STATE OF FLORIDA
DEPARTMENT OF NATURAL RESOURCES
Harmon Shields, *Executive Director*

DIVISION OF RESOURCE MANAGEMENT
Charles M. Sanders, *Director*

BUREAU OF GEOLOGY
Charles W. Hendry, Jr., *Chief*

REPORT OF INVESTIGATIONS NO. 78

APPRAISAL OF THE WATER RESOURCES OF CHARLOTTE COUNTY, FLORIDA

By
H. Sutcliffe, Jr.

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
and the
BUREAU OF GEOLOGY
FLORIDA DEPARTMENT OF NATURAL RESOURCES

Tallahassee, Florida
1975

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DEPARTMENT
OF
NATURAL RESOURCES

LETTER OF TRANSMITTAL

Bureau of Geology
Tallahassee
August 28, 1975

Governor Reubin O'D. Askew, Chairman
Florida Department of Natural Resources
Tallahassee, FL 32304

Dear Governor Askew:

The Bureau of Geology of the Division of Resource Management, Florida Department of Natural Resources, is publishing as its Report of Investigations No. 78, a study, "Appraisal of the Water Resources of Charlotte County, Florida", by Mr. H. Sutcliffe, Jr. of the U. S. Geological Survey.

This study is to document the water resource potential in an area where substantial growth is anticipated. This type of regional study is most important to the planning of the development of the county, as it enables one to realistically anticipate the quantity and quality of the water resource which may be developed and where potential problems can be expected to occur. It is hoped this type of study will be of substantial benefit to those persons and agencies responsible for the conservation of the resource.

Respectfully yours,

Charles W. Hendry, Jr., *Chief*
Bureau of Geology

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May 7, 1975
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Florida Department of Natural Resources
Division of Resource Management
Bureau of Geology

Tallahassee
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APPRAISAL OF THE WATER RESOURCES OF CHARLOTTE COUNTY, FLORIDA

By

H. Sutcliffe, Jr.

ABSTRACT

The coastal area of Charlotte County, in west-central Florida, is undergoing rapid urbanization and is experiencing major problems in obtaining sufficient water of suitable quality to meet public-supply requirements. The relatively flat county is drained by two major streams, the Myakka and Peace Rivers, and many small streams and canals. Neither of the major streams is used for water supply. Although the average rainfall is 54 inches per year, the low-flow characteristics are such that little or no flow will occur in most streams for as much as 30 consecutive days on the average once every 20 years. The chemical quality of water in most of the streams and canals is suitable for use by public water supplies. However, most favorable reservoir sites are already in use.

The rock units underlying the county range in age from Holocene to Eocene and contain a water-table aquifer and five artesian aquifers. The water-table aquifer contains permeable sand and shell beds, which extend 20 to 50 feet below land surface. In the western part of the county, the transmissivity of the aquifer is about 1,880 ft^2 per day (feet squared per day). In the eastern part where the aquifer contains highly permeable shell beds, the transmissivity may exceed 6,680 ft^2 per day, and wells tapping the aquifer may yield as much as 600 gpm (gallons per minute). The water-table aquifer is a source of water supply for the Cape Haze and Gasparilla Island water systems.

The upper artesian aquifer, or Zone 1, lies 50 to 150 feet below land surface. This zone is commonly used as a source for domestic and small irrigation supplies and provides some water for public supplies. A few wells tapping this zone yield as much as 400 gpm although most yield about 30 gpm. In western Charlotte County, the dissolved-solids concentration of water in Zone 1 ranges from 500 to 5,000 milligrams per liter. In the eastern part, it is less than 500 milligrams per liter.

Zone 2 lies 150 to 250 feet below land surface. Many wells that penetrate this zone also are open to Zone 1. Zone 2 is used extensively by irrigators in eastern Charlotte County, and 6-inch wells finished in this zone commonly yield more than 400 gpm. In some areas the wells flow. Water from this zone is usually more saline than water from Zone 1.

Zone 3 lies 250 to 400 feet below land surface. Most wells finished in this zone also are open to Zones 1 and 2. Irrigation wells that tap this zone flow as much as 500 gpm, and the water level in many wells can rise about 30 feet above land surface Many unused irrigation wells tapping this zone are being plugged by land developers to prevent the movement of saline water (5000 milligrams per liter of dissolved solids) from Zone 3 into the upper zones. Use of the water from Zone 3 is limited to flood irrigation.

Zone 4 lies 600 to 800 feet below land surface. Most wells drilled into this zone are open to all zones above and flow as much as 500 to 600 gpm. The water level in this zone may rise 30 feet or more above land surface. The water from this zone is more saline than water from the upper zones.

In the western half of the county, the shallow aquifer has been intruded by salt water from the Gulf and the estuaries and from deeper zones. The intrusion from deeper zones results from a combination of well-construction methods and naturally occurring differences in water levels—the water levels in the deeper zones being higher than those in the shallow zones. The salt-water intrusion from deeper zones can be lessened by changing well-construction methods and by plugging abandoned wells and holes.

Large water supplies for Charlotte County will be obtained in the future chiefly from: (1) the water-table aquifer in the southeastern part where permeable shell beds can yield as much as 600 gpm of potable water; (2) Zones 1 and 2 where they have not been contaminated by saline water; (3) desalted ground water; and (4) water imported from outside the county.

INTRODUCTION

Charlotte County has experienced a major increase in population during the last decade, 1960-70, and growth probably will continue during the next decade at a comparable or increased rate. Principal among the problems resulting from growth is the need for water of acceptable quality in adequate quantity.

Shallow surface-water reservoirs provide most of the public water supplies in the populated coastal area of Charlotte County. However, they are generally inadequate and unsatisfactory. Nearly 60 percent of the annual rainfall occurs from June through September, providing more runoff than can be stored in the reservoirs. In contrast, during extended periods of little or no rain, from September through June, withdrawals may nearly exceed the combined inflow and the storage capacity of the reservoirs. Also, the warm year-round climate fosters lush growth of aquatic plants and weeds which rapidly clog drainage ways and reservoirs and create taste and odor problems in the supplies.

Ground water is used as a source of supply in the inland area and is used locally for public supply along the coast. Salt-water intrusion is a problem in developing ground water for public supply. Before the 1930's, water meeting the State's standards for drinking water was probably available all along the coast. Construction of tidewater canals and other waterways has resulted in the lowering of groundwater levels in some areas and the intrusion of salt water into the shallow aquifers in other areas. This intrusion has made parts of these aquifers unsuitable as a source of drinking water. In the western half of the county, saline water from deep zones has moved upward in well bores and has intruded fresh-water zones in the shallow aquifers.

PURPOSE AND SCOPE

This 3-year cooperative investigation was begun in 1967 by the U. S. Geological Survey at the request of the Southwest Florida Water Management District as part of their continuing program of water-resources investigations within the Management District. The purpose of the investigation was to provide a generalized description of the hydrology of Charlotte County and to identify the major hydrologic problems of the county; particularly with respect to use of ground and surface water for public supply. Because most of the available surface-water resources in the County had already been developed, emphasis was placed on evaluating the ground-water resources. This report summarizes the findings of the investigation.

METHODS OF INVESTIGATION

Information on the flow and water quality of major streams was obtained from the existing basic records network in the area. Water samples were obtained from most of the wells inventoried, and specific conductance, chloride, and sulfate concentration of the samples were determined in the field. Water samples were collected from the public supplies for more complete analyses by the U. S. Geological Survey.

Geophysical logs including electric, gamma ray, and caliper, were obtained from about 50 wells, and rock cuttings from about 60 wells were studied and described. Seven observation wells were drilled, and information on the changes in water level and chemical quality of distinct water-bearing zones were obtained. Eighteen test holes were augured using hollow stem to determine the depth to water-bearing limestone and shell beds and to obtain information on the quantity and quality of water available from the surficial clastic sediments. Thirteen of these test holes were also used as observation wells.

PREVIOUS INVESTIGATIONS

Matson and Sanford (1913) and Sellards and Gunter (1913) were the first to describe the ground-water resources of a part of Charlotte County. Stringfield (1936) included information on Charlotte County in his study of the principal artesian aquifer in Florida. Parker and Cooke (1944) discussed the relation of the geology and water resources of the County to those of southern Florida. Additional references to the geology of Charlotte County were made by Cooke (1945), MacNeil (1950) and Parker and others (1955). DuBar (1958a, 1958b, 1962, 1968) reported on the Neogene stratigraphy and biostratigraphy of the general area.

Specific information on the hydrology of the county was given by Toler (1967) who provided information on the fluoride concentration of ground and surface water; by Kaufman and Dion (1967, 1968) who summarized the ground water resource data available in 1967 and the chemical quality of water in the Floridan aquifer; by Flippo and Joyner (1968) who described the low-flow conditions of some of the streams; and by Sutcliffe and Joyner (1968) who presented the results of test drilling.

ACKNOWLEDGMENTS

Particular recognition is given C. R. Sproul, geologist, formerly with the Florida Bureau of Geology, and H. J. Woodard, geologist, Florida Bureau of Water Resources, for their assistance in geophysical logging and interpretation of these logs. Jimmy Miller located many of the old wells in the area and failthfully collected well cuttings from many of the wells he drilled. Bennet and Bishop, Consulting Engineers, furnished data on tests made on production wells in the Cape Haze and Gasparilla Island well fields. The Humble, Mobil, and Chevron Oil Companies graciously permitted the collection, inspection, and description of many sets of cuttings from test holes in the county. Appreciation is expressed to Sidney Wells, Utilities Director, General Development Corporation, the Babcock Florida Corporation, the Charlotte County Commission, and many county citizens for their interest and assistance.

Appreciation also is expressed to G. G. Parker, Chief Hydrologist, Southwest Florida Water Management District, for his comments and suggestions concerning the report and to J. S. Rosenshein, U. S. Geological Survey, for his extensive revision and technical and editorial review of the report. D. H. Boggess, hydrologist, U. S. Geological Survey, provided information on the correlation of geologic formations in Lee County and assisted in interpreting many of the well cuttings.

The investigation was under the general direction of C. S. Conover, district chief for Florida and the immediate supervision of J. S. Rosenshein, subdistrict chief.

GEOGRAPHY

Charlotte County borders the Gulf Coast of southwestern Florida (fig. 1) and is the southernmost county in the Southwest Florida Water Management

District. The county has an area of 832 square miles, of which 703 are land. The shoreline is about 120 miles long but only about 12 miles fronts directly on the Gulf. The balance is frontage on the Charlotte Harbor estuary and lagoons.

DRAINAGE AND TOPOGRAPHY

The State is divided into major and subdrainage basins (Kenner, Pride, and Conover, 1967) to facilitate storage and retrieval of hydrologic information on streamflow. The streams and canals in Charlotte County contribute runoff to five of these drainage basins (fig. 2) four of which empty into Charlotte Harbor, and the fifth into the Gulf via the Caloosahatchee River which lies to the south of the investigation area. The position of the divides is somewhat arbitrary inasmuch as most of the area drains by sheet flow.

In the interior part of the county, canals have been excavated to drain agricultural land. Their excavation has not followed any general drainage plan. On the other hand, the canal system in Port Charlotte (fig. 3), typical of the urbanizing area, has been carefully planned and consists of about 26 miles of waterways. The longest of these canals is the 12-mile long Coco Plum Waterway, which can transfer water through control gates from its western end into the Big Slough Canal.

Much of Charlotte County forms a low-lying plain. The western part forms a peninsula whose altitude is generally less than 10 feet above sea level. The central part has a maximum altitude of about 40 feet, and much of the land surface slopes gently toward the south. Except for the incised drainage of Shell Creek, the eastern part forms a broad, gently-sloping, sandy, low-level plain. The plain rises for several miles from the eastern edge of Charlotte Harbor to an altitude of about 20 feet and is flat lying for the next 20 miles. The land surface reaches its highest altitude—70 feet—in the northeast corner of the county.

CLIMATE

The climate of Charlotte County is subtropical and is characterized by warm, wet summers and mild, relatively dry winters. Frost occurs in the eastern part in about three out of four winters. The dry period generally extends from November through May and the wet season from June through September. Extreme tropical disturbances such as hurricanes may cause torrential rainfall which may result in an unusually wet month.

Figure 4 shows the range in monthly temperature at Punta Gorda based on records from 1931-60 and rainfall for 1965-67 at Punta Gorda, Port Charlotte, and North Port Charlotte. Although the annual rainfall on the county

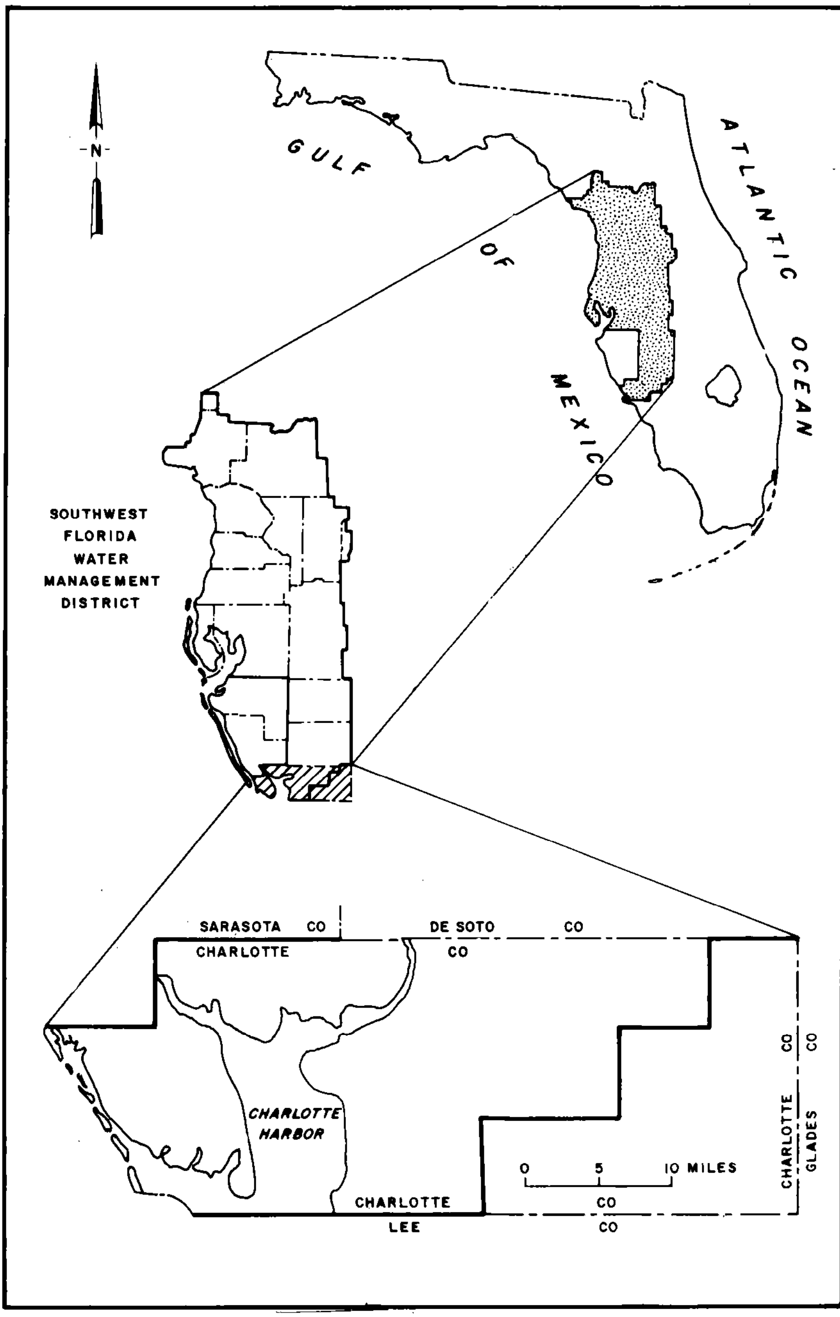

Figure 1.—Area of investigation.

