses of Samples Collected in the St. Johns and Indian River Basins, September 1952 to September 1958

Location	No. of Samples	Chloride		Hardness		Color	
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Jane Green Creek near Deer Park	31	36	7.5	54	18	360	25
St. Johns River near Melbourne	38	125	11	124	23	270	45
St. Johns River near Cocoa	183	403	21	294	30	280	45
St. Johns River near Christmas	41	555	20	386	28	220	45
Econlockhatchee River near Chuluota	36	179	8.0	162	18	600	40
St. Johns River above Lake Harney near Geneva	34	680	30	412	31	300	40
Ellis Canal near Indian River City	35	1,150	315	* 690	* 410	* 160	* 35
Clear Lake near Cocoa	32	980	25	568	36	180	1
Surface Water Slough near Cocoa	35	40	6.5	47	9	500	90
Elbow Creek near Eau Gallie	35	250	19	..	..	..	..
Crane Creek near Melbourne	36	300	38	462	84	280	30
Turkey Creek near Palm Bay	34	340	7.0	..	..	..	..
Goat Creek, 2 mi. W. of Valkaria	34	620	56	..	..	..	..
Fellsmere Canal near Fellsmere	32	270	46	† 284	† 112	† 300	† 50

* Samples collected only during period September 1954 to August 1956.
† Samples collected only during period October 1956 to July 1958.

purposes following treatment for the removal of color and hardness. However, at times during the study, concentrations of various ions exceeded desirable limits. These excessive concentrations were most noticeable downstream from Lake Poinsett during periods of low flow in the early summer of 1956.

Although rainfall, discharge, and use are factors influencing the chemical composition of water in the St. Johns River, the inflow of artesian water, especially during periods of low flow, is the greatest single factor that affects the chemical quality. This water becomes mineralized by mixing with sea water that was left when the sea inundated the state several times during the Pleistocene Epoch (fig. 4, 25). Artesian water is used for irrigation throughout most of the county and is added to the St. Johns River and other streams by drainage, free-flowing wells, and flushing of soil solutions. In some areas, contamination of surface water may result from upward seepage of artesian waters through underlying faults and crevices.

Water in the headwaters of the St. Johns River is generally low in dissolved solids, highly colored, and receives little contamination from artesian water. During periods of high flow, pumpage from the Melbourne-Tillman Drainage District causes a slight increase in the mineral content.

The water of Jane Green Creek near Deer Park is also highly colored and low in dissolved solids. The creek starts in an area of sandy soils and the water has little opportunity to contact and dissolve materials. Color is derived from cypress trees and water grasses that grow in the lower reaches of the stream. Although there is an indication of a relationship between solids concentration and water discharge at this station, this relationship is disrupted by periods in which the river ceases to flow. At these times, concentration of solids in the stream increases as a result of evaporation and transpiration and increased influences of the more highly concentrated ground water. In general, the water of Jane Green Creek would be suitable for most purposes after color removal. The creek would not provide a continuous supply unless it could be impounded.

The quality of the water of the St. Johns River near Melbourne is similar in many respects to that of the headwaters of the St. Johns River and of Jane Green Creek (fig. 23; table 7). There is an increase in concentration of mineral constituents near Melbourne, but at no time during the study did concentrations, at the time of sampling, exceed the recommended maxima for municipal supplies. There is some correlation between the specific conductance and dissolved-solids content of the water at this station and an indication of correlation between the dissolved-solids content and sustained water discharge.

Results of analyses of samples collected at downstream locations show that there is a general increase in most chemical constituents as the St. Johns

River flows northward. As previously mentioned, the greatest increases were noted during early summer and were particularly evident during the drought of 1956. Samples collected in June 1956 show that chloride and dissolved-solids concentrations as far south as Lake Winder at Bonaventure approached maximum allowable concentrations established for municipal supplies by the U.S. Public Health Service. There are several drainage canals entering the St. Johns River between the station near Melbourne and the station at Lake Poinsett. The increase in concentration of dissolved solids in the St. Johns River between these locations may be attributed to drainage of irrigation waters from these canals.

Investigations conducted to evaluate the quality of the water of Lake Poinsett included several phases of collection and analysis of water samples. Initially, samples were collected daily from St. Johns River (at Lake Poinsett outlet) near Cocoa and from Lake Poinsett at Poinsett Lodge on the northeastern shore. Measurements of temperature and conductance were made on samples collected at the outlet station and determinations of chloride were made on samples collected near the lakeshore. Correlation between conductance and chloride at the outlet station provided daily values of chloride concentrations that were compared to those obtained at the lakeshore station. Results of this comparison are shown by the duration curve of chloride content (fig. 24). Although the chloride concentration at the lakeshore station was consistently higher than the concentration at the lake outlet, the relation between these locations was not uniform, particularly during periods of low flow. This is due primarily to the inflow of highly mineralized irrigation water near the lakeshore station. The irregularity of this flow accounts for the disuniformity of the duration curve for this station during periods of high chloride concentrations. The wide range in concentration that occurred at the station during the period of study is shown by bar graph (fig. 25).

Because of the differences noted between the two daily stations and the fact that chloride concentrations increased more than 100 percent between the St. Johns River near Rockledge and the outlet of Lake Poinsett, a reconnaissance of the lake was made to determine the source of this influence. Samples were collected at 74 points in the lake and its tributaries. Results of this reconnaissance are shown on a map (fig. 26). The major contributors of highly mineralized water are the tributaries along the northeastern shore of the lake. They are recipients of irrigational drainage and add considerably to the mineral content of the lake water.

Daily records obtained at St. Johns River (at Lake Poinsett outlet) near Cocoa show the variations in chemical quality of the water that occurred at this station during the study. Figure 27 shows the maximum, average, and minimum values of specific conductances observed each month, and illustrates the ranges and seasonal trends of the quality of the water. As mentioned before, concentrations of minerals are higher during periods of low flow and lower during high flow. Thus, concentrations of dissolved solids increased in the winter and spring and decreased in the summer and fall in direct response to rainfall. The variations that occurred are well illustrated by that portion of the graph for September 1956 wherein the conductance dropped from 1,340 to 140 micromhos or from approximately 700 to 75 ppm of dissolved solids.

Floods and the drought that occurred during the study did much to exaggerate the variations in mineral content of the water. Continuous rains and flooding occurred in the St. Johns River basin just before and soon after the establishment of the daily station near Cocoa in 1953. This was sufficient to flush the soils of highly mineralized soil solutions to the extent

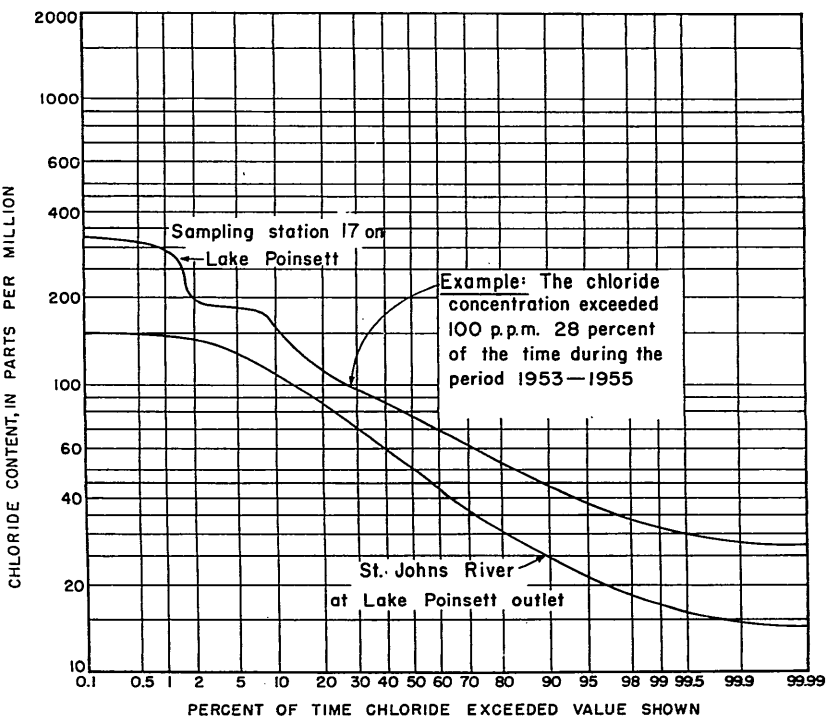

Figure 24. Duration curve of the chloride content at sampling station 17 on Lake Poinsett and the St. Johns River at Lake Poinsett outlet near Cocoa, October 1953-September 1955.

that low concentrations of dissolved solids were observed during October 1953. Rainfall was less during subsequent years of the study with a resultant buildup of dissolved solids.

The drought, caused by deficient rainfall, was most severe in this area in June 1956. Stages were low during this period with the major portion of

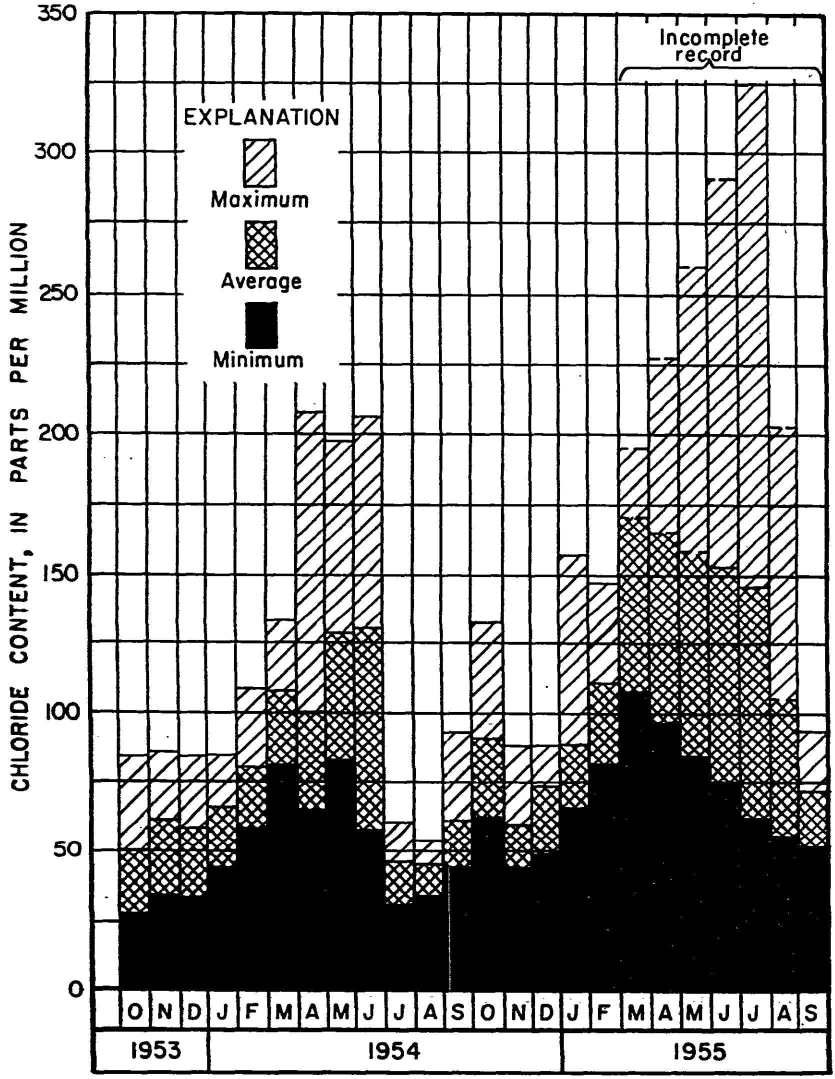

Figure 25. Maximum, average, and minimum daily chloride concentration at station 17 on Lake Poinsett.

stream discharge being derived from ground-water discharge and irrigation drainage. The high mineral content of water from these sources increased the dissolved-solids and chloride concentrations of the water at the daily station beyond the recommended maxima of public water supplies. It must be emphasized that the interval between flooding and drought at this time was only a little more than 2½ years. If the time interval should increase between these extreme conditions, the effect of water losses due to transpiration and evaporation, and the addition of minerals by irrigation flow could cause such high concentrations in the soil solutions and shallow ground water that the ultimate concentration of the river would exceed those observed during the present study.

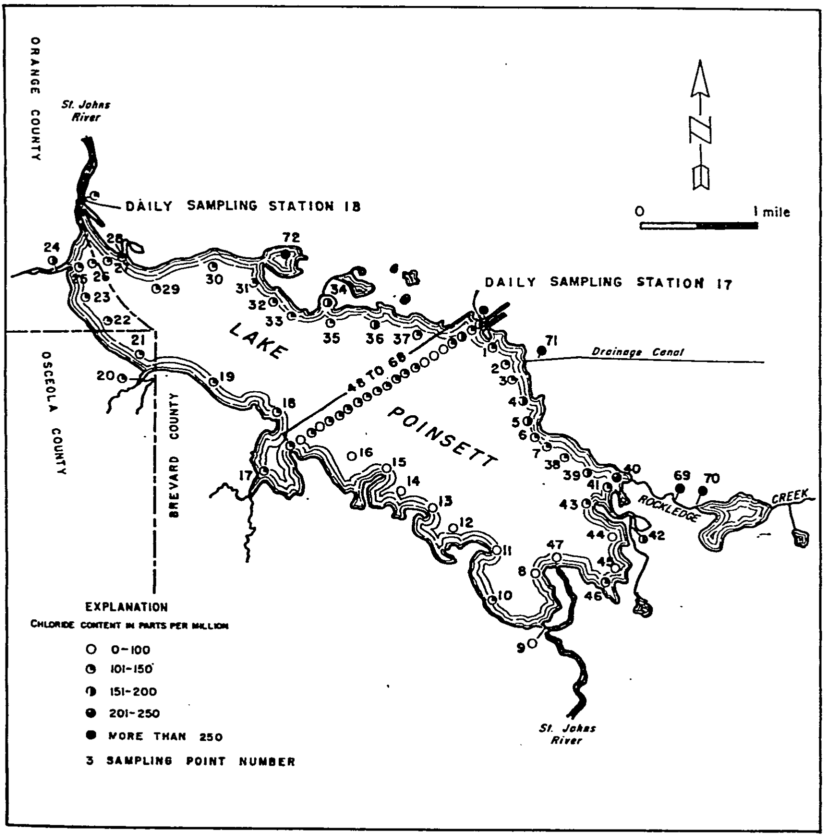

Figure 26. Lake Poinsett near Cocoa, showing chloride concentration at various points during period of approximate minimum flow of the St. Johns River. Samples collected in May 1955.

Following the drought of 1956 the discharge of St. Johns River increased as a result of heavy rainfall to the extent that, in some areas, discharge values exceeded those observed in October 1953. Because of shorter duration of the rainfall and the buildup in concentration of the soil solutions that had occurred during the drought, flushing during the 1956 flood was not as complete as that which occurred during 1953. Thus higher concentrations of dissolved solids were observed at the lake outlet during the period October 1956 to September 1957 than during corresponding periods from October 1953 to the early part of 1956.

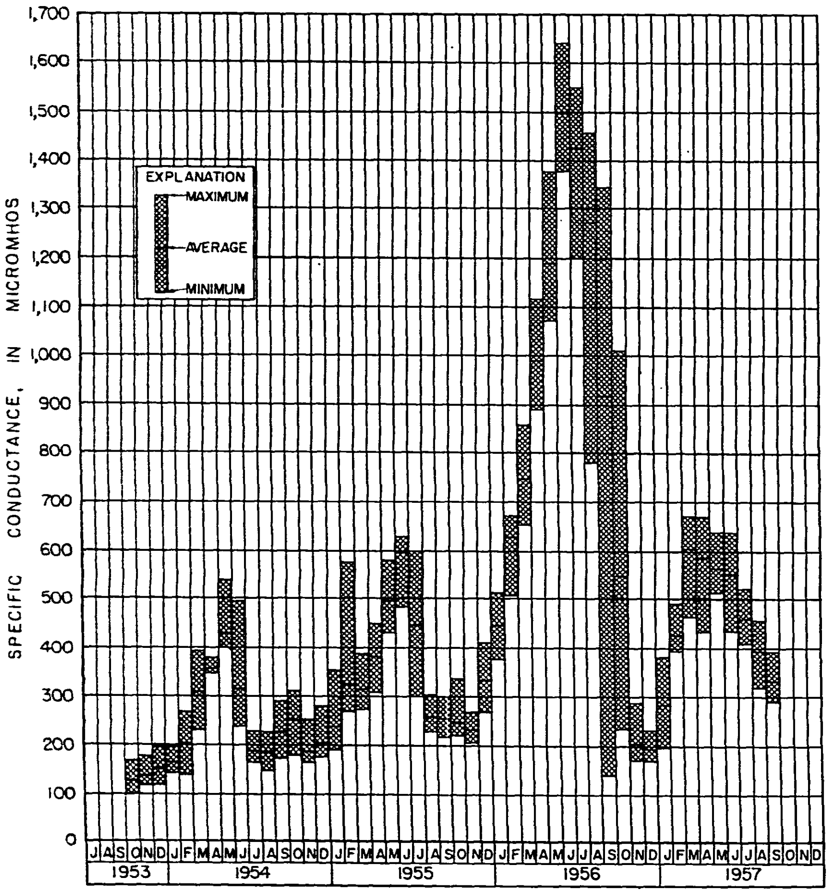

Figure 27. Maximum, average, and minimum specific conductance of the St. Johns River near Cocoa, October 1953 to September 1957.

During the early part of the investigation, an approximate relationship existed between chloride and discharge in that chloride concentration increased with a decrease in discharge. It was noted, however, that concentrations did not decrease immediately in response to rising discharge. This may be attributed to the initial flushing of the minerals from the soils into the river and then additional volumes of water served to dilute the river so that concentrations decreased with continued increases in discharge.

During the drought of 1956 there was a departure from the earlier correlation between chloride and discharge in that chloride concentrations were higher than previously observed for the same discharge. Even following the flood of 1956, concentrations of chloride, although lower than those observed in 1956, were still higher than those observed during the first 2 years of record. This may have been caused by increased use of artesian water during the period of deficient rainfall. Some of this irrigation water eventually reached the St. Johns River and caused increases in chloride concentration at the daily station. Where this quantity had been relatively constant before, approximate values of chloride could be predicted on the basis of variations in discharge of the stream. With the introduction of use of artesian water as another variable, however, the chloride-discharge relationship became less definite.

More detailed chloride and discharge data would probably result in better definition of the relationships. Chloride values, determined from conductance of once-daily samples, do not represent changing conditions that occur during the day. Discharge records for the station at the lake outlet were calculated on the basis of discharge near Melbourne and gage height at Lake Poinsett and later, on the basis of several measurements at the station and gage height of Lake Poinsett. Although these records have some value in showing approximate relationships, adverse effects of wind and storage in Lake Poinsett limit the value in defining predictable correlations.

If precautions were taken to prevent contamination of the river by artesian water and if the water level of the river were maintained at a sufficiently high level by control structures, the concentration of dissolved solids in the river would be more uniform and at a more desirable level.

There is, of course, the possibility of contamination by upward leakage of artesian water. The reconnaissance of Lake Poinsett in May 1955 did not indicate such contamination at that time. Leakage from the artesian aquifer would create a depression in the piezometric surface but the piezometric contours, figures 34, 35, and 36, do not indicate a depression or leakage. The chloride concentration increased from 87 ppm at the lake inlet to 103 ppm at the lake outlet. This increase is attributed to the inflow of highly mineralized waters from tributaries and canals along the northeastern shore of Lake Poinsett.

Quantitative measurements were not made to determine the amount of upward seepage from the artesian aquifer, if any; this should be determined if the lake is to be completely evaluated as a water supply. A discussion on the contamination of the nonartesian aquifer by artesian water is on pages 94-95. Even with the possibility of contamination from the artesian aquifer, it is felt that if the water level in Lake Poinsett were maintained at a sufficient level, the effect of this influence would be minimized.

In order to present a brief summary of the chemical-quality conditions that were observed at the daily station during the 4-year study, a cumulative frequency curve showing the percentage of time that conductance exceeded a given value is given in figure 28. Conductance has been correlated with some individual constituents and the curves in figure 29 may be used to obtain approximate values for chloride, total hardness, and sum of determined constituents (dissolved solids) by use of the conductance values.

