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FEASIBILITY OF WATER-SUPPLY DEVELOPMENT FROM THE UNCONFINED AQUIFER IN CHARLOTTE COUNTY, FLORIDA

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 78-26

Prepared in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

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April 1978

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For use of those readers who may prefer to use metric units rather than U.S. customary units, the conversion factors for the terms used in this report are listed below:

U.S. customary units	Multiply by	Metric units
inches (in)	25.40	millimeters (mm)
feet (ft)	.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
acres	.4047	hectares (ha)
gallons (gal)	3.785 3.785×10^{-3}	liters (L) cubic meters (m^3)
million gallons (Mgal)	3785	cubic meters (m^3)
cubic feet (ft^3)	2.832×10^{-2}	cubic meters (m^3)
gallons per minute (gal/min)	.06309 6.309×10^{-5}	liters per second (L/s) cubic meters per second (m^3/s)
cubic feet per second (ft^3/s)	28.32	liters per second (L/s)
million gallons per day (Mgal/d)	.04381	cubic meters per second (m^3/s)
million gallons per year (Mgal/yr)	1.200×10^{-4}	cubic meters per second (m^3/s)
gallons per minute per foot [(gal/min)/ft]	.2070	liters per second per meter [(L/s)/m]
square feet per day (ft^2/d)	.09290	square meters per day (m^2/d)
feet per day (ft/d)	.3048	meters per day (m/d)
feet per day per foot [(ft/d)/ft]	1.000	meters per day per meter [(m/d)/m]

FEASIBILITY OF WATER-SUPPLY DEVELOPMENT FROM THE UNCONFINED AQUIFER IN CHARLOTTE COUNTY, FLORIDA

By

Richard M. Wolansky

ABSTRACT

The unconfined aquifer in Charlotte County contains some potable water over most of the area, and represents a potential source of water supply to help satisfy the increasing demands of development. The unconfined aquifer extends throughout the county and averages about 35 feet thick; it is composed of sand, marl, shells, and limestone. A sequence of clay with an average thickness of about 40 feet separates the unconfined aquifer from the underlying confined (artesian) aquifers.

An estimated 150 billion cubic feet of relatively good quality water is stored in the unconfined aquifer in Charlotte County. The transmissivity of the unconfined aquifer averages about 500 square feet per day, ranging from about 100 to 7,000 square feet per day. The specific yield of the unconfined aquifer is estimated to be about 0.25.

Although recharge of the unconfined aquifer is primarily from rainfall, a significant amount of recharge occurs by upward movement of water from the underlying confined aquifers through abandoned and flowing irrigation wells. The average annual recharge is estimated at about 12 inches per year, and ranges from less than 1 inch to 16 inches per year, depending on the permeability and thickness of aquifer material and the topography.

The chemical quality of the water in the unconfined aquifer is variable. Except in tidal areas and where brackish water enters the aquifer from wells that tap the confined aquifers, however, the chloride concentration of water from the unconfined aquifer generally is less than 50 milligrams per liter. In water from some wells, concentrations of dissolved iron and color exceed the limits established by the U.S. Environmental Protection Agency. Both iron and color are easily removed from water as part of the water treatment process, however.

Cape Haze and Gasparilla Island well fields are the only water-supply facilities presently (1977) withdrawing from the aquifer. Their total withdrawal is about 0.43 million gallons per day. About 1,000 private and industrial wells pump about 2 to 4 million gallons per day. Average well yield throughout Charlotte County is about 10 to 30 gallons per minute.

The area of greatest potential yield is located east of Telegraph Swamp in eastern Charlotte County. The unconfined aquifer in this area can be developed by constructing conventional wells, collector wells, or tile drains. The amount of water that could be salvaged by capturing natural water loss (evaporation and runoff) of 12 inches annually is about 14 million gallons per day for a 25-square-mile area.

INTRODUCTION

Nearly everywhere in Charlotte County, the unconfined aquifer contains potable water and represents a potential source of water supply--a source of considerable importance because the water in the confined aquifers that underlie the county at depth contain water of poor chemical quality (Sutcliffe, 1975).

Developing the unconfined aquifer for water supply will be complicated; pumping will at least partly dewater the aquifer and decrease its thickness and thus its transmissivity as water is withdrawn. The susceptibility of the aquifer to contamination from the land surface and by poor quality water from the confined aquifers also complicates its use as a major water-supply source.

Urban development is increasing in the coastal areas and Charlotte Harbor, while the eastern part of the county is being used primarily for agriculture. The increase in the number of canals and ditches to drain areas of both kinds of development will remove some of the water from the unconfined aquifer that could be used otherwise.

Purpose and Scope

This report presents the results of a 2-year study undertaken by the U.S. Geological Survey in cooperation with the Southwest Florida Water Management District. It describes the geology and hydrology of the unconfined aquifer in Charlotte County, and the most feasible methods for reasonably developing the water-supply potential of the aquifer--so that there will not be a long-term decrease in the quantity of water remaining in storage each year. The investigation is based upon information obtained from test holes, observation wells, private wells and excavations into the unconfined aquifer. Some sites outside the county were also investigated to broaden the information base. The overall intent of the investigation is to describe the unconfined aquifer system and to assess the water-supply potential of the aquifer so as to aid in planning for development and future growth of the county.

Previous Investigations

The geology and ground-water resources of Charlotte County are described in several reports. Parker and Cooke (1944) described the geology and water resources of the county. Cooke (1945) supplied information on Pleistocene shorelines in the county.

References to flowing artesian wells in Charlotte County have been made by Hendry and Lavender (1957, 1959). DuBar (1958, 1961) reported on the Neogene stratigraphy and biostratigraphy of the Caloosahatchee

River area. Kaufman and Dion (1967, 1968) summarized the ground-water resources of the county. Sutcliffe and Joyner (1968) reported on the results of test drilling in the county. Information on the surficial sediments in the eastern section of the county has been compiled by Wahl and Timmons (1972). Sutcliffe (1975) prepared an appraisal of the water resources of the county.

Location and Geography

Charlotte County is on Florida's southwest coast (fig. 1). The Gulf of Mexico forms the western boundary, Sarasota and DeSoto Counties the northern boundaries, Glades County the eastern boundary, and Lee County the southern boundary. Charlotte County is 832 mi^2 in area; bays, estuaries, and rivers comprise about 129 mi^2.

Land surface in Charlotte County is relatively flat, sloping from about 70 ft above sea level in the northeast to sea level near the coast. Physiographic features of the county are the Gulf Coastal Lowlands of the western and central part of the county and the Caloosahatchee Incline and the DeSoto Plain of the northeastern part (fig. 2).

GEOHYDROLOGY OF THE UNCONFINED AQUIFER SYSTEM

All sediments that overlie the Tamiami Formation and parts of the Tamiami, where relatively impermeable clayey sediments are not present, comprise the unconfined aquifer in Charlotte County. These sediments range in age from early Pliocene to Holocene. Layers of clay and marl below the unconfined aquifer, and within the Tamiami separate that aquifer from permeable zones below.

Geologic Setting

Charlotte County is generally covered by a few feet of recently deposited Holocene sand and alluvium.

The Pliocene and Pleistocene is represented by the Caloosahatchee Marl, the overlying sand of the Fort Thompson Formation, and the marine terraces. Terrace deposits of the Penholoway, Talbot, and Pamlico Formations, and Silver Bluff Formation of local usage are present in the report area. According to Cooke (1945) the altitudes of the terrace shorelines are 70 ft for the Penholoway, 42 ft for the Talbot, 25 ft for the Pamlico, and 5 ft for the Silver Bluff. Figure 3 shows the altitude of the land surface in Charlotte County.

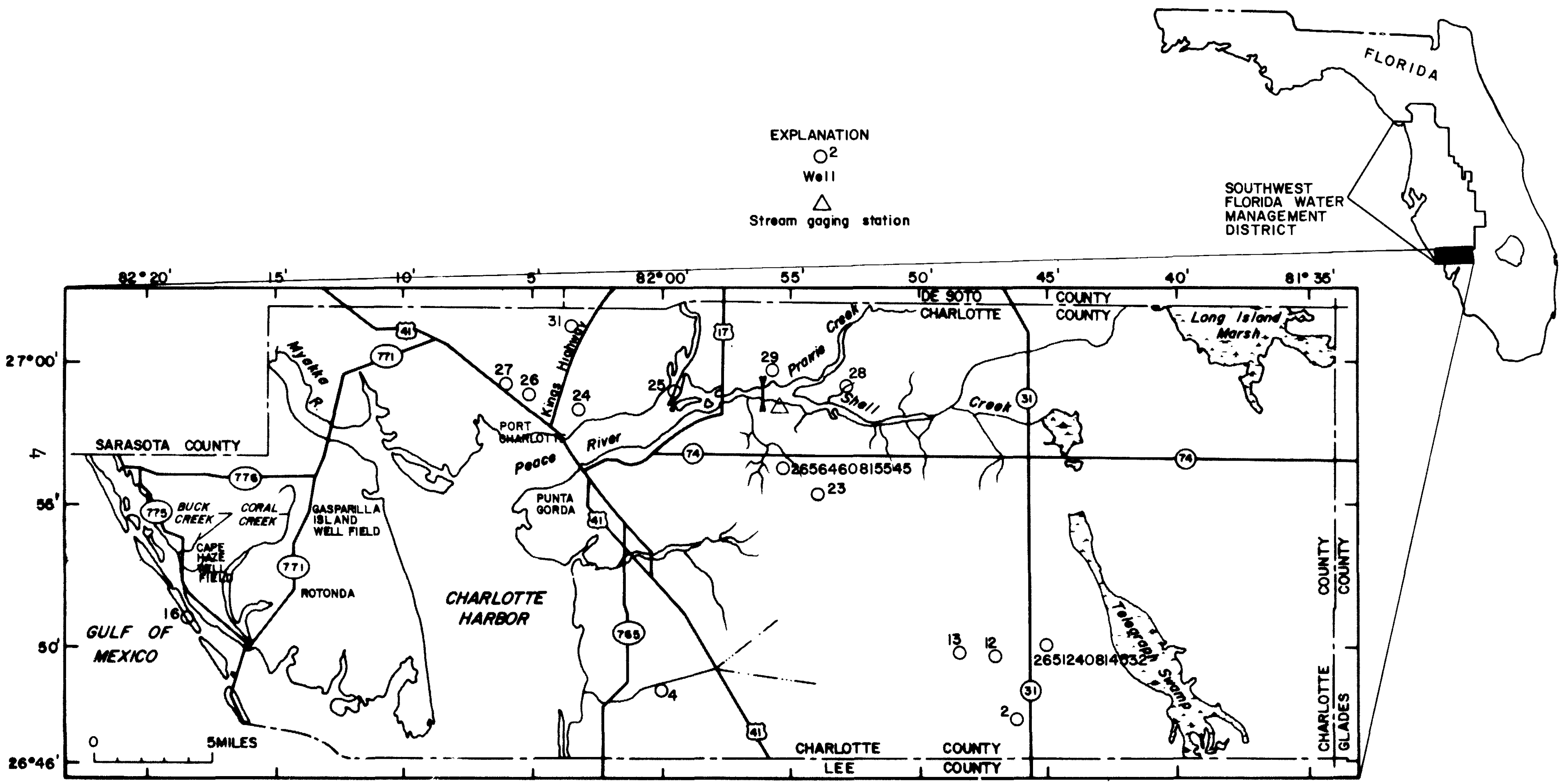


Figure 1. --Area of investigation and location of wells and Shell Creek gaging site referred to in this report