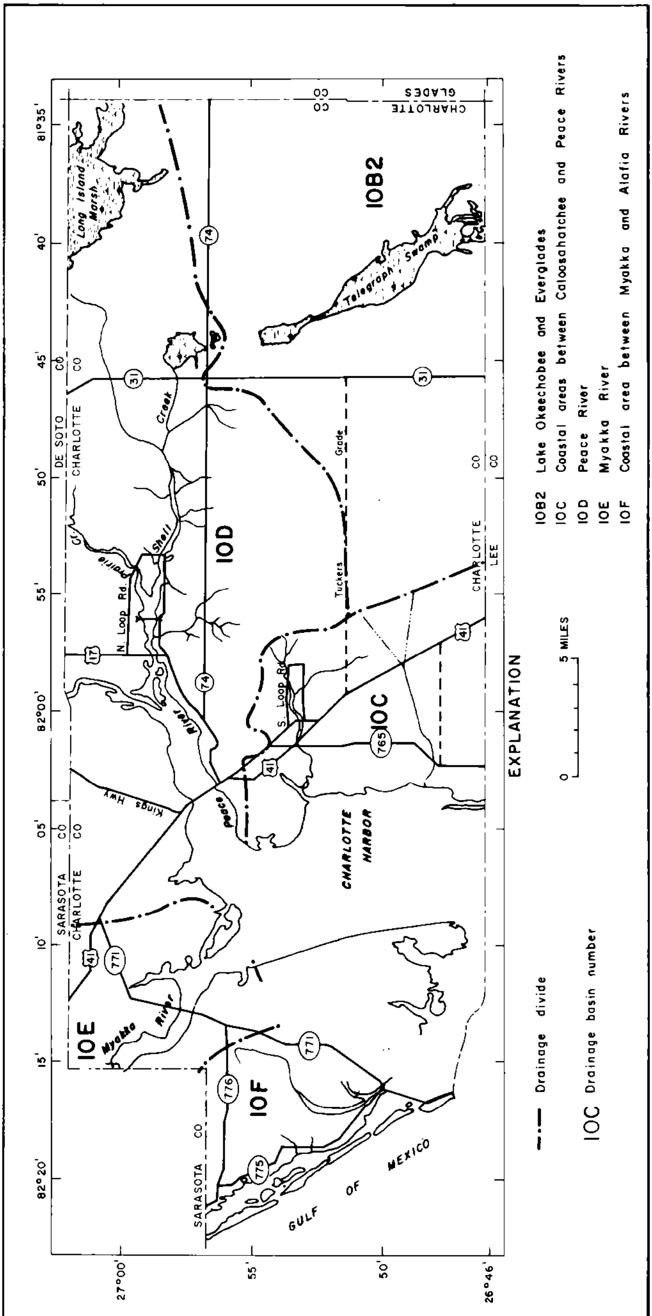

Figure 2.—Drainage basins in Charlotte County.

averages 54 inches, the figure shows that rainfall varies noticeably from site to site. In a specific year, a marked variation in areal distribution of rainfall also occurs with about 60 percent of the total rainfall occurring in June-September.

URBAN AND AGRICULTURAL DEVELOPMENT

The changing pattern of land use resulting from both urban and agricultural development has markedly increased the water requirements in the county. In addition, these changing patterns have had an impact on the hydrology of the area through drainage of land and through increased urban and agricultural irrigation water use from October-May. As the pattern of development continues, competition for the available water resources between the urban and agricultural user will become keener, and careful water management will be required to minimize conflicts between these two major water users.

The areas of present and potential urban growth are concentrated along the coastal part of Charlotte and adjacent counties (fig. 3). Charlotte County's population increase of about 120 percent between 1960 and 1970 is one of the highest in the State. This population was 27,559 in 1970. Four major housing developments practically encircle Charlotte Harbor, and in the near future the intervening open spaces will be filled with high-density housing, which will be the impetus for continued population growth and an increased need for water for public supplies.

Agricultural products have always been important to the economy of the county. The long growing season and the lack of severe frosts permit growing of two crops per year on truck farms. Before 1945, the coastal area south of Punta Gorda was used chiefly for cultivation of gladiolus. Since 1945, the land cropped for this purpose has markedly decreased, owing in part to urban growth. The county has about 7,000 acres in citrus concentrated in the northern and eastern parts, about 75 percent of which has been planted since 1960.

Large acreages on some ranches are used to grow crops such as watermelons, peppers, tomatoes, and eggplants. The growers clear and drain the land and drill wells for irrigation. At the end of the growing year, this improved land is converted to irrigated pasture for cattle. The amount of irrigated pasture increases from 1,000 to 3,000 acres annually and in part will be the impetus for increased need for water for agricultural supplies.

GEOLOGY

The land surface of Charlotte County consists chiefly of sand. This sand forms a thin mantle, generally less than 25 feet thick, beneath which lie many

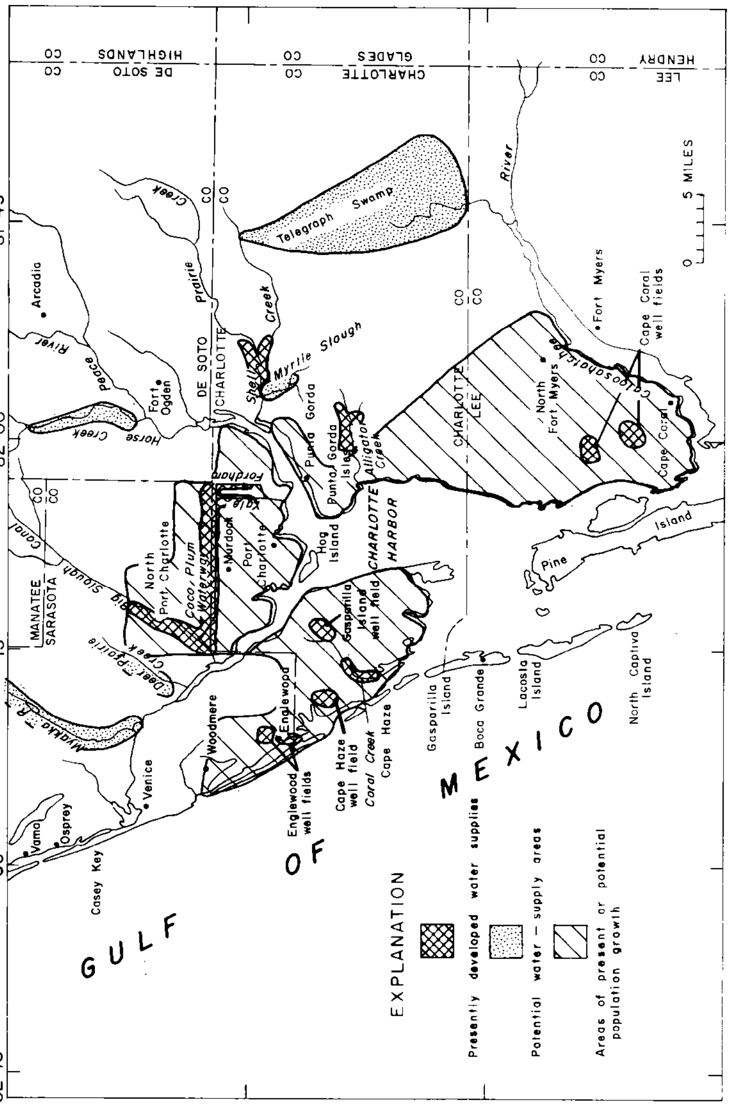

Figure 3.—Areas of present and potential water-supply development and urban growth.

more layers of sedimentary rock. The geologic units comprising the upper 1,500 feet of the sedimentary rock are the Caloosahatchee Marl; the Tamiami and Hawthorn Formations; the Tampa and Suwanne Limestones; the Ocala Group; and the Avon Park Limestone (table 1). The units below the Tamiami Formation consist chiefly of limestone and dolomite and the sequence becomes more dolomitic with depth. These rocks form the framework in which ground water occurs, and the study of the areal and vertical extent and variation in the properties of these rocks provides important information needed to evaluate the county's water resources.

Because the terrain is so flat, the methods used to study the geology, particularly the stratigraphic features, are limited to the interpretation of (1) well cuttings, which are samples recovered during drilling, and (2) geophysical logs, which are graphic records of variations in electrical and radioactive properties of the rocks in place.

The graphic lithologic log shown on figure 5 was prepared from samples obtained from well 16. This well penetrated almost the entire stratigraphic section listed in table 1, and the log is generally representative of rock materials encountered in Charlotte County. A suite of geophysical logs and an interpretation of the stratigraphic units obtained through use of both the samples and geophysical logs are shown with the lithologic log. Once the geophysical characteristics have been correlated with actual geologic materials found in wells, geophysical logs, particularly the gamma ray log, can be used to interpret the formations in wells for which no rock samples are available for study. Both rock cuttings and geophysical logs were used to :(1) interpret the geologic framework in Charlotte County; (2) determine the position of water-bearing rocks; and (3) determine changes in characteristics of the rocks that would effect their water-bearing properties.

Geologic sections (fig. 6) were compiled for the eastern part of the county by correlation of rock samples and geophysical logs. The location of the sections is shown in figure 7, and the latitude-longitude number of wells along the sections are listed in table 2. These sections show the major stratigraphic units in the upper 1,500 feet beneath the eastern part of the county and their variation in thickness and depth. The thickness of each geologic unit such as the upper and lower units of the Hawthorn Formation, varies markedly from place to place as does the depth of each unit below land surface. Similarly, these units vary in depth and thickness in the western part of the county.

HYDROLOGY

During wet weather, water in the streams that flow across Charlotte County is derived from rain that either falls on the county or on the streams' head-

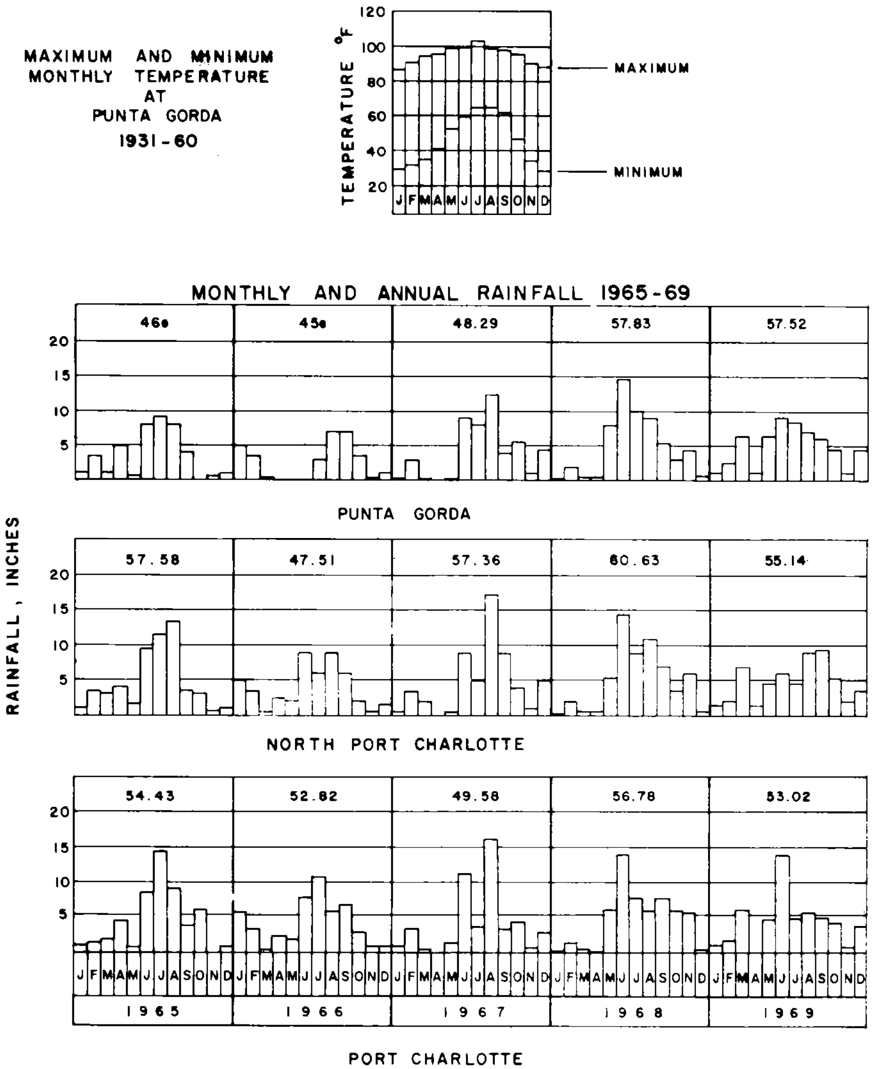

Figure 4.—Rainfall at Punta Gorda, North Port Charlotte, and Port Charlotte, 1965-69, and range in temperature at Punta Gorda, 1931-60.

TABLE 1.—Generalized stratigraphic section, Charlotte County. (Stratigraphic nomenclature conforms in part to that of the Florida Bureau of Geology, Puri and Vernon, 1964)

System	Series	Stratigraphic unit		Thickness (feet)	Lithology
Quaternary	Holocene	Surface sand		0-20	Quartz sand, medium to fine-grained, some localized yellow marl.
	Pleistocene	Terrace sand		0-5	Quartz sand, same as above.
		Caloosahatchee Marl		0-50	Shell, sand, marl, and limestone.
Tertiary	Late Miocene	Tamiami Formation		75-250	Green sandy clay; green and gray-green clay; tan limestone; gray sandstone. Phosphatic dark-gray sandy clay which may contain phosphorite pebbles at base; 5-40 feet thick.
	Middle Miocene	Hawthorn Formation	Upper unit	70-260	Interbedded gray to gray-white sandy clay and gray-white sandy limestone; abundant phosphorite throughout.
			Lower unit	50-130	Interbedded gray to gray-white limestone and gray to green clay; occasional thin streaks of dolomite; abundant phosphorite throughout; clay bed at the base.
	Early Miocene	Tampa Limestone		90-450	Interbedded gray to tan sandy limestone and gray to white clay; less phosphorite than above.
	Oligocene	Suwannee Limestone		140-450	Tan to creamy-white limestone, sandy limestone, and sand.
	Late Eocene	Ocala Group		400	Tan chalky limestone; darker and dolomitized near the bottom.
	Middle Eocene	Avon Park Limestone		500	Tan to dark-brown dolomite and hard limestone.