As shown by the frequency distribution curve for conductance and by the correlation curves, chloride concentrations exceeded 250 ppm only 6

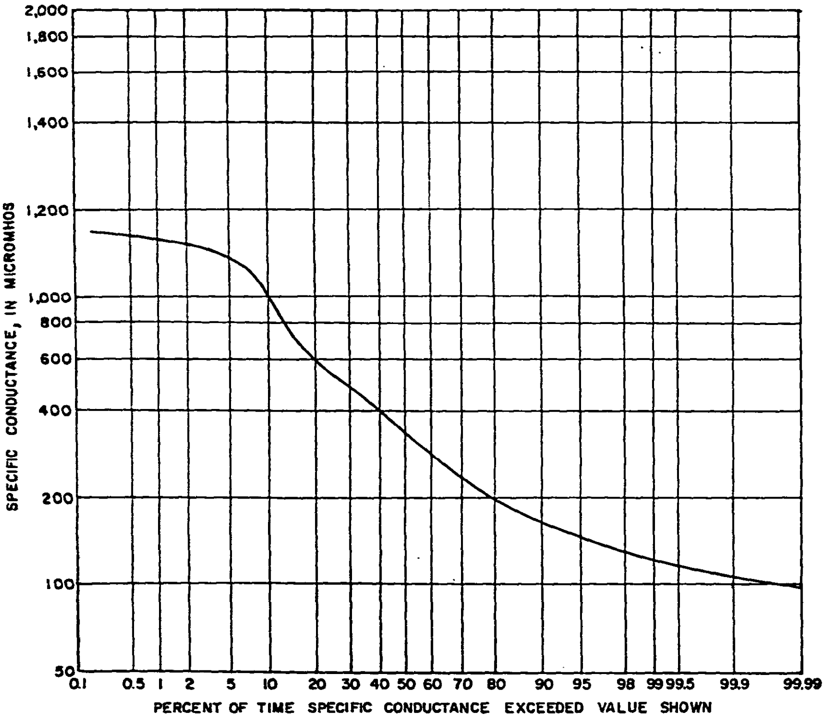

Figure 28. Cumulative frequency curve of specific conductance of the St. Johns River near Cocoa, October 1953-September 1957.

percent of the time or approximately 88 days during the 4 years of the study. Similarly, dissolved solids exceeded a concentration of 500 ppm only about 12 percent of the time.

Clear Lake was used by the city of Cocoa as a municipal supply from 1937 to 1957. Although the supply was generally sufficient during this period, concentrations of dissolved solids were often excessive (fig. 21). This was evident particularly in 1956 when low rainfall and high withdrawal rates caused chloride concentrations of nearly 1,000 ppm.

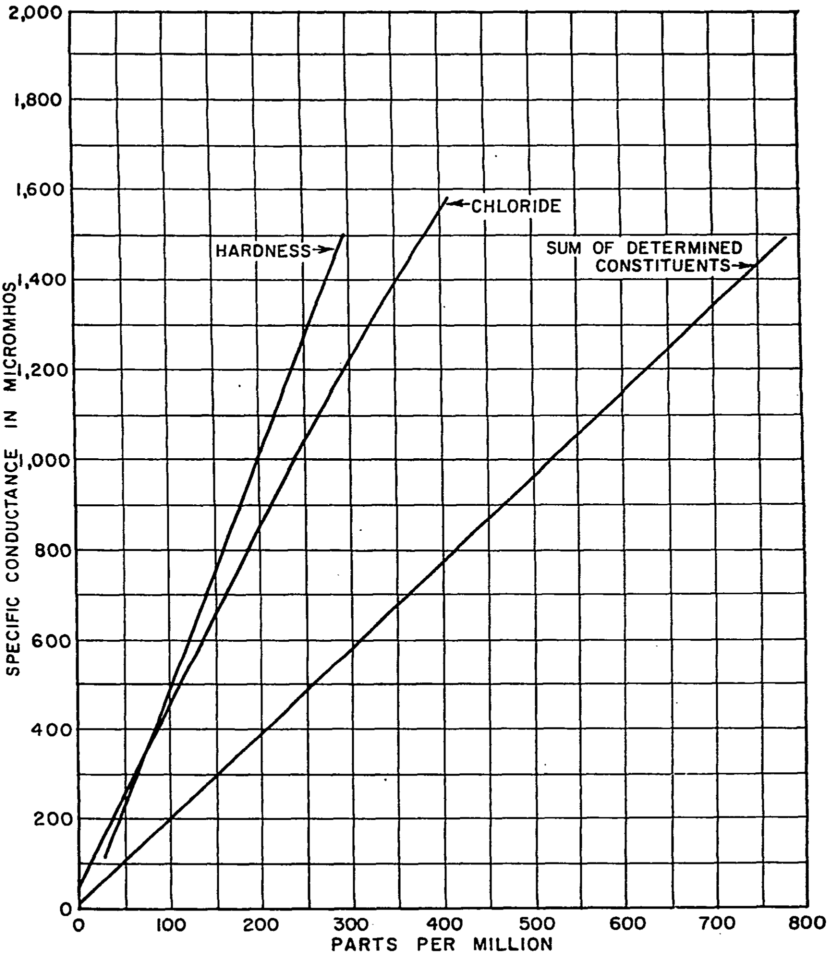

Figure 29. Relation of specific conductance to hardness, chloride, and sum of determined constituents for St. Johns River near Cocoa.

Clear Lake was unable to meet the increased demands of Cocoa and was discontinued as a water supply in 1957 in favor of a more adequate ground-water source in Orange County. The lake could still be used as a small water supply as before and could be expected to provide water of suitable quality during normal rainfall conditions.

Results of analyses on samples from the surface water slough near Cocoa indicate that this source is suitable for most uses. Concentrations of all mineral constituents were low but the water would have to be treated for adjustment of pH and removal of color before it could be used for some purposes. The water was often acidic, pH values being well below the neutral point of 7.0. With low pH, low mineral content and high color, the water would be corrosive to metal surfaces.

The water in the St. Johns River near Christmas (station 20) is quite similar in character to that at Lake Poinsett outlet but is more mineralized. Lack of data prevents accurate interstation correlations, but calculations based on available information indicate that the increased concentration of the water is not due to a large inflow or upward leakage of highly mineralized artesian water. This increased concentration at Christmas probably is due to some inflow of ground water and surface water of moderate concentration. As with the water at Lake Poinsett outlet, St. Johns River near Christmas could be used, after treatment, for many purposes. Dissolved-solids and chloride concentrations did exceed recommended maxima for municipal supply for several months during 1956 but the water could be used if a better supply was not available.

Loughmans Lake and Salt Lake near Mims are shallow lakes that contain water with relatively high concentrations of dissolved solids. These dissolved solids are believed to be introduced through upward leakage of the artesian waters. The composition of the water in the lakes is quite similar to the artesian water of the area. Because of the large surface areas and relatively shallow depths of these two lakes, high evaporation and transpiration losses cause an increase in the concentration of solids so that at times it exceeds that of the water from artesian sources.

Reports of springs in these lakes led to investigations in October 1957 and August 1958. Conductance readings taken at many locations showed that a fairly uniform composition existed throughout both lakes with some dilution by surface inflow on the northern edge of Salt Lake. There were no indications of spring sources within the lakes at that time. Drainage from these two lakes enters the St. Johns River and causes a considerable increase in the mineral content of that stream.

A few miles downstream from Loughmans Lake and Salt Lake the Econlockhatchee River flows into the St. Johns River. The drainage area of the Econlockhatchee River at Chuluota is 260 square miles, or about 13 percent of the total drainage area of the St. Johns River above Lake Harney. Approximately 15 percent of the average flow of the St. Johns River at Lake Harney is contributed by the Econlockhatchee River. The quality of the water of Econlockhatchee River is good. Even during the period of the drought the dissolved-solids and chloride concentrations did not exceed the recommended maxima for municipal supplies. This flow has a dilution effect on water of the St. Johns River but because the percentage of flow to that of the St. Johns River is low, the dilution effect is not sufficient to lower the mineral concentration to desirable limits.

The dissolved-solids and chloride concentrations of samples collected from the St. Johns River above Lake Harney were far in excess of the maxima recommended for municipal supplies. The quality of water at this location limits its use for purposes other than irrigation during most of the year.

In addition to contamination by drainage from Salt Lake and Loughmans Lake there are indications that upward leakage of artesian water occurs for some distance upstream above Lake Harney, adding large amounts of minerals directly to the St. Johns River. A depression has been created in the piezometric surface (fig. 35) that indicates discharge from the artesian aquifer and probably upward leakage to the St. Johns River.

There is some correlation of chemical concentrations of water among the stations in the St. Johns River basin. Better definition of these relationships will be of considerable value in future planning of water use and control of the river. Installation and operation of conductivity-recording instruments at several of these locations concurrent with the operation of daily discharge stations could provide considerable information on the effect that conditions at one location have on another location. The city of Melbourne, for instance, will soon be withdrawing water from Lake Washington at the rate of 10 mgd (million gallons per day) (15.5 cfs) for a municipal supply. This withdrawal will amount to about 1.3 percent of the amount of water in Lake Washington each day when the lake is at normal stage or about 2 percent of the average flow of the St. Johns River near Melbourne. Because the water at this source is rather low in mineral content withdrawal during periods of low flow will probably cause an increase in the concentration of dissolved solids in the water at downstream locations.

INDIAN RIVER BASIN

The Indian River is a lagoon rather than a stream. The Brevard County section of this lagoon, including the part called Banana River, covers 235 square miles and receives the runoff from 838 square miles of the surrounding land area. The Indian River is separated from the Atlantic Ocean by a long narrow island ranging from a few hundred feet to a few thousand feet in width except near Cocoa where it widens to form Cape Canaveral. This section of the Indian River has only one direct connection to the ocean, Sebastian Inlet. It has two indirect connections. At the northern end an indirect connection is through Haulover Canal to Indian River Lagoon and thence through Ponce de Leon Inlet to the Atlantic. Southward the connection is through Fort Pierce Inlet at Fort Pierce.

Flow and stage: A number of small streams on the east slope of the coastal ridge flow into the Indian River. In practically every case the natural flow of these streams has been increased by connecting the upper reaches to ponds and sloughs on top of the coastal ridge. The natural flow has been increased tremendously in those that now receive the runoff from the diked areas west of the ridge. These creeks in Brevard County, including Sebastian Creek, now carry to the Indian River the excess water from about 240 square miles of land that formerly drained to the St. Johns River.

Discharge measurements of eight of these creeks show that several of them would provide a good source of supply. Turkey Creek in particular, which carries the outflow from the Melbourne-Tillman Drainage District, seems to be an excellent supply source. The streamflow information on this creek consists of flow determinations made at 6-week intervals (table 8) from October 1954 to January 1956 and a record of daily discharge from January 1956 through October 1958. The minimum flow from October 1954 to October 1958 was 25 cfs (16.5 mgd) on March 30, 1956, during the widespread drought of that year. The minimum flow of Fellsmere Canal was also 25 cfs and occurred in the same year. The other streams on which discharge measurements (table 8) were made are Ellis Canal, Elbow Creek, Crane Creek, Goat Creek, and the North Prong and South Prong of Sebastian Creek.

Fluctuations in the level of the Indian River are relatively small. From September 1951 to September 1957, at Titusville, the highest stage that occurred was 2.32 feet above mean sea level. The lowest stage that occurred during the same period was 0.78 foot below mean sea level. Because of the large surface area, wind causes considerable short-term fluctuation. Strong winds blowing in a north-south direction may produce as much as 2 feet of rise at one end of the river with a concurrent lowering at the opposite end. Rains produce rapid rises in the river, the amount of rise depending upon the intensity and areal extent of the rain. The storm rains during the middle of October 1956 averaged about 12 inches over the entire river area in a 2-day period and produced a 1-foot rise in the river. Inspection of the stage-recorder chart from the Titusville station indicates that the water level rose

TABLE 8. Discharge of Small Streams Tributary to the Indian River.

Stream	Discharge (in cu. ft. per sec.) and date of measurement					
	1954			1955		
Ellis Canal	11.2 (Sept. 27)	2.82 (Nov. 8)	2.74 (Dec. 13)	2.68 (Jan. 31)	2.26 (Mar. 15)	1.97 (Apr. 25)
Elbow Creek	11.3 (Sept. 28)	*1.75 (Nov. 10)	2.58 (Dec. 14)	1.57 (Feb. 1)	.642 (Mar. 16)	.546 (Apr. 25)
Crane Creek	24.5 (Sept. 29)	23.1 (Nov. 17)	10.1 (Dec. 14)	7.87 (Feb. 3)	6.44 (Mar. 16)	4.83 (Apr. 26)
Turkey Creek	144 (Oct. 2)	53.2 (Nov. 10)	47.8 (Dec. 15)	57.8 (Feb. 3)	31.8 (Mar. 22)	31.6 (Apr. 26)
Goat Creek	13.4 (Oct. 1)	5.18 (Nov. 11)	3.60 (Dec. 15)	5.37 (Feb. 3)	2.30 (Mar. 17)	1.95 (Apr. 27)
North Prong Sebastian Creek	223 (Oct. 1)	85.4 (Nov. 18)	27.4 (Dec. 15)	19.4 (Feb. 2)	8.87 (Mar. 17)	8.71 (Apr. 27)
Fellsmere Canal	184 (Oct. 1)	134 (Nov. 11)	106 (Dec. 16)	124 (Feb. 2)	82.7 (Mar. 23)	69.1 (Apr. 27)
South Prong Sebastian Creek	114 (Oct. 1)	336 (Nov. 18)	28.2 (Dec. 16)	42.4 (Feb. 2)	25.0 (Mar. 23)	21.0 (Apr. 27)
Sum	725.4	641.45	228.42	261.09	160.012	139.706

*Field estimate

Stream	Discharge (in cu. ft. per sec.) and date of measurement					
	1955					
Ellis Canal	1.68 (June 6)	2.78 (July 19)	2.30 (Aug. 29)	2.45 (Oct. 10)	2.25 (Nov. 16)	2.14 (Dec. 19)
Elbow Creek	.621 (June 8)	.660 (July 20)	1.15 (Sept. 1)	11.3 (Oct. 14)	.815 (Nov. 17)	.783 (Dec. 19)
Crane Creek	4.43 (June 8)	5.89 (July 22)	4.84 (Sept. 1)	19.3 (Oct. 14)	6.00 (Nov. 17)	5.45 (Dec. 21)
Turkey Creek	40.5 (June 7)	55.2 (July 22)	68.3 (Aug. 30)	81.9 (Oct. 11)	50.6 (Nov. 18)	41.2 (Dec. 22)
Goat Creek	1.25 (June 9)	1.18 (July 21)	1.17 (Sept. 1)	37.9 (Oct. 14)	1.63 (Nov. 18)	1.52 (Dec. 20)
North Prong Sebastian Creek	7.11 (June 9)	7.57 (July 21)	9.16 (Aug. 31)	32.3 (Oct. 12)	7.94 (Nov. 19)	7.79 (Dec. 20)
Fellsmere Canal	46.8 (June 9)	72.3 (July 21)	75.8 (Aug. 31)	207 (Oct. 12)	51.8 (Nov. 18)	59.7 (Dec. 20)
South Prong Sebastian Creek	12.1 (June 9)	18.3 (July 21)	23.8 (Aug. 31)	80.0 (Oct. 12)	21.1 (Nov. 18)	15.1 (Dec. 20)
Sum	114.491	163.880	186.52	472.15	142.135	133.683

TABLE 8. (Continued)

Stream	Discharge (in cu. ft. per sec.) and date of measurement					
	1956					
Ellis Canal	1.93 (Jan. 30)	1.75 (Mar. 12)	1.36 (Apr. 23)	1.15 (June 4)	1.86 (July 18)	1.28 (Aug. 28)
Elbow Creek	1.12 (Jan. 28)	.525 (Mar. 13)	.837 (Apr. 27)	* .45 (June 5)	.484 (July 19)	* .67 (Aug. 31)
Crane Creek	7.65 (Jan. 27)	4.94 (Mar. 12)	7.53 (Apr. 27)	3.53 (June 5)	6.58 (July 18)	4.06 (Aug. 31)
Turkey Creek	40.6 (Jan. 30)	28.7 (Mar. 13)	51.3 (Apr. 30)	39.6 (June 6)	36.8 (July 19)	81.9 (Aug. 31)
Goat Creek	1.53 (Jan. 29)	1.04 (Mar. 15)	1.75 (Apr. 30)	* .80 (June 6)	2.51 (July 19)	1.54 (Aug. 30)
North Prong Sebastian Creek	7.37 (Jan. 29)	6.44 (Mar. 15)	8.70 (Apr. 30)	8.82 (June 6)	8.76 (July 19)	11.6 (Aug. 30)
Fellsmere Canal	59.3 (Jan. 29)	37.2 (Mar. 14)	32.7 (Apr. 30)	44.1 (June 7)	52.4 (July 17)	162 (Aug. 29)
South Prong Sebastian Creek	17.4 (Jan. 29)	15.9 (Mar. 14)	19.1 (Apr. 30)	9.36 (June 6)	37.4 (July 16)	66.1 (Aug. 29)
Sum	136.9	96.495	123.277	107.81	146.794	329.15

*Field estimate

Stream	Discharge (in cu. ft. per sec.) and date of measurement					
	1956					
Ellis Canal	10.7 (Oct. 8)	....	28.7 (Oct. 19)	....	....	9.16 (Nov. 19)
Elbow Creek	2.34 (Oct. 9)	83.3 (Oct. 17)	30.9 (Oct. 18)	11.8 (Oct. 23)	7.98 (Oct. 24)	1.26 (Nov. 20)
Crane Creek	21.2 (Oct. 9)	264 (Oct. 16)	....	....	....	....
Turkey Creek	....	2,230 (Oct. 16)	1,680 (Oct. 19)	1,320 (Oct. 23)	1,270 (Oct. 24)	213 (Nov. 21)
Goat Creek	17.4 (Oct. 9)	....	377 (Oct. 19)	....	87.2 (Oct. 24)	....
North Prong Sebastian Creek	53.1 (Oct. 9)	981 (Oct. 18)	777 (Oct. 19)	....	....	....
Fellsmere Canal	186 (Oct. 10)	1,680 (Oct. 16)	1,560 (Oct. 18)	1,460 (Oct. 19)	1,210 (Oct. 23)	....
South Prong Sebastian Creek	142 (Oct. 10)	1,780 (Oct. 18)	1,490 (Oct. 19)	....	....	....
Sum	....	....	....	....	....	....

TABLE 8. (Continued)

Stream	Discharge (in cu. ft. per sec.) and date of measurement					
	1957					
Ellis Canal	8.16 (Jan. 8)	2.45 (Feb. 19)	2.58 (Apr. 8)	4.52 (May 15)	2.93 (June 26)	2.03 (Aug. 6)
Elbow Creek	.75 (Jan. 10)	1.47 (Feb. 20)	2.04 (Apr. 5)	1.31 (May 12)	* .22 (June 24)	9.02 (Aug. 9)
Crane Creek	5.61 (Jan. 10)	7.28 (Feb. 21)	9.34 (Apr. 9)	6.25 (May 12)	5.10 (June 24)	12.3 (Aug. 5)
Turkey Creek	92.6 (Jan. 9)	82.2 (Feb. 18)	79.1 (Apr. 9)	90.6 (May 14)	47.6 (June 26)	212 (Aug. 7)
Goat Creek	1.56 (Jan. 9)	2.16 (Feb. 20)	16.6 (Apr. 5)	14.8 (May 14)	7.80 (June 26)	85.9 (Aug. 7)
North Prong Sebastian Creek	7.68 (Jan. 8)	8.78 (Feb. 19)	82.2 (Apr. 3)	9.56 (May 13)	16.9 (June 26)	442 (Aug. 7)
Fellsmere Canal	68.2 (Jan. 8)	52.8 (Feb. 19)	148 (Apr. 3)	190 (May 13)	82.2 (June 25)	223 (Aug. 6)
South Prong Sebastian Creek	22.8 (Jan. 8)	29.0 (Feb. 19)	115 (Apr. 3)	45.2 (May 13)	19.6 (June 25)	57.8 (Aug. 6)
Sum	207.36	186.14	454.86	362.24	182.35	1,044.05

*Field estimate

Stream	Discharge (in cu. ft. per sec.) and date of measurement					
	1957			1958		
Ellis Canal	10.8 (Sept. 18)	4.07 (Oct. 29)	2.86 (Dec. 10)	8.88 (Jan. 24)	3.04 (Mar. 18)	2.27 (May 12)
Elbow Creek	8.22 (Sept. 18)	1.36 (Oct. 29)	1.37 (Dec. 2)	127 (Jan. 24)	20.5 (Mar. 19)	2.01 (May 12)
Crane Creek	12.0 (Sept. 16)	6.84 (Oct. 29)	6.35 (Dec. 2)	7.56 (Jan. 20)	17.7 (Mar. 17)	8.03 (May 12)
Turkey Creek	205 (Sept. 16)	68.1 (Oct. 29)	43.0 (Dec. 4)	353 (Jan. 22)	151 (Mar. 19)	45.2 (May 14)
Goat Creek	25.2 (Sept. 18)	3.08 (Oct. 29)	5.45 (Dec. 3)	54.6 (Jan. 22)	6.70 (Mar. 18)	2.50 (May 14)
North Prong Sebastian Creek	164 (Sept. 18)	15.1 (Oct. 30)	9.86 (Dec. 3)	158 (Jan. 22)	22.3 (Mar. 18)	12.7 (May 13)
Fellsmere Canal	299 (Sept. 17)	51.5 (Oct. 30)	45.0 (Dec. 3)	67.4 (Jan. 21)	139 (Mar. 18)	55.6 (May 13)
South Prong Sebastian Creek	289 (Sept. 17)	28.3 (Oct. 30)	21.1 (Dec. 3)	40.1 (Jan. 21)	43.3 (Mar. 18)	35.9 (May 13)
Sum	1,013.22	178.35	134.99	816.54	403.54	164.21

TABLE 8. (Continued)

Stream	Discharge (in cu. ft. per sec.) and date of measurement		
	1958		
Ellis Canal	1.83 (July 7)	1.05 (Sept. 2)	1.39 (Oct. 29)
Elbow Creek	1.30 (July 9)	2.05 (Sept. 1)	2.19 (Oct. 29)
Crane Creek	5.71 (July 7)	9.61 (Sept. 1)	18.0 (Oct. 27)
Turkey Creek	31.9 (July 9)	39.9 (Sept. 3)	71.5 (Oct. 27)
Goat Creek	1.20 (July 8)	1.23 (Sept. 3)	2.62 (Oct. 28)
North Prong Sebastian Creek	6.92 (July 8)	6.14 (Sept. 2)	11.0 (Oct. 28)
Fellsmere Canal	67.1 (July 8)	65.5 (Sept. 2)	63.5 (Oct. 28)
South Prong Sebastian Creek	46.6 (July 8)	17.2 (Sept. 2)	21.4 (Oct. 28)
Sum	162.56	142.68	191.60

rapidly the 15th and 16th, was steady on the 17th and 18th, then fell gradually, returning to normal on the 27th.