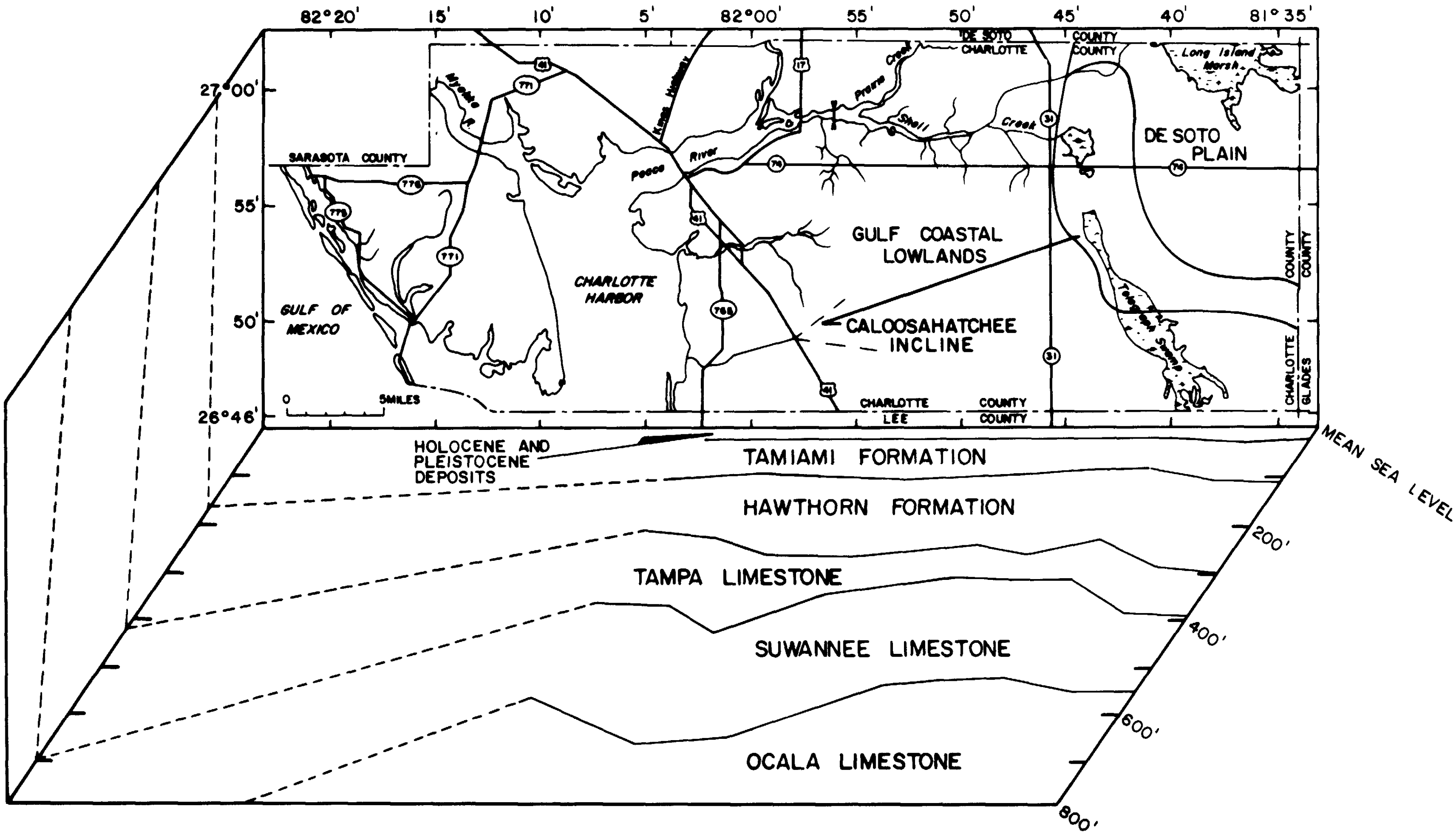
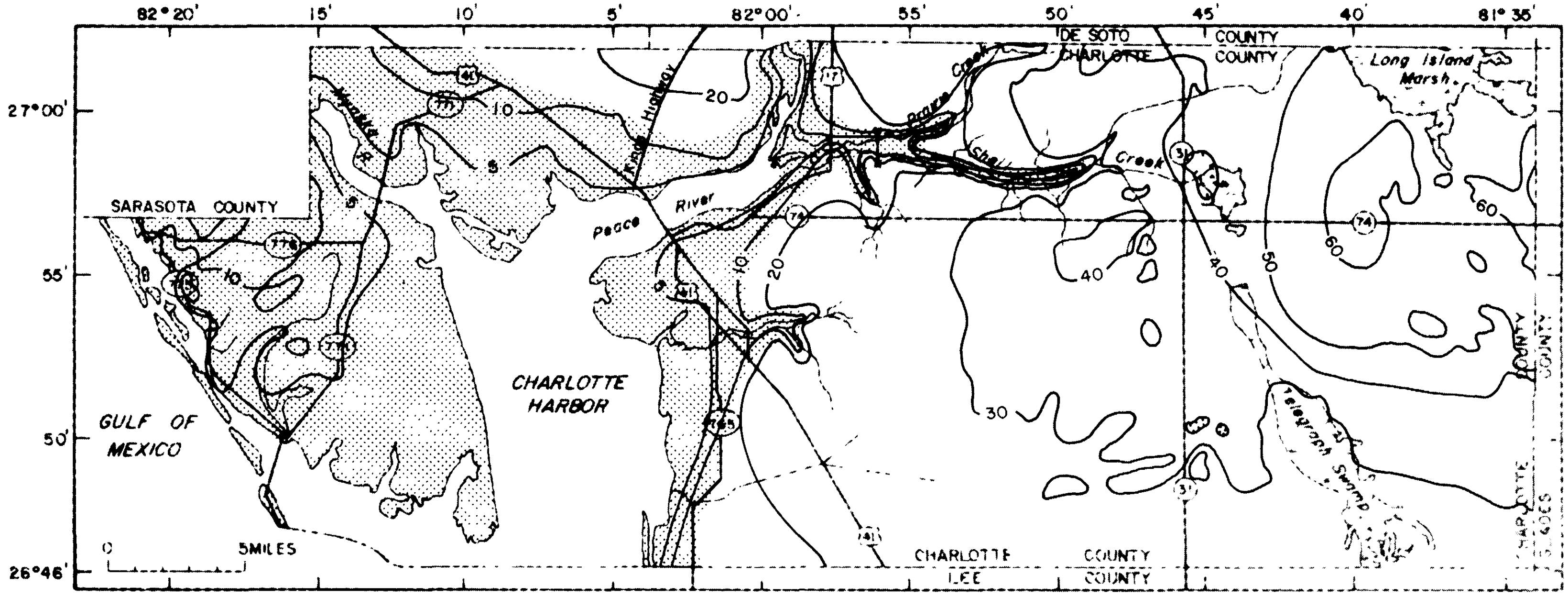


Figure 2. --Physiographic features and geologic formations underlying Charlotte County



EXPLANATION

—— 40 ——

LAND-SURFACE CONTOUR
Shows altitude of land surface.
Contour interval 5 and 10 feet.
Datum is mean sea level

100-Year tidal inundation

FIGURE 3.--Altitude of land surface and 100-year tidal inundation area.

Rocks older than early Pliocene are not exposed at land surface within the county. The early Pliocene is represented by the Tamiami Formation. Underlying the Tamiami Formation are limestone and dolomite in which are the confined aquifers. These rocks include the Hawthorn Formation, the Tampa and Suwannee Limestones, the Ocala Limestone, and the Avon Park Limestone. Figure 2 shows all formations underlying the county except the Avon Park.

Description of the Unconfined Aquifer

The unconfined aquifer in Charlotte County includes deposits of Holocene, Pleistocene and Pliocene age (fig. 4). Holocene deposits consist of surficial, white, quartz sand and alluvium. Holocene sand and alluvium are found throughout most of the county, and range in thickness from 0 to 15 ft, reaching a maximum near the coast.

The terrace sand, clay, and shell marl of the Pleistocene Fort Thompson Formation unconformably underlie the Holocene sand and alluvium. The sand of the Fort Thompson is usually unfossiliferous, indicating deposition close to shorelines, mainly above sea level. It is predominantly fine to medium grained, well-sorted, and pale yellow-orange and ranges from 0 to 20 ft thick in the county. Thickness and areal distribution of the clay and shell marl facies of the formation are more variable than those of the sand. The clay is generally less than 1 ft thick and light gray-green and the unconsolidated shell marl is generally 5 ft thick or less.

The Caloosahatchee Marl of Pliocene and Pleistocene age unconformably underlies the Fort Thompson Formation. Typically, the Caloosahatchee sediments consist of unconsolidated shell beds; light gray, sandy, shelly marl; marl; and thin beds of hard, sandy limestone. The marl varies laterally from very shelly to very sandy and silty. The Caloosahatchee Marl generally ranges in thickness from 5 ft to 40 ft. In sections of the county, however, the Caloosahatchee Marl has been eroded away or was never deposited.