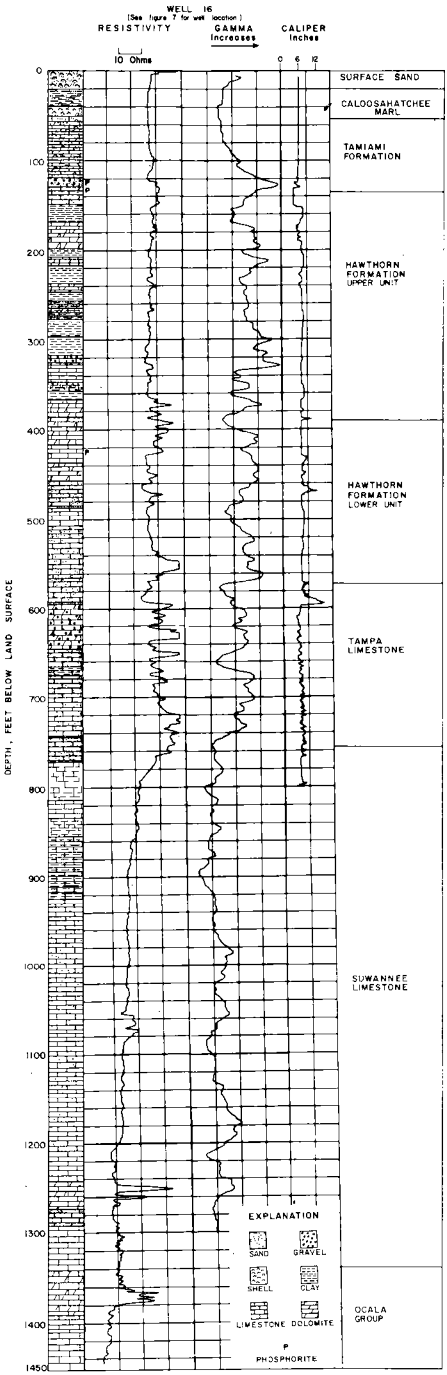

Figure 5.—Lithologic and borehole geophysical logs, well 16.

waters outside the county. Water in the aquifer system is also derived from rain that has either fallen on the county or on recharge areas outside the county. During dry weather, most of the streamflow is derived from the shallow aquifers.

The demand for water from the streams and the aquifer system that meets requirements for use as public supply has markedly increased with urbanization of the county. Because of this demand, emphasis is placed in this section on those aspects of the hydrology that govern the availability and current or potential use of surface and ground water for this purpose. Many parts of the county are prone to flooding from either streams or storm driven tides. Delineation of flood prone areas and description of hydrologic problems associated with flooding are beyond the scope of this investigation.

SURFACE WATER

DISCHARGE

Information on the flow of some of the streams draining the county has been collected since the 1930's (fig. 8, table 3). The records for all the sites measured since 1960 have been published in the annual series of reports on water resources data for Florida. Records are also published every 5 years in the U. S. Geological Survey Water Supply Papers entitled "Surface Water Supply of the United States: South Atlantic Slope and Eastern Gulf of Mexico Basins."

The average discharge of the major streams draining the county and adjacent areas for which more than 5 years of record is available ranges from 67 mgd (million gallons per day) to 808 mgd (table 3).

Although the average discharge of even the smallest stream is sizeable, a wide variation exists between maximum, average, and minimum discharge, and little or zero flow has been recorded in all the streams except Peace River at Arcadia. An unpublished evaluation of the low-flow characteristics of the streams listed in table 3 (J. F. Turner, oral commun., 1972) indicates that little or no flow will occur in all the streams except Prairie Creek and Peace River for as much as 30 consecutive days on the average once every 20 years. The average minimum 30-day low flow expected to occur on the average once every 2 years is about equal to the discharge equaled or exceeded 90 percent of the time. As a result of these low-flow characteristics, use of the major streams for any sizeable water supply would require storage of water in a reservoir—the storage capacity of which would depend in part upon the withdrawal rate desired.

Flippo and Joyner (1968) described the discharge of a few small streams and canals under low-flow conditions. Their report indicates that most have

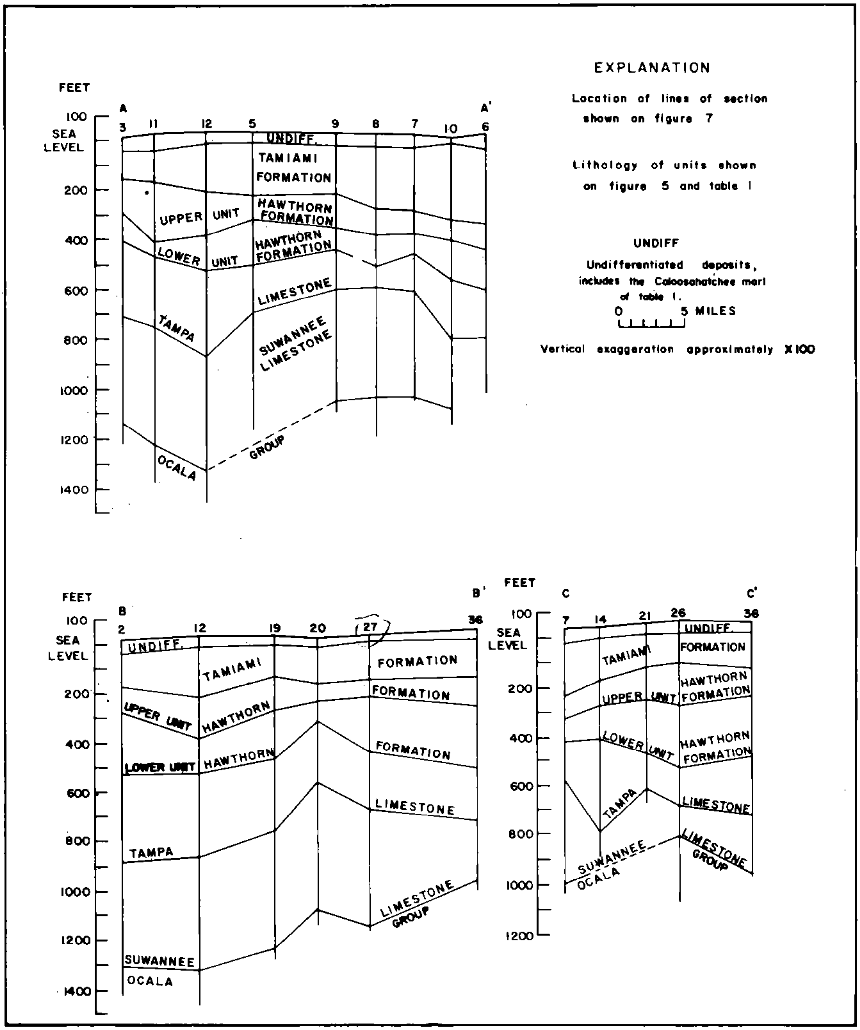

Figure 6.—Generalized sections across central and eastern Charlotte County, Florida.

negligible or no flow during normal dry weather periods and low annual yields. Therefore, these small streams and canals have no potential for use as a reliable source for water supply.

CHEMICAL QUALITY

The dissolved solids concentration of the surface water changes markedly from wet to dry season, because the chemical quality in and around Charlotte County varies with discharge (table 4).

During high discharge, the water in the streams generally is low in dissolved solids. Conversely, during low discharge, the water generally is high in dissolved solids. During both high and low discharge, the dissolved solids are made up chiefly of calcium, bicarbonate and sulfate. Included in the dissolved solids are some constituents whose concentrations at times limit the use of water in the streams for public supply.

Florida has adopted the Public Health Service Drinking Water Standards which set limits on the amount of dissolved solids and the concentrations of specific constituents in water for public use on interstate carriers. Some constituents in raw water in this part of Florida occur in concentrations that exceed these limits. The principal problem constituents and Public Health Service recommended limits are listed below.

Constituent	Public Health Service Recommended Limit (milligrams per liter)
Dissolved solids	500
Sulfate (SO^4)	250
Chloride (Cl)	250
Fluoride (F)	1.4
Iron (Fe)	.3
Color (platinum and cobalt units)	15

Water in all streams except Alligator Creek near Punta Gorda meet the requirements for dissolved-solids concentration during high and low flow (table 4). At this station, much of the low flow is ground water discharged by irrigation wells and by uncontrolled flowing wells in the area. The ground-water contribution during low flow increases the dissolved-solids concentration in water from Alligator Creek to a point where this Public Health Service limit is exceeded part of the time. Sulfate in water from the Peace River usually does not occur naturally in concentrations as great as that listed in

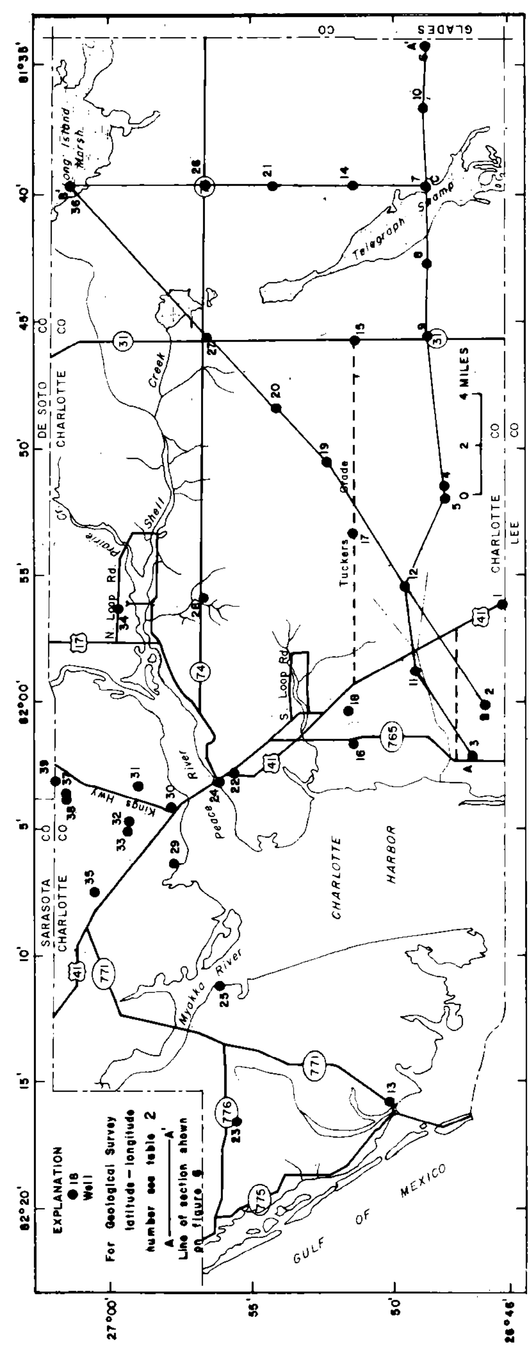

Figure 7.—Locations of wells referred to in this report.

TABLE 2.—Geological Survey's latitude-longitude number assigned to wells referred to in this report for computer storage and retrieval of well data.

Well referred to in this report	Latitude-longitude number
1	264611N0815554.1
2	264644N0820009.1
3	264808N0820208.1
4	264811N0815138.1
5	264811N0815158.1
6	264842N0813405.1
7	264843N0813940.1
8	264843N0814242.1
9	264844N0814535.1
10	264859N0813634.1
11	264912N0815856.1
12	264938N0815522.1
13	265017N0821537.1
14	265123N0813947.1
15	265124N0814537.1
16	265124N0820124.1
17	265127N0815325.1
18	265138N0820022.1
19	265222N0815032.1
20	265408N0814822.1
21	265410N0813939.1
22	265534N0820251.1
23	265557N0821522.1
24	265606N0820306.1
25	265612N0821104.1
26	265640N0813940.1
27	265642N0814535.1
28	265646N0815545.1
29	265745N0820619.1
30	265759N0820401.1
31	265902N0820328.1
32	265916N0820449.1
33	265922N0820456.1
34	265941N0815614.1
35	270030N0820718.2
36	270118N0813938.1
37	270133N0820346.1
38	270133N0820346.2
39	270159N0820331.1

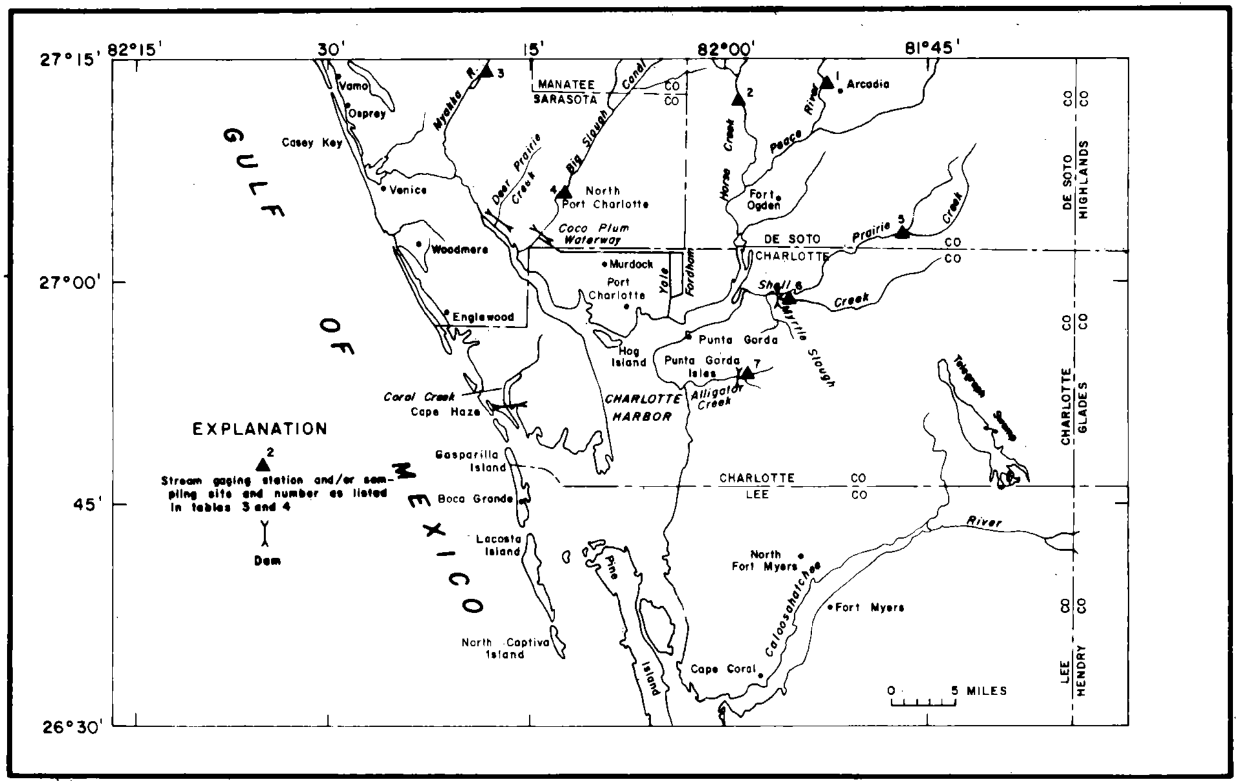

Figure 8.—Location of principal surface-water gaging sites in Charlotte County and vicinity.

table 4. Most of this sulfate is derived from leakage and discharge from ponds in the mining areas upstream. The concentration of chloride in Alligator Creek exceeds the Public Health Service limit during low flow as a result of well discharge. The flouride limit of 1.4 mg/l (milligrams per liter) is exceeded in water from the Peace River during low flows as a result of mining activities upstream.