The problem of obtaining water supplies economically is prevalent throughout the Brevard section of the Indian River basin. With the proper precautions to prevent chloride contamination, several of the streams on the eastern slope of the coastal ridge can be used as sources. In several cases the topography is well suited for small-scale impoundment. However, on Merritt Island and the barrier islands it appears that there is no suitable surface source available. Although the rainfall is sufficient to meet the needs were it possible to provide catchment and impoundment works, the flat topography and porous soils appear to make such a course economically infeasible.

Sykes Creek is the only stream on Merritt Island of appreciable size. This creek, more aptly described as an arm of the Indian River, occupies the low, marshy area down the center of the island and is canalized throughout much of its length. The movement of water in the creek is erratic, the rate and direction of flow being dependent upon inflow, wind, and changes of stage in the Indian River. Estimates or measurements of flow, made at times of periodic inspections, are listed below:

Date	Flow*	Direction of flow
12-13-54	10 cfs	To the south
3-22-55	Slight	To the south
4-28-55	None discernible	
6- 8-55	5 cfs	To the south
7-19-55	10 cfs	To the north
9- 2-55	30 cfs	To the north
11-17-55	9 cfs	To the south
12-19-55	6 cfs	To the south
1-28-56	15 cfs	To the south
3-13-56	None discernible	
4-25-56	30 cfs	To the north
6- 4-56	2 cfs	To the north
7-19-56	No flow	
8-28-56	Slight	To the south
10- 8-56	25 cfs	To the south
1- 7-57	6 cfs	To the south
2-21-57	20 cfs	To the south
4- 5-57	No flow	
5-15-57	10 cfs	To the south
6-27-57	24 cfs	To the south
8- 9-57	44 cfs	To the south
9-20-57	7 cfs	To the south
10-31-57	10 cfs	To the south
12- 5-57	10 cfs	To the south
1-24-58	15 cfs	To the south
3-21-58	5 cfs	To the south
4-16-58	No flow	
7-10-58	No flow	
9- 4-58	No flow	
10-31-58	No flow	

*Estimates were made when flow conditions were unsuitable for measuring.

Chemical quality: In order to determine the quality of surface water in the coastal ridge of Brevard County, samples were collected for comprehensive analysis at 6-week intervals from three locations. These stations included Ellis Canal near Indian River City, Crane Creek near Melbourne, and Fellsmere Canal near Fellsmere. Samples for determination of chloride were collected at 6-week intervals at several other locations. Samples were collected for comprehensive analysis at some of these stations so that through comparison of the chloride content, a more comprehensive evaluation of the water quality could be made. Also two samples were collected and analyzed from South Lake near Titusville.

Ellis Canal near Indian River City drains a relatively high area composed of sand, clay, and coquina shell. Analyses indicate that this water would be suitable for only a few purposes. Thirty samples were collected over a 4-year period. During the first 2 years of the study comprehensive analyses were made; during the last 2 years chloride and conductance determinations were made. During the 4-year period only one sample had a chloride concentration of less than 500 ppm. This sample was collected in January of 1958 and had a concentration of 315 ppm of chloride. A sample collected on October 8, 1956, had the highest chloride concentration, 1,150 ppm. The chloride concentration ranged between 505 and 715 ppm for all of the other samples. Samples collected during the first 2 years of the study showed concentrations of sulfate ranging from 199 to 278 ppm, dissolved solids from 1,380 to 1,640 ppm, and hardness of 410 to 690 ppm.

Determinations of chloride and specific conductance of 33 samples collected from Elbow Creek near Eau Gallie showed the water to be acceptable for municipal water supplies. Chloride concentrations ranged from 19 to 250 ppm and the conductance ranged from 116 to 1,140 micromhos. Although the chloride concentrations did not exceed the recommended maximum, color in some of the samples collected exceeded the permissible maximum.

Chloride concentrations and conductance of 32 samples collected from Turkey Creek near Palm Bay indicate that the quality of the water of this stream is similar to that of Elbow Creek except for slightly higher concentrations of dissolved solids. Chloride concentrations ranged from 7.0 to 340 ppm. The quantity of water available from Turkey Creek is considerably greater than that from Elbow Creek.

Thirty samples for comprehensive analysis were collected from Crane Creek at Melbourne during the investigation. Of these samples concentrations of chloride ranged from 38 to 300 ppm and the dissolved solids from 131 to 808 ppm. It is reported that the stream is polluted by untreated sewage, but there were no high concentrations of nitrate in samples collected.

Determinations of chloride and specific conductance of samples collected at 6-week intervals from the North Prong of Sebastian Creek near Micco indicate that this stream is suitable as a municipal or industrial water source only part of the time. During the period from October 1954 to September 1958 the chloride content of the samples exceeded 250 ppm only during August 1955 and from December 1955 to July 1956.

Chemical analyses of samples collected from Fellsmere Canal near Fellsmere indicate that the water, after treatment, would be satisfactory for most uses. This canal receives irrigation-drainage water from a system of laterals west of Fellsmere. A reconnaissance in October 1957 showed that the chloride concentration of the canal near its western end was 18 ppm. Progressively higher concentrations were noted at points east of this location to as much as 67 ppm at State Highway 507 just north of Fellsmere. A sample collected from one of the contributing laterals just west of State Highway 507 had a chloride concentration of 187 ppm. Free-flowing artesian wells in the vicinity of Fellsmere increase the mineral content of Fellsmere Canal.

Samples for the determination of chloride as an indication of the salinity of Indian River were collected semiannually during the investigation. Concentration ranges observed during the 4-year period are shown graphically (fig. 30).

GROUND WATER

The following discussion of the occurrence of ground water has been adapted in part from Meinzer (1923a, p. 2-102), whose report includes a more detailed discussion of the general principles of ground water.

The materials that form the outer crust of the earth contain numerous open spaces called voids or interstices. These interstices are the receptacles that hold the water found below the land surface. The amount of water that can be stored in any rock depends upon the size and number of interstices. The permeability of a rock may be defined as its ability for transmitting water under hydraulic head, and is measured as the rate at which a rock will transmit water through a given cross section under a given head per unit of distance. Rocks that will not transmit water are said to be impermeable. Some deposits, such as well sorted silt or clay, may have a high porosity but, because of the minute pores, transmit water very slowly. Other deposits, such as well sorted gravel containing large openings that are freely interconnected, transmit water readily. Part of the water in any deposit is not available to wells because it is held against the force of gravity by molecular attraction—that is, by the cohesion of the molecules of the water itself and by their adhesion to the walls of the pores. The ratio of the volume of water that a rock will yield by gravity, after being saturated, to its own volume is known as the specific yield of the rock.

Below a certain level, which in Brevard County is near the land surface, the permeable rocks are saturated with water. These saturated rocks are

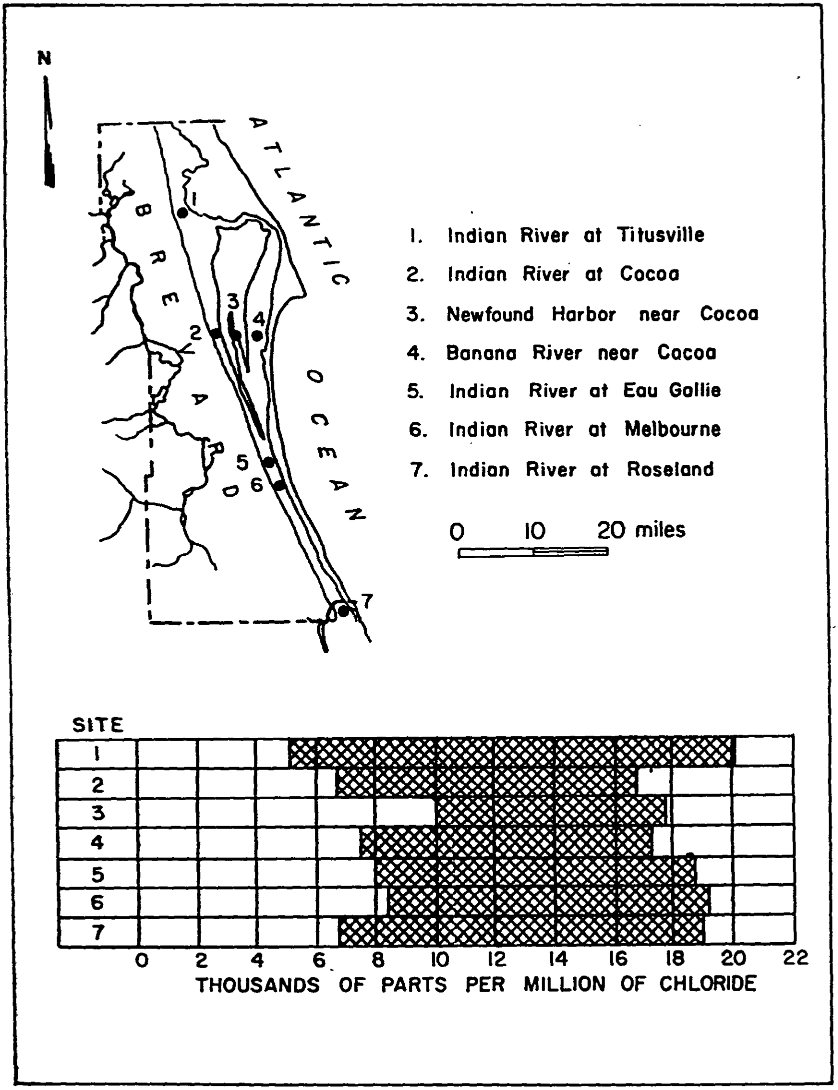

Figure 30. Graph showing range of observed chloride concentrations in Indian River, Banana River, and Newfound Harbor during the period 1953-57.

said to be in the zone of saturation, and the upper surface of this zone is called the water table. Wells dug or drilled into the zone of saturation will become filled with water to the level of the water table.

The permeable rocks that lie above the zone of saturation are said to be in the zone of aeration. As water from the surface percolates slowly downward to the zone of saturation, part of it is held in the zone of aeration by molecular attraction to the walls of the open spaces through which it passes. In fine grained material there is invariably a moist belt in the zone of aeration just above the water table known as the capillary fringe. Although water in the zone of aeration is not available to wells, much of it is withdrawn by transpiration and by evaporation from the soil.

ARTESIAN WATER

Ground water that rises in wells above the point at which it is first encountered is said to be artesian water (Meinzer and Wenzel, 1942, p. 451). The artesian pressure that causes water to rise in a well develops in a formation that is overlain by a confining layer that inhibits upward movement of the water. If the artesian pressure is sufficient to cause the water to flow at the ground surface, the well is termed a flowing artesian well; if water does not flow, the well is called a nonflowing artesian well.

The pressure head or artesian pressure of water at a given point in a formation is expressed as the height of a column of water that can be supported by the pressure. It is the height that a column of water will rise in a tightly cased well and is expressed in feet of water in reference to a datum.

A rock stratum or formation that will yield water in sufficient quantity to be of consequence as a source of supply is called an "aquifer," or simply a "water-bearing formation." It is water bearing not in the sense of holding water but in the sense of yielding or conveying water. The Floridan aquifer in Brevard County consists of a series of limestone formations of Eocene to Miocene in age which have a total thickness of several thousand feet and underlies all of Florida and parts of Georgia and Alabama. Stringfield (1936) described the aquifer and mapped the piezometric surface in 1933 and 1934. The name "Floridan aquifer" was introduced by Parker and others (1955) to include "parts or all of the middle Eocene (Avon Park and Lake City limestones), upper Eocene (Ocala limestone), Oligocene (Suwannee limestone), and Miocene (Tampa limestone and, permeable parts of the Hawthorn formation that are in hydrologic contact with the rest of the aquifer)." The aquifer is overlain by confining beds that, although porous and capable of absorbing water slowly, will not readily transmit water. The confining beds overlying the limestone in Brevard County are comprised chiefly of clays, silts, marls, dense limestones, and fine sediments with greater or lesser admixtures of sand, fine gravel, and shell. The permeability is extremely low and this layer of confining material prevents appreciable upward movement of water and thus maintains the artesian pressure within the aquifer.

The artesian pressure in flowing wells and the water level in nonflowing wells were measured during the inventory of wells. There were 1,024 artesian wells inventoried during the investigation. The locations of these wells are shown on a map, figure 31. The water levels and artesian pressure in many of the artesian wells that had been measured during the 1946-47 investigation were measured again for comparative purposes. The number of wells in the flood plain of the St. Johns River has increased greatly since the 1946-47 investigation.

In areas where information could not be obtained from existing wells, test wells were constructed to collect geologic and hydrologic data.

The test-drilling program in the Floridan aquifer was divided into two parts: (1) Three wells were drilled to locate the eastern limits of the fresh water in the Floridan aquifer in the area near the north end of Lake Poinsett, and (2) five wells were drilled in the St. Johns River valley for general information on the Floridan aquifer (fig. 5).

Test well 822-051-1, west of Cocoa, was constructed to determine the artesian pressure at different depths in the Floridan aquifer. In general, it appears that the artesian pressure increases very little with depth into the aquifer. When the well was completed it was equipped with a 2-inch diameter casing inside the 6-inch diameter casing from land surface to 550 feet below land surface as shown in figure 6. A concrete plug was installed at a depth of 493-529 feet with the 2-inch casing extending through the plug to a depth of 550 feet.

Thus, it was possible to measure the artesian pressure in the zone between 530 and 553 feet through the 2-inch casing and the artesian pressure in the zone between 138 and 493 feet through the outer 6-inch casing. The artesian pressures of the two zones were measured periodically for 2½ years and the artesian pressures were found to be essentially the same. The difference in artesian pressure between the two zones varied from 0 to 1.5 feet during the period of observation. It was observed also that as this test well and other test wells were drilled deeper into the aquifer the composite artesian pressure did not increase appreciably.

The artesian pressure at a well head is the composite pressure of all producing zones. When a well has zones of varying pressure, the water from the zones of higher artesian pressure will move into zones of lower artesian pressure. Thus, the pressure measured at the discharge pipe may not represent the maximum pressure within the well.

FLUCTUATION IN ARTESIAN PRESSURE

The artesian pressure in 12 wells was measured periodically during this investigation to determine the characteristics of the artesian-pressure fluctuations. Water-level recorders were installed on two wells to obtain data on the daily and seasonal changes in the water level due to tidal and barometric effects. Five wells have been measured periodically since 1948 as a part of the statewide water-level program. Locations of the water-level observation wells are shown on figure 32.

The hydrographs of five wells (fig. 33) show, in addition to seasonal variations, a gradual downward trend from 1946 to 1956 and a slight recovery during 1957 and 1958. The average monthly precipitation graph in figure 4 indicates that the highest rainfall generally occurs in Brevard County from June through October. Accordingly, the water levels are generally highest during or slightly after this period. The period of low rainfall generally occurs from November to May. Water levels begin to decline near the end of the year and generally are lowest in June or July.

In areas where there are a large number of wells, such as the Melbourne-Eau Gallie area, the artesian pressure in wells fluctuated several feet during a year. Well 805-045-1, 9 miles west of Melbourne, is in an area of heavy withdrawal of ground water. The well had a record high water level of 30.0 feet above land surface on October 15, 1949, and a record low water level of 20.2 feet above land surface on May 21, 1956. The average water level in the well during the period of record, August 1934 to July 1958, was 26.34 feet above land surface. During this period the yearly range of fluctuation was smallest in 1950 (1.6 feet) and greatest in 1956 (6.3 feet).

Well 847-051-1, northeast of Scottsmoor near the Volusia County line, is not affected by the withdrawal from other wells, and the hydrograph shows the fluctuations caused by changing rates of recharge and discharge. This well had a record high water level of 6.7 feet above land surface on June 26, 1946, and again on August 29, 1946. The record low water level was 0.14 foot above land surface on May 20, 1956. The average water level during the period June 1946 to July 1958 was 3.53 feet above land surface. In this well the yearly range of fluctuation was smallest in 1953 (1.60 feet) and greatest in 1950 (4.12 feet).

PIEZOMETRIC SURFACE

The piezometric surface is an imaginary surface to which water will rise in tightly cased wells that penetrate an artesian aquifer. It is mapped by determining the altitude of the water level in a network of wells. This surface is represented on maps by contours that connect points of the same altitude.

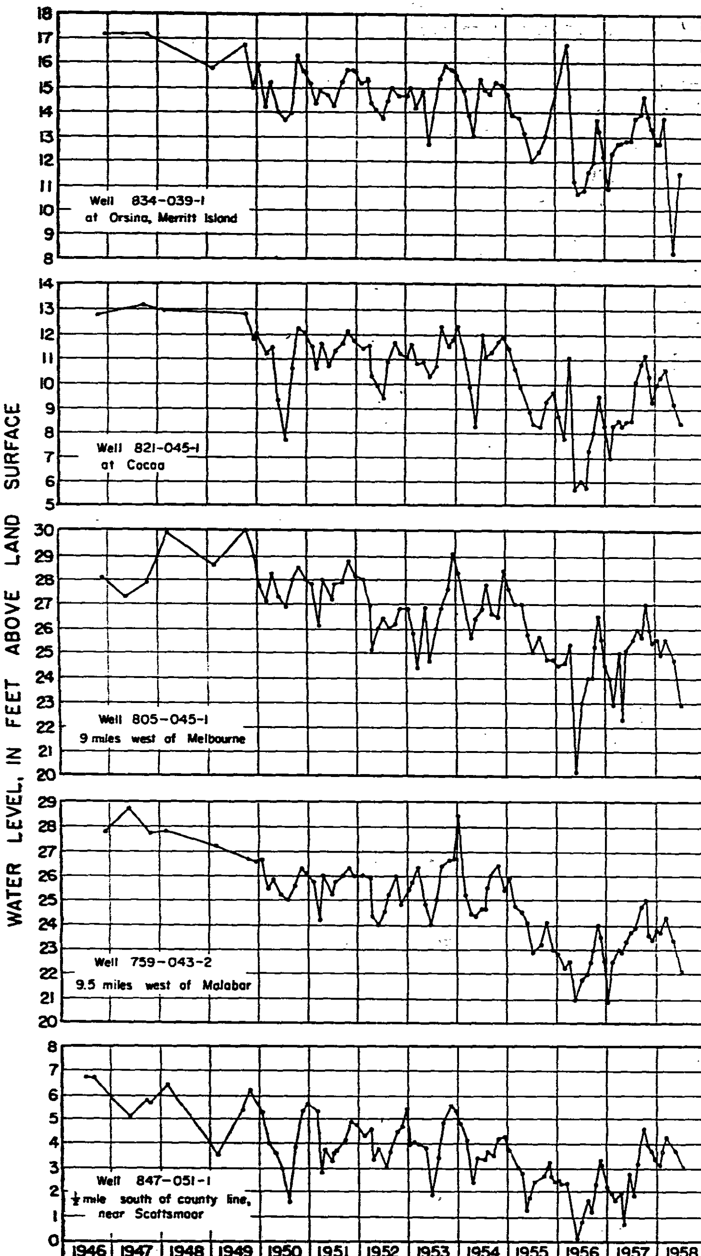

Figure 33. Hydrographs of artesian pressure in selected artesian wells in Brevard County.