The base of the unconfined aquifer generally is the top of the Tamiami Formation which lies unconformably below the Caloosahatchee Marl. Locally permeable zones in the top of the Tamiami Formation are included in the unconfined aquifer. In general, however, throughout Charlotte County a gray through tan, calcareous, nearly impermeable clay in the uppermost part of the Tamiami Formation forms a confining layer that ranges in thickness from 0 to 100 ft and averages about 50 ft.

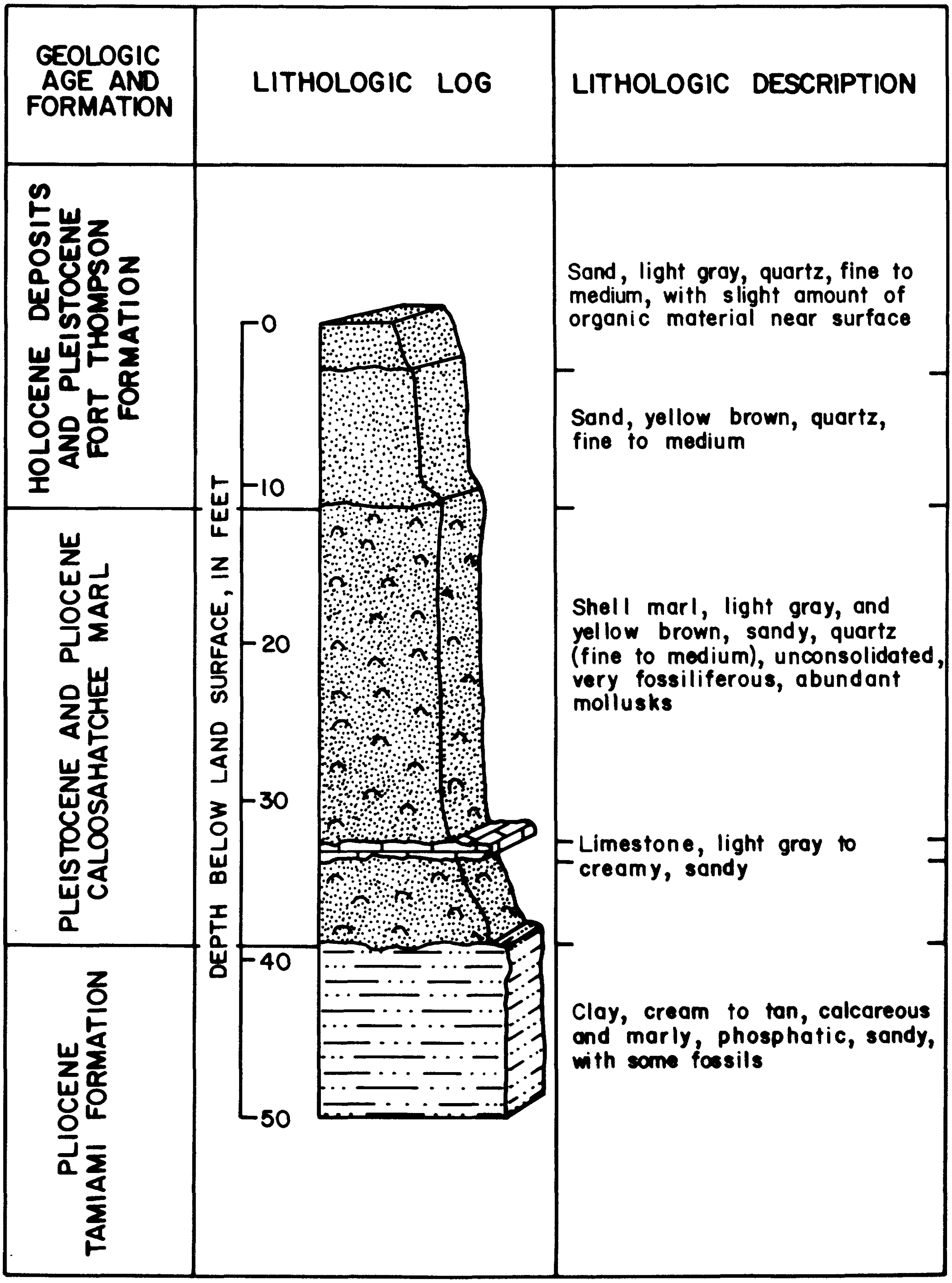


Figure 4. --Generalized lithologic columnar section of unconfined aquifers in Charlotte County

Lateral and Vertical Extent

The unconfined aquifer extends throughout Charlotte County and is about 10 to 80 ft thick (fig. 5). Areal variation in thickness of the aquifer is probably related to the location of Pleistocene shorelines within the county. The aquifer is thickest in the vicinity of Telegraph Swamp and west and north of the swamp along the Caloosahatchee Incline, an emergent relict submarine shoal (White, 1970, p. 141).

The lithologic logs of wells that penetrate the unconfined aquifer and the confining bed in different parts of the county are presented graphically in figure 6; they provide information on the types of materials likely to be encountered when drilling wells.

Hydraulic Properties

Generally, aquifer tests provide a dependable means of determining hydraulic properties of an aquifer. In areas where aquifer test data are not available, lithologic logs, testing of core samples for hydraulic conductivity and specific yield, grain-size analyses, and specific capacity tests of wells can also be used to estimate these properties.

An aquifer test in the Gasparilla Island well field (fig. 1), where wells penetrated 10 to 20 ft into a sandy shell bed, indicates a transmissivity of about 1,500 ft^2/d and a specific yield of about 0.2 (Bennett and Bishop Consulting Engineers, 1967). Aquifer testing of about 40 ft of sand and laminated sand and sandy clay in northwest Hillsborough County yielded a transmissivity of about 270 ft^2/d and a specific yield of about 0.20 (Sinclair, 1974). In Polk County, where the unconfined aquifer is composed of about 75 ft of sand and clayey sand, transmissivity is estimated to be 1,900 ft^2/d and the specific yield is estimated to be 0.25 to 0.30 (C. B. Hutchinson, U.S. Geological Survey, written commun., 1976).

Within the study area, the specific capacity of wells penetrating 10 to 50 ft of sandy shell beds and unconsolidated, relatively clean beds of shells range from about 5 to 30 (gal/min)/ft giving an estimated transmissivity range of 1,000 to 10,000 ft^2/d. Wells that tap sand and sandy clay have specific capacity values of 1 to 10 (gal/min)/ft. The aquifer, where it includes clayey material, has an estimated transmissivity range based on specific capacities of about 100 to 1,200 ft^2/d.

Estimates of hydraulic conductivity for lithologic units present in the unconfined aquifer are listed in table 1. Transmissivity is determined by multiplying the saturated thickness of a unit by its hydraulic conductivity.

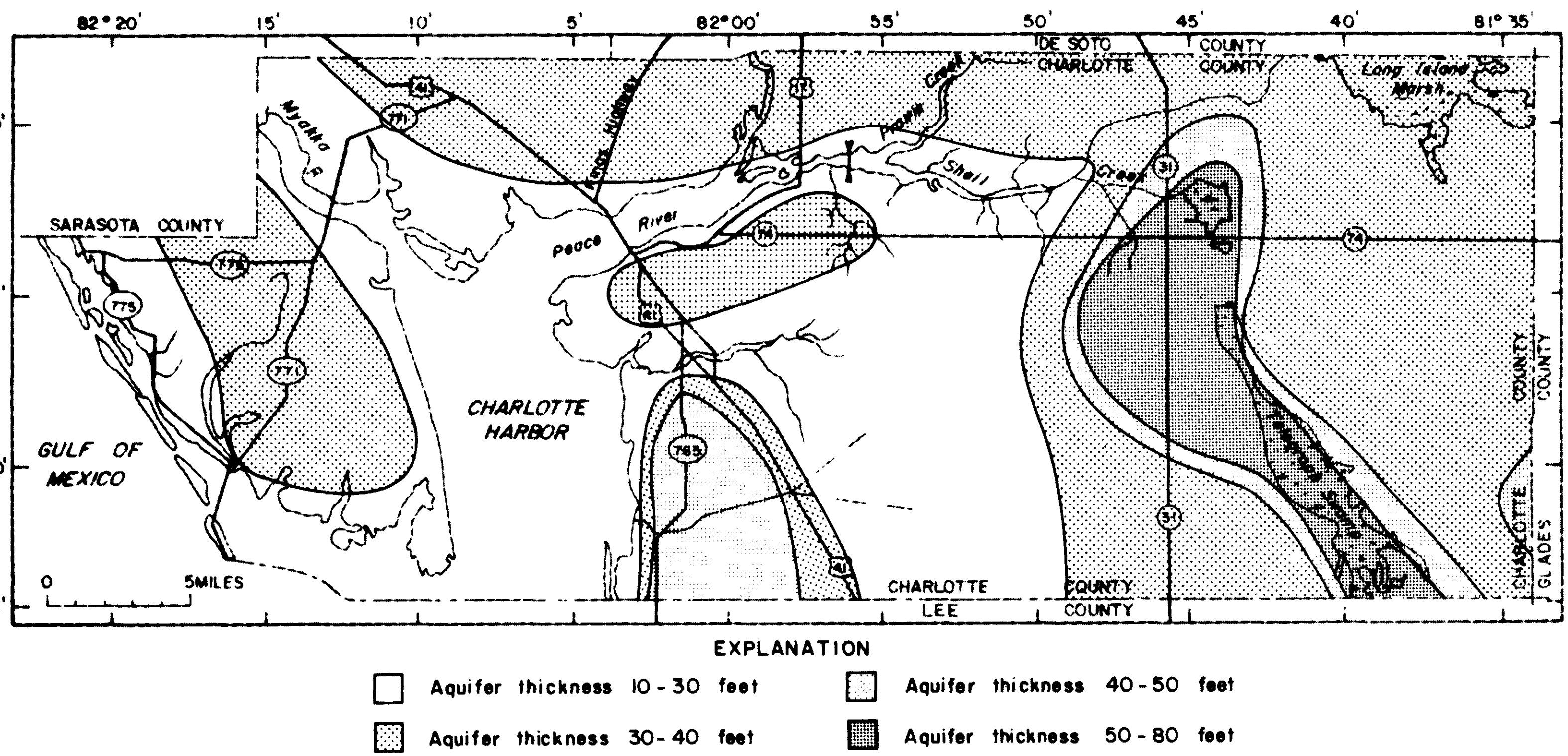


Figure 5. --General thickness of unconfined aquifer in Charlotte County

Table 1.--Estimates of hydraulic conductivity range for the unconfined aquifer

Lithologic unit	Hydraulic conductivity range (ft/d)
Sand (fine to medium)	5 - 35
Silty sand	1 - 10
Clayey sand	10^{-2} - 2
Shell bed and sandy shells	50 - 1000
Shelly marl	10^{-1} - 15
Sandy marl	10^{-1} - 15
Limestone	10^{-2} - 15
Sandy clay	3×10^{-4} - 3×10^{-2}
Clay	10^{-5} - 10^{-4}