Although no Public Health Service limit is placed on the phosphate concentration of water, high concentrations can create taste and odor problems in supplies derived from surface-water bodies in the county. Phosphorus from phosphate in combination with other plant nutrients stimulates growth of algae and plants such as hyacinths in streams, canals, and reservoirs. The undesirable taste and odor is produced during extensive growth and die-off of these plants.

The iron concentration in water from the streams exceeds the Public Health Service limit generally during high flow. Both color and iron in the water from streams is caused chiefly by organic compounds derived from the decay of vegetation. Color is more apparent during high flow when the streams receive runoff from marshes, swamps, and ponded areas. During low flow, the color of water and the concentration are generally low. With proper treatment, the iron concentration can be lowered to an acceptable level. The State requires that the color of finished water for public supply not exceed 15 units.

PUBLIC WATER SUPPLIES

Most surface-water bodies containing water of acceptable quality in the county have been developed for public supplies. However, an undetermined amount of additional water could be made available by impounding Myrtle Slough (fig. 3). Several potential surface-water sources lie outside the county. The Peace River north of Ft. Ogden is a potential source although its flow is subject to contamination from several sources. For short periods during extremely high tides, salt water from the Gulf can move upstream beyond Ft. Ogden, and some type of barrier would be required to prevent salt water from entering a public-supply diversion from the Peace River at Ft. Ogden or farther downstream. In addition, failure of dams in the mining areas upstream have allowed turbid water containing a high concentration of phosphate to enter the stream for as long as several weeks at a time. Therefore, if water were diverted from the Peace River for public supply, an alternate source would be required when the water in the Peace River is not usable.

Horse Creek near Ft. Ogden in DeSoto County and the Myakka River in Sarasota County have potential impoundment sites (fig. 3). Deer Prairie Creek in Sarasota County might also be able to provide a small amount of

TABLE 3.—Summary of discharge characteristics of principal streams in the Charlotte County area. (Station: See figure 8 for location of station. Discharge: cfs, cubic feet per second; mgd, million gallons a day.)

Station	Drainage area (square miles)	Period of record (years)	Minimum flood (cfs)	Minimum daily discharge		Average discharge		Discharge equalled or exceeded 90 percent of time	
				cfs	mgd	cfs	mgd	cfs	mgd
1. Peace River at Arcadia	1,367	38	36,200	37	24	1,250	808	-	-
2. Horse Creek near Arcadia	218	19	11,700	0	0	228	147	2.8	1.8
3. Myakka River near Sarasota	235	33	8,670	0	0	265	171	.04	.03
4. Big Slough near Murdock	87.5	6	2,560	.02	.01	104	67	1.2	.8
5. Prairie Creek near Fort Ogden	233	5	2,860	0	0	166	107	4.4	2.8
6. Shell Creek near Punta Gorda	373	3	3,680	0	0	-	-	-	-

water. All three, together, could supply quantities of water ranging from 4.5 to 24.5 mgd depending on reservoir storage as shown in the following table.

Station	Drainage area (square miles)	Withdrawal (million gallons a day)	Storage required to sustain withdrawal through a drought period of 20-year recurrence (acre-feet)
Horse Creek near		1.5	190
Arcadia	218	7.0	1,960
		14.0	5,000
Myakka River		1.5	520
near Sarasota	235	7.5	2,600
Deer Prairie Creek		1.5	400
near Woodmere	56	3.0	950

PORT CHARLOTTE

The principal water source for Port Charlotte is an impoundment on Yale and Fordham waterways. This source is supplemented by water from wells. The estimated storage capacity of the impoundment and its tributary canals (1965) is 101 million gallons, and inflow to the impoundment averages about 1.5 mgd. Water is routed to a treatment plant which has a design capacity of about 2 mgd and treats about 1 mgd. In 1969, the system supplied 163 commercial and 5, 646 domestic connections in the Port Charlotte area.

Growth of aquatic plants in the tributary canals of Port Charlotte's supply is a continuing problem. Frequent chemical treatment of the water in the canals is required to retard growth of the aquatic plants, and the plants must be removed. Although the water from the canals is acceptable for use on the basis of the chemical constituents listed in table 5, it often must be specially treated at the water plant to control taste, odor, and color. Also, because the canals receive runoff and seepage from the urbanized areas in Port Charlotte, the city is considering either importing ground water or surface water, or desalting locally available ground water.

PUNTA GORDA

Before 1936, individual or community wells, such as Punta Gorda's water-fountain well (well 24), furnished water to the town's residents. In 1936, a supply was obtained primarily from a small, shallow reservoir on Alligator

TABLE 4.—Changes in quality of streamflow with changes in discharge during medium and low flow. (Station location shown on figure 8. Discharge: cfs, cubic feet per second. Color: Pt-Co, Platinum-Cobalt. Results in milligrams per liter except where indicated.)

Station Location	Date	Discharge (cfs)	Iron (Fe)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids (Calculated)	Specific conductance (micromhos at 25°C)	pH	Color (Pt-Co units)
1. Peace River at Arcadia	6/1/65	76	0.03	109	120	18	1.5	0.9	6.8	300	460	7.6	10
	7/31/65	3,850	.33	21	14	8.0	.7	0	2.9	64	105	6.6	240
	2/23-28/66	5,563	.16	16	15	12	1.0	.2	10	71	120	6.8	120
	5/1-10/66	160	.01	84	92	18	2.0	.3	18	270	435	7.7	15
	5/11-20/67	94	0	104	140	16	2.4	0	11	340	540	7.2	5
	8/18-31/67	2,010	.33	29	29	11	1.0	1.5	4.4	99	157	6.9	240
2. Horse Creek near Arcadia	5/11/65	.5	.01	139	25	20	.7	.2	1.6	180	326	8.0	40
	2/28/66	808	.09	15	5.1	13	.4	.1		42	91	6.1	120
	5/23/66	3.4	.05	105	99	19	.7	.7		260	450	7.8	50
	6/8/67	1.7	.02	136	69	24	.8	.2	2.1	250	450	7.3	30
	9/1-7,9,12-15,29/67	569	.17	15	8.8	7.2	.3	0		40	64	6.1	120
3. Myakka River near Sarasota	6/1-7/65	0	.1	28	19	29	.4	0	.3	92	170	7.1	80
	8/2-5/65	1,930	.21	16	6.4	6.8	.4	.3	.92	38	62	6.8	200
	5/21-31/66	.01	.32	27	25	20	.4	.5	.73	92	175	6.8	120
	6/22-28/66	765	.21	20	1.6	8.0	.4	.2	.81	39	72	6.4	280
	5/1/67	0	.16	71	28	29	.4	.2	.37	140	270	7.4	100
4. Big Slough near Murdock	1/7/65	.7	.02	215	72	68	.7	0	.58	380	651	7.4	30
	5/3/65	1.1	.05	203	62	66	.8	.2	.92	360	630	7.7	20
	4/27/66	1.8	0	211	78	71	.9	.8	.65	400	700	7.7	45
	6/6/66	10.8	.13	63	48	32	.5	0	.95	170	280	7.2	120
	5/4/67	0	.03	198	18	47	.6	.9	1.6	270	490	7.3	35
5. Prairie Creek near Fort Ogden	4/21/66	9.2	.09	220	36	57	.2	.4	0	330	590	7.4	100
	5/9/67	3.8	.03	208	90	78	1.0	0	.02	430	748	7.6	20
6. Shell Creek near Punta Gorda	4/28/66	70	.06	118	10	44	.2	.7	0	180	349	7.4	35
	5/4/67	0	.08	200	12	77	1.0	.6	.06	310	575	7.5	60
7. Alligator Creek near Punta Gorda	4/27/66	1.0	0	232	98	450	.6	1.7	0	1,000	2,000	7.6	15
	5/5/67	1.7	.04	272	11	130	.5	1.2	0	460	850	8.1	20

Creek just south of Punta Gorda and a supplemental supply from a well. In 1938, a treatment plant was added. This system sufficed until 1965 when water was diverted from a reservoir built on Shell Creek. This reservoir has a capacity of about 9 billion gallons and supplies Punta Gorda and several nearby housing developments. During high water in the spring of 1970, the center of the reservoir dam was undermined threatening a dam failure and the loss of the reservoir. However, the dam was reinforced, and the immediate need for developing supplemental source of supply was alleviated.

The water from this reservoir is high in color and is low in dissolved solids, chloride and sulfate (table 6). The water is treated in a plant which has a capacity of 2.4 mgd, and activated carbon is used to remove color, taste and odor. The water from this reservoir is of better chemical quality than that obtained from the older wells and the reservoir on Alligator Creek.

TABLE 5.—Chemical analysis of raw water from the public supply at Port Charlotte. (Results in milligrams per liter except as indicated.)

Date of Collection	11/18/69
Silica (SiO_2)	6.7
Calcium (Ca)	71
Magnesium (Mg)	3.8
Sodium (Na)	27
Potassium (K)	0
Bicarbonate (HCO_3)	218
Sulfate (SO_4)	15
Chloride (Cl)	47
Fluoride (F)	.4
Nitrate (NO_3)	0
Nitrite (NO_2)	.2
Dissolved solids:	
Calculated	280
Residue on evaporation	311
Hardness, as $CaCO_3$	190
Noncarbonate hardness	14
Specific conductance (micromhos at 25°C)	480
pH	7.9
Color (Pt-Co units)	60

GROUND WATER

Charlotte County is underlain by a sequence of hydrogeologic units that, to a depth of about 1,500 feet, comprise a water-table and five artesian aquifers (table 7). The water-table aquifer is the uppermost hydrogeologic unit and occurs in the surficial sand and the Caloosahatchee Marl. Most of the recharge to this aquifer is from local rainfall. Some recharge is derived from the slow upward movement of water from the deeper artesian aquifers in the southern and western part of the county. Additional recharge comes from flowing wells. The water-table aquifer discharges chiefly by evapotranspiration, and from springs, lakes, rivers, canals, drainage ditches and wells. Some water also moves downward into the underlying artesian aquifers in the northern and eastern part of the county where the elevation of the potentiometric surface of the artesian system is lower than the elevation of the water

TABLE 6.—Chemical analyses of water from Shell Creek and from wells in Punta Gorda. (Results in milligrams per liter except as indicated.)

	Shell Creek	Well 24 (at town water fountain)	Well 22 (at old water plant)
Date Collected	10/69	10/69	10/69
Silica (SiO_2)	4.6	-	-
Calcium (Ca)	25	-	-
Magnesium (Mg)	3.5	-	-
Strontium (Sr)	.66	-	-
Sodium (Na)	18	-	-
Potassium (K)	.8	-	-
Bicarbonate (HCO_3)	74	-	-
Sulfate (SO_4)	9.6	51	370
Chloride (Cl)	33	340	1,300
Fluoride (F)	.2	1.3	1.0
Phosphate (PO_4)	-	.02	.01
Dissolved solids: Calculated	130	-	-
Residue on evaporation	163	-	-
Hardness, as $CaCO_3$	78	-	-
Noncarbonate hardness	18	-	-
Specific conductance (micromhos at 25°C)	248	1,490	5,100
pH	6.8	-	-
Color (Pt-Co units)	90	-	-
Temperature °C	25	26.5	29

table. The water table may be at or above land surface for months in poorly drained areas and more than 10 feet below land surface in areas that are extensively drained or where wells are heavily pumped. The water level in

TABLE 7.—Hydrogeologic units underlying Charlotte County.

Hydrogeologic unit	Equivalent stratigraphic unit	Remarks
Water-table aquifer	Surface and terrace sand Caloosahatchee Marl	Source of water for domestic and public supply wells along the coast. Also used for lawn irrigation and watering stock. Wells tapping shell beds in Caloosahatchee Marl yield as much as 600 gpm (gallons per minute) in eastern part of the county.
Confining bed	Tamiami Formation	Green clay
Zone 1	Tamiami Formation	Domestic and irrigation wells tapping limestone beds in this aquifer yield as much as 200 gpm. Used chiefly for irrigation in the eastern part of the county.
Confining bed	Tamiami Formation	Sandy clay, phosphorite pebbles
Zone 2	Hawthorn Formation, upper unit	Source of water for domestic and irrigation wells. Aquifer used extensively in the populated areas. Wells tapping aquifer yield as much as 200 gpm. Water in aquifer is saline west of Charlotte Harbor.
Confining bed	Hawthorn Formation, upper unit	White clay
Zone 3	Hawthorn Formation, lower unit Tampa Limestone	Source of water for irrigation wells only. Yield of wells tapping aquifer usually increases with depth of penetration. Most of the water obtained near the contact between the Hawthorn Formation and Tampa Limestone. Contains saline water in western part of the county.
Confining beds	Tampa Limestone	White to gray impermeable limestones and clays.
Zone 4	Tampa Limestone Suwannee Limestone Ocala Group	Source of water for irrigation wells only. Most permeable part of the aquifer occurs near the contact between the Tampa and Suwannee Limestones and near the contact between the Suwannee Limestone and Ocala Group. Generally, the upper part of the aquifer yields as much as 1,000 gpm and the lower part more than 1,000.
Confining bed	Ocala Group	Tan, chalky, impermeable limestone
Zone 5	Avon Park Limestone	Not used as a source of water in Charlotte County.