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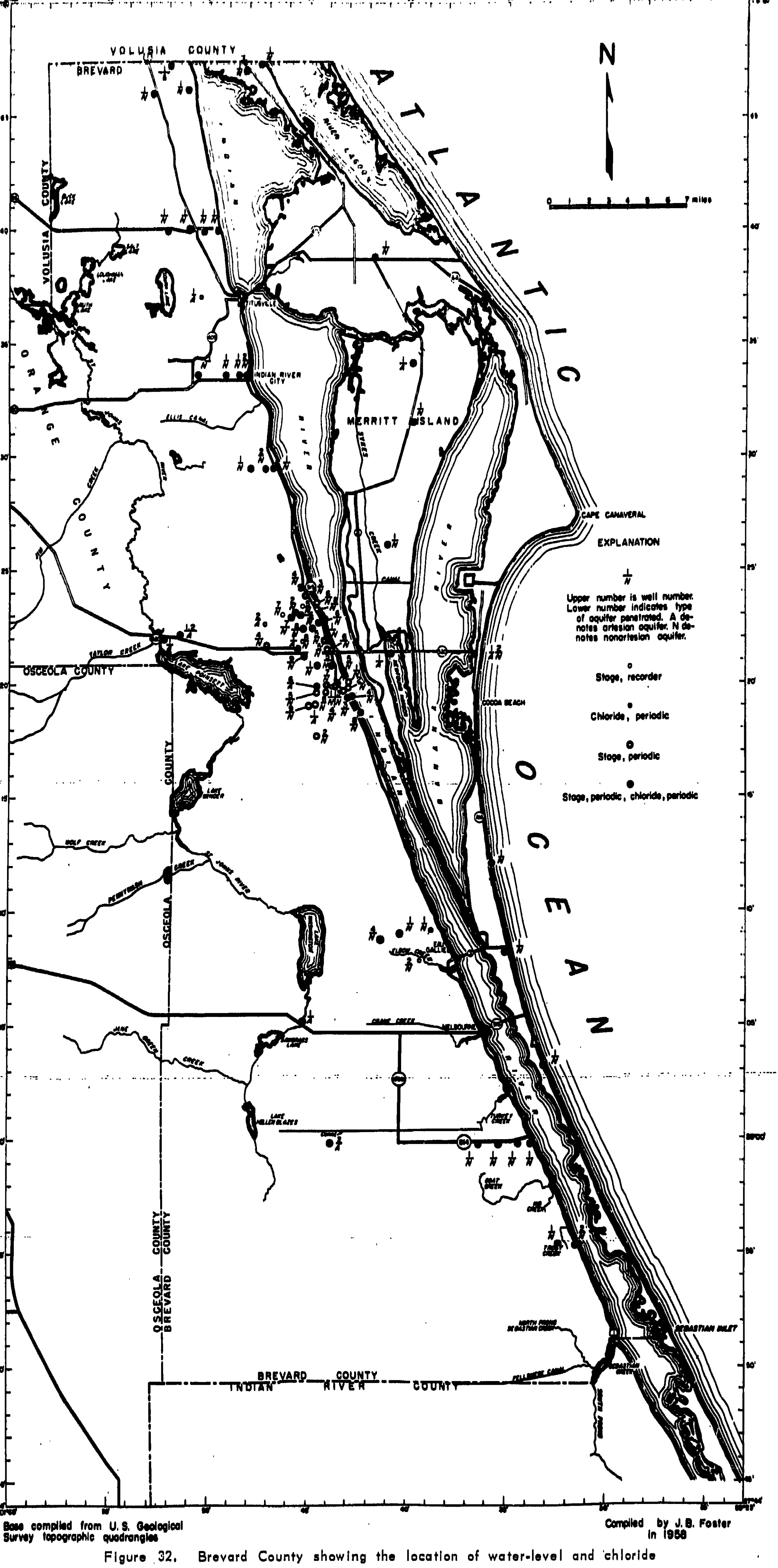

Figure 32. Brevard County showing the location of water-level and chloride observation wells.

The direction of flow within an aquifer is shown by the configuration of the piezometric contours. Water moves from a contour of higher altitude to one of lower altitude in a direction nearly perpendicular to the contour.

In Brevard County, wells used to prepare the piezometric maps were selected to give an optimum areal distribution. In the northeast and northwest parts of the county the poor chemical quality of the artesian water has restricted its utilization. Consequently, there were few wells in which water-level measurements could be obtained. The depth of each well into the Floridan aquifer was not a critical factor in the selection of the well as a control point because variation in the depth the wells penetrate the aquifer makes little or no difference in the artesian pressure. It was necessary to select wells with water-tight casings so that none of the artesian pressure would be lost through leaks in the casing.

Three maps (fig. 34, 35, 36) of the piezometric surface were compiled to show the piezometric surface under different seasonal conditions and weather conditions. The maps represent conditions during the following periods: January 1957, a period of low artesian pressure (fig. 34); July 1957, a period of average artesian pressure (fig. 35); February 1958, a period of high artesian pressure (fig. 36).

The piezometric surface in February 1958 was more than 45 feet above sea level in the southwestern part of the county and sloped to less than 10 feet above sea level in the northeast part of the county. As shown in figure 14, ground-water movement in the Floridan aquifer is eastward or northeastward in the adjacent counties of Osceola, Orange, and Seminole. In Brevard County, the direction of flow shifts from eastward in the southern part of the county to northeastward in the central part of the county. In the area west of Indian River from Rockledge to Mims, the direction of ground-water movement is northeastward, but on the barrier islands north of Cocoa Beach, the direction shifts from northward to Cocoa Beach, to northwestward at Cape Canaveral, and to nearly westward at the northern end of Merritt Island.

The direction of ground-water movement in Brevard County changes near the Osceola-Brevard county boundary and along Indian River in the northern half of the county. The fault (fig. 9) in the formations of the Floridan aquifer in the western part of the county probably causes the eastward moving water in Osceola County to move northeastward in Brevard County. In the northern half of the county the water moves northeastward in the area west of Indian River and northwestward in the area east of Indian River. The change in direction of water movement in the area near Indian River is probably caused by upward leakage of water from the artesian aquifer.

Depressions in the piezometric surface reveal areas in which water was being discharged from the aquifer; either by natural outlets, such as springs or upward leakage through the confining bed or by manmade features, such as wells. The biggest depression, and hence the area of greatest discharge, is in the northeastern part of the county. Inasmuch as there is a relatively small number of wells in this area the depression is probably the result of natural discharge of large quantities of water from springs or upward leakage through the confining beds.

The small depression at the north end of Lake Poinsett indicates that artesian water is probably being discharged by upward leakage into the St. Johns River, where the confining beds are thin. There are several shallow depressions in the area south of Eau Gallie that are probably the result of the withdrawal of water by the many wells in the area.

A comparison of the piezometric surfaces in October 1947 (fig. 37), as shown by Neill (1955), and in February 1958 (fig. 36), shows a decline of 5 feet in the piezometric surface in the county. The decline may be attributed to an increased use of ground water during the past 10 years and drought conditions during 1954-56.

AREAS OF FLOW

Wherever the piezometric surface stands higher than the land surface, artesian wells will flow. The areas of flowing and nonflowing artesian wells are shown on figure 34. This figure shows that artesian wells flow in all but a small part of the county. The area in which artesian wells do not flow is in the Atlantic Coastal Ridge from Cocoa northward into Volusia County. During periods of dry weather, as in 1956, the artesian pressure dropped to 1 or 2 feet above land surface in the area along the high ridge of the city of Eau Gallie and consequently reduced the yield of the wells in this area.

The approximate water level to be expected in a well can be determined by a comparison of the altitude of land surface at the well site with the altitude of the piezometric surface. If the piezometric surface (fig. 34-37) is above the land surface (fig. 3), the well will flow and the artesian pressure (in feet of head) will be approximately the difference in feet between the two surfaces. A well will not flow where the land surface is above the piezometric surface. In this case the difference in feet between the two surfaces will give the approximate depth to water below land surface in a well penetrating the artesian aquifer.

RECHARGE

In central Florida the Floridan aquifer receives much of its recharge in Polk and surrounding counties. One of the most conspicuous features of the

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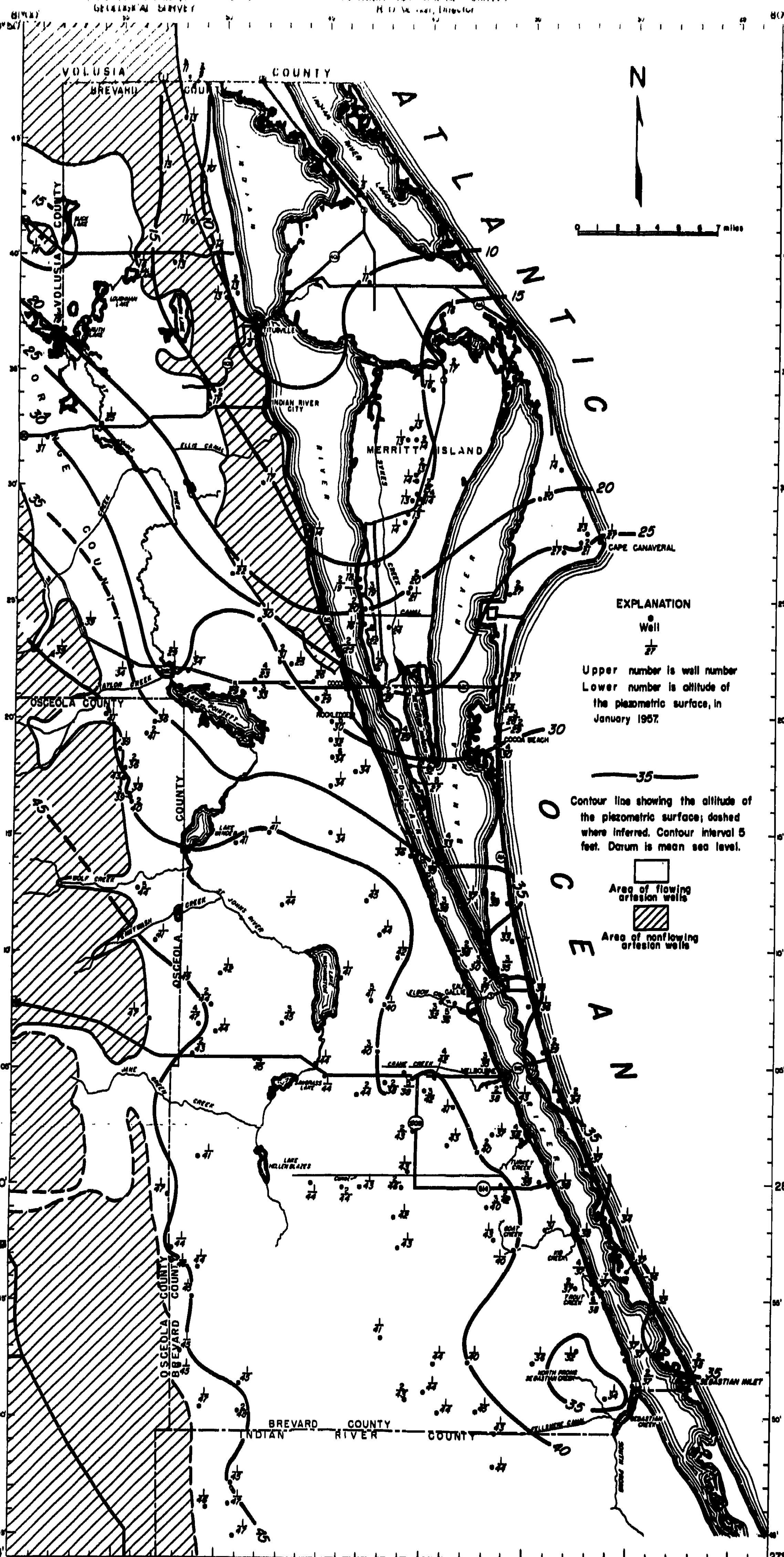
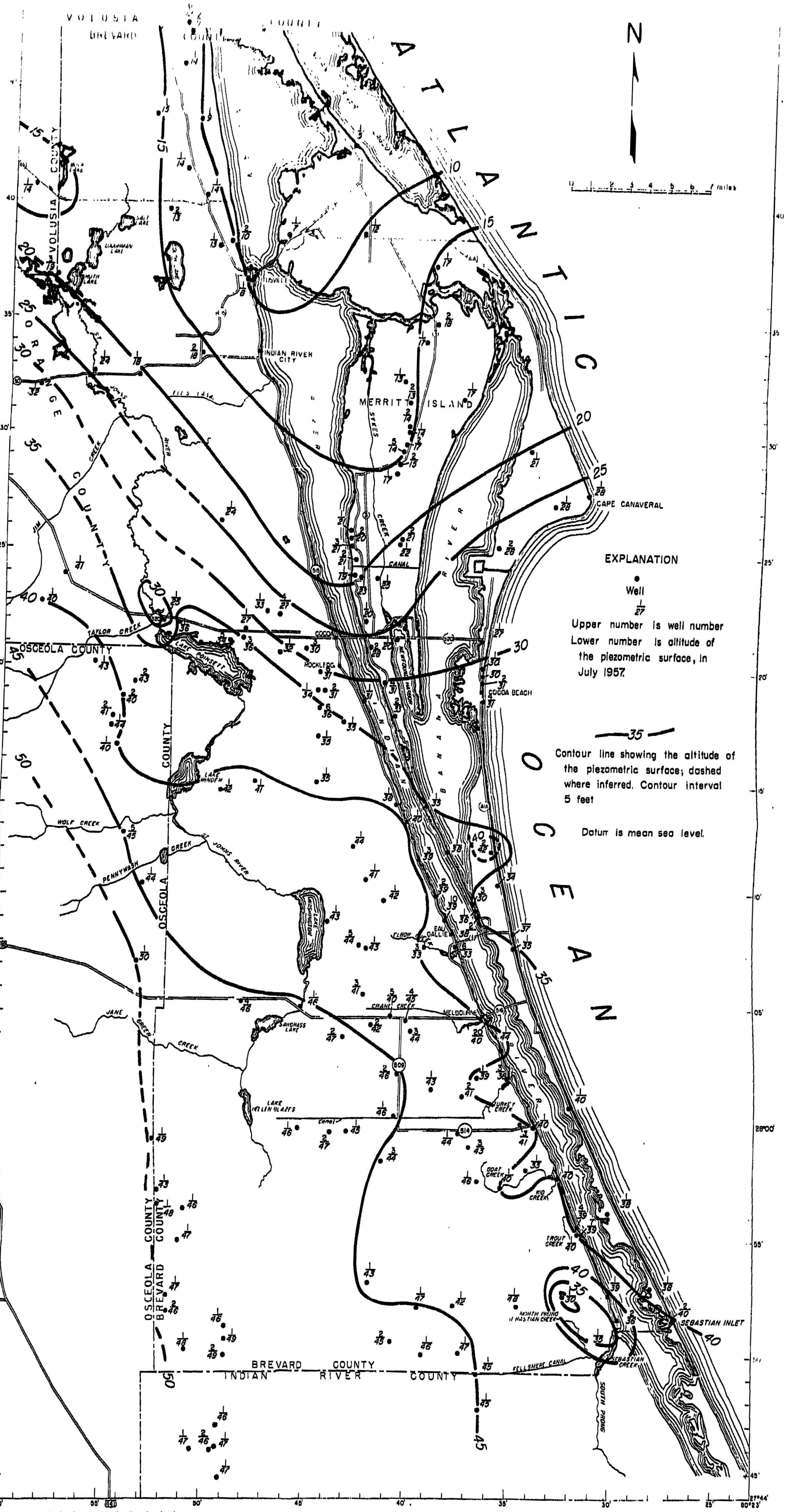


Base compiled from U. S. Geological Survey topographic quadrangles.

Hydrology by J. B. Foster in 1958

Figure 34. Brevard County showing generalized contours on the piezometric surface of the Floridan aquifer and flowing and nonflowing areas in January 1957.



Base compiled from U. S. Geological Survey topographic quadrangles.

Hydrology by J. B. Foster in 1958

Figure 35. Brevard County showing generalized contours on the piezometric surface of the Floridan aquifer in July 1957.

piezometric surface of Florida (fig. 14) is the dome centered in Polk County, which indicates that considerable recharge enters the aquifer in this area (Stringfield, 1936, p. 148).

In Brevard County an area of local recharge has been defined in the Atlantic Coastal Ridge north of Indian River City. The area has been delineated largely on the basis of the chemical quality of the water and the relationship of water levels in the artesian and nonartesian aquifers. Water samples from wells penetrating the top of the Floridan aquifer in the local recharge area had chloride concentrations of less than 100 ppm, while water from artesian wells both east and west of the recharge area had chloride concentrations ranging from 850 to 13,300 ppm.

A comparison of the piezometric contours and the water table (fig. 35, 41) in the Mims area shows the water table to be 12.5 feet higher than the piezometric surface in the center of the recharge area. Thus, fresh water from the nonartesian aquifer moves downward into the artesian zone and has developed a zone of fresh water in the upper part of the artesian aquifer. Spicer (1947) made resistivity studies in the vicinity of Mims along State Highway 46, and drew a cross section showing the top of the water of high chloride content to be 125 feet below land surface in the highest part of the ridge. This is also confirmed by wells in the same general area that penetrate the aquifer to depths of 128 and 132 feet below land surface and produce water with chloride concentrations of less than 100 ppm.

DISCHARGE

Discharge of water from the Floridan aquifer in Brevard County is by: (1) wells, (2) upward leakage into the nonartesian aquifer, (3) springs and seeps, and (4) ground-water underflow out of the county.

Ground water is discharged by flowing wells in all of Brevard County except in a small area in the Atlantic Coastal Ridge where wells do not flow at the surface (fig. 34).

The area of highest yielding wells in the artesian aquifer is bordered on the north by Lake Poinsett, on the south by Lake Washington, on the west by Lake Winder, and on the east by Indian River. The yield and depth of the wells in the area are shown in figure 38. There are 8-inch diameter wells, 125 to 225 feet deep, which flow at a rate of about 3,000 gpm (gallons per minute) and other 8-inch diameter wells within the area as deep as 600 feet that have yielded from 550 to 1,000 gpm. The wells with high yields are apparently penetrating zones in the top of the limestone of Eocene Age that contain solution cavities.

There are a few turbine pumps used to boost the natural flow of artesian water for municipal and industrial supplies. In areas of nonflow or where the artesian pressure above land surface is low, portable centrifugal pumps are used for irrigation of groves and the flooding of tide lands for mosquito abatement. Small jet pumps are used to supply water from the nonflowing artesian wells in the Atlantic Coastal Ridge for domestic or commercial purposes.

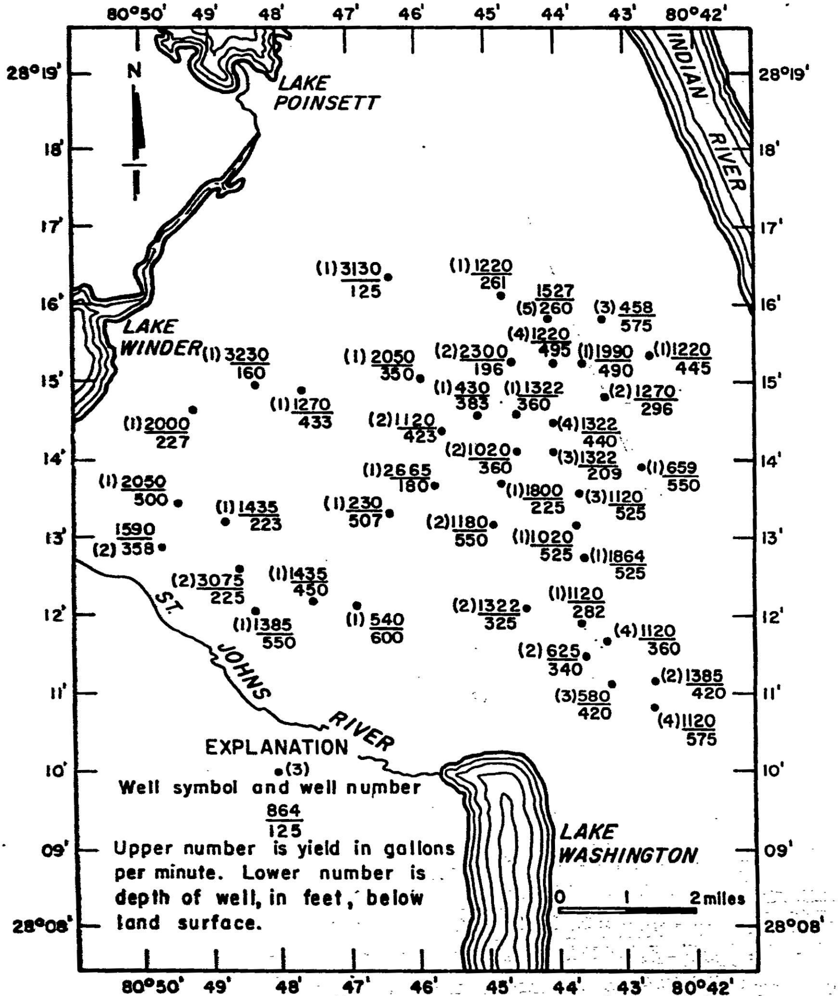


Figure 38. The central part of Brevard County showing well yield and well depth.