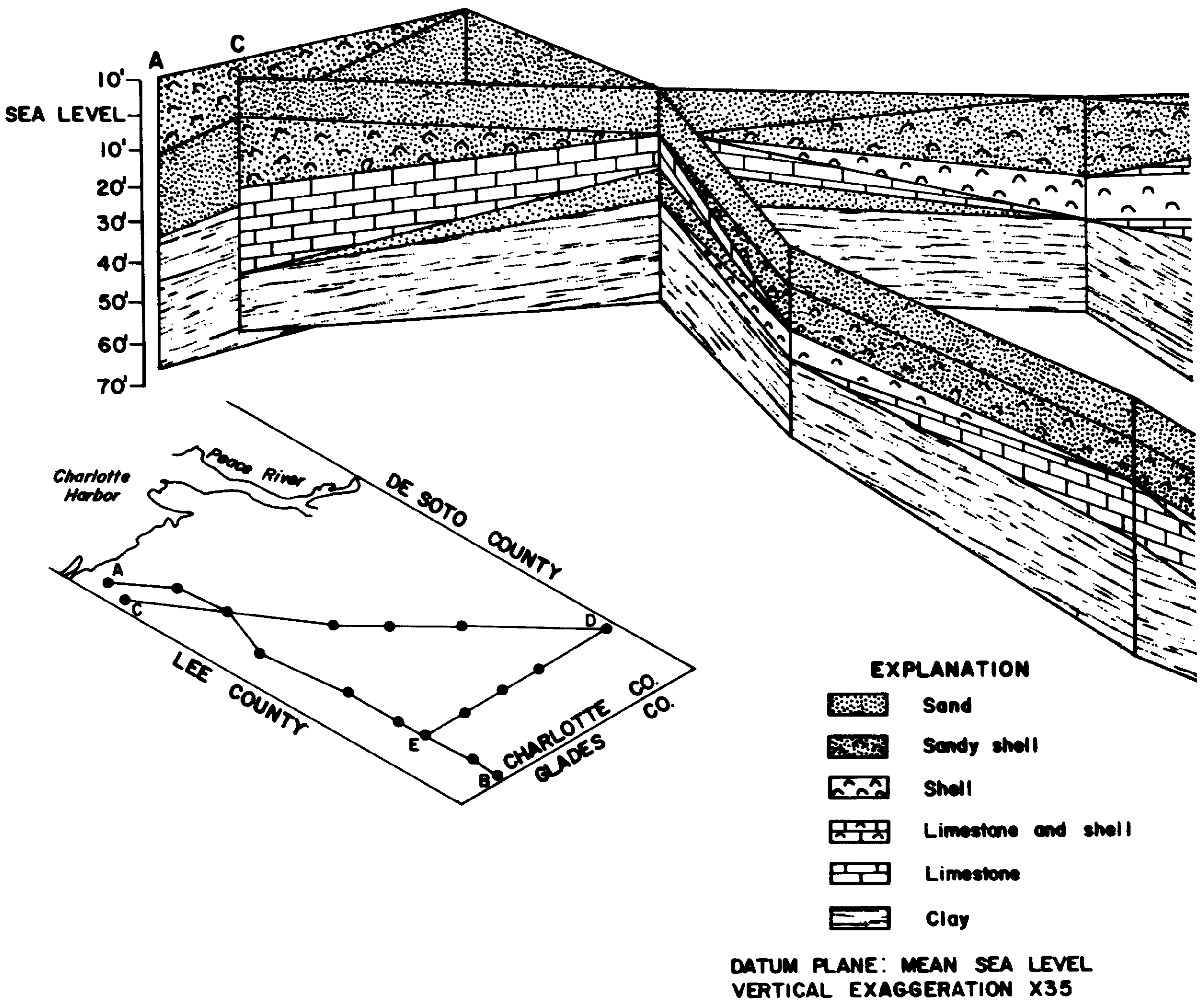
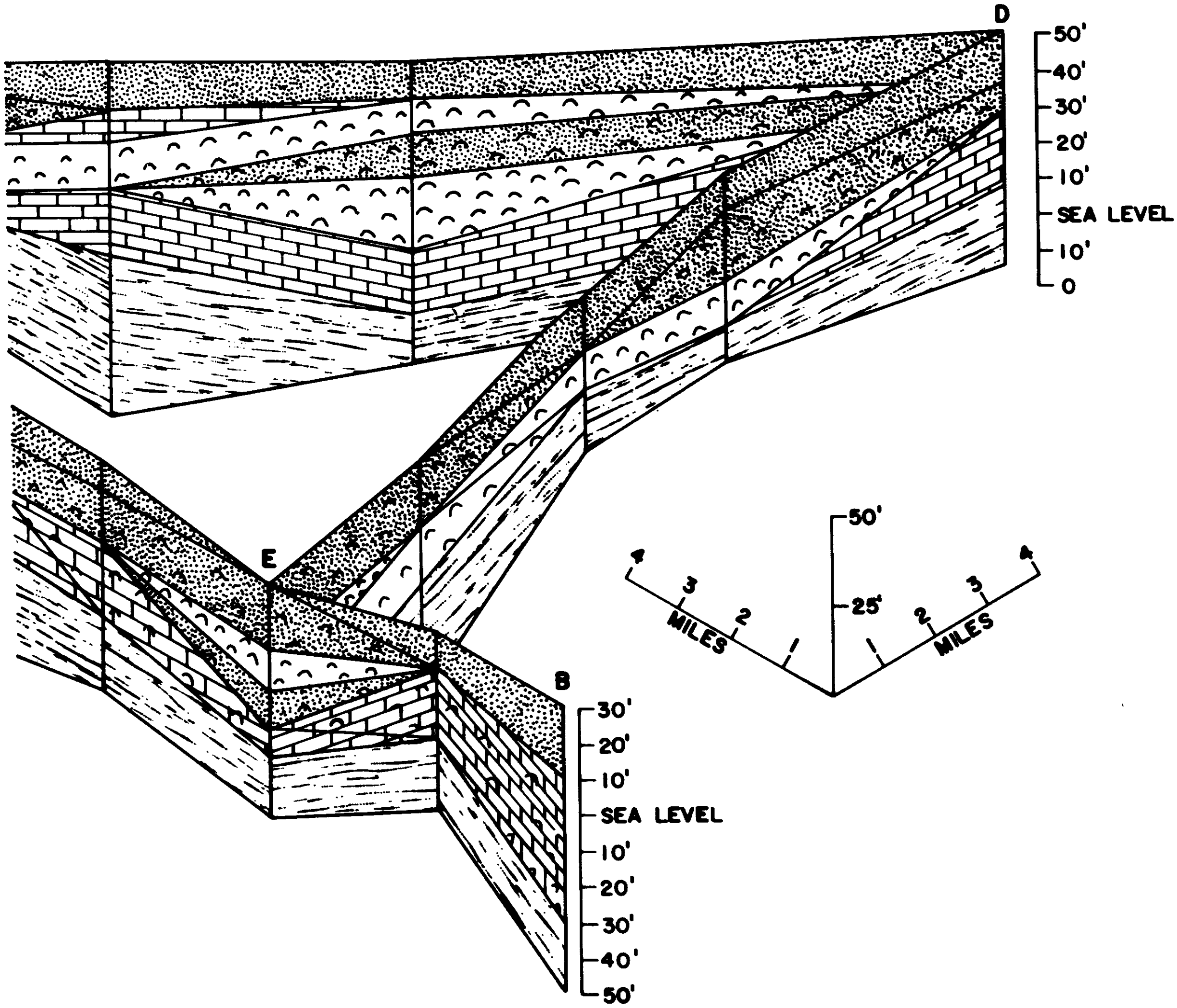


Figure 6. --Lithologic correlation of



unconfined aquifer and clay in Charlotte County

Ground-Water Storage

By multiplying the area of the unconfined aquifer by the area's average specific yield, and by its average saturated thickness, a value is obtained that is an approximation of the quantity of water in storage. The average saturated thickness of the unconfined aquifer is about 35 ft and the specific yield, derived from laboratory and aquifer tests for similar sediments, is about 0.25. Therefore, the volume of ground water that can be released from storage in the total county land area of 703 mi^2 is about 150 billion ft^3, and in the 481-mi^2 area above the 100-year flood contour (fig. 3), about 100 billion ft^3. The area below the 100-year flood contour is subject to an annual tidal flood of 1-percent probability, and therefore, about one-third of the water in storage in the unconfined aquifer is subject to saltwater contamination if a hurricane were to cause a transient rise in sea level.

Recharge

Most of the natural recharge to the unconfined aquifer in Charlotte County is by infiltration of rainfall during those periods when it exceeds evapotranspiration. Another source of natural recharge to the unconfined aquifer is upward leakage from the confined aquifers where the potentiometric surface is higher than the water table throughout the year. However, the quantity of recharge from this source is small when compared to the quantity supplied by rainfall. A small amount of recharge to the aquifer is derived from ground-water underflow from outside the county in the northwest section of the county. An appreciable quantity of water is artificially recharged to the unconfined aquifer by wells open to the confined aquifer. These wells are used for irrigation where water quality permits; however, many are no longer used and are allowed to flow continuously.