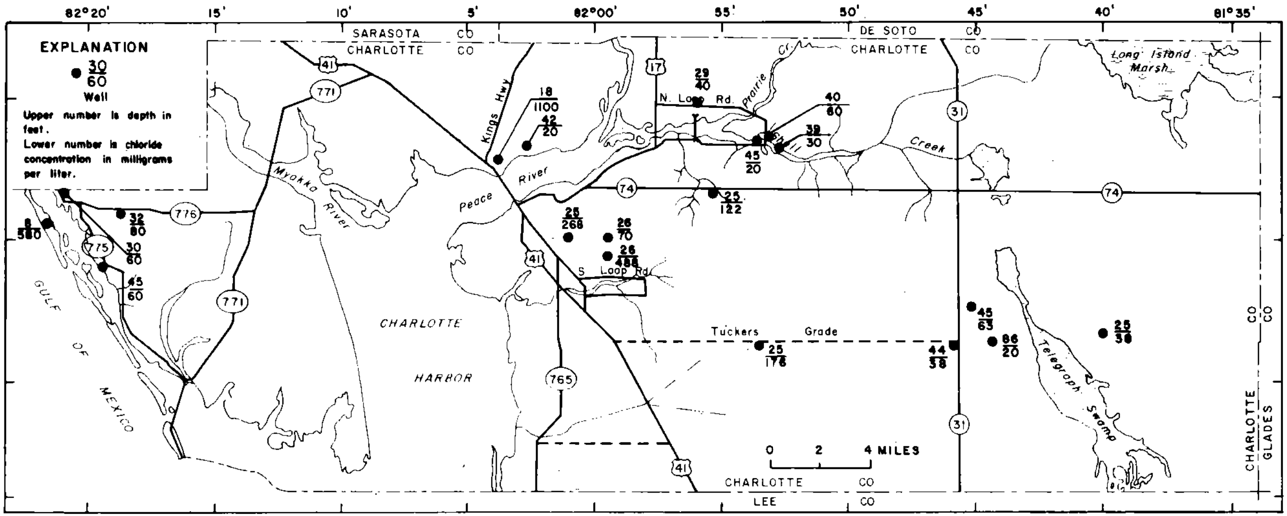

Figure 9.—Location, depth, and chloride concentration of inventoried wells tapping the water-table aquifer in Charlotte County.

the aquifer generally fluctuates less than 5 feet seasonally. The aquifer is as thick as 85 feet in some places but is generally less than 50 feet thick.

The chloride concentration of water in the water table aquifer ranges from 20 to 1,100 mg/l (fig. 9). The water is generally acceptable for domestic use except locally where mixed with water from the Gulf or with saline water from nearby deep wells.

Underlying the water-table aquifer is a thick sequence of rock units consisting chiefly of soft limestones which grade downward into harder, dense, crystalline limestone and dolomite. These rock units form a complex hydrogeologic system that contains five artesian aquifers (table 7) and their interbedded leaky confining layers. These confining layers are composed chiefly of beds of clayey limestone and clay like those that occur in the upper unit of the Hawthorn Formation (fig. 5). The water levels in wells that tap the aquifers rise above the top of the aquifers and, in the southern and western part of the county, frequently rise above land surface. These aquifers are referred to in this report as Zone 1, 2, 3, 4, and 5 and, the rock units in which they occur are listed in table 7. These hydrogeologic units underlie the Myakka River basin to the northwest and may, in part, underlie the northern edge of Lee County. Somewhere north and east of Charlotte County, Zones 3, 4, and 5 lose their hydrogeologic identity and form a single hydrogeologic unit, the Floridan Aquifer.

The permeability of the deeper artesian aquifers is generally greater than that of the shallower artesian aquifers. For example, Zone 4 is more permeable than Zones 1-3. The permeability of the rock within each zone also changes vertically, particularly in Zones 3 and 4. These aquifers are most permeable near the contact of contiguous stratigraphic units (table 7).

Zones 1 and 2 are recharged chiefly by leakage from the water-table aquifer where differences in water levels between the aquifers permit downward movement of water. Zones 3-5 are recharged by leakage from the overlying zones in the eastern part of the county and by lateral inflow from areas northeast and east of the county. All the zones discharge by: (1) diffused upward leakage into the water-table aquifer in the western part of the county; (2) flow from springs to the south of the county; (3) flowing wells; and (4) pumping from wells.

Water levels in the artesian aquifers range from about 30 feet above land surface along the coast to about 20 feet below land surface in the highest areas of the county. However, the depth to the water level at any given well is dependent on: (1) which zone or zones are open to the well bore, (2) altitude of land surface, and (3) the amount of water being withdrawn from other wells in the area. In general, the deeper aquifers have higher heads so that the

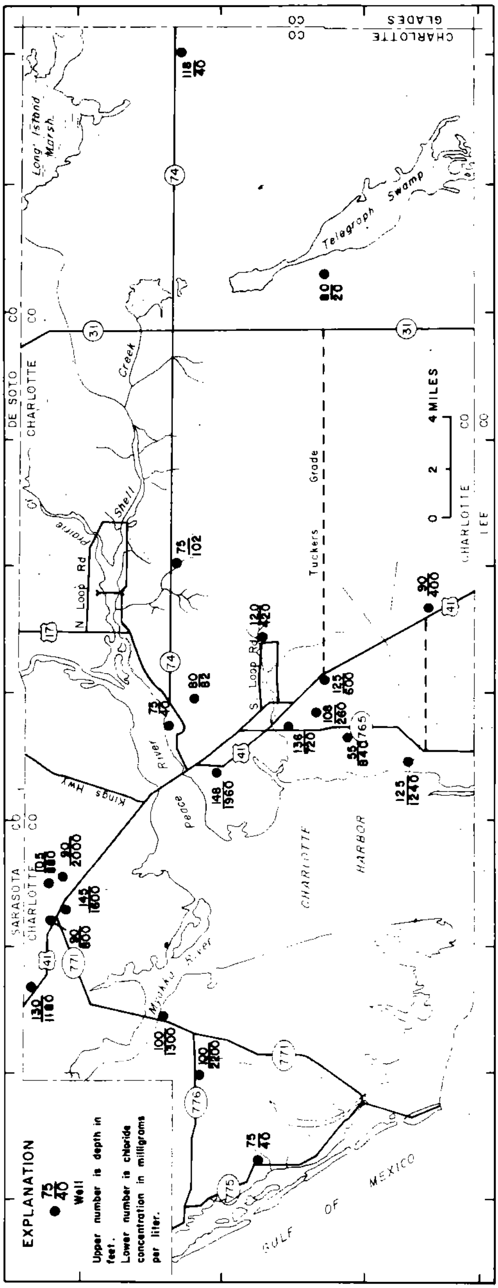

Figure 10.—Location, depth, and chloride concentration of inventoried wells tapping Zone 1 in Charlotte County.

deeper wells have higher water levels. Wells producing from the artesian aquifers are generally open to more than one producing zone, and the water level in the well is a composite of the levels of all the zones tapped by the well. Withdrawals of water from wells can lower water levels several feet at small pumping rates to several tens of feet at large pumping rates.

Chloride can be used in Charlotte County as a general indicator of the salinity of water—although chloride is not the only ion present in the water from the artesian zones. Where the chloride concentration exceeds 1,000 mg/l, the chloride generally constitutes 40 to 50 percent of the dissolved solids contributing to the salinity of the water. At most places in the county, the chloride concentration and the salinity of the water from the artesian aquifers increases with depth (figs 10, 11, and 12). Therefore water from Zone 1 is less saline than that from Zone 2, and water from Zone 2 is less saline than that from the deeper zones.

GROUND-WATER CONDITIONS BY AREA

Ground-water conditions vary widely within the county. To facilitate a description of these conditions, the county has been divided into four hydrologic areas (fig. 13).

AREA A

Area A lies in the western, peninsular part of the county. The only source of fresh water in this area is the shallow water-table aquifer, which is used by all the public water supplies and most of the private supplies. The water in the artesian aquifers is too saline to be used without demineralization.

Water-Table Aquifer

The water-table aquifer consists of 25 to 50 feet of permeable shell and sand and is underlain by clay. The aquifer is subject to intrusion by salt water from the Gulf during exceptionally high storm tides, and in places water from the aquifer may contain as much as 12,000 mg/l chloride. Intrusion by salt water also takes place where the low lying land of the peninsula has been drained by sea level canals. Where the aquifer has not been subjected to intrusion as at Cape Haze and Gasparilla Island (fig. 3), fresh water with a chloride concentration less than 75 mg/l (table 8) can be obtained from wells less than 30 feet deep.

Isolated lenses of fresh water occur in the water-table aquifer on the offshore barrier islands. These lenses are underlain by saline water at shallow depths, and only small quantities of fresh water can be pumped without causing upward movement of saline water into the wells. Water is generally considered saline if its dissolved-solids concentration is 1,000 mg/l or more.

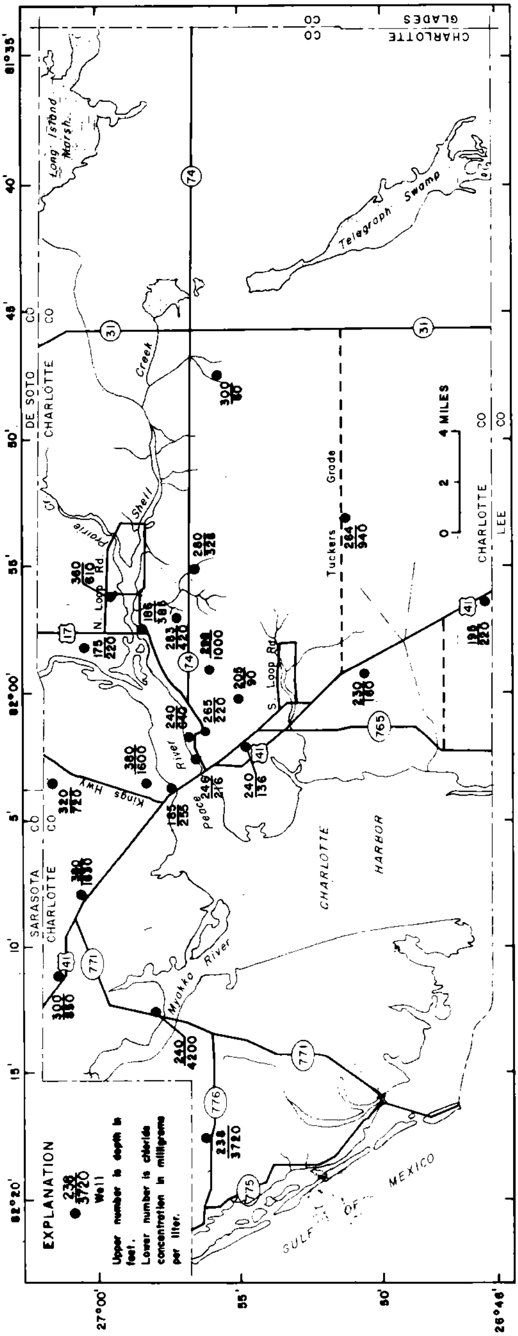

Figure 11.—Location, depth, and chloride concentration of inventoried wells tapping Zone 2 in Charlotte County.

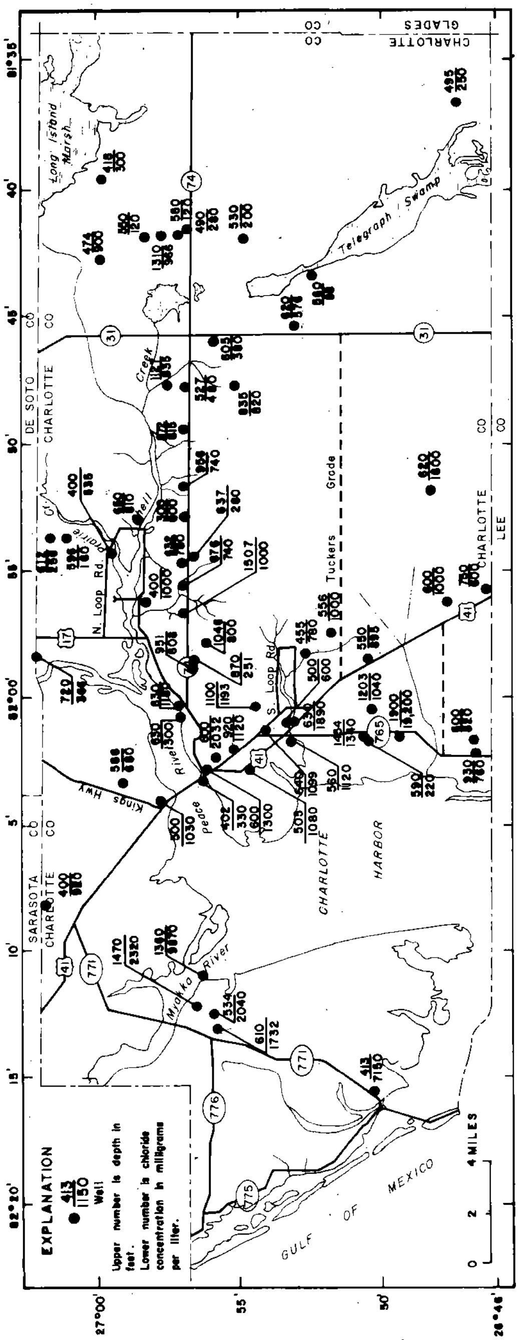

Figure 12.—Location, depth, and chloride concentration of inventoried wells tapping Zones 3 and 4 in Charlotte County.

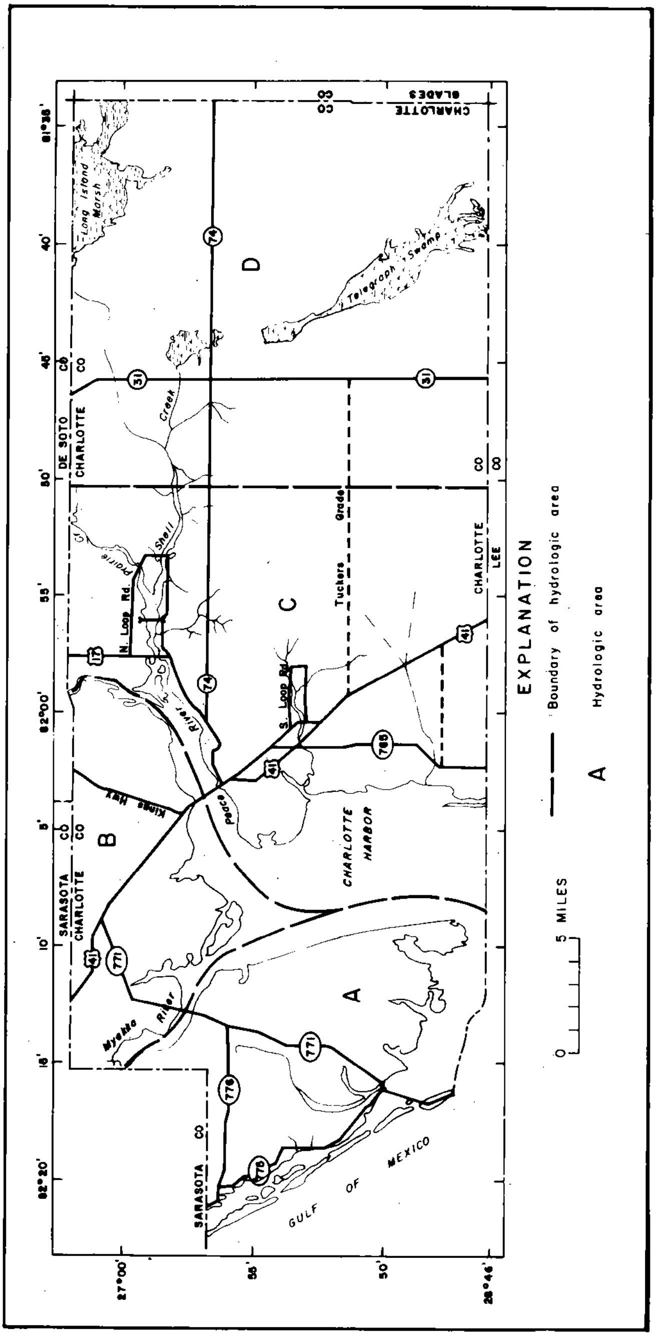

Figure 13.—Hydrologic areas for which ground-water conditions are described.