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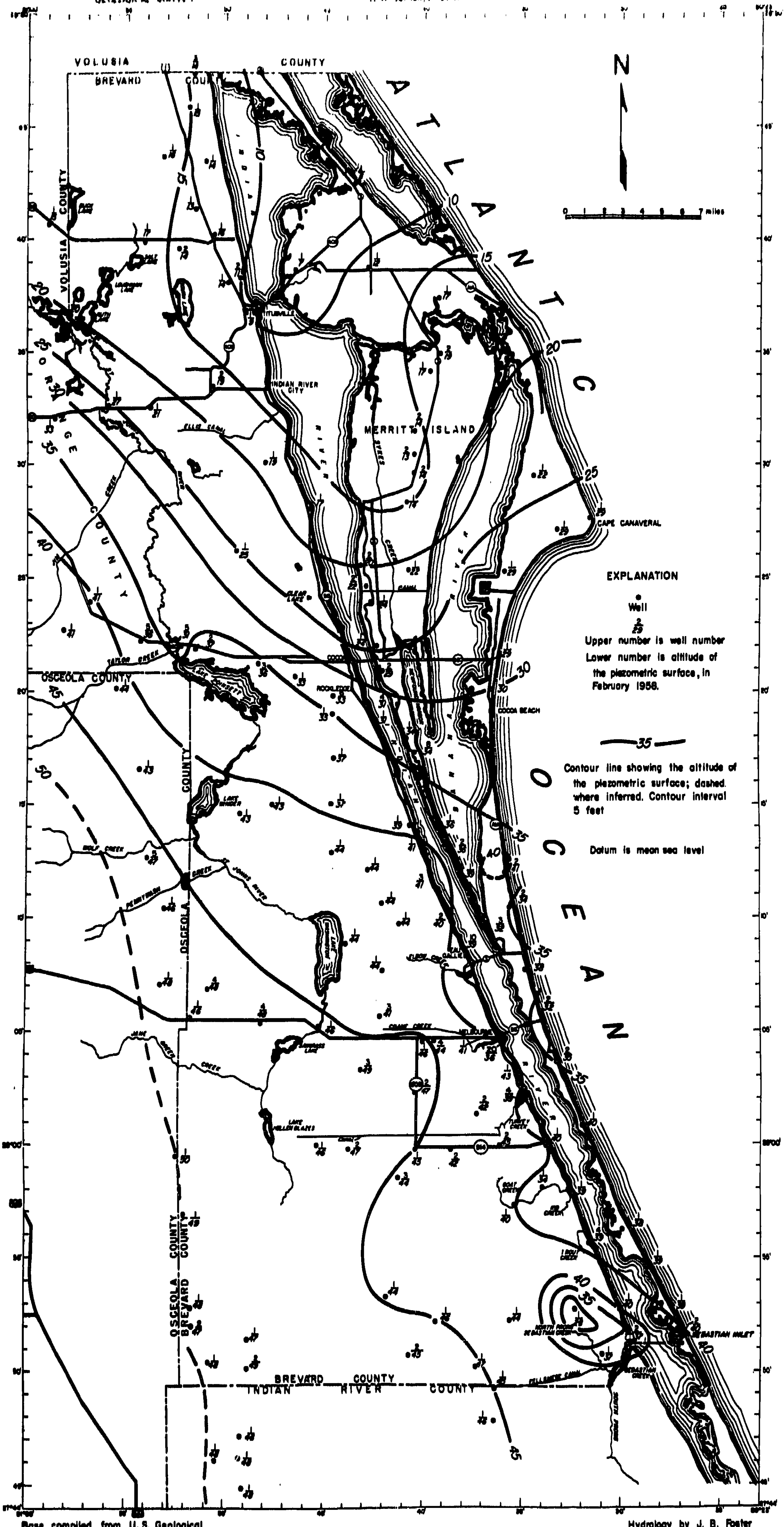

Base compiled from U. S. Geological Survey topographic quadrangles.

Hydrology by J. B. Foster in 1958

Figure 36. Brevard County showing generalized contours on the piezometric surface of the Floridan aquifer in February 1958.

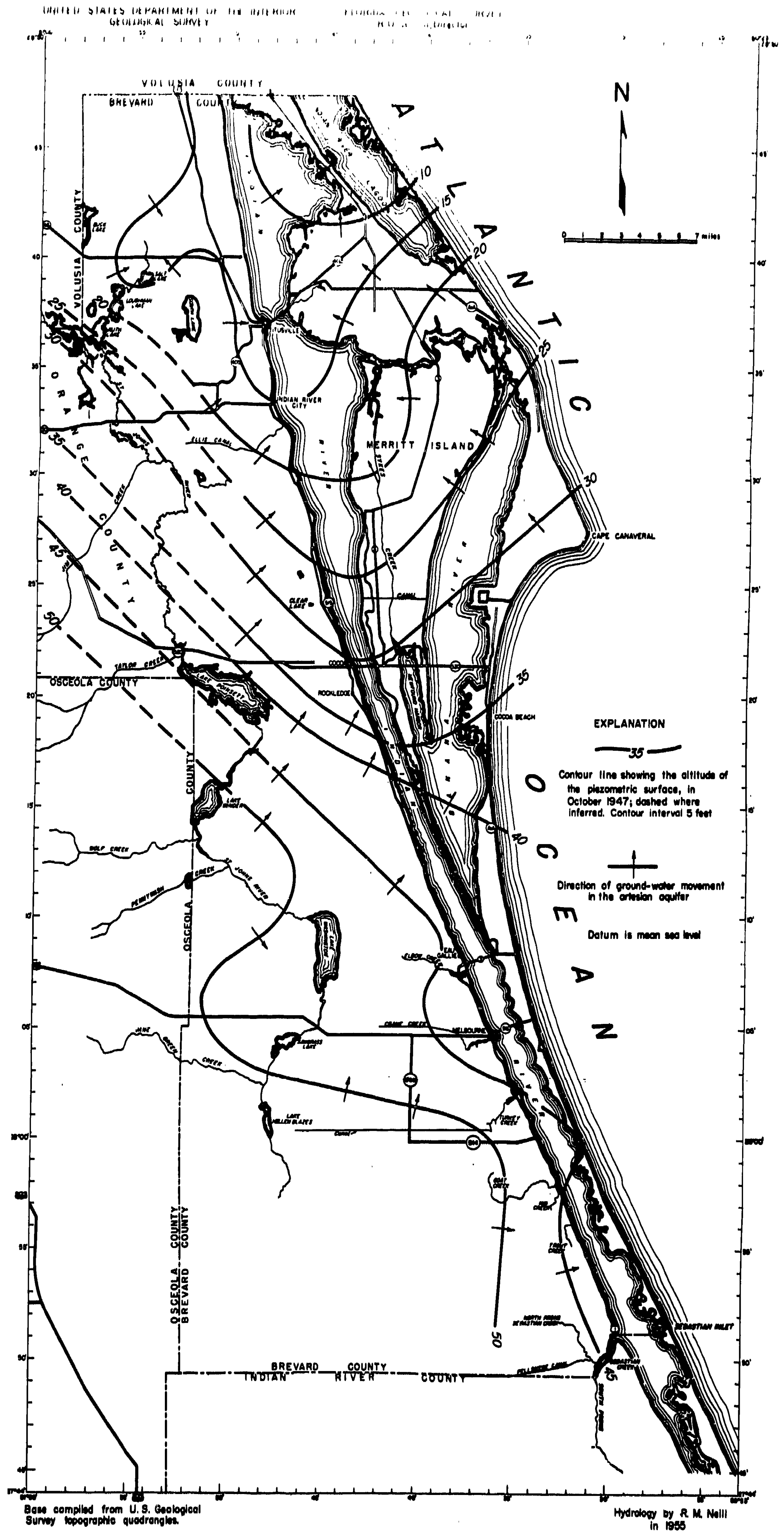

Figure 37. Brevard County showing generalized contours on the piezometric surface of the Floridan aquifer in October 1947.

Depressions in the piezometric surface in the northeast part of the county and north of Lake Poinsett indicate that large quantities of water are being discharged from the aquifer. These depressions are probably the result of natural discharge from the aquifer by springs or seeps. Small seeps or springs have been reported by local residents along the St. Johns River and they are referred to locally as "soup doodles" or "salt boils." The water from these seeps is reported to have a very salty taste. The salty water would indicate upward leakage of artesian water from the Floridan aquifer. Two large submarine springs have been reported off the coast of Brevard County, one is about 20 miles east of Eau Gallie and the other is northeast of Cape Canaveral.

IRRIGATION SUPPLIES

During the past few years several thousand acres of the St. Johns River valley between Lake Poinsett and the Indian River County line have been cleared and diked off for improved pasture. Artesian wells have been drilled in the area to irrigate the pastures during the periods of low rainfall. A network of canals and smaller ditches has been constructed to control the water for these pastures. When properly planned, installed, and maintained such systems provide drainage during the rainy season and irrigation ditches for the distribution of water from the flowing wells in periods of low rainfall. The irrigation wells are usually located on the highest land to be irrigated and the water is distributed by gravity through the system of main ditches and field laterals.

Subirrigation is used extensively in Brevard County by raising or lowering the water level in the ditches surrounding the irrigated field. The water table is maintained in dry seasons by flooding the ditches with water from artesian wells. Water is maintained in the field laterals until the water table rises to within 12 inches of the surface, then the wells are shut off and the water table is allowed to recede by plant transpiration, evaporation, and downward percolation to 24 inches below land surface. When the water table is at a depth of 24 inches the wells are turned on again and the procedure is repeated.

The minimum amount of water in addition to precipitation required for efficient operation of the system is about 7.5 gpm per acre irrigated, if the system is operated for 24 hours a day (Renfro, 1955, p. 278). One acre requires about 11,000 gpd for optimum grass growth.

The major citrus growing areas in the county are along Indian River from the south edge of the city of Rockledge to the Volusia County line and on Merritt Island. In these areas artesian water with as much as 1,800 to 2,000 ppm of chloride is used for subirrigation. Some groves have been badly burned and in some cases killed by over irrigation with salty artesian water.

HYDROLOGIC PROPERTIES OF ARTESIAN AQUIFER

The rate of movement of ground water is determined by the size, shape, number, and degree of interconnection of the interstices in the formation; the density and viscosity of the water; and the hydraulic gradient. The capacity of a water-bearing material to transmit water under a hydraulic gradient is known as permeability or transmissibility.

The coefficient of transmissibility, which is a measure of the capacity of an aquifer to transmit water, is the quantity of water in gallons per day that will move through a vertical section of the aquifer 1 foot wide under a hydraulic gradient of 1 foot per foot. The coefficient of storage, which is a measure of the capacity of an aquifer to store water, is defined by the U. S. Geological Survey as the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

Pumping tests: In order to determine the coefficient of transmissibility and the coefficient of storage for the artesian aquifer, a pumping test was made using five wells located northeast of Scottsmoor. Wells 847-051-1, 847-051-2, 847-051-3, and 847-051-5 were used as observation wells and well 847-051-4 was used as the discharge well. An orifice was installed on the discharge pipe of well 847-051-4 to measure the volume of flow during the test. Well 847-051-4 was turned on at 1:15 p.m. on January 15, 1958, and the flow was adjusted to 90 gpm. During the test the drawdowns in the four observation wells were recorded by water-level recorders. The flowing well was shut off after 24 hours and the water-level recovery was measured by the water-level recorders for 24 hours.

The water-level record from well 822-047-2, west of Cocoa, was used to correct the drawdowns in the test wells for seasonal trend and barometric effect. The corrected drawdowns for the observation wells were analyzed by the Theis graphical method (Wenzel, 1942, p. 87-89) and indicates a coefficient of transmissibility of about 300,000 gpd/ft. and a storage coefficient of about 8.0×10^{-4} for the upper part of the artesian aquifer.

SPECIFIC CAPACITY

The yield of a flowing well penetrating the Floridan aquifer is dependent on the following factors: (1) diameter of the well; (2) depth into the aquifer; (3) method of construction; (4) transmissibility of the aquifer; and (5) amount and type of well development. Specific capacity is a term

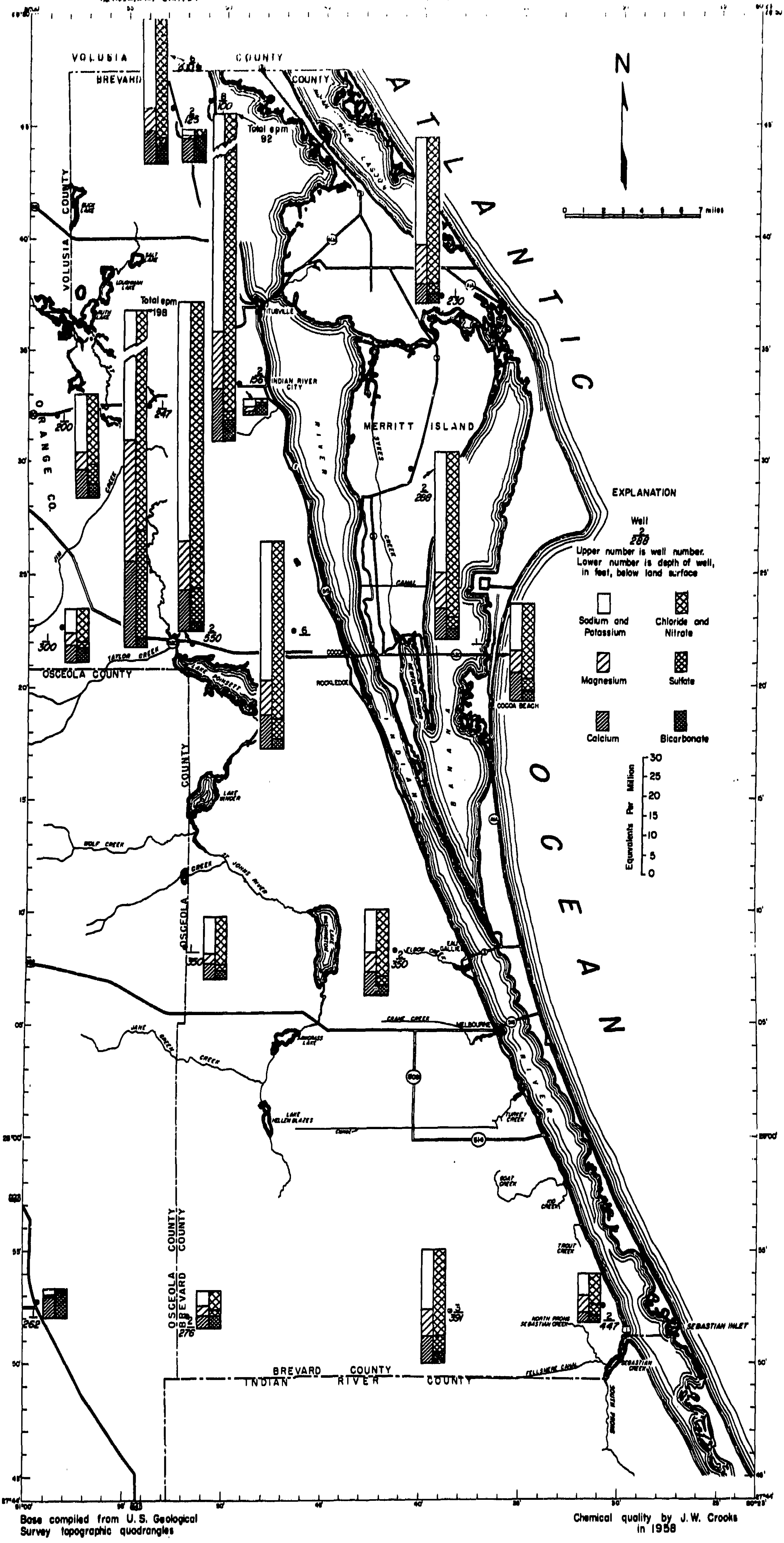

Figure 39. Brevard County showing the chemical composition of artesian water.

generally used to indicate the productivity of a well and is defined as the amount of water, in gallons per minute, yielded for each foot of drawdown of water level in the well. The specific capacity of flowing wells is obtained by dividing the yield of the well in gallons per minute by the height of the static water level above the well outlet.

The productivity of 165 wells in Brevard County was compared by computing the specific capacity of the wells. A summary of the specific capacities is shown in table 9. The specific capacities ranged from less than 1 to more

TABLE 9. Summary of Specific Capacities of Wells in the Floridan Aquifer

Well diameter (inches)	Number of wells	Specific capacity (gpm per foot of drawdown)	
		Average	Range
2	14	3.6	0.2 to 10.9
3	11	6.1	.9 to 30.0
4	32	15.9	.6 to 43.7
6	67	29.9	4.8 to 68.2
8	41	79.0	23.0 to 143.7

than 143 gpm per foot of drawdown. However, in comparing the specific capacities of wells of the same diameter the range is smaller and the average can be considered a reasonable specific capacity for a well of similar diameter in Brevard County. Generally, a well of small diameter can be expected to have a lower specific capacity than a well of larger diameter.

The transmissibility of an aquifer can be roughly approximated from specific capacity values under ideal conditions. Owing to the wide range of specific capacities, the transmissibility of the Floridan aquifer cannot be estimated from the specific capacity of the wells. The wide range in specific capacities may be due partly to differences in transmissibility and partly to differences in construction and development of the wells.

CHEMICAL QUALITY OF ARTESIAN GROUND WATER

Comprehensive chemical analyses were made of water samples collected from 77 artesian wells in Brevard County and published in Florida Geological Survey Information Circular 32. The chemical composition of artesian water in various parts of the county is shown on a map by bar graphs (fig. 39). A generalized map (fig. 40) was prepared showing the chloride concentration of water from the Floridan aquifer.

Several factors influence the chemical quality of artesian water in Brevard County. These factors include the composition of the formations that comprise the aquifer and the residual saline water found in some parts of the aquifer.

Although each formation exhibits different characteristics in composition, assortment, and transmissibility, these differences are not reflected by great variations in the chemical composition of the water in the aquifer. Increases in concentration of chemical constituents in the water occur as a result of prolonged contact between the water and the geologic formations. Thus, water from the artesian aquifer in Brevard County is higher in mineral content than water in the same aquifer in Polk County, the principal recharge area for the aquifer. Variations in composition of the water may occur where faults have obstructed the flow of ground water and where there is local recharge or discharge. Local recharge will change the chemical composition of the artesian water by adding water of a different quality. An example of this is the recharge area of the Atlantic Coastal Ridge, north of Indian River City, where the chloride content of the artesian water is less than 100 ppm, while the artesian water on either side of the recharge area ranges from 850 to 13,300 ppm.

Probably the most significant influence on the quality of the artesian waters in Brevard County is the presence of residual saline waters which entered the formations at the time of the Pleistocene marine invasions. Since the last retreat of the Pleistocene sea, fresh water has been recharging the Floridan aquifer and flushing out the residual salt water. The chloride content of the artesian water is less than 1,000 ppm in the area south of Lake Poinsett and it ranges from 1,000 to 13,000 ppm in the area north of Lake Poinsett. Thus, flushing has proceeded more rapidly in the southern part than in the central or northern part of the county. In general, the chloride content of the artesian water increases toward the fault (fig. 9); that is, along the western edge of the county. For example, the chloride content of the water in the area west of the fault increases eastward from 293 to 1,120 ppm in wells 822-058-1 and 821-054-1, respectively. The chloride content of the water in the area east of the fault increases westward from 628 ppm at Cocoa Beach to 2,400 ppm in well 821-051-1 near the fault. The highly mineralized artesian water in the county north of Lake Poinsett may indicate a geologic structure north of Lake Poinsett and beneath or west of the St. Johns River. The fault apparently interferes with the normal eastward flow of water through the aquifer and has resulted in differential flushing of the aquifer in the area. Test wells were drilled in an east-west direction near the north end of Lake Poinsett to determine the chemical quality of the water in the Floridan aquifer. The chloride content of water from test wells 821-051-1, 822-055-1, 823-056-1, and 822-058-1 was 2,420 ppm, 925 ppm, 340 ppm, and 293 ppm, respectively.