To determine the quantity of natural recharge (rainfall minus evapotranspiration and overland runoff) to the unconfined aquifer in the county, use was made of streamflow measurments of Shell Creek, a stream whose basin is partly in Charlotte County and partly in DeSoto County. Data for this basin were used for the estimate because neither streamflow nor the altitude of the water table have been affected by man's activities. In addition, leakage upward or downward between the unconfined and the artesian aquifer below is negligible nor are there uncontrolled flowing wells. Because of these characteristics, the flow in the stream can be equated to natural recharge for the basin inasmuch as the overland runoff is negligible because of low gradients and permeability of the surface materials. For the 5-year period, 1969-73, average annual streamflow was 11.7 in. The natural recharge is estimated to be about 12 in annually. For this same period, the average annual rainfall at the Arcadia station (about 24 mi northwest of Punta Gorda) and at the Punta Gorda station was 49.1 in (fig. 7). The water evapotranspired from the Shell Creek basin is the difference between runoff and rainfall, or about 37 in annually, or about 75 percent of the rainfall.

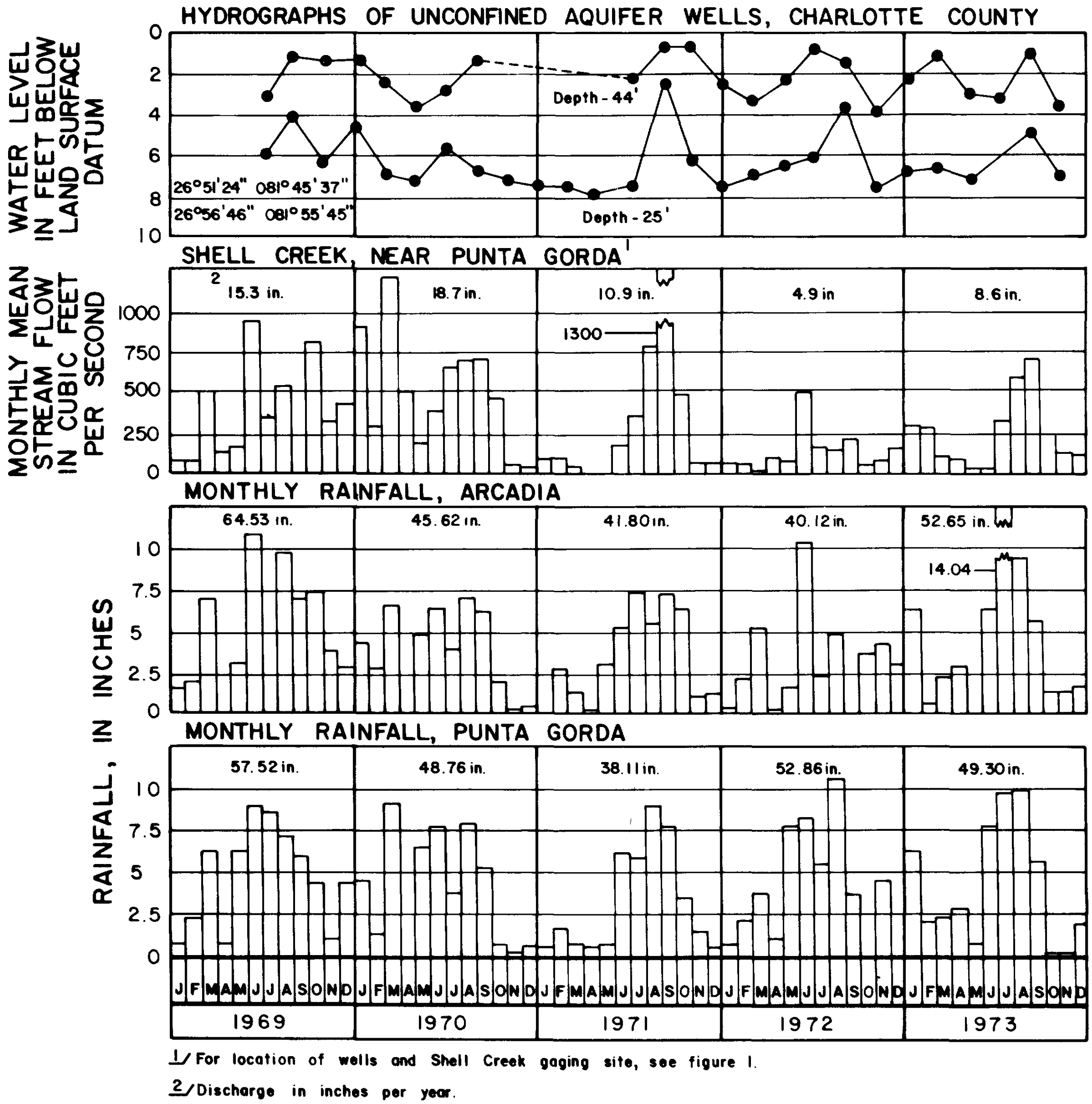


Figure 7. --Rainfall at Punta Gorda and Arcadia, streamflow of Shell Creek near Punta Gorda, and hydrographs of two unconfined aquifer wells in Charlotte County

The rainy-season (June to October) rise in water levels in wells in the unconfined aquifer where the levels are not affected by pumping offers a method to estimate the net increase in storage. Hydrographs for the period 1969-73 indicate that the unconfined aquifer usually receives 9 to 12 in of rain per year as natural recharge (fig. 7), on the basis of an average effective porosity of 0.25 for the aquifer.

Figure 8 shows a generalized relation between rainfall and recharge to be anticipated with the normal range of rainfall, extrapolated from rainfall-streamflow relations and hydrographs and lithologic logs of wells open to the unconfined aquifer. The following probable correlations are shown in the illustration: recharge and evapotranspiration and overland flow increase with rainfall, recharge increases at a greater rate than evapotranspiration and overland flow, and areas of high potential recharge lose less water to evapotranspiration and overland flow than areas of lesser potential. Other causes of variable potential are areal differences in topography, lithology, and thickness of the aquifer. Evapotranspiration could be greater or less than the 37 in indicated for Shell Creek basin and Charlotte County depending on the rate at which water infiltrates into the unconfined aquifer. If water moves rapidly through the aquifer, evapotranspiration is probably less than 37 in, and if the aquifer rapidly saturates to the surface, evapotranspiration will be greater than 37 in and overland flow will increase. Therefore, a reasonable range for recharge in the county is presumed to be less than 1 in or as much as 16 in per year and will vary according to permeability and thickness of aquifer material and the topography.

The values for natural recharge to the aquifer where it is very transmissive cannot be reliably applied to areas where the aquifer is less transmissive. Much of these areas is covered by water standing in ponds and depressions. Due to the high water table, evapotranspiration from these areas would almost equal yearly potential evapotranspiration, which is about 54 in in Charlotte County (Visher and Hughes, 1969). Most of the water not lost to evapotranspiration probably leaves the area as overland flow.

Upward leakage of water from the confined to the unconfined aquifer constitutes a minor source of natural recharge. Figure 9 shows the relation of the unconfined aquifer water level (water table) to the confined aquifer water level (potentiometric surface). Based upon an estimated average vertical hydraulic conductivity of 1.3×10^{-4} ft/d (Sinclair, 1974) and an estimated average thickness of 50 ft for the clay confining bed, the leakance (vertical hydraulic conductivity divided by thickness of the confining bed) is estimated to be 2.6×10^{-6} (ft/d)/ft over the county. With an average head difference of 14 ft between the two aquifers within that part of the county where the potentiometric surface is above the water table--an area of 650 mi^2--the estimated upward leakage is about 2,300 Mgal/yr. In the 53-mi^2 northeast section of the county where the unconfined water level is about 10 ft above the level in the confined aquifer, leakage downward to the artesian aquifer is estimated at about