Interpretation of data obtained from tests on production wells at the Gasparilla Island well field indicates that the aquifer has a transmissivity that ranges from 1,340 to 1,870 ft^2 per day and a hydraulic conductivity that ranges from 47 to 60 ft. per day. The specific capacity of production wells in this well field is 5 gallons per minute per foot of drawdown, and the wells yield as much as 60 gpm. The yield of each well is restricted to about 20 gpm to prevent excessive drawdawn which might produce upconing of the underlying salty water.

TABLE 8.—Chemical analyses of water from the water-table aquifer underlying the Cape Haze and Gasparilla Island well fields. (Results in milligrams per liter except as indicated.)

	Cape Haze Well Field	Gasparilla Island Well Field
Date of Collection	11-19-69	11-18-69
Silica (SiO_2)	11	9.4
Calcium (Ca)	100	120
Magnesium (Mg)	2.1	5.6
Strontium (Sr)	.45	.35
Sodium (Na)	26	42
Potassium (K)	.3	0
Bicarbonate (HCO_3)	262	354
Sulfate (SO_4)	8.8	0
Chloride (Cl)	48	74
Fluoride (F)	.3	.2
Nitrate (NO_3)	.8	.8
Dissolved solids:		
Calculated	370	470
Residue on evaporation	327	421
Hardness, as $CaCO_3$	260	310
Noncarbonate hardness	47	21
Specific conductance (micromhos at 25°C)	600	750
pH	7.6	8
Color (Pt-Co units)	40	50

The water-table aquifer is used as a source of water for public-supply water for Cape Haze and Gasparilla Island (fig. 3). Cape Haze, a large housing development, installed a water-treatment plant in 1953 with a capacity of 0.288 mgd. The plant treats water from 18 shallow wells and serves about 350 people (1969) through 1 commercial and 113 domestic connections. In addition, a supplemental supply of 350 gpm is available from a reservoir on the west branch of Coral Creek (fig. 3).

The Gasparilla Island Water System started operation September 1968 and has a plant capacity of 0.57 mgd. Water is obtained from 16 shallow wells. An expansion area has been reserved for an additional 16 wells. In 1969, the system served about 400 persons through 250 connections on Gasparilla Island. The well field is bounded on three sides by salt water. Part of the recharge to the well field comes from seepage from the reservoir on the west branch of Coral Creek northwest of the field. Without this recharge, the well field might be subject to salt-water intrusion.

TABLE 9.—Chemical analyses of water samples from well 25. (Results in milligrams per liter except as indicated.)

Interval sampled (feet)	65 - 85	85 - 189	85 - 410	85 - 743	85-1,031	85 - 1,406
Zone penetrated	1	1,2	1,2	1,2,3	1-5	1-5
Silica (SiO_2)	17	26	18	22	17	7.9
Iron (Fe)	.19	0	.07	.02	0	0
Calcium (Ca)	300	130	240	240	300	460
Magnesium (Mg)	470	90	180	170	270	670
Strontium (Sr)	18	27	41	38	39	32
Sodium (Na)	3,400	230	1,200	1,000	1,900	5,200
Potassium (K)	120	15	32	28	60	190
Bicarbonate (HCO_3)	196	194	148	154	148	134
Sulfate (SO_4)	500	17	520	510	720	1,500
Chloride (Cl)	7,000	760	2,300	2,100	3,600	9,900
Fluoride (F)	.7	1.3	1.0	1.0	1.3	1.5
Nitrate (NO_3)	5.8	2.4	1.7	6.3	13	7.5
Phosphate (PO_4)	.14	0	0	.04	0	.03
Dissolved solids Residue on evaporation	24,500	2,130	5,320	4,900	8,040	18,000
Hardness (as $CaCO_3$)	2,700	730	1,400	1,400	1,900	3,900
Noncarbonate hardness	2,600	570	1,200	1,200	1,800	3,800
Specific conductance (micromhos at 25° C)	21,600	2,730	7,880	7,350	11,800	28,600
pH	7.5	7.2	7.4	7.5	7.1	7.0
Color (Pt-Co Units)	10	0	0	0	0	5
Temperature °C	—	—	—	—	33	28

Artesian Aquifers

Much of Zones 1 and 2 in Area A contain saline water. Specific information on salinity of water in the aquifers has been obtained from test drilling. Test well 23, (fig. 7) yielded water with dissolved-solids concentration of about 5,000 mg/l from depths less than 225 feet (Zones 1 and 2). Test well 13 yielded water with a dissolved-solids concentration less than 9,000 mg/l from depths less than 340 feet (Zones 1 and 2). The differences in quality of water from the same zones penetrated by these test wells suggests that the dissolved-solids concentration of water in Zones 1 and 2 decreases to the north.

Well 25 (fig. 7) penetrated Zones 1-5, and during its drilling the dissolved-solids concentration of the water in the aquifer generally increased with depth (table 9) except within the interval 85-189 feet. In this interval, the well penetrated Zone 2, and the dissolved-solids concentration of the water decreased as a result of a decrease in chloride concentration. This decrease indicates that Zone 2 at this site contains water with lower salinity than water contained in the other areas.

The altitude of the water level in Zones 1-5 is above land surface, and all wells penetrating these zones flow. Seasonal fluctuation of water levels in these zones probably does not exceed 4 feet (fig. 14). The artesian pressure is higher in the deeper zones than in shallow zones as is shown by comparison of the altitudes in well 23 which taps Zone 2 and well 25 which taps Zones 1-5. As a result of this increase with depth, an upward gradient exists which permits water to move from the deeper to the shallower zones in wells open to more than one zone. Because the water in deeper zones is more saline than water in shallower zones (table 9), this upward movement results in local deterioration in the quality of the water in the shallower zones. In addition, where water from these wells discharges at the surface, this water has caused the quality of water in the water-table aquifer to deteriorate. This condition exists in the eastern part of the area where many unused irrigation wells that penetrate Zones 2 and 3 flow freely.

Although none of the artesian aquifers contains fresh water, some of the water contained in Zones 1 and 2, at depths less than 280 feet below land surface, may be usuable for irrigation of salt-tolerant crops. A properly constructed well, cased to about 130 feet and drilled to less than 280 feet, may yield 10 to 30 gpm of water whose chloride concentration probably would not exceed 2,000 mg/l.

AREA B

Area B lies between the Myakka and Peace Rivers (fig. 13) and is the most urbanized part of Charlotte County. The area has undergone a marked population growth since the mid-1950s. The original plan of development for Port Charlotte included a public water-supply system for the central part and an individual well for each home in the rest of the development. However, of 311 test wells drilled in the area to be served by individual home wells, only 9 produced water usuable without treatment; 39 produced water that could readily be treated by household water conditioners; 76 produced water suit-

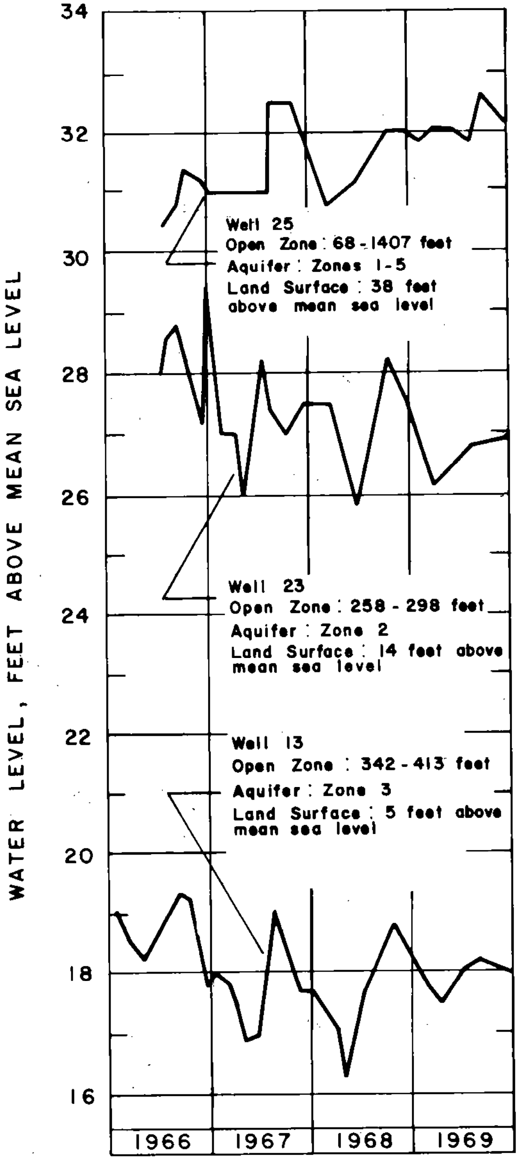

Figure 14.—Hydrographs of observation wells that penetrate the artesian aquifers in Area A.

able for treatment commonly used in public-supply systems; and 187 produced water unsuitable for use without demineralization. As a result, plans were altered to supply water to the entire development from an undetermined source or sources.

Water-Table Aquifer

The thickness of the water-table aquifer averages about 40 feet and ranges from 20 to 60 feet. The aquifer consists chiefly of fine to medium sand with locally interbedded gravel and shell. As a result, its hydraulic conductivity

TABLE 10.—Chemical analyses of water from wells that tap the water-table aquifer in Zone 2 underlying Port Charlotte. (Results in milligrams per liter except as indicated.)

Aquifer	Water Table	Water table	Zone 2
Date Collected	9/25/56[a]	5/10/61[b]	11/18/69[c]
Silica (SiO_2)	—	—	17
Iron (Fe)	3.0	0.5	—
Calcium (Ca)	96	110	100
Magnesium (Mg)	10	9.0	18
Strontium (Sr)	—	—	1.1
Sodium (Na)	—	—	42
Potassium (K)	—	—	5.8
Bicarbonate (HCO_3)	329	288	322
Sulfate (SO_4)	22	0	13
Chloride (Cl)	—	48	100
Fluoride (F)	—	.40	.6
Nitrate (NO_3)	—	—	0
Nitrite (NO_2)	—	—	.07
Dissolved solids:			
Calculated	—	430	460
Residue on evaporation	—	—	509
Hardness as $CaCO_3$	—	310	330
Noncarbonate hardness	—	24	64
Specific conductance (micromhos at 25°C)	—	—	800
pH	—	7.3	7.6
Color (Pt-Co Units)	150	35	10
Temperature °C	24	24	—

[a] Sample from one of Port Charlotte's original water-supply wells. Analysis by General Development Utilities.
[b] Composite sample from 19 6-inch diameter wells, about 45 feet deep. Analysis by General Development Utilities.
[c] Composite sample from seven wells at Port Charlotte's golf course. Analysis by U. S. Geological Survey.

may be higher in places than in area A. Based on the hydraulic properties determined for the aquifer in Area A, its hydraulic conductivity is estimated to average about 53 ft per day and its transmissivity 2,140 ft^2 per day. In places where the aquifer is thicker or contains shell beds of higher hydraulic conductivity, transmissivity may be more than 3,340 ft^2 per day.

The altitude of the water table ranges from near sea level adjacent to the Charlotte Harbor estuary to more than 25 feet above mean sea level in the northeastern part of the area. Seasonal fluctuations of the water table in this area are generally less than 5 feet.

TABLE 11.—Chemical analyses of water from wells that tap Zone 2, Area B.
(Results in milligrams per liter except as indicated.)

	Well 37[a]	Well 32[b]	Well 29[b]
Interval sampled (feet)	183-235	121-230	185-205
Date collected	11/11/65	3/13/61	2/6/68
Silica (SiO_2)	22	—	—
Iron (Fe)	.01	0.1	0
Calcium (Ca)	62	50	170
Magnesium (Mg)	36	29	97
Sodium (Na)	78	—	—
Potassium (K)	8	—	—
Bicarbonate (HCO_3)	218	151	156
Sulfate (SO_4)	8	15	320
Chloride (Cl)	210	150	1,000
Fluoride (F)	1.5	1.1	1.3
Nitrate (NO_3)	0	—	—
Phosphate (PO_4)	.04	—	—
Dissolved solids:			
Calculated	530	430	2,600
Residue on evaporation	560	—	—
Hardness as $CaCO_3$	300	240	820
Noncarbonate hardness	120	120	690
Specific conductance (micromhos at 25°C)	1,100	—	—
pH	7.9	7.9	7.4
Color (Pt-Co Units)	5	5	5
Temperature °C	—	24	25

[a] Analysis by U. S. Geological Survey.
[b] Analysis by General Development Utilities.

Although the quality of the water in the aquifer is generally good (table 10), the aquifer is not commonly used as a source of supply for drinking water. The dissolved-solids concentration meets the State's standards for public supply. The iron and color are high, and the water would require treatment if used for public supply. The chloride concentration of the water in the aquifer is highest near the Charlotte Harbor estuary and in areas adjacent to the salt-water-canals that have been dredged inland as part of urban development. These canals have allowed salt water to intrude south of U. S. Highway 41, which has been established as a salt-water barrier line. Controls have been installed in the canals at the barrier line to prevent salt water from moving farther inland.

Port Charlotte's original water supply was obtained from six 4-inch wells 20 feet deep. These wells tapped a shell bed in the aquifer. Later 19 wells about 45 feet deep were drilled. In 1959, the original 23 wells were replaced by wells tapping Zone 2.

Although the water-table aquifer is not extensively used in Area B, it is a potential source of a large quantity of water. Use of infiltration galleries may be effective in providing large quantities where the aquifer is thin. Well screens are needed to obtain maximum yields from the aquifer where it is thick although screens are not commonly used in the area. A properly screened well requires a screen length equal to 25 to 50 perecent of the saturated thickness. Where the aquifer is fine-grained, a coarse sand pack can help decrease the drawdown in the well due to entrance loss by permitting use of a screen with a larger slot opening than normally would be used. Estimates of the hydraulic properties of the aquifer indicate that screened wells 6 inches in diameter should produce 7 to 10 gpm per foot of drawdown and where the water level is 10 to 25 feet above sea level and the aquifer more than 30 feet thick, 70 to 200 gpm without causing salt-water intrusion.

Artesian Aquifers

Zone 1.—Zone 1 lies about 70 feet below land surface, and the water levels in the few wells that penetrate the zone rise nearly to land surface. At many places in Area B, the zone contains layers of loose sand, and the sand is generally cased out to prevent caving into the well bore. To complete a well in the sandy part of the aquifer, a screen with proper-sized openings would be required to prevent the hole from caving and to keep sand out of the well.