The piezometric surface is above mean sea level in most of Brevard County and the intrusion of salt water from the Atlantic Ocean or Indian River is unlikely. However, the piezometric surface in the northeastern part

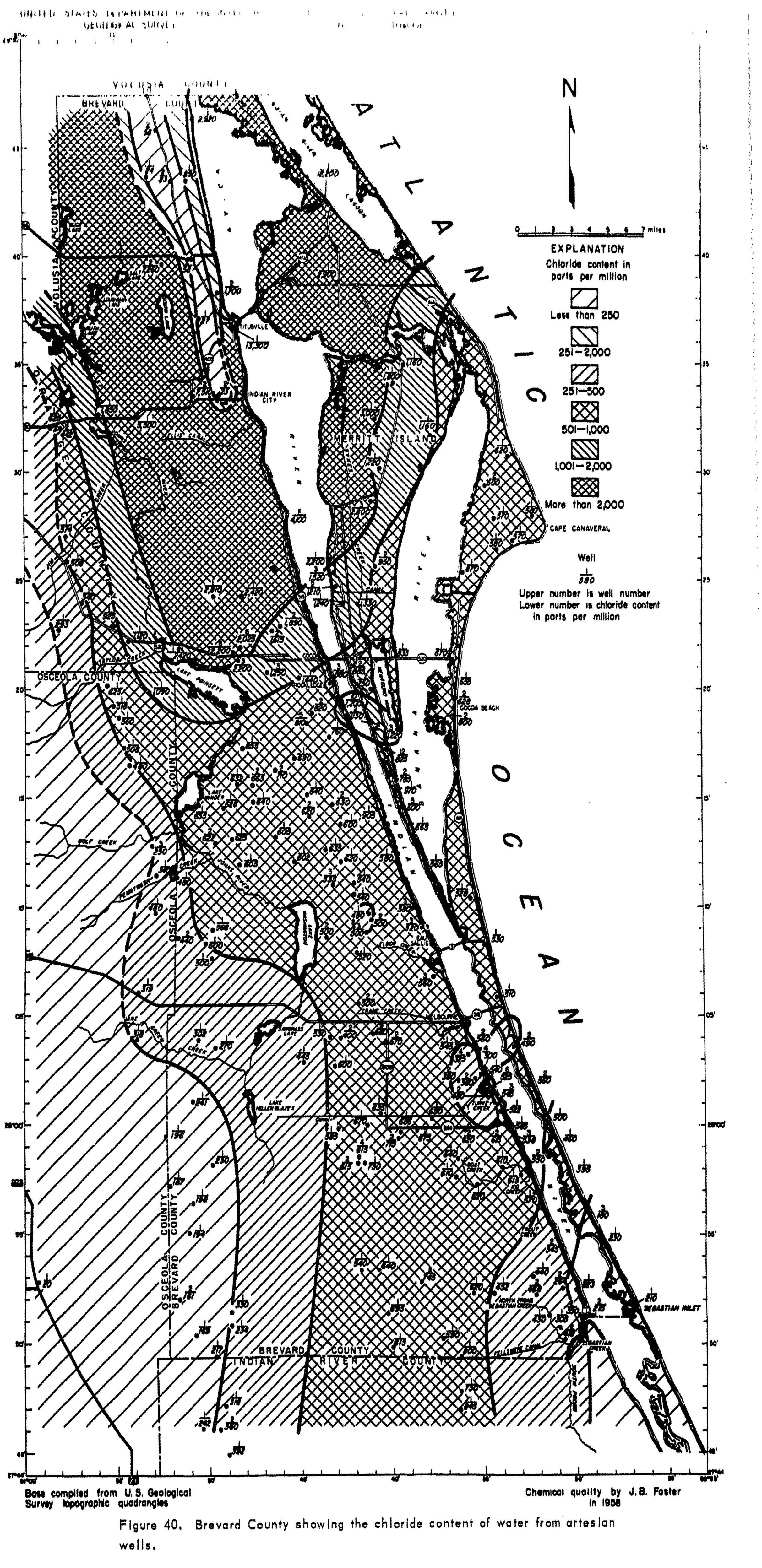

Figure 40. Brevard County showing the chloride content of water from artesian wells.

of the county is only a few feet above sea level and the saline water in the aquifer may be the result of intrusion of salt water from the Atlantic Ocean or Indian River. The chloride content of water from wells sampled during the present investigation compared closely with samples tested during the 1946-47 investigation. In the past few years there has been a large increase in the number of wells used for irrigation of pastures in the southern half of the county and there has been no indication of an increase in chloride content of the water. Well 801-035-1, about 4 miles south of Melbourne, is 1,360 feet deep and discharges at about 3,000 gpm. This well has been flowing wild since it was drilled in 1916. The chloride content of the water from this well was determined in 1947 and again in 1956 and found to be 535 ppm and 540 ppm, respectively. This would indicate that in the local area continued withdrawal from a deep artesian well does not increase the chloride content of the water.

Although there are some changes in the quality of water at various depths, these differences are not significant within the first few hundred feet of the artesian aquifer, as may be seen by the analyses of samples taken at different depths from well 822-051-1.

The concentration of ions in artesian water within Brevard County generally exceeds the maxima for domestic or industrial supply. Moderate to high concentrations of silica, sodium, chloride, sulfate, and calcium are present in most of these waters and limit the usefulness of the water. The principal uses of artesian water within the county are for irrigation and stock watering. Although the mineral content of most of the water used seems excessive for even this use, citrus production appears good even when the water contains as much as 2,000 ppm chloride. Frequent flushing of the soils by rain is perhaps the main reason that water of such high mineral content is tolerated by the crops without crop-burning.

The dissolved-solids content of the artesian water throughout most of the county exceeds the maximum recommended by the U.S. Public Health Service for a public water supply. The dissolved solids in samples from selected wells ranged from 79 to 23,000 ppm. In the local recharge area in the northern part of the county the dissolved solids in water samples did not exceed 376 ppm. Therefore, water obtained from the artesian aquifer in this area would be suitable for public and industrial supplies.

The hardness of the water from the artesian aquifer in the county exceeds most industrial standards. Water from the recharge area in the northern part of the county has a hardness of 294 ppm as calcium carbonate; it could be treated and used by industries requiring water with little or no hardness.

Artesian water in Brevard County contains only minor traces of iron. The iron concentration in water samples from wells in the county ranged from 0 to 0.09 ppm. The amount of iron in the artesian waters of Brevard County does not exceed the maximum allowable limits for the industries listed in table 5, and conforms to U.S. Public Health Service standards for drinking water.

The limestone formations of the Floridan aquifer are composed essentially of calcium carbonate with varying amounts of magnesium carbonate. Therefore, the water in the aquifer contains large amounts of calcium carbonate and magnesium carbonate. Solution of the carbonates is brought about by carbon dioxide as indicated by the following reactions:

$$CaCO_3 + H_2O + CO_2 \rightarrow Ca\ (HCO_3)_2$$
$$MgCO_3 + H_2O + CO_2 \rightarrow Mg\ (HCO_3)_2$$

The pH, which is a measure of hydrogen ion concentration in water, indicates the degree of acidity or alkalinity of the water. A solution having a pH of 7.0 is said to be neutral. Decreasing values of pH below 7.0 denote increasing acidity, and increasing values above 7.0 increasing alkalinity. Artesian waters in the county are alkaline and range in pH from 7.03 to 8.01.

Silica or silicon dioxide occurs most commonly as quartz in the earth's crust. However, quartz is only slightly soluble in water. The quantity of silica in ground water generally ranges from a few parts per million to a few tens of parts per million. In potable or irrigation water its presence is not important. However, silica contributes to the formation of the so-called "permanent" boiler scale in steam-generating units. This hard crust can be removed only with difficulty, being scarcely affected by acids and requiring vigorous mechanical treatment. The silica content of artesian water in Brevard County ranges from 2.9 to 41 ppm.

Ions of calcium and magnesium cause most of the hardness or soap-consuming capacity of water. Calcium and magnesium generally occur in ground water as carbonates or bicarbonates and less frequently as sulfates and chlorides. Ground water contaminated by sea water or which contains connate water is generally high in these constituents. The calcium and magnesium content of artesian water varies in the county. In the southern half of the county the calcium concentration ranged from 54 to 139 ppm and the magnesium concentration ranged from 6.2 to 76 ppm. In the northern half of the county the calcium and magnesium concentrations were higher; the calcium concentration ranged from 11 to 560 ppm and the magnesium concentration from 12 to 772 ppm. The water containing higher concentrations of calcium and magnesium also had higher chloride concentration which indicates that the samples were in part probably derived from sea water.

Moderate concentrations of sodium and potassium in water do not affect its suitability for public or industrial use. High concentrations of sodium are generally associated with the mineralization of water resulting from salt-water intrusion or from mixing with residual sea water in the formation. Sodium and potassium concentrations in artesian water increase from south to north in the county. Potassium content ranged from 1.7 to 102 ppm and the sodium content ranged from 14 to 6,600 ppm. Water from the recharge area in the Atlantic Coastal Ridge, north of Mims, had sodium and potassium concentrations of 32 and 1.7 ppm, respectively.

Carbon dioxide in ground water is present almost entirely as the bicarbonate radical (HCO_3) and as free carbon dioxide (CO_2), and rarely as the carbonate radical (CO_3). The bicarbonate and carbonate are often reported as alkalinity expressed as calcium carbonate ($CaCO_3$).

The bicarbonate concentration in artesian water in most of the county ranged from 130 to 180 ppm. Bicarbonate in water from the local recharge area near Titusville was as high as 404 ppm.

All natural waters generally contain some sulfate and chloride. The sulfate concentration increases rather abruptly from south to north in the county. The sulfate content of the artesian water ranged from 0.5 to 1,670 ppm. A water sample from the recharge area near Titusville had the low concentration of sulfate of only 0.5 ppm.

The chloride content of the artesian waters in the county was used to determine the extent that fresh ground water has become contaminated with sea water because about 90 percent of dissolved solids of sea water are chloride salts. Water was analyzed for chloride content from all but a few of the wells inventoried. East of the St. Johns River, in Brevard County, the chloride content generally increases from south to north and from east to west. The decrease in chloride content from the western or central part of the county to the ocean is opposite of the trend in most of the other coastal counties in Florida. In the latter counties, the chloride content of the artesian water generally increases toward the ocean.

West of the St. Johns River, in Orange and Osceola counties, the chloride content generally increases from west to east. In the southeast corner of Orange County the chloride content of the artesian water increases eastward, in about 4 miles, from 293 ppm in well 822-058-1 to 1,120 ppm in well 822-054-1. There are three areas in Brevard County where artesian water can be obtained with less than 250 ppm of chloride. They are: (1) the southwest corner of the county, (2) the southeast corner of the county, and (3) the recharge area in the Atlantic Coastal Ridge from Indian River City northward to the Volusia County line. In nearly every part of the county there are a few wells that have yielded samples of water with a chloride content higher or lower than the surrounding wells. These small irregularities are due in part to the fact that the wells are sampled during different water-level conditions and in part to the fact that some had been pumped extensively prior to sampling.

The chloride concentration of the water in the first few hundred feet of the Floridan aquifer is relatively uniform but the amount of change in the chloride content of water from the different producing zones varies from area to area in the county. Samples of water taken at 5-foot intervals in well 822-051-1 indicated that the chloride concentrations ranged from 2,000 to 2,600 ppm (fig. 8). In the area south of Rockledge, wells 200 feet deep yield water with chloride content of 640 ppm; whereas, deeper wells, 550 to 625 feet deep, yield water with a chloride content of 600 ppm. In the southern half of the county the chloride content of the artesian water changes very little with depth into the Floridan aquifer. In the northern part of the county the chloride concentration increased from 5,500 ppm at 100 feet to 6,270 ppm at 150 feet in test well 832-053-1, located 6 miles west of Indian River City. The chloride concentration increases considerably with depth into the aquifer in the recharge area along the Atlantic Coastal Ridge in the northern part of the county. Here the chloride content of water samples from the top of the aquifer ranges between 20 and 60 ppm; however, below the lens of fresh water the chloride content would probably be several thousand ppm.

Hydrogen sulfide is found in appreciable amounts in the artesian water of Brevard County. It causes a very pronounced taste and odor which has given this water the common name of "sulphur water." One water sample from well 822-051-1 contained 0.6 ppm of hydrogen sulfide. Hydrogen sulfide gas in water can be reduced by aeration but complete removal requires other treatment, including pH adjustment and chlorination.

SALT-WATER CONTAMINATION

The sediments of the Floridan aquifer were deposited in a marine environment and any water entrapped during deposition of the sediments is referred to as connate water. Saline connate water must be diluted or flushed from the aquifer before the aquifer can be utilized as a source of fresh water.

After deposition of the limestones of Eocene Age, the area emerged from the sea several times in post-Eocene time. Connate water was undoubtedly flushed from the Floridan aquifer by fresh water during these periods. However, saline water re-entered the aquifer many times during the following geologic periods when Brevard County was inundated by the sea. The alternate formation and melting of ice during the Pleistocene Epoch caused the sea level to fluctuate. During high stages of the sea during interglacial periods, sea water flooded into the aquifer and during low stages of the sea during glacial periods sea water discharged from the aquifer. Flushing of the aquifer has been in progress since the recession of the last glacier, which marked the beginning of the Recent interglacial stage. The climatic optimum of this stage during which maximum temperatures occurred is believed to have been between 4,000 to 6,000 years ago. The climatic optimum probably caused the sea to rise and cut the Silver Bluff shoreline, which is 8 to 10 feet above sea level (Parker, 1955, p. 146-147). At that time, sea water would have entered the aquifer in areas along the coast.

Contamination of the Floridan aquifer by encroachment of the ocean is possible in areas where the piezometric surface is a few feet above sea level and wherever it is below sea level. In Brevard County, the piezometric surface ranges from more than 50 feet to less than 10 feet above sea level. Salt-water encroachment possibly could occur in areas near Indian River, Banana River, Indian River Lagoon or the Atlantic Ocean where the piezometric surface is a few feet above sea level.

The chemical quality of the water from the Floridan aquifer improves from north to south in the county, possibly because of differential flushing. Such differential flushing might be due to the presence of relatively impermeable material in the Osceola low, or the north-south fault on the eastern side of the Osceola low, which would impede the eastward flow of artesian water from the central part of the state to Brevard County.

CONSTRUCTION OF ARTESIAN WELLS

Most of the wells in the county are less than 8 inches in diameter and are drilled with jet rigs. Wells 8 inches in diameter or larger are usually drilled by cable-tool methods. In general, ordinary black casing is used in the construction of wells. The casing is driven and seated on a limestone layer in the Hawthorn Formation or the Ocala Group. The material inside the casing is cleaned out and an open hole is drilled into the Floridan aquifer to a depth sufficient to produce a good supply of water. Wells in the north part of the county generally use about 80 to 85 feet of casing and are usually less than 150 feet deep. Wells in the central area of the county generally use 105 feet of casing and are usually less than 200 feet in total depth. Wells in the southern half of the county generally use 105 feet of casing and range from 300 to 500 feet in total depth.

NONARTESIAN WATER

Ground water that does not rise in wells above the level at which it is encountered in the aquifer is said to be nonartesian or unconfined. The upper surface of the zone of saturation in ordinary permeable soil or rock has been defined as the water table. The water table is not a plane surface but conforms generally to the configuration of the land surface. It contains small mounds or depressions that are due to local gain or loss of water. The water table does not remain stationary but fluctuates up and down in a manner similar to that of a water surface in a lake or reservoir.

The Pleistocene and Recent deposits are the principal deposits forming the nonartesian aquifer. There are some wells developed in the shell beds of the Hawthorn Formation. The Atlantic Coastal Ridge, which parallels the Indian River in Brevard County, forms the thickest part of the nonartesian aquifer. The nonartesian aquifer thins eastward and westward from the crest of the Atlantic Coastal Ridge. Sandy ridges that form a large part of the barrier islands are sources of nonartesian water for local residents and commercial establishments. In Brevard County the water table of the nonartesian aquifer ranges in depth from 0 to 22 feet below land surface but occurs generally at depths of less than 10 feet.

As a part of the investigation, 56 holes were augered and cased with 1¼-inch pipe and used as observation wells. The wells were located along east-west lines across the Atlantic Coastal Ridge and the lines were spaced from 6 to 12 miles apart (fig. 6). These wells were constructed to collect geologic information, to observe water-level fluctuations, and to procure water samples for chemical analysis.

SHAPE AND SLOPE OF THE WATER TABLE

The shape and slope of the water table is shown by means of water-table contours on a map of Brevard County (fig. 41). A water-table contour is a line along which all points on the water table have the same altitude. The water-table contours show the configuration of the water table in the same manner that topographic contours show the configuration of the land surface. Although the water table generally has less relief than the land surface, the configuration of the water table generally conforms to the shape of the land surface. Ground water moves downgradient at right angles to the water-table contours; thus, the contours indicate the general direction of ground-water movement, though not the rate. The rate is a function of the hydraulic gradient and the permeability of the sediments through which the water moves.

A ground-water divide is an imaginary line along each side of which the water table slopes downward and away from the line. The ground-water divide is analogous to the land divide between two drainage basins. The ground-water divide in Brevard County is shown in figure 41. This divide line generally follows the topographic high of the Atlantic Coastal Ridge.

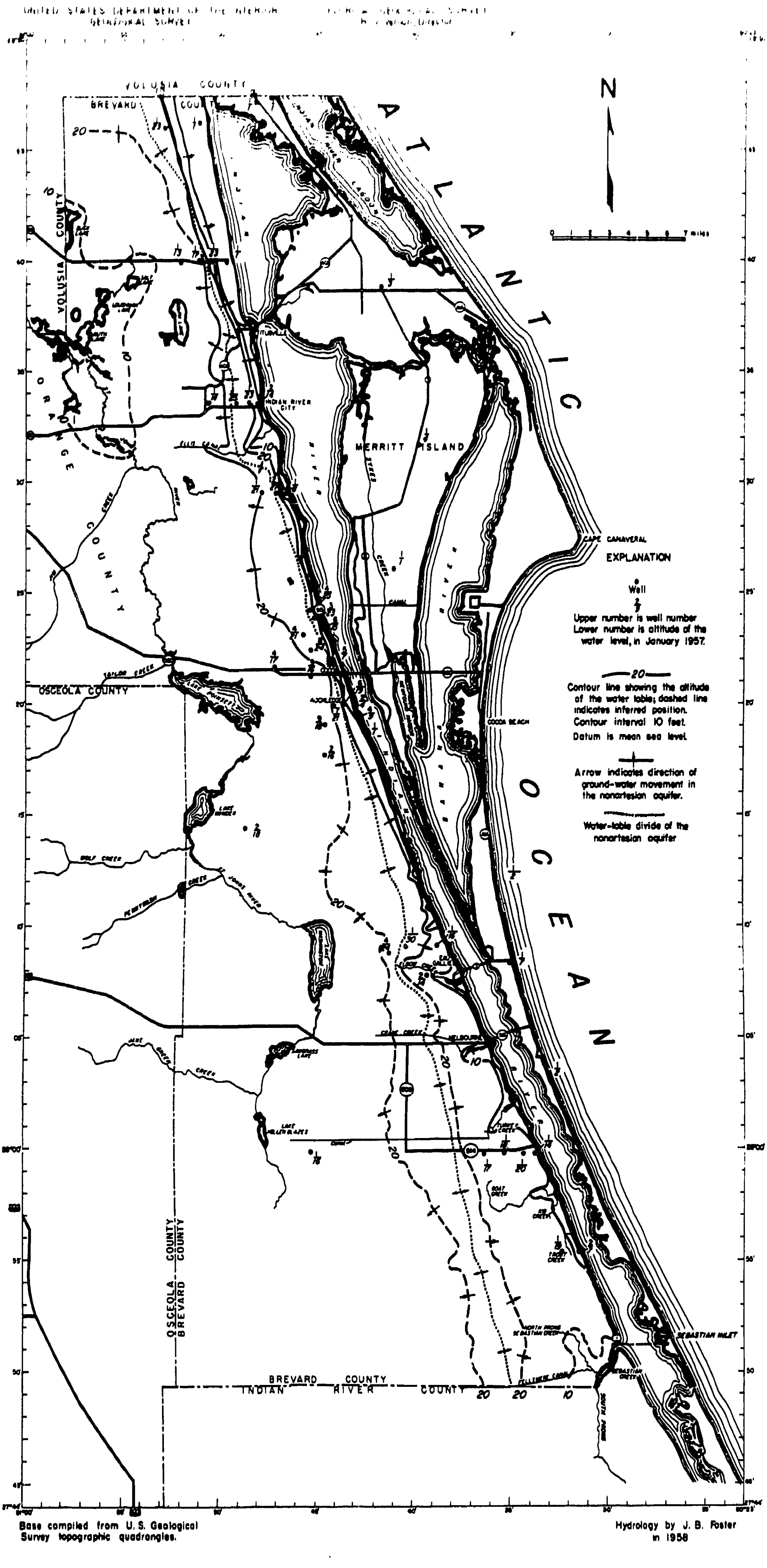

Figure 41. Brevard County showing water-table contours.