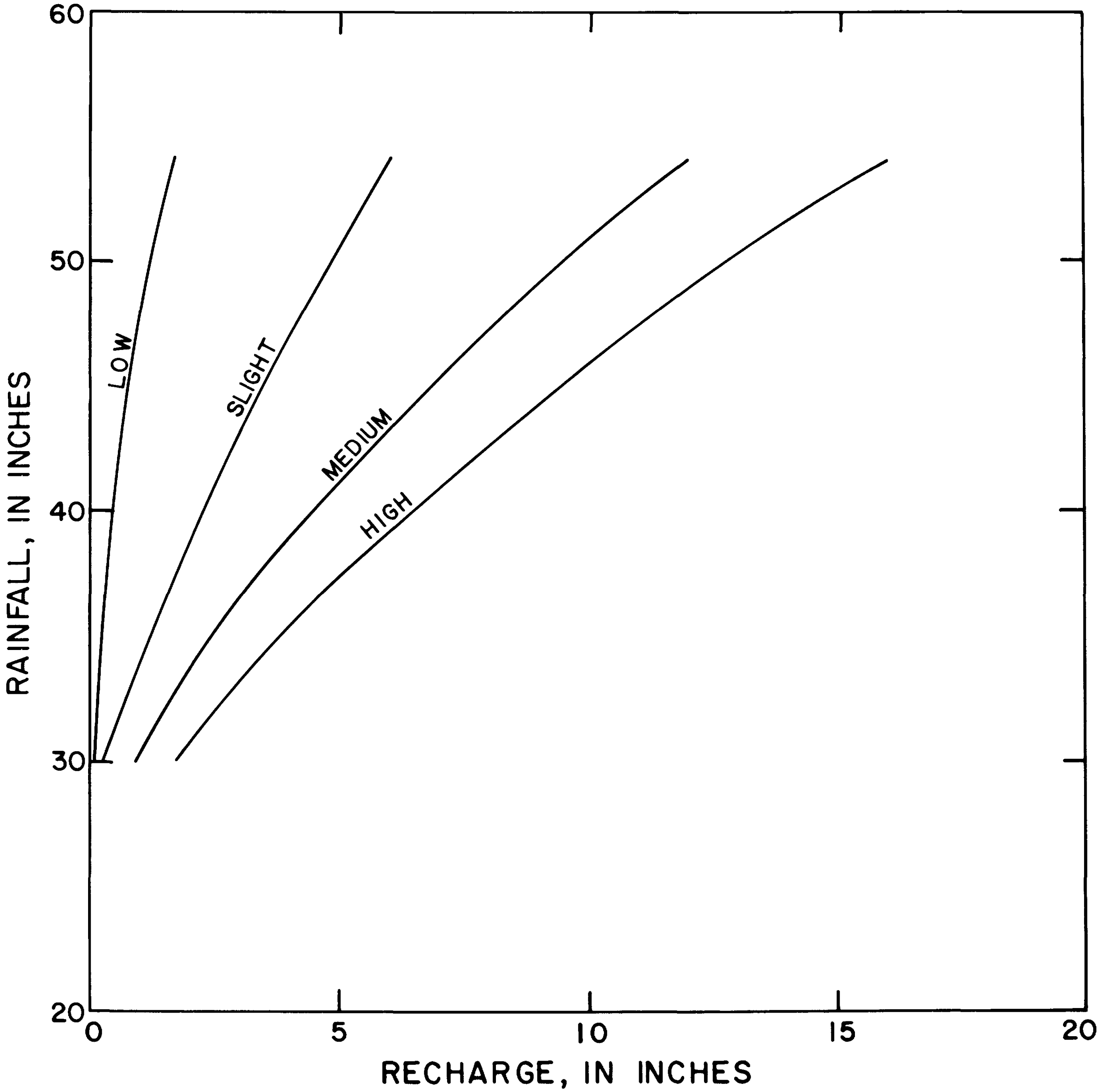
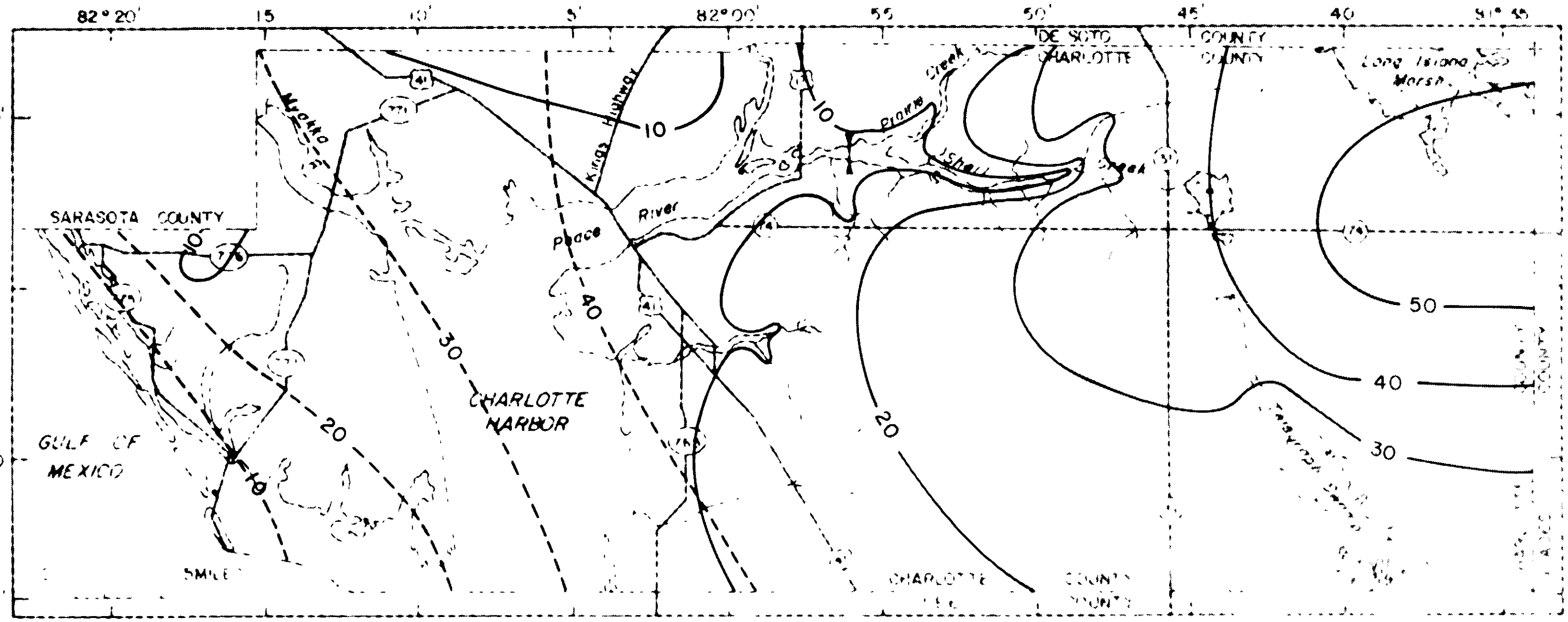


Figure 8. --Graph of generalized relation between rainfall and recharge for areas of high, medium, slight, and low potential recharge



EXPLANATION

——40—— WATER-TABLE CONTOUR
Shows altitude of water table Contour interval 10 feet. Datum is mean sea level

-----30----- POTENTIOMETRIC CONTOUR
Shows altitude at which water level would have stood in tightly cased wells. Contour interval 10 feet Datum is mean sea level

Figure 9. --Generalized water levels in the unconfined aquifer, and potentiometric surface of confined aquifers, May 1974

140 Mgal/yr. Over the entire county's land area of 703 mi^2, estimated upward leakage exceeds estimated downward leakage by about 2,160 Mgal/yr or 0.18 in/yr.

An estimate of the total inflow, by way of the unconfined aquifer, into the county in the northwest section was made. Based upon an average transmissivity of 500 ft^2/d, a hydraulic gradient of 1 ft/mi, and a distance between flow lines of 20 mi, inflow is about 80,000 gal/d.

Artificial recharge of the unconfined aquifer by irrigation water from the confined aquifer is estimated to be about 10 Mgal/d. Added to the estimated 25 Mgal/d from continuously flowing wells, an estimated 1.0 in of water per year artificially recharges the unconfined aquifer over the county land area.

Discharge

Long-term natural discharge from the unconfined aquifer equals recharge to the aquifer. Natural discharge includes ground-water flow into streams, low areas, and the Gulf and Charlotte Harbor, evapotranspiration from the water table, and downward leakage. Artificial discharge includes pumpage from the unconfined aquifer, and seepage into canals and drainage ditches.

Most of the water discharging naturally (about 12 in annually) seeps into streams and low areas. During the dry season, most of the flow in streams is made up of ground water from the unconfined aquifer.

When water moving laterally downgradient in the unconfined aquifer approaches the surface, it either evaporates or is transpired by plants. Possibly as much as 4 in of water per year is discharged in this manner. Total outflow in coastal areas to Charlotte Harbor and the Gulf was estimated to be 300,000 gal/d based upon an average transmissivity of 500 ft^2/d, a hydraulic gradient of 1 ft/mi and a distance between flow lines of 80 mi.

The 140 Mgal/yr of water that leaks downward to the artesian aquifer in the northeastern section of the county is only a small portion of the total quantity of natural discharge.

About 1,000 wells over the 703-mi^2 area and that tap the unconfined aquifer withdraw about 3 Mgal/d or about 0.1 in of water per year. A significant but unknown amount of artificial discharge from the aquifer is due to canals and drainage ditches.

Water Quality

The quality of the water in the unconfined aquifer varies according to the source of the water, the type and solubility of sediments that the water moves through or over, and the length of time the water has been exposed to the aquifer matrix. Generally, the quality of the water in the unconfined aquifer in Charlotte County is within the Environmental Protection Agency (National Academy of Sciences and National Academy of Engineering, 1973) standards. However, there are many sites where water samples from the unconfined aquifer have high concentrations of chloride or color and iron. Constituents that represent the principal water-quality problems and the EPA recommended limits are listed below.

Constituents	Range, water in unconfined aquifer (mg/L)	U.S. Environmental Protection Agency Standard for public supply (mg/L)
Dissolved solids	273-470	500*
Sulfate (SO_4)	1.6-8.8	250
Chloride (Cl)	11-270	250
Fluoride (F)	0.2-1.0	1.4
Iron (Fe)	0.14-72.0	0.3
Color (Platinum-cobalt units)	30-50	75

* No recommended U.S. Environmental Protection Agency limit. U.S. Public Health Service (1962) limit is 500 milligrams per liter.

The quality of water from wells tapping the aquifer is variable. Table 2 lists the concentrations of chemical constituents of water from 13 representative wells that tap the unconfined aquifer.

Excess chloride concentrations pose the principal water-quality problem in the use of water from the unconfined aquifer throughout much of Charlotte County. Other constituents also, such as color and iron, are found in concentrations exceeding the EPA standards but simple treatment processes can lower these to EPA limits.

Factors Affecting Chloride Distribution

There are approximately 300 continuously flowing artesian wells in Charlotte County, each of which, on the average, flows about 75 gal/min (H. Sutcliffe, U.S. Geological Survey, oral commun.). The water from many of these wells is too saline for most uses. They are no longer used and the control devices have been removed, or the saline water has destroyed the casing or the control device, permitting the saline water to leak beneath the surface or to flow above the surface. This leakage and flow has caused water-quality deterioration in the unconfined aquifer in

Table 2.--Analyses of water samples from the unconfined aquifer in Charlotte County

[Values in milligrams per liter, except as noted]

U.S. Geological Survey 16-digit latitude-longitude well number	Local well number	Depth of well (ft)	Depth of casing (ft)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Strontium (Sr)	Bicarbonate (HCO_3)
[a]2647000814615.01	2	12		4/3/74		0.14						
2648000815945.01	4	12		4/4/74		.71						
2651200814820.01	12	12		4/5/74		.33						
2651200815150.01	13	12		4/3/74		5.8						
2652180821836.01	16	33	30			1.3						
2654580815337.01	23	30		4/6/73	9.5	6.8	92.0	1.2	28.0	0.2	0.5	273
2657580820317.01	24	17	14	4/5/73		2.3						
2658040815914.01	25	21	18	4/6/73		72.0						
2658050820504.01	26	26	23	4/5/73		2.0						
2658410820617.01	27	15	12	4/5/73		32.0						
2658490815316.01	28	45		4/6/73		2.0						
2659410815614.02	29	29	20	4/6/73		2.1	68.0	5.2	19.0	.6	.4	208
2701500820350.01	31	12		4/4/74		.29						
Cape Haze well field				11/19/69			100.0	2.1	26.0	.3	.45	
Gasparilla Island well field				11/18/69			120.0	5.6	42.0	0	.35	

a For location of wells and well fields see figure 1.