In the north central part of Area B, several wells which yield 20 to 30 gpm have been completed in the limestone and clay sections of Zone 1. The chloride concentration of the water from the wells exceeds State limits for public-water supply and is marginal for irrigation use.

Zone 2.—Zone 2 is the most heavily pumped aquifer underlying area B. The top of the zone lies 115 to 120 feet below land surface and the zone's thickness ranges from 110 to 135 feet. Wells tapping this zone yield more than 30 gpm. The quality of the water is usually suitable for irrigation use but generally does not meet State standards for drinking water except locally as at Port Charlotte (table 10). Here, water from seven 6-inch wells is used to supplement Port Charlotte's surface-water supply. Wells tapping Zone 2 that are tightly cased to about 150 feet and are less than 230 feet deep can generally produce water with a dissolved-solids concentration less than 1,000 mg/l (table 11). The water levels in wells that tap the upper part of the zone usually rise to about land surface. The water level in wells tightly cased into the lower part of the zone generally rises above land surface, and the wells flow.

TABLE 12.—Chemical analyses of water from wells that tap Zones 2 and 3, Area B. (Results in milligrams per liter except as indicated.)

	Well 31	Well 39	Well 30	Well 35
Interval sampled (feet)	146-586	69-427	162-270	144-450
Date Collected	10/28/69	11/11/65	4/5/65	10/28/69
Silica (SiO_2)	—	—	17	—
Calcium (Ca)	—	93	220	—
Magnesium (Mg)	—	62	150	—
Sodium (Na)	—	—	800	—
Potassium (K)	—	—	23	—
Bicarbonate (HCO_3)	—	—	134	—
Sulfate (SO_4)	280	210	530	430
Chloride (Cl)	650	420	1,600	1,200
Fluoride (F)	1.1	1.2	1.2	1.1
Phosphate (PO_4)	.03	.03	.20	.02
Dissolved solids:				
Calculated	—	—	3,400	—
Residue on evaporation	—	—	4,040	—
Hardness as $CaCO_3$	—	—	1,200	—
Noncarbonate hardness	—	—	1,000	—
Specific conductance (micromhos at 25°C)	2,750	2,050	5,800	4,700
pH	—	7.9	7.6	—
Temperature °C	26.5	25	29	27

Zone 3.—Zone 3 is the deepest aquifer underlying area B for which hydrologic information was obtained. The top of Zone 3 generally lies about 250 feet below land surface, and the zone is about 150 feet thick. The upper part of the zone is less permeable than the lower part, and wells that tap both the upper and lower part yield as much as 300 gpm. The dissolved solids concentration of water increases with depth and exceeds 2,000 mg/l in the lower part. The water from this part of the aquifer also has a high concentration of chloride and sulfate. Most wells in the area that tap Zone 3 also tap Zone 2, and the quality of water from some wells that produce from these zones is shown in table 12.

The water levels of wells that penetrate Zone 3 generally rise above land surface so that the wells flow. The water level in this zone is higher than that in Zones 1 and 2 (fig. 15). As a result, a strong upward vertical gradient exists between Zone 3 and the shallower Zones 1 and 2 and water moves upward in wells that are open to any of the shallower zones. In older wells where the casing is broken or corroded, water from Zone 3 will move upward in the well bore into the water-table aquifer. Because the water in Zone 3 is of poorer quality than that in the overlying aquifers, this upward movement is a cause of widespread salt-water intrusion into the overlying aquifer.

AREA C

Area C lies in the central part of the county and is bordered on its western edge by Charlotte Harbor. The coastal part of the area is partly urbanized, and obtaining water of good quality for public supply from the water-table and artesian aquifers is a major problem.

Water-Table Aquifer

The water-table aquifer is used extensively as a source of water for domestic and some irrigation supplies. Most wells tap the sand and discontinuous shell beds and are generally less than 30 feet deep. Small diameter wells that tap the shell beds yield as much as 20 gpm. Wells constructed with screens may yield considerably larger quantities.

During the investigation, 10 test wells were drilled in the aquifer. One 2-inch screened well yielded as much as 40 gpm, and all but one yielded water that met the State's standards for drinking water. However, many wells that tap the aquifer produce water with more than 2 mg/l of iron. Wells drilled near Charlotte Harbor or on fill overlying former salt-water marshes produce water whose chloride concentration exceeds 250 mg/l.

Locally inland, some salt water has migrated into the aquifer. The salt water comes from free-flowing wells that tap artesian aquifers containing saline water. A test well drilled immediately north of South Loop Road (fig. 9) yielded water from a depth of 26 feet with a chloride concentration of 490 mg/l.

Artesian Aquifers

Most of the flowing wells that tap the artesian aquifers underlying area C were drilled before 1935 for irrigating gladioli and truck crops. As the area became urbanized, use of these wells was discontinued. Many were improperly plugged and then buried beneath the land surface after the casings were either

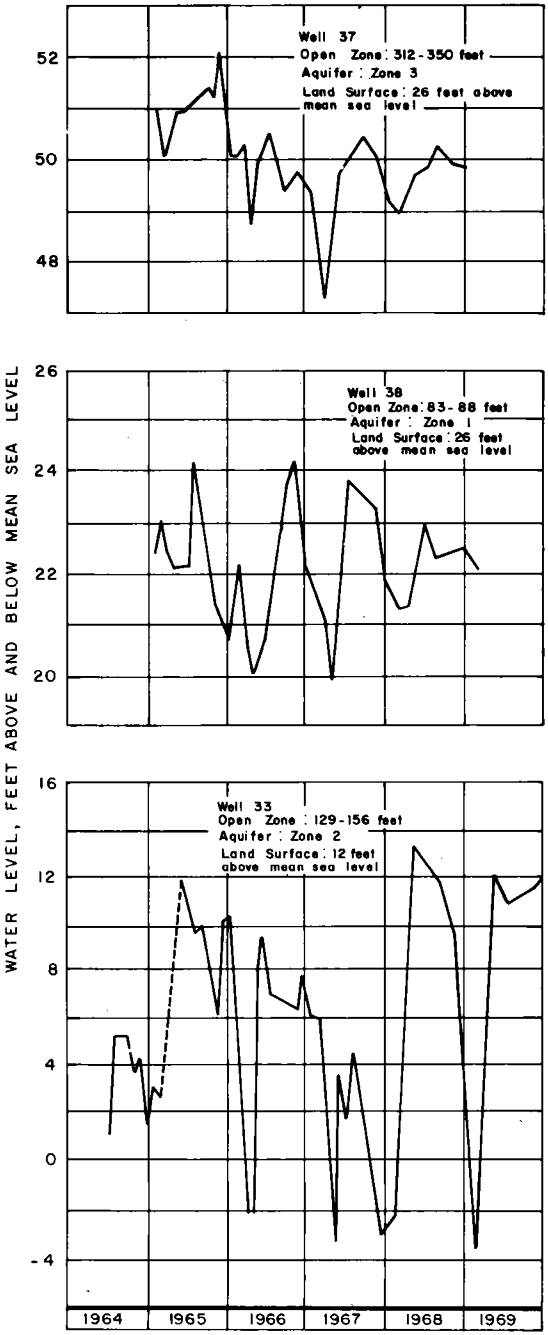

Figure 15.—Hydrographs of observation wells that penetrate the artesian aquifers in Area B.

cut or broken off when the land was prepared for home building. The buried, improperly plugged wells act as conduits that allow saline water from deeper zones to contaminate the shallow artesian and water-table aquifers.

Zone 1.—Zone 1 is the most heavily pumped artesian aquifer underlying Area C. The zone is a source of supply for domestic use and irrigation. Wells for domestic use are commonly 2 inches in diameter and generally yield 15 to 30 gpm. Wells for irrigation are of larger diameter and commonly yield less than 200 gpm.

In the western half of the area water from Zone 1 generally does not meet the State's drinking water standards. These standards are exceeded by chloride (concentration more than 250 mg/l) and dissolved solids (concentration more than 500 mg/l). In a few isolated places as at well 1 (fig. 7), water from this zone meets these standards. Water from this well had a specific conductance of 840 mircromhos, a dissolved-solids concentration less than 500 mg/l (based on specific conductance), a chloride concentration of 220 mg/l and a sulfate concentration of 10 mg/l. Although this well is open to Zones 1 and 2 from 140 to 190 feet below land surface, most of the water comes from the phosphatic gravel, sandstone, and limestone of Zone 1.

In the eastern half, water from Zone 1 meets the State's drinking water standards. The chloride generally is less than 100 mg/l, and the dissolved solids less than 500 mg/l. Water levels in Zone 1 are nearly everywhere less than 15 feet below land surface and fluctuate naturally less than 1 foot annually. During the irrigation season, water levels in wells affected by pumping may be lowered as much as 25 feet (fig. 16).

Zone 2.—Zone 2 is used chiefly as a source of irrigation water because the water it contains does not meet the State's standards for drinking water. Wells that tap this zone generally are less than 400 feet deep; are 4 inches or more in diameter; and are open also to Zone 1. In the eastern part of the area, wells yield as much as 400 gpm.

The chloride concentration of the water in the aquifer increases from north to south, and the sulfate concentration seems to increase with depth of penetration (table 13).

Water levels in the aquifer rise above land surface in parts of the area (fig. 17), and many wells that penetrate Zone 2 flow. Seasonal fluctuations of water levels in the aquifer probably do not exceed several feet (well 17, fig. 17). Locally, where large quantities of water are withdrawn for irrigation, this fluctuation may range from 2 to 4 feet (wells 28 and 34).

Zone 3 and deeper zones.—Many of the irrigation wells drilled before 1935 along the coast between Punta Gorda and Fort Myers obtained water from Zone 3 and other zones at depths greater than 900 feet. Nearly all of these

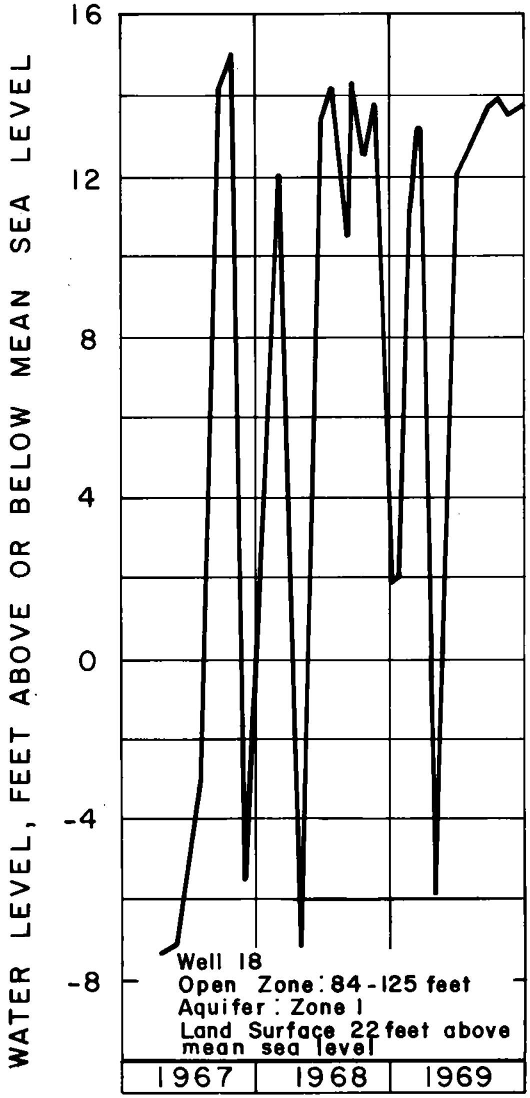

Figure 16.—Hydrograph of a well affected by nearby heavy pumping.

wells were also open to the overlying zones. The shut-in pressure was as much as 30 feet above land surface, and 6-to 8-inch wells would flow at least 500 gpm. The water was saline but suitable for flood irrigation. When irrigation was not needed, rainfall ordinarily flushed the salts from the soil, preventing an accumulation that could not be tolerated by crops. As the coastal area urbanized, many of these wells were capped, and water of poor quality has continued to move up the bore into the shallower zones. Within recent years, some effort has been made to plug these wells using methods that follow State requirements.

AREA D

Area D is sparsely populated. The land is used chiefly for raising livestock, citrus, and truck-farm crops. Several thousand acres are under cultivation for watermelons, cucumbers, tomatoes, peppers, and citrus.

This area is underlain by several shallow aquifers that have a large public water-supply potential. These aquifers, tapped only by a few irrigation wells, represent the only major undeveloped source of fresh water in the county.

TABLE 13.—Chemical analyses of water from test wells that tap Zone 2, Area C. (Results in milligrams per liter except as indicated.)

	Well 17		Well 28	Well 34	
Interval sampled (feet)	187-195	214-264	194-215	124-160	172-225
Date of collection	7/1/68		8/1/68		7/22/68
Sulfate (SO_4)	24	280	62	—	36
Chloride (Cl)	1,200	1,200	330	180	260
Fluoride (F)	—	.9	—	1.1	—
Phosphate (PO_4)	—	.01	—	.01	—
Specific conductance (micromhos at 25°C)	3,900	4,050	1,460	860	1,140

Water-Table Aquifer

The eastern two-thirds of Area D is underlain by a water-table aquifer which has a potential for development of large quantities of water for public supply in Charlotte County. The upper part of the aquifer consists of sand and the lower part interbedded shell and limestone (fig. 18). These beds are underlain by a clay layer. The aquifer ranges in thickness from less than 25 to more than 100 feet, is thickest beneath Telegraph Swamp, and thins toward the east and west.

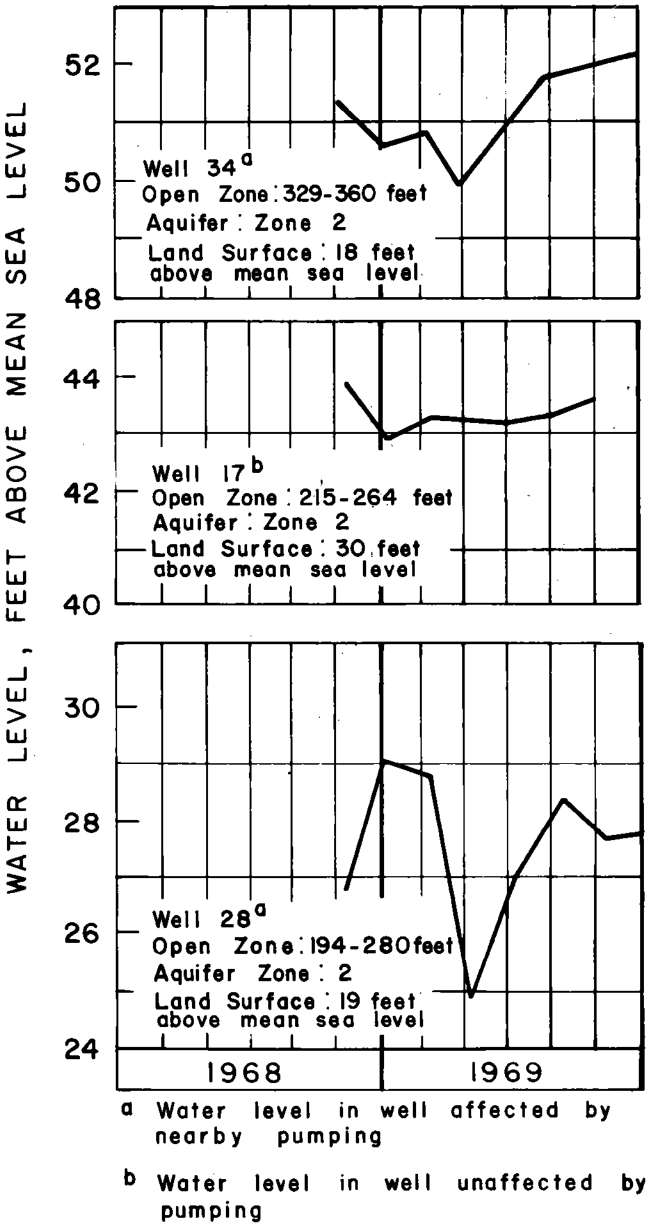

Figure 17.—Hydrographs of wells tapping Zone 2, Area C.