In some places where streams have cut across the Atlantic Coastal Ridge, the ground-water divide will follow around the drainage basin of the stream.

In Brevard County the ground water in the nonartesian aquifer generally moves eastward and westward, away from the divide. The gradient from the divide (center of Mims profile) eastward to the Indian River is about 20 feet to the mile (fig. 42). From the divide at Mims westward to the

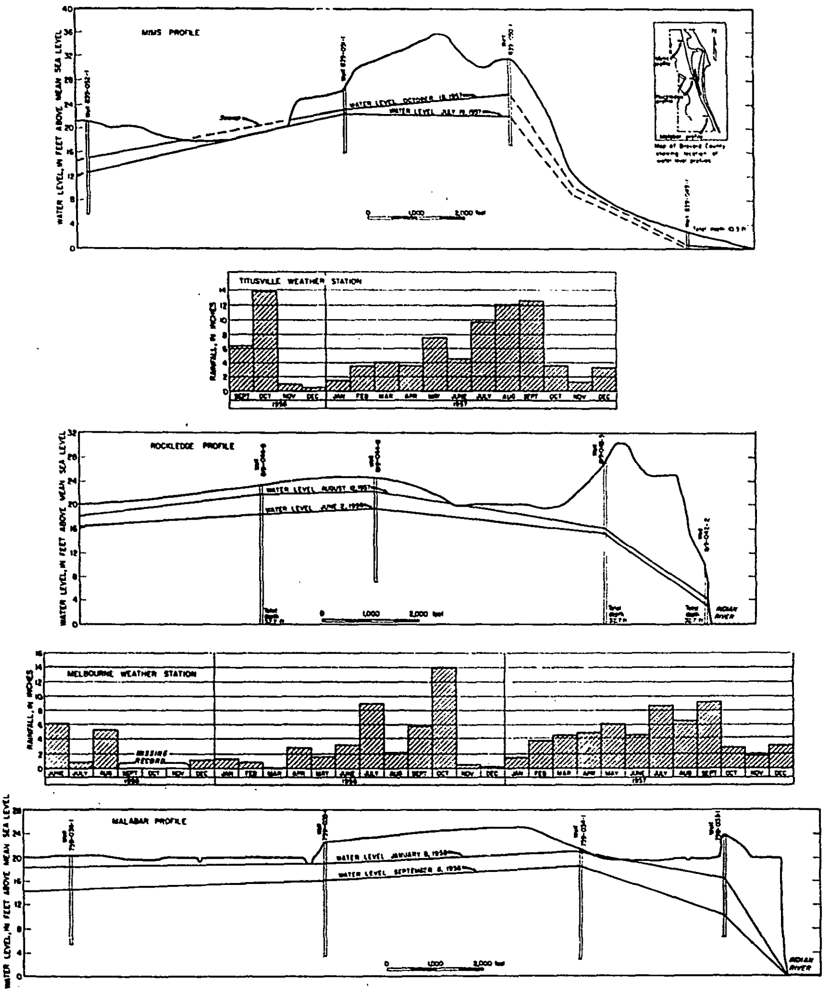

Figure 42. Water-table profiles across the Atlantic Coastal Ridge near Mims, Rockledge, and Malabar, Florida.

St. Johns River marsh, the gradient is about 4 feet to the mile. In the Cocoa-Rockledge area the gradient from the divide eastward to a point about half a mile from the Indian River is about 10 feet to the mile (fig. 42). The gradient then steepens toward Indian River, averaging about 70 feet per mile at the edge of the river. In the area south of State Highway 520, the gradient is about 10 feet per mile between the divide and the marsh of the St. Johns River. In the area north of State Highway 520, the gradient west of the divide is 20 feet per mile over a distance of about a mile, beyond which it gradually decreases westward until it is about 1 foot per mile at the edge of the marsh of the St. Johns River. In the Malabar area the gradient from the divide to within one-half mile of the Indian River is about 6 feet to the mile, figure 42; from this point to the river the gradient steepens to about 65 feet per mile. The gradient from the divide west to the St. Johns River marsh is about 1.5 feet to the mile.

FLUCTUATIONS OF WATER TABLE

The water table does not remain stationary but fluctuates in a manner similar to the water surface of a lake or reservoir. The rise and fall of the water table depends upon the amount of recharge and discharge. If the recharge exceeds the discharge the water table will rise; if the discharge exceeds recharge the water table will decline. Addition or subtraction of a given quantity of water from the water table will cause a greater fluctuation than in a reservoir of surface water because ground water occupies only the voids or interstices between the rock particles. The change in the position of the water table by the addition of a certain amount of water can be determined by using the specific yield of the particular water-bearing formation. If the specific yield for a sand formation is 25 percent, the addition of 1 foot of water to the sand will raise the water table in that material about 4 feet. Hydrographs of water levels in wells show the fluctuations of the water table, hence, show changes in the amount of water stored in the ground-water reservoir.

Factors that largely control the rise of the water table in Brevard County are (1) recharge from irrigation, (2) recharge from precipitation, and (3) recharge from artesian aquifers through leakage or surface discharge. Principal factors that control the decline of the water table in the area are (1) discharge by evapotranspiration, (2) discharge into streams and drains, and (3) discharge from wells.

During dry years the water table will decline even if there is little or no pumping from wells and during wet years the water table will rise. A decline in the water table during a dry year, therefore, does not necessarily mean that there has been an excessive withdrawal of water by wells from the ground-water reservoir, but it indicates that the discharge is greater than the recharge. A rise in the water table during wet years indicates that recharge is greater than discharge.

Fluctuations in the water table were recorded by periodic water-level measurements and by water-level recorders. Twenty-five wells, 1¼ inches in diameter, were constructed in the Cocoa area in June 1955 and monthly water-level measurements were begun at the time of installation and were carried on through the course of the investigation. An additional 31 wells, 1¼ inches in diameter, were augered in July and August 1956 and monthly water-level measurements were made in the wells until the end of field work in January 1958. Five wells, 4 inches in diameter, were drilled to install water-level recorders. The water-level fluctuations in selected wells are shown by hydrographs (fig. 43).

RECHARGE

In Brevard County rainfall is the principal means of recharge to the nonartesian aquifer. Irrigation water and upward leakage from the artesian aquifer probably contribute some recharge to the nonartesian aquifer. There is some recharge from streams when the streams are at higher levels than the water table.

In areas where the water table is near land surface the nonartesian aquifer becomes filled quickly during periods of heavy rainfall and the excess water remains on the surface or runs off in streams or rivers. The unsaturated material above the water table in the coastal ridge provides storage for water that might otherwise run off to streams and rivers.

Large areas of pasture and grove lands are subirrigated with artesian water. Some of the water that is used for irrigation percolates downward and recharges the nonartesian aquifer. Subirrigation along the coastal ridge is difficult because it requires a large volume of water to bring the water table up near the root zone of the plants. Many residents in the county use water pumped from the nonartesian aquifer for lawn irrigation.

Streams and canals recharge the nonartesian aquifer when the water surface of the streams and canals is higher than the water table. The water-table contours on figure 41 indicate that in January 1957 the nonartesian aquifer was discharging water into the streams.

The amount of water that recharges the nonartesian aquifer is determined by the intensity and duration of the precipitation; the shape of the land surface; the porosity and permeability of the soil and subsoil; and the vegetative cover.

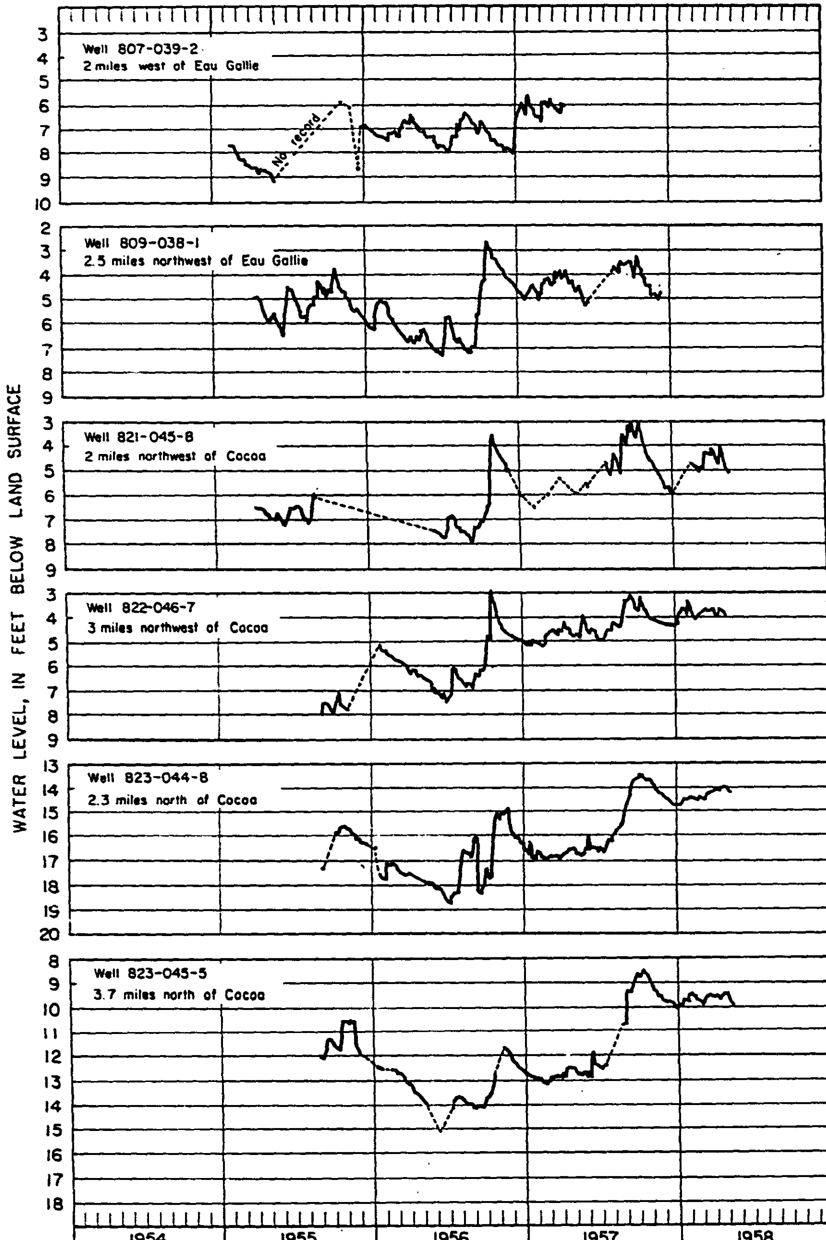

Figure 43. Hydrographs of water levels in selected nonartesian wells in Brevard County, Florida.

About 60 percent of the annual precipitation occurs as slow steady showers between June and October. However, there are occasional torrential rains, associated with tropical storms, that rapidly saturate the soil.

The slope of the land surface is an important factor in determining whether the precipitation that falls on the land surface will become runoff on the surface or will penetrate the soil and reach the ground-water reservoir. Steeper slopes, of course, are conducive to greater runoff. Streams that cross the Atlantic Coastal Ridge become flooded during heavy rains and carry large volumes of water to the Indian River. There are, however, numerous small lakes and depressions on the ridge that collect rain and allow it to percolate slowly into the nonartesian aquifer. The relatively flat valley of the St. Johns River occupies a large part of the county and during periods of heavy rain the valley is flooded and the water table stands at or above land surface.

Porosity of the soil is an important factor in the infiltration of precipitation. Infiltration of water is quite rapid through the sand that mantles most of the county.

The nonartesian aquifer receives water from the artesian aquifer by means of flowing wells—either by leakage through faulty or inadequate casing or by discharge on the surface and downward percolation. A nonartesian well near a leaky artesian well may yield water that is similar in chemical composition to the water in the underlying artesian aquifer. In areas where the artesian water is saline the leakage may seriously contaminate the nonartesian water.

DISCHARGE

Ground water may be discharged from the nonartesian aquifer by seeps, springs, wells, and ditches or other manmade structures or from the capillary fringe by evapotranspiration.

Ground water is taken from the zone of saturation or from the capillary fringe by plants and it is discharged into the atmosphere by transpiration. The depth from which plants will lift ground water varies with species of plant and type of soil but it ranges from only a few feet for ordinary grasses to 50 feet or more for certain types of desert plants. Inasmuch as the water table in Brevard County is held at or near the root zone of most plants—either naturally or artificially—during most of the year, large volumes of nonartesian water are discharged to the atmosphere by this process. The average depth to water in most of the area is less than 10 feet and may be as little as 1 foot in the stream valleys and the subirrigated areas.

Where the water table is near land surface, ground water moves upward by capillarity through the small pores in the soil to the surface and is evaporated. The rate of evaporation varies with the depth to the water table, the porosity of the soil, the climate, the season, and other factors.

Withdrawal of water from the nonartesian aquifer by wells for domestic and commercial purposes is extensive in areas not served by public water systems. Most nonartesian wells are small 1¼-inch to 2-inch sandpoint wells which produce less than 30 gpm. Titusville, Eau Gallie, and Melbourne obtain their municipal supplies from the nonartesian aquifer. However, the city of Melbourne is constructing a new water treatment plant near Lake Washington that will use water from the lake.

The base flow of the tributary streams that drain into the Indian River and the St. Johns River is maintained by ground-water discharge. During periods of heavy rain the water level in these streams sometimes rises above the water table and recharges the nonartesian aquifer.

STORAGE OF WATER IN THE NONARTESIAN AQUIFER

The quantity of water in storage under nonartesian conditions can be estimated from the specific yield. The specific yield of a rock or material with respect to water is defined by Meinzer (1923, p. 28) as the ratio of (1) the volume of water which, after being saturated, it will yield by gravity to (2) its own volume. This ratio may be stated either as a percentage or a decimal fraction. To obtain the volume of water in storage, the specific yield is multiplied by the total volume of saturated material in the area.

The specific yield of the water-bearing deposits of the central area was estimated roughly by comparing them with similar materials in other areas, for which the specific yields were known. The Pleistocene and Recent deposits are composed of fine to medium sand with very little silt and clay. Their specific yield is estimated to be about 15 percent.

In order to calculate the volume of potable nonartesian water in storage it was necessary to determine the thickness and areal extent of the material saturated with potable nonartesian water. This information was obtained by test drilling in the Pleistocene and Recent deposits and making analyses of the chloride content of water samples taken from different depths in the test holes. The base of the Pleistocene and Recent deposits and the base of the potable nonartesian water do not coincide in all areas because, in some places, the water of the nonartesian aquifer has been contaminated by saline water. For example, it is known that relatively saline artesian water has moved upward in some areas and contaminated the water in the lower part of the nonartesian aquifer. The chloride content of the nonartesian water generally increases as the depth increases, though slightly.

A chloride concentration of 250 ppm was selected to represent the base of the potable nonartesian water (fig. 11).

Calculations were made of the amount of stored potable nonartesian water in the strip of land 2 miles wide, extending northward from the southern city limits of Rockledge to the northern city limits of Cocoa. This area, called the Cocoa area, comprises approximately 9,600 acres. The sections in figure 8 were used in the calculations of the average thickness of the material that was saturated with potable nonartesian water. The volume of water in the nonartesian aquifer in the Cocoa area was determined by multiplying the specific yield of the saturated material by the area in acres and by the average thickness, in feet, of the material that was saturated with potable nonartesian water. It was calculated to be 53,000 acre-feet, or about 17 billion gallons. Not all the stored potable water is available for use, however, as the withdrawal of any large fraction of it would allow damaging encroachment of the saline water.

The amount of water being discharged into the Indian River from the nonartesian aquifer in the Cocoa area may be calculated by using the water-table gradient, permeability of the sediments, and cross-sectional area of the discharge face. These factors fit into an equation expressing Darcy's law of laminar flow, as follows:

$$Q = PIA,$$

in which Q is the rate of discharge, P is the coefficient of permeability of the material, I is the hydraulic gradient, and A is the cross-sectional area of the material through which water percolates (Wenzel, 1942, p. 2-7). For field computation, Q is usually expressed in gallons per day; P is the rate of flow of water, in gallons per day, through a cross section 1 mile wide and 1 foot thick, under a hydraulic gradient of 1 foot per mile; I is expressed in feet per mile measured in the direction of gradient; and A is expressed in feet of thickness and miles of width of the water-transmitting material.

The permeability coefficient used for the nonartesian aquifer is 300 gpd per square foot. This value is an average of the laboratory and field determinations of the permeability of the sediments in the zone of saturation.

The hydraulic gradient is obtained from the geologic cross section D-D' (fig. 11). The average gradient determined for the discharge face at Indian River is about 70 feet per mile.

The cross-sectional area of the discharge face adjacent to the Indian River is obtained by multiplying the saturated thickness of the nonartesian aquifer at the Indian River (thickness taken from cross section D-D', in fig. 11) by the distance in miles along the Indian River shoreline from the northern city limits of Cocoa to the southern city limits of Rockledge. The length of the section is 7.5 miles and the thickness is 21 feet; thus, the area is 157.5 foot-miles.

Using these figures in the equation given above, the discharge into the Indian River in the Cocoa area is computed to be about 3 mgd. This rate of discharge is computed using the water table in July 1955 and should not be interpreted as being the average discharge.

CHEMICAL QUALITY OF NONARTESIAN GROUND WATER

Analyses of water from about 70 shallow wells in Brevard County were made to determine the chloride content of the water. Samples were collected for comprehensive chemical analysis from 30 wells in the central part of the county. The locations of these wells are shown on a map of Brevard County (fig. 31), and the results of the analyses are given in Florida Geological Survey Information Circular 32.

In general, water from the nonartesian aquifer is higher in iron and color, but considerably lower in other constituents, than water from the artesian aquifer. There are exceptions to this as some nonartesian water is quite similar to the artesian water. The chemical character of the water from the nonartesian aquifer differs greatly from place to place. The hardness of the 30 samples analyzed ranged from 9 to 790 ppm, and chloride concentrations ranged from 4.0 to 1,270 ppm. The calcium content ranged from 1.3 to 162 ppm, magnesium from 1.1 to 94 ppm, and sulfate from 0 to 200 ppm. Samples containing the higher concentrations of chloride had also the higher concentrations of calcium, magnesium, and sulfate, indicating the samples were contaminated by artesian water from the underlying limestone formations. The pH of the nonartesian water samples ranged from 4.8 to 7.7. No samples contained more than 0.2 ppm of fluoride or 4.0 ppm of iron. The color exceeded 200 in 11 samples and exceeded 1,000 in 1 sample.

After treatment for color and hardness, most of the nonartesian water within the Brevard County area can be used for most purposes. There are some locations in which nonartesian wells produce water of high mineral content. In these locations, the nonartesian aquifer may have become contaminated by salt-water encroachment from the Indian River or Atlantic Ocean or by upward movement of the artesian water from the Floridan aquifer.

Where the piezometric surface of the artesian aquifer is higher than the water table of the nonartesian aquifer the relatively salty artesian water may be able to move upward through the confining beds and into the lower part of the nonartesian aquifer. The rate of this upward flow, and hence the extent of contamination in the nonartesian aquifer, depends in part on the altitude of the water table in relation to the altitude of the piezometric surface of the artesian aquifer and transmitting ability of the confining bed between the artesian and nonartesian aquifers. This is illustrated in profiles C-C' and D-D', in figure 11, which shows that the 250-ppm isochlor is depressed where the water table is high, and high where the water table is low.

The depth of the 250-ppm isochlor probably changes in response to fluctuations in the water table and piezometric surface. In the areas where the piezometric surface is higher than the water table, the 250-ppm isochlor should rise when the difference between the piezometric surface and water table is increased and decline when the difference between the two surfaces is decreased. Thus, the zone of potable nonartesian water should vary in thickness in response to fluctuations of the water table and piezometric surface.