Table 2.--Analyses of water samples from the unconfined aquifer in Charlotte County - continued

[Values in milligrams per liter, except as noted]

U.S. Geological Survey 16-digit latitude-longitude well number	Local well number	Depth of well (ft)	Depth of casing (ft)	Date of collection	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Dissolved solids (residue at 180°C)	Total hardness, as $CaCO_3$	Noncarbonate hardness, as $CaCO_3$	pH	Specific conductance (umho/cm at 25°C)	Color (Pt-Co units)
[a]2647000814615.01	2	12		4/3/74		51		0.4				7.5	678	
2648000815945.01	4	12		4/4/74		110		.3				7.2	815	
2651200814820.01	12	12		4/5/74		26		.3				7.5	427	
2651200815150.01	13	12		4/3/74		16		.5				7.2	906	
2652180821836.01	16	33	30			94							740	
2654580815337.01	23	30		4/6/73	1.6	40	0	.2	328	230	6.0	7.6	560	40
2657580820317.01	24	17	14	4/5/73		11							96	
2658040815914.01	25	21	18	4/6/73		270							1020	
2658050820504.01	26	26	23	4/5/73		81							800	
2658410820617.01	27	15	12	4/5/73		40							368	
2658490815316.01	28	45		5/6/73		12							480	
2659410815614.02	29	29	20	4/6/73	1.6	35	.8	1.0	273	190	19.0	7.3	445	30
2701500820350.01	31	12		4/4/74		87		.5				7.2	743	
Cape Haze well field				11/19/69	8.8	48	.8	.3	370	260	47.0	7.6	600	40
Gasparilla Island well field				11/18/69	0	74	.8	.2	470	310	21.0	8.0	750	50

a For location of wells and well fields see figure 1.

parts of the county. Figure 10 shows the location and chloride concentration of continuously flowing artesian wells that tap the confined aquifers. Figure 11 shows the location and chloride concentration for wells that tap the unconfined aquifer. Comparison of figures 10 and 11 shows that high chloride concentrations in water from the unconfined aquifer, in the vicinity of the intersections of Highways 41 and 771, 776 and 771, 41 and 765, and the Telegraph Swamp area, probably are caused by nearby flowing wells tapping the confined aquifers. The sparseness of the available data does not allow detailed delineation of the areas contaminated by flowing wells.

Southwest Florida Water Management District program to locate and plug free-flowing artesian wells will prevent, or at least retard, further contamination so that eventual flushing of the unconfined aquifer by rains can take place.

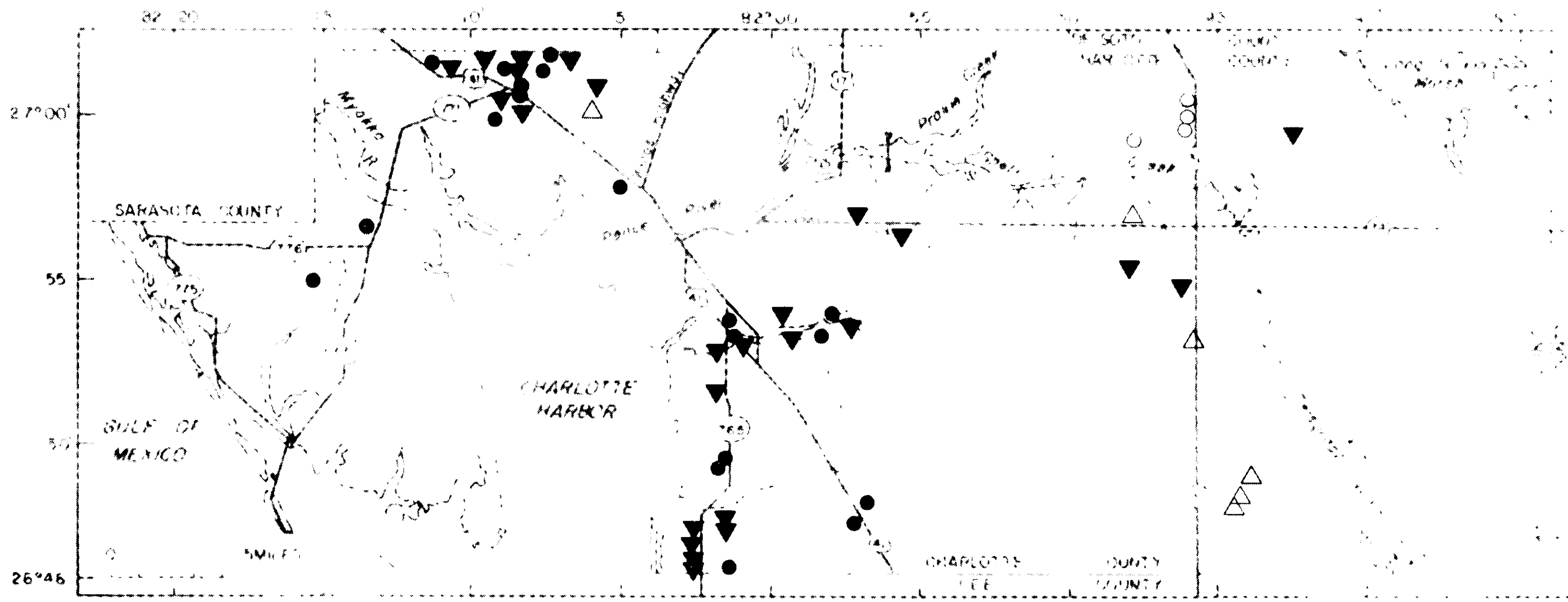
Most of the unconfined aquifer in southwest peninsular Charlotte County and the coastal areas surrounding Charlotte Harbor and the Peace and Myakka Rivers, is subject to saltwater contamination from the Gulf during high storm tides. Figure 2 shows the 100-year tidal flood, indicating that about 30 percent of the county land area would be inundated.

Pumping and drainage of the unconfined aquifer can cause saltwater encroachment near the coast. In coastal areas, as the water table is lowered by pumping, saltwater can move laterally within the permeable zones of the unconfined aquifer. Saltwater encroachment of this nature apparently has occurred along the Gulf and Charlotte Harbor (fig. 11).

Drainage ditches and canals in the coastal areas of Charlotte County that artificially drain the aquifer also pose a threat to use of the unconfined aquifer for water supply as these ditches and canals induce movement of saltwater into the aquifer.

Iron and Color

Throughout Charlotte County, the amount of iron and intensity of color in water from the unconfined aquifer often exceeds EPA recommended limits for public supply (National Academy of Science and National Academy of Engineering, 1973). Both iron and color, when present in water in high concentrations, are a nuisance. The water may have an unpleasant taste and odor, it may stain porcelain fixtures, although both generally can be easily removed during the water treatment. Neither iron nor color likely will cause health problems, even when present in huge excess. As shown in table 2, in water from many of the wells, the iron concentration is much higher than 0.3 mg/L, the EPA limit. The concentration of iron and color in water from the unconfined aquifer is usually higher near marshes. Decaying plants release iron and organic compounds that can then be taken into solution by infiltrating water and carried downward into the aquifer.



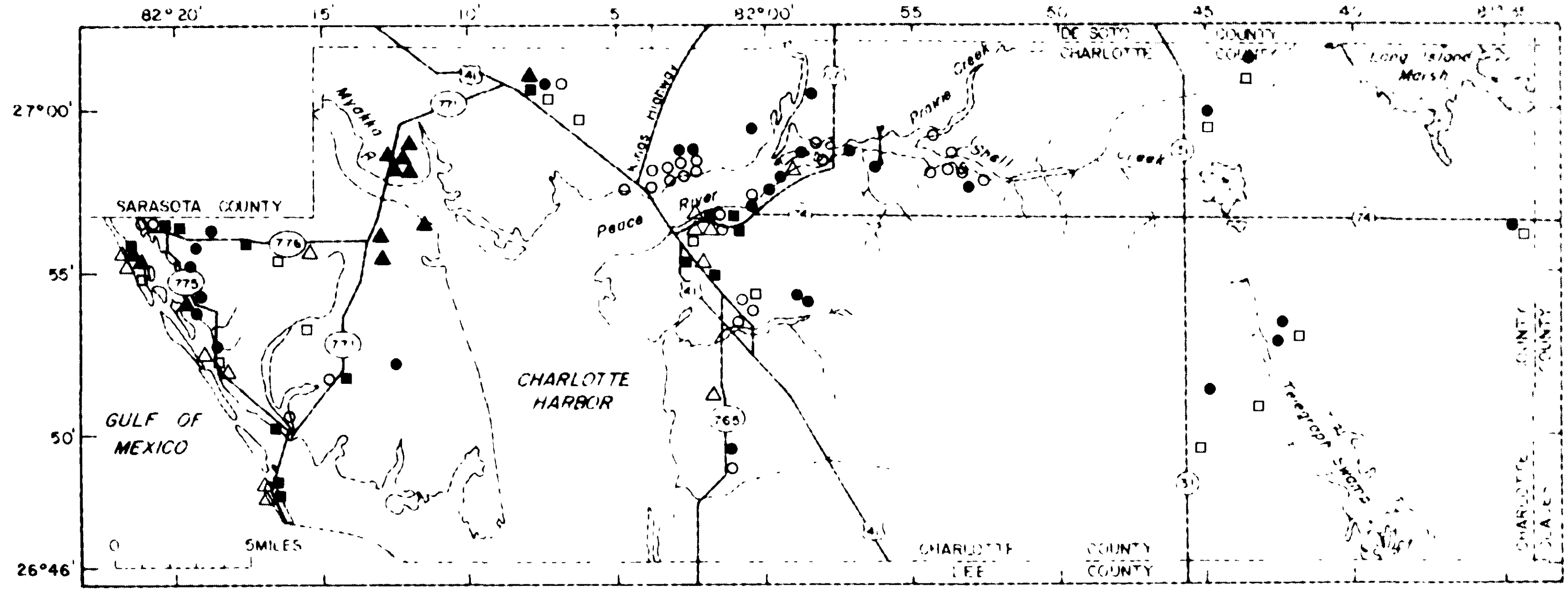
EXPLANATION

CHLORIDE RANGES IN MILLIGRAMS PER LITER

○ 0-250 ▼ 500-1,000

△ 250-500 ● Greater than 1,000

Figure 10. --Chloride concentrations in water from flowing wells open to the confined aquifers