Irrigation wells that tap the shell and limestone beds generally are 6 inches in diameter and less than 40 feet deep. The wells, equipped with centrifugal pumps, yield as much as 600 gpm. Water from these wells is low in chloride and sulfate.

The hydraulic conductivity of the shell and limestone beds is not known; it probably varies from less than 53 to more than 135 ft per day. Where the aquifer is thickest and hydraulic conductivity is high, its transmissivity may exceed 6,680 ft^2 per day. Because of this relatively high transmissivity, the hydraulic connection with Telegraph Swamp, and the ease with which the aquifer can be recharged by precipitation, the aquifer has a potential for yielding large quantities of water to properly constructed wells. In addition, where the aquifer is thin, moderately large quantities of water might be obtained through use of horizontal infiltration galleries.

Artesian Aquifer

Zone 1.—Zone 1 lies about 100 feet below land surface, beneath a blue-green clay. Although this aquifer is less than 50 feet thick it yields as much as 200 gpm to wells that tap a 10-foot section in the area south of Highway 74 and east of Highway 31. Elsewhere, the aquifer is not tapped. Based on specific conductance measurements, water from Zone 1 may have as much as 400 mg/l dissolved solids.

Zone 2.—Zone 2 lies about 175 feet below land surface. In area D, this aquifer contains water that meets the State's standards for drinking water, on the basis of analysis of water from well 15. The water from this well had less than 200 mg/l dissolved solids (based on specific conductance); 30 mg/l chloride; less than 1 mg/l sulfate; and 0.1 mg/l fluoride. This well was open to the aquifer from 212 to 235 feet below land surface.

Zone 3 and deeper zones.—Zone 3 is the deepest aquifer tapped in Area D and lies 250 to 300 feet below land surface. Water from Zone 3 meets the State's standards for drinking water in some places. Water from wells that tap the aquifer ranges in specific conductance from 500 to 1,200 micromhos, in dissolved solids (based on specific conductance) from 300 to 700 mg/l, in chloride from 80 to 180 mg/l, and in sulfate from 30 to 40 mg/l. Water from aquifers deeper thanZone 3 does not meet the State's standards for drinking water as indicated by samples obtained from a 1,310-foot well. This well, drilled in the north-central part of the area, penetrated Zone 4 at a depth of about 900 feet and is cased to 715 feet. This water had a specific conductance of 3, 980 micromhos, a dissolved-solids concentration of 2,500 mg/l (based on specific conductance), and chloride and sulfate concentrations of 970 and 370 mg/l, respectively. The water was not suitable for irrigation of citrus, and the

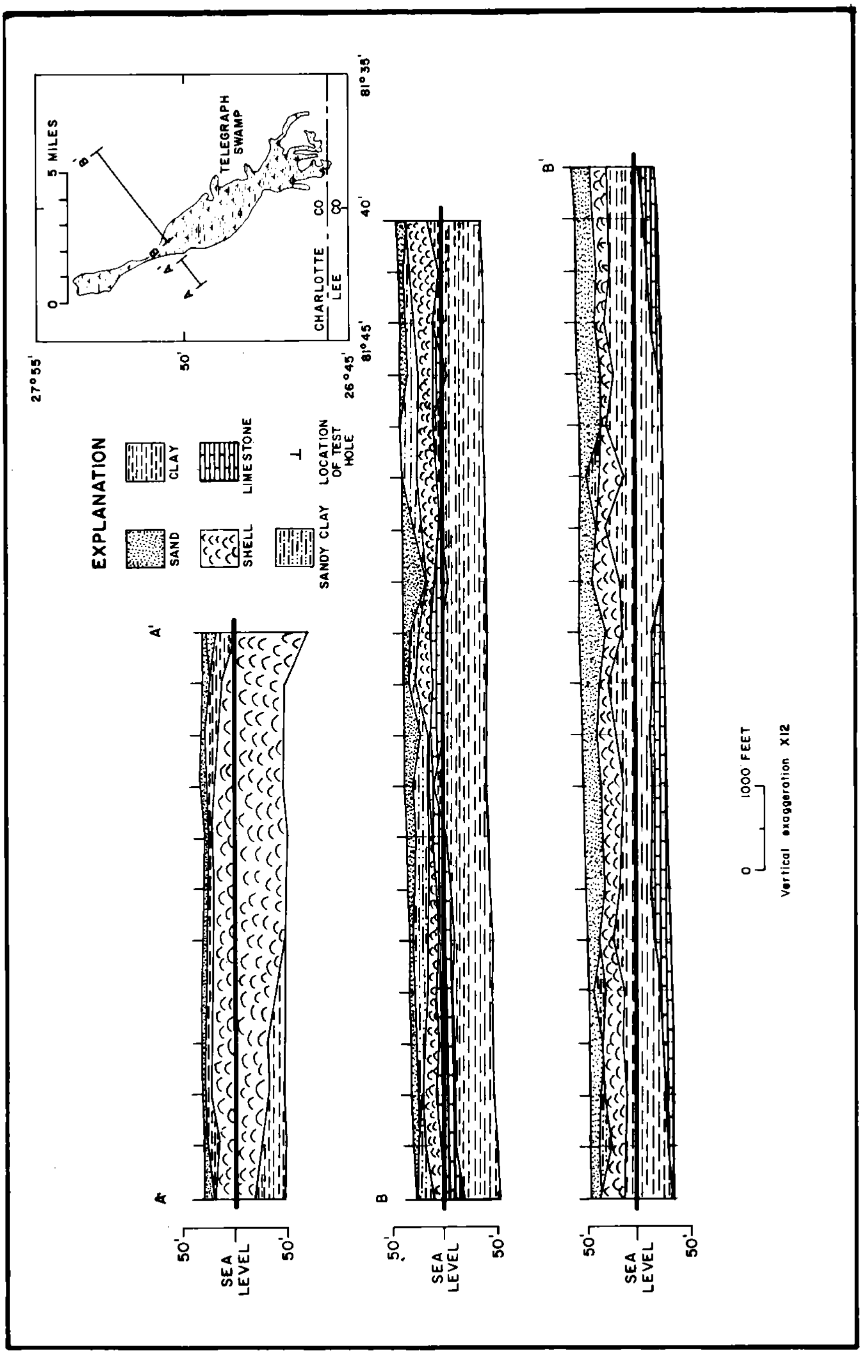

Figure 18.—Generalized sections across the Telegraph Swamp area, eastern Charlotte County.

well was plugged to prevent intrusion of this water into the upper producing zones.

WELL CONSTRUCTION AND USE IN RELATION TO WATER QUALITY

In Areas A, B, and C, saline water occurs in the artesian aquifers at a shallow depth. The potentiometric surface of each aquifer increases with depth, and in many places the water level rises above land surface. As a result, saline water moves upward in wells that tap both shallow and deep aquifers to invade shallow artesian aquifers formerly containing only fresh water. Locally, saline water has intruded the water-table aquifer by way of uncontrolled flowing wells and corroded well casings that formerly sealed off the water-table aquifer from multiaquifer wells.

Modifying the construction of wells in Charlotte County would prevent upward movement of water in them. Installing casing opposite aquifers where dissolved-solids concentration markedly exceeds 500 mg/l and whose water-level will rise to or above that in the overlying aquifer, will prevent the upward movement of water into the overlying aquifers. The well casing could be extended through the zone or zones containing potable water and be firmly seated in the rock zone that forms the confining layer of the underlying aquifer. The annular space between the casing and the well bore could be filled with neat cement grout. This type of well construction will minimize the effects of saline water intruding the overlying aquifers.

The problems associated with intrusion of saline ground water could be lessened by following conservation practices. Flowing wells could be fitted with shutoff valves at the well heads to be closed when the water is not being used. Unused wells that yield saline water should be carefully plugged from bottom to top with grout. Burying such wells by breaking off the casing below land surface and back filling the well site will not keep them from contaminating shallow aquifers. It is nearly impossible to relocate and properly plug these buried wells. The construction of many wells currently in use in the county could be improved by installing and grouting several hundred feet of casing. This modification is needed in all areas, but particularly where irrigation wells are near urbanized areas.

SALINE WATER RESOURCES

The artesian aquifers underlying Charlotte County contain a large quantity of saline water whose dissolved-solids concentration is less than 5,000 mg/l. Water with this dissolved-solids concentration is generally suitable for demineralization and represents a potential future source of raw water for public supply for coastal Charlotte County. The depth to the zones containing this water increases inland from the coast in Areas A to D. As a result, the shallow Zones 1 and 2 in Area A contain water whose dissolved-solids concentration is about 5,000 mg/l and only the deeper zones 4 and 5 in Area D contain water of this salinity.

Some ground water with a dissolved-solids concentration of 3,000 mg/l is already being desalted by several small water utility companies near Charlotte County. The water is desalted using the reverse osmosis and electrodialysis process. The finished water delivered to the customers has a dissolved-solids concentration that is reported to be 450 mg/l. In general, no use is now being made of saline water resources of the county.

CONCLUSIONS

Most of the fresh surface water of usuable quality in Charlotte County has already been developed for public supply. A reservoir on Myrtle Slough could yield an additional small supply. Fresh surface water might be imported into the county from Horse Creek in DeSoto County or from Myakka River in Sarasota County, where reservoir sites exist.

The largest potential source of fresh ground water is the water-table aquifer underlying the Telegraph Swamp area. This aquifer also has a potential for use as a source for small supplies in other parts of the county. The artesian aquifers underlying the county contain large quantities of saline water which is suitable for demineralization. Moderately saline water can be obtained from shallow zones in the artesian aquifers near the Gulf coast and around Charlotte Harbor and from the deeper zones in the eastern part of the county.

Bringing fresh water some distance to the coastal urban area or demineralizing saline ground water for use as a water supply will sustain the urbanizing coastal area so that the county can continue to grow.

SELECTED REFERENCES

Cooke, C. Wythe, 1945, *Geology of Florida*: Florida Geol. Survey Bull. 29, 339 p.

DuBar, J. R. 1958a, *Stratigraphy and paleontology of the late Neogene strata of the Caloosahatchee River of southern Florida*: Florida Geol. Survey Bull. 40, 267 p.

—1958b, *Neogene stratigraphy of southwestern Florida*: Gulf Coast Assoc. Geol. Soc. Trans., v.8, p. 129-155.

—1962, *Neogene biostratigraphy of the Charlotte Harbor area in southwestern Florida*. Florida Geol. Survey Bull. 43, 83 p.

—1968, *Stratigraphy and paleontology of the late Neogene strata of the Caloosahatchee River area of southern Florida*: Guidebook, 2nd Ann. Field Trip, Miami Geol. Soc., p. 55-64.

Flippo, H. N., Jr., and Joyner, B. F., 1968, *Low streamflow in the Myakka River Basin area in Florida*: Florida Bur. Geology Rept. Inv. 53, 34 p. 5 figs.

Johnson, Lamar, 1969, *Engineering and economic feasibility of the proposed Horse Creek Reservoir project, DeSoto County Florida*: Consulting Engineer, Lake Wales, Florida, 40 p.

Kaufman, M. I., and Dion, N. P., 1967, *Chemical character of water in the Floridan aquifer in southern Peace River Basin, Florida*: Florida Bur. Geology Map Ser. 27, 1 sheet.

—1968, *Ground-water resources data of Charlotte, DeSoto and Hardee Counties, Florida*: Florida Bur. Geology Inf. Circ. 53, 24 p. 4 figs.

Kenner, W. E., Pride, R. W., and Conover, C. S., 1967, *Drainage basins in Florida*: Florida Bur. Geology Map Ser. 27, 1 sheet.

MacNeil, F. S., 1950, *Pleistocene shoreline in Florida and Georgia*: U. S. Geol. Survey Prof. Paper 221-F, p. 91-107.

Matson, G. C., and Sanford, Samuel, 1913, *Geology and ground water of Florida*: U. S. Geol. Survey Water-Supply Paper 319, 445 p.

Parker, G. G., and Cooke, C. W., 1944, *Late Cenozoic geology of southern Florida, with a discussion of the ground water:* Florida Geol. Survey Bull. 27, 119 p.

Parker, G. G., Ferguson, G. E., Love, S. K., and others, 1955, *Water resources of southeastern Florida*: U. S. Geol. Survey Water-Supply Paper 1255, 965 p.

Puri, H. S., and Vernon, R. O., 1964, *Summary of the geology of Florida and a guidebook to the classic exposures*: Florida Geol. Survey Spec. Pub. 5, 312 p.

Sellards, E. H., and Gunter, Herman, 1913, *The artesian water supply of eastern and southern Florida*: Florida Geol. Survey Ann. Rept. 5, p. 113-290.

Stringfield, V. T., 1936, *Artesian water in the Florida peninsula*: U. S. Geol. Survey Water-Supply Paper 773-C, p. 115-195.

—, 1966, *Artesian water in Tertiary limestone in the southeastern states*: U. S. Geol. Survey Prof. Paper 517, 226 p.

Sutcliffe, H., Jr., and Joyner, B. F., 1968, *Test well exploration in the Myakka River basin area, Florida*: Florida Bur. Geology Inf. Cir. 56, 61 p., 15 figs.

Toler, L. G. 1967, *Fluoride in water in the Alafia and Peace River basins, Florida*: Florida Bur. Geology Rept. Inv. 46, 46 p., 18 figs.

University of Florida, 1969, *Florida statistical abstract* 1969: Coll. of Bus. Adm., Gainesville, 492 p.

U. S. Geological Survey, 1971, *Water resources data for Florida, Part* 1, *Surface Water Records, vol. 2, Streams—Southern Florida, Lake Okeechobee and the Everglades*: U. S. Geological Survey, Tallahassee, Florida, Published annually.

U. S. Public Health Service, 1962, *Public Health Service drinking water standards*: U. S. Public Health Service Pub. 956, 61 p.

Wells, S. W., 1969, *Water resources survey, Port Charlotte, Florida*: General Development Utilities, Inc., Miami, Florida, 47 p.