The lowering of water levels in the nonartesian aquifer by the pumping of wells should cause the 250-ppm isochlor to move upward. Thus, the fluctuations of the water table, piezometric surface, and the 250-ppm isochlor will have to be observed closely if optimum utilization of the nonartesian aquifer is to be achieved.

Salt-water encroachment can occur in areas adjacent to salt-water bodies when the water level in the nonartesian aquifer has been lowered sufficiently by pumping or low rainfall to permit coning or upward movement of the salt water. Many wells along the Atlantic Ocean on the barrier islands became salty during the dry year of 1956 through lowering of the water table.

The chloride content of ground water is generally a reliable indication of the extent to which normally fresh ground water has become contaminated with sea water. Therefore, periodic samples for determination of chloride were collected from 51 wells during 1956 and 1957 to determine the quality of water in relation to time, location, and water-table level. Figure 44 shows these relationships. It may be seen from the figure that minor changes in water level resulted in considerable changes in chemical quality of water in some wells.

CONSTRUCTION OF WELLS

Most of the nonartesian wells in the county range from 1¼ to 2½ inches in diameter and from 10 to 40 feet in depth. A few domestic wells draw water from coquina deposits or permeable beds in the Hawthorn Formation. These wells generally range in depth from 50 to 140 feet. The screen used in these wells is open on both ends so that it may be fitted to the lower end of the casing, and a 5-foot section of casing is added below the screen. The well is constructed by driving the casing and screen until the screen is opposite a formation that can be expected to produce water of good quality and sufficient quantity. The casing is cleaned out by the jetting method to a foot or so below the screen which leaves a 3- or 4-foot plug in the casing below the screen. This plug prevents the sand or other material from being pulled up into the well when it is pumped.

The municipal supply wells for the city of Titusville are gravel-packed wells. These wells were constructed by driving 24-inch casing to the depth predetermined by test drilling for setting the screen. The casing was then cleaned out and a bronze screen on an 8-inch diameter casing was set inside of and at the bottom of the 24-inch diameter casing. The space between the 8-inch casing and the 24-inch casing was filled with gravel and then the 24-inch casing was pulled up to expose the bronze screen and gravel to the formation.

MUNICIPAL USE

Annual estimates of population in Brevard County indicate an increase of about 320 percent from 1950 to July 1959. Urbanization has been somewhat dependent upon the expansion of existing water systems and the development of new sources of water supply. Each of the four major cities of Brevard County have, during the past 5 years, either gone to new sources of water supply and improved their facilities or are in the process of doing so. Titusville, which 5 years ago distributed approximately 300,000 gpd, averaged about 1 mgd during 1957. Six new wells drilled in 1957 are 24 inches in diameter and 110 feet deep, and supply the present needs of this city and surrounding area. The rated capacity of the treatment plant is presently 1½ mgd with a finished water storage of half a million gallons. Chlorination is the only treatment of the water prior to distribution.

Cocoa has shown the greatest proportionate increase in population of any city in the county or state. Providing an adequate water supply has been one of the greatest problems in the development of that city. Prior to August 1957, water was obtained from Clear Lake and adjacent surface-water supplies. Increased withdrawal from these sources caused increased mineralization to the extent that, even after treatment, the delivered water often contained chloride and dissolved solids in excess of desirable concentrations. A new well field was developed about 18 miles west of Cocoa in Orange County and began operation in August 1957. Distribution of water for this city has increased from less than 1 mgd of a year ago to approximately 6 mgd in 1958. The rated capacity of the treatment plant is 12 mgd with a storage capacity of 1½ million gallons of raw water and 1½ million

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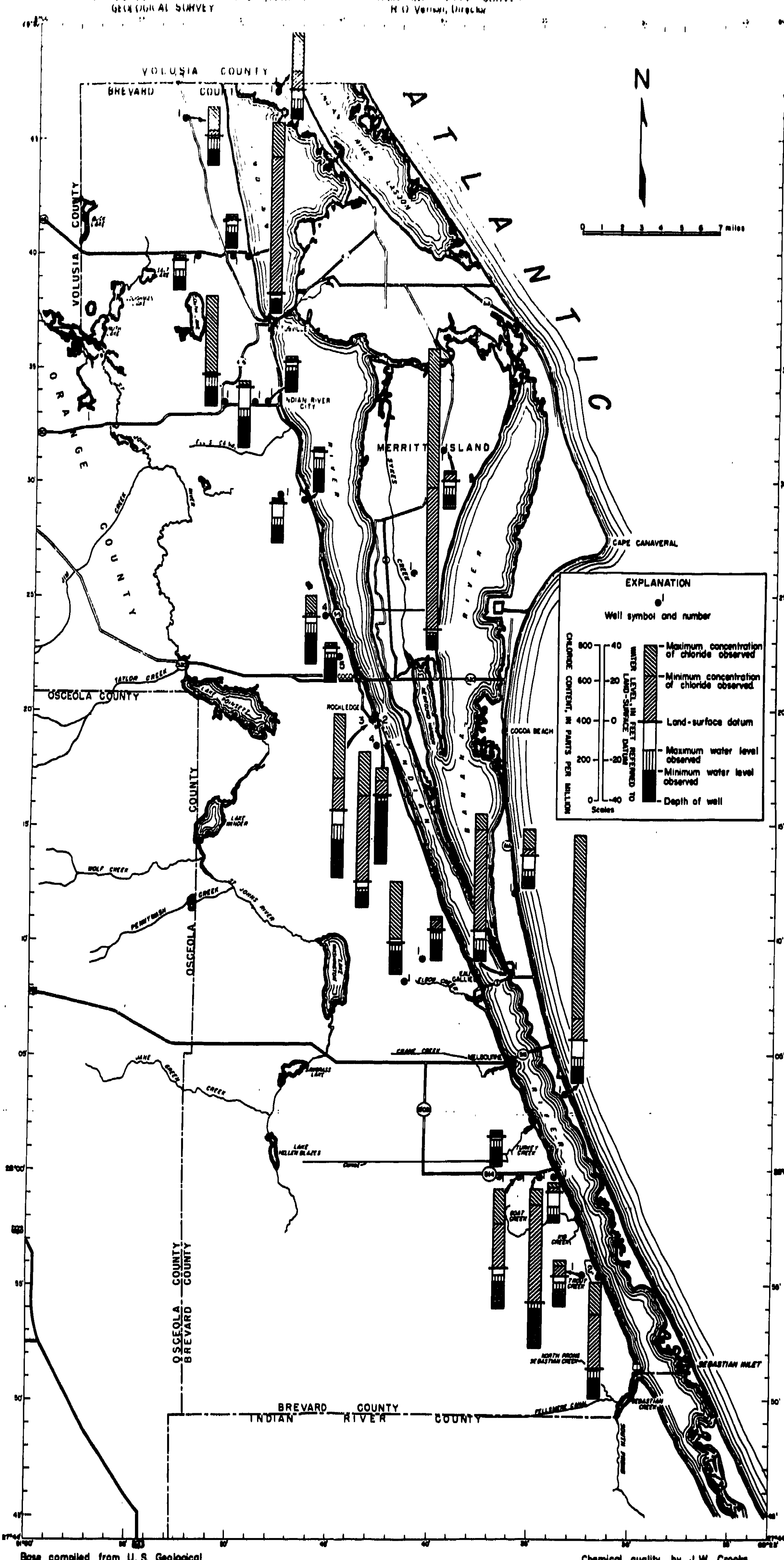

Figure 44. Brevard County showing variations in chloride content and water level of nonartesian water.

gallons of finished water. The treatment provided by the plant is chlorination, aeration, softening, and fluoridation.

The current supply at Eau Gallie is obtained from seven nonartesian wells that are 40 to 60 feet deep, and from one artesian well that provides approximately 50 percent of the delivered water. Distribution of treated water has increased from 286,000 gpd in June 1956 to 933,000 gpd in June 1958. The rated capacity of the treatment plant is 400,000 gpd with a storage capacity of 450,000 gallons of finished water. Treatment of the water prior to distribution consists of chlorination and softening.

The municipal water supply for Melbourne is obtained currently from shallow wells located west of the city in the coastal ridge. The tremendous increase in population has created demands for water almost beyond the capacity of the treatment plant. The city has work underway to obtain water from Lake Washington. The capacity of the treatment plant will be increased to 10 mgd. The current capacity of the treatment plant is approximately 1 mgd with a storage capacity of finished water of 750,000 gallons. Current treatment is chlorination, aeration, and softening.

Results of analysis of samples of raw water and treated supplies are shown in table 10.

FUTURE PROGRAM

As part of its program to evaluate the natural resources of the nation, the U.S. Geological Survey will continue to collect water-resource data in Brevard County in cooperation with local agencies. The objectives of the continuing program will be to provide day-to-day data for the evaluation of available water supplies and the prediction of trends in stream discharge, stream and lake levels, and to provide ground-water levels that will indicate the probable status of important water supplies in the future. These data will aid in appraising the magnitude and frequency of floods and droughts and will furnish information for use in basic research. Furthermore, the long-term continuous records of stream discharge, lake and stream stages, and ground-water levels will serve as a framework to which many short-term records collected during an intensive investigation may be related.

The continuing water-resource observation stations in Brevard County are shown on figure 45. The observation of water levels in the nonartesian and artesian aquifers will be by measuring periodically the water level in five wells and the operation of automatic water-level recording instruments in five wells. Artesian pressures in the artesian aquifer in Brevard County will be observed in the five wells measured periodically and in one well equipped with a water-level recording instrument. Water levels in the

TABLE 10. Analyses of Raw and Treated Water from the Municipal Supplies of Titusville, Cocoa, Eau Gallie, and Melbourne

	Titusville, Florida		Cocoa, Florida		Eau Gallie, Florida		Melbourne, Florida	
	8-13-58		8-12-58		8-13-58		8-13-58	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Silica (SiO_2)	15	13	23	22	13	13	14	15
Iron (Fe)	.01	.00	.01	.05	.01	.01	.02	.01
Calcium (Ca)	30	36	138	124	116	122	126	83
Magnesium (Mg)	.7	1.7	9.8	20	15	8.6	.9	8.5
Sodium (Na)	14	12	75	74	74	77	28	54
Potassium (K)	1.0	.8	3.0	2.9	2.2	2.4	.6	1.7
Bicarbonate (HCO_3)	88	112	294	290	270	240	344	190
Sulfate (SO_4)	3.5	3.0	115	115	50	50	22	32
Chloride (Cl)	20	17	125	135	165	185	55	114
Fluoride (F)	.3	.2	.3	.4	.3	.3	.2	.3
Nitrate (NO_3)	.1	.3	.0	.1	.1	.0	.0	.0
Dissolved Solids	138	142	672	695	692	721	466	494
Hardness as $CaCO_3$								
Total	78	97	385	392	351	340	318	242
Noncarbonate	61	5	144	154	130	144	36	86
Color	5	3	22	17	17	10	30	22
pH	7.2	7.5	7.5	7.6	7.5	7.4	7.5	7.5
Specific conductance (micromhos at 25° C.)	230	241	1,040	1,040	1,020	1,030	711	721

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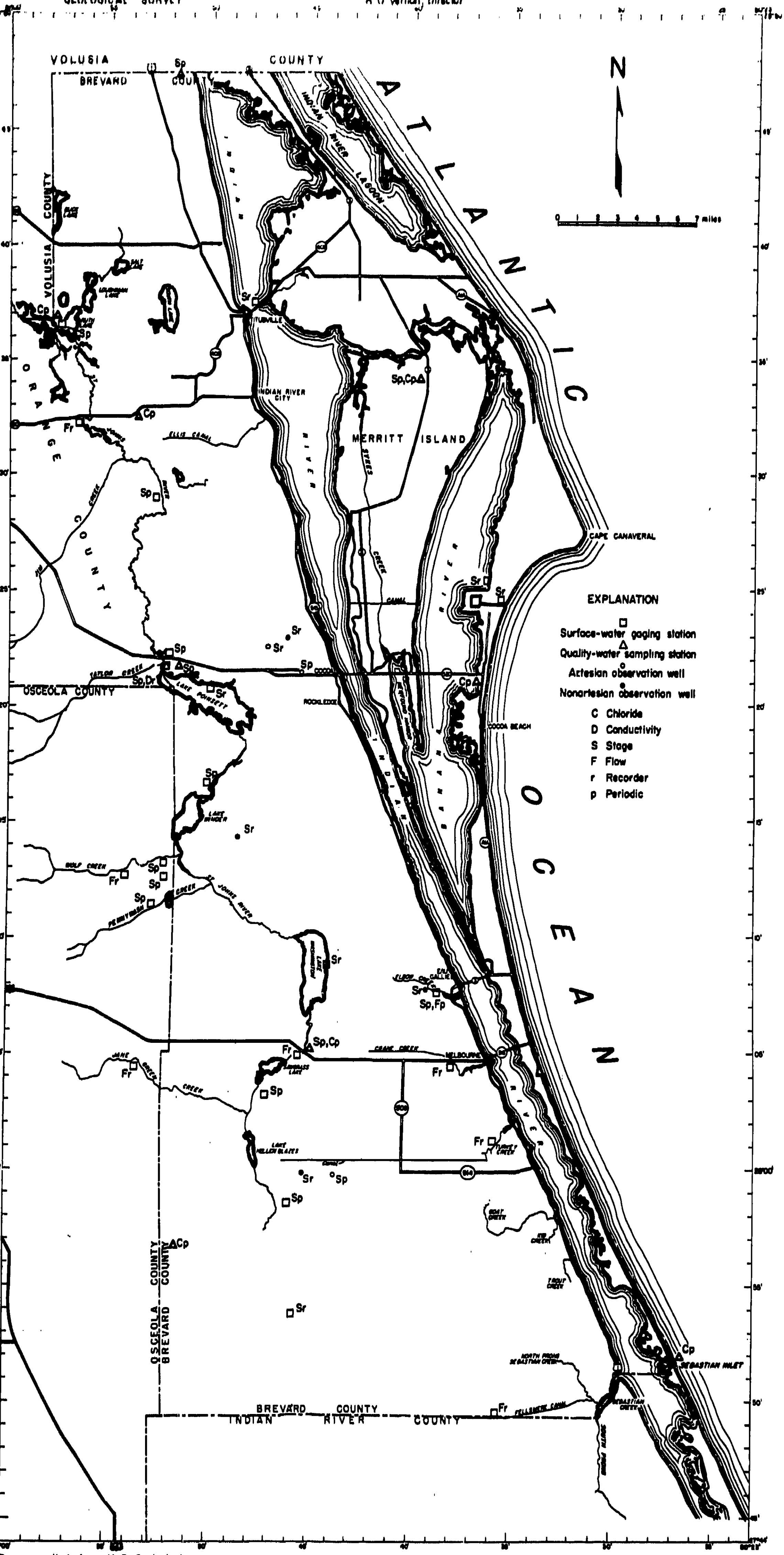

Base compiled from U. S. Geological Survey topographic quadrangles.

Compiled by D.W. Brown in 1958

Figure 45. Brevard County showing the location of permanent water-resource observation stations.

nonartesian aquifer in the St. Johns River valley will be observed in four wells equipped with water-level recording instruments.

Although there was a necessary reduction in the number of lake and stream-gaging stations at the close of the intensive investigation, the stations that were deemed most desirable were continued in operation to provide basic coverage of a long-term nature. The continued operation of these stations will not only enhance the value of past records but will provide up-to-date information. They consist of daily flow stations on the St. Johns River near Melbourne and near Christmas, on Jane Green Creek, Wolf Creek, Crane Creek, Turkey Creek, and Fellsmere Canal; and daily stage stations on the St. Johns headwaters near Kenansville and Vero Beach, on the St. Johns River near Geneva on Lakes Poinsett and Washington, and on the Indian River at Wabasso. Nine crest-stage gages will be operated on the St. Johns River. A periodic flow-measurement station and crest-stage gage will be operated on Elbow Creek.

The investigation of the quality of surface and ground waters in Brevard County was essentially completed in September 1958. However, semiannual samples for chloride determinations will be collected from 10 artesian wells in the county. In addition, a continuous conductivity recorder will be operated at the station on the St. Johns River near Cocoa. Periodic samples will be collected at this station for analysis so that correlations can be made between the conductivity and dissolved solids.

SUMMARY AND CONCLUSIONS

Large quantities of surface water are available at many places in Brevard County. The St. Johns River, throughout its length in the county, constitutes a potential source of water for municipal, industrial, and agricultural supplies. The average discharge of the river at the Christmas gaging station (State Highway 50) for the period 1934 to 1957 was 1,360 cfs, or 878 mgd, and at the Melbourne station for the period 1940-57 was 800 cfs or 517 mgd. The St. Johns River flows through several large lakes which are natural reservoirs that have large storage capacities. The amounts of water in storage in the lakes at their lowest stages during the period of record were as follows: Lake Hellen Blazes, 650 million gallons; Sawgrass Lake, 650 million gallons; Lake Washington, 3,200 million gallons; Lake Winder, 1,080 million gallons; and Lake Poinsett, 1,660 million gallons. A storage-duration curve for Lake Poinsett indicates that for 50 percent of the time of record the lake contained at least 9.5 billion gallons of water.

The analyses of water from the St. Johns River show that the river is low in mineral content but rather high in color at the source area. The hardness, chloride content, and dissolved solids generally increase downstream from the source. The greatest increase in concentration was downstream from Lake Poinsett.

The maximum and minimum chloride concentration observed at the Lake Poinsett outlet during the period December 1952-September 1958 was 403 and 21 ppm, respectively. Analyses of water from various points in Lake Poinsett indicate that the chloride content of water from the northeastern part of the lake generally is higher than that from the southwestern part. The high chloride concentrations in the northeast part are attributed to surface-water drainage from adjacent areas that are irrigated with water from artesian wells, and possibly to upward leakage from the artesian aquifer.

The streams that flow eastward out of the Atlantic Coastal Ridge in the Indian River continue to flow even during periods of low rainfall. The analyses of water from these streams indicate that several offer promise for water-supply development.

The source of the largest supplies of ground water in Brevard County is the Floridan aquifer, which is composed of limestone formations of Eocene Age and permeable beds in the basal part of the Hawthorn Formation, of Miocene Age. The top of the aquifer is about 75 feet below sea level in the northwestern part of the county and more than 300 feet below sea level in the southeastern part. Artesian water under the mainland of Brevard County flows northeastward, except in the area south of Melbourne where it flows almost directly east. On Merritt Island and the other barrier islands it flows northwestward in the area north of Cocoa Beach, northeastward in the area between Cocoa Beach and Melbourne, and directly east in the area south of Melbourne. The piezometric surface in Brevard County has declined about 5 feet during the period 1947-57.

The chloride content of water from the Floridan aquifer in Brevard County ranged from 32 to 14,500 ppm. In general, the quality of the artesian water is unsuitable for public drinking supplies, except in a small area in the southeastern corner of the county, in two small local areas of recharge near Titusville, and west of the St. Johns River.

The Floridan aquifer is the principal source of water for agricultural purposes in the county. In areas of the county where the quality is not objectionable or where suitable water is not available, it is utilized for domestic supplies.

The zone of potable nonartesian water in Pleistocene and Recent sediments has an average thickness of about 40 feet under the Atlantic Coastal Ridge but is thinner toward the St. Johns and Indian rivers. Ground-water flow in the nonartesian aquifer is generally east and west from the water-table divide, which is parallel to and 0.5 to 1.5 miles west of Indian River.

A ground-water mound exists northwest of Cocoa and southeast of Clear Lake, and the water-table contours indicate that ground water from this mound feeds into Clear Lake. The volume of potable water stored in the nonartesian aquifer in the area extending northward from the southern city limits of Rockledge to the northern city limits of Cocoa and inland 2 miles from the Indian River is estimated at 17,000 million gallons, only a part of which could be withdrawn without inducing encroachment of saline water. The ground-water discharge from the nonartesian aquifer into the Indian River along this section is about 3 mgd. Relatively salty water from the artesian aquifer flows upward into the lower part of the nonartesian aquifer in some places where the water table is lower than the piezometric surface.

The quality of the nonartesian water is generally superior to that of the artesian water. The high chloride content and hardness of samples of nonartesian water are due at least in part to contamination by upward-flowing artesian water. The chemical composition of water from the nonartesian aquifer is such that the water after treatment for iron, color, and hardness, is suitable generally for all purposes. The nonartesian aquifer in the Atlantic Coastal Ridge is the source of supply for several municipalities and hundreds of privately owned wells.

The development of any large water supply from the nonartesian aquifer should be undertaken with the understanding that a lowering of the water table will cause an increase in the upward flow of artesian water into the nonartesian aquifer where such flow is occurring, or cause such a flow to begin in areas where the flow is now downward.

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