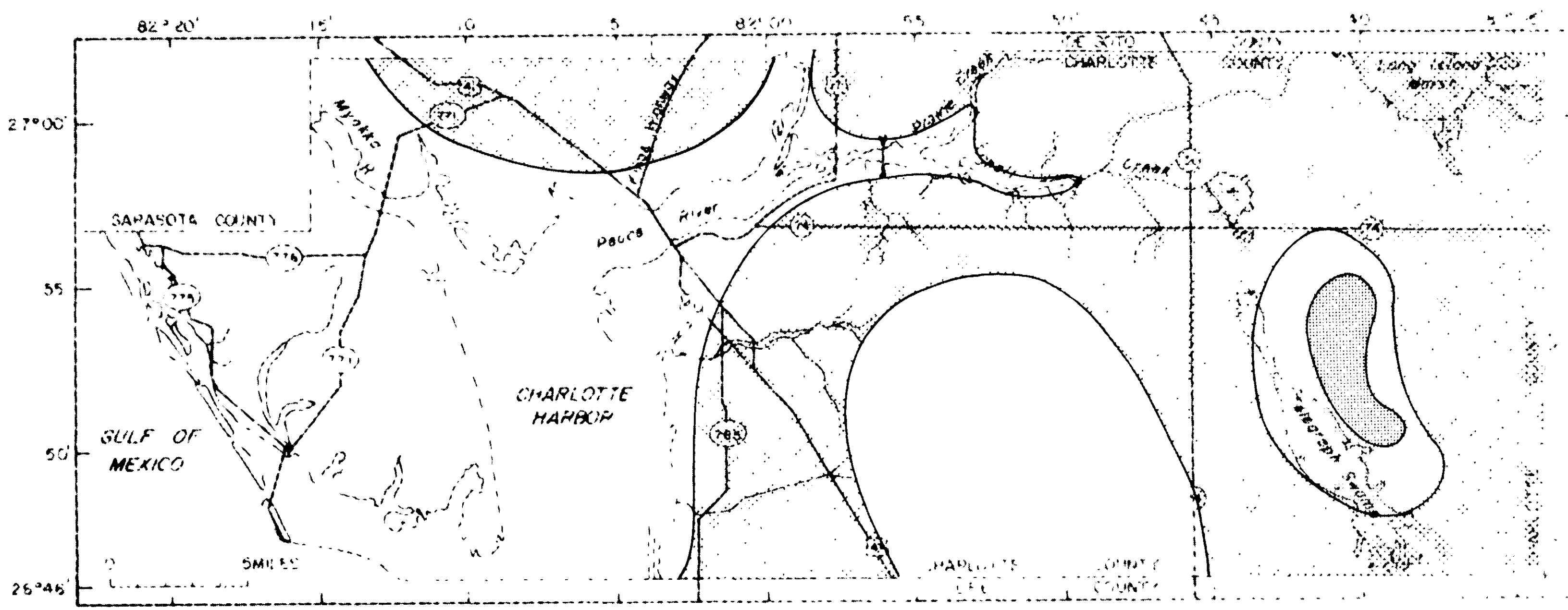
EXPLANATION

CHLORIDE RANGES IN MILLIGRAMS PER LITER

○ 0-25 □ 50-100 △ 250-1000

● 25-50 ■ 100-250 ▲ Greater than 1000

Figure 11. --Chloride concentrations in water from wells that tap the unconfined aquifer



EXPLANATION

LOW POTENTIAL
Wells yield 1-15 gallons per minute

SLIGHT POTENTIAL
Wells yield 15-50 gallons per minute

MEDIUM POTENTIAL
Wells yield 50-250 gallons per minute

HIGH POTENTIAL
Wells yield 250-750 gallons per minute

Figure 12. --Potential yield to wells tapping the unconfined aquifer

WATER-SUPPLY POTENTIAL OF THE UNCONFINED AQUIFER

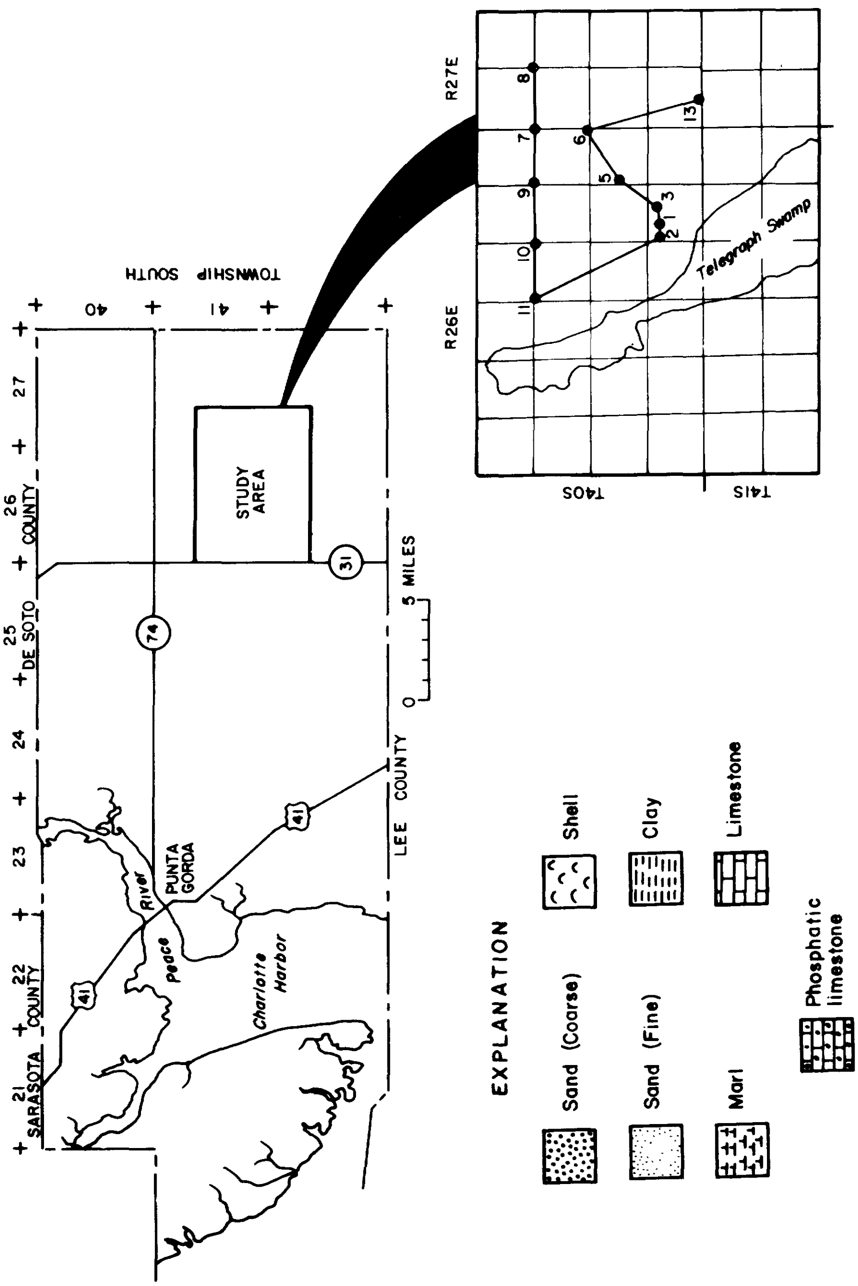
In Charlotte County, the potential of the unconfined aquifer as a source of water for public supply varies greatly from place to place in the county. Nonetheless, it is considerable: there are places in the county that could yield large quantities of water. The potential varies as the physical characteristics of the aquifer and the conditions of recharge to and discharge from the aquifer vary. That these variations exist can be expected by even a cursory analysis of the hydrologic and geologic data. Further, these data indicate, of course, that capture of all the natural discharge is not feasible.

Areas with Water-Supply Potential

Charlotte County was divided into four areas of differing potential yield to wells from the unconfined aquifer on the basis of the yields of existing wells and hydrologic and geologic data obtained from test wells. In the most productive area of high potential recharge, yields to large diameter wells (6 in or larger) are 250-750 gal/min; in the area of medium potential, 50-250 gal/min; in the area of slight potential, 15-50 gal/min; and in the area of low potential, 1-15 gal/min. These generalized areas of differing potential yield are delineated in figure 12. Table 3 shows the maximum and minimum recharge to the aquifer and yield to wells to be expected in the areas of differing development potential. As expected, the yield to wells increases in areas of greater recharge. This trend is reasonable as recharge to the aquifer and yield to wells are both related to the aquifers physical characteristics such as thickness and permeability, which determine an aquifer's ability to accept or reject recharge and yield water to wells.

The areas of high and medium potential are in the southeastern section of Charlotte County, a few miles east of Telegraph Swamp (fig. 13). Many water-table wells in this area yield about 600 gal/min and have specific capacities of at least 30 (gal/min)/ft. These wells tap the shell beds shown in the fence diagram in figure 13. The shell beds are relatively well sorted and have the greatest hydraulic conductivity of the units present in the unconfined aquifer (table 1). On the basis of well logs, the shell beds coincide with the area of high and medium potential in figure 12. Assuming an average recharge of 12 in annually in the area of high and medium potential, and an areal extent of about 25 mi^2, as much as 14 Mgal/d might be available from the aquifer in this area.

In most of north and east Charlotte County, the unconfined aquifer is predominantly sand and clayey sand with small local deposits of sandy shell and of slight potential (yields to wells of 15 to 50 gal/min).



RANGE EAST
21
22
23
24
25
26
27
SARASOTA COUNTY
DE SOTO COUNTY
TOWNSHIP SOUTH
40
41
STUDY AREA
74
31
41
Peace River
PUNTA GORDA
Charlotte Harbor
LEE COUNTY
0
5 MILES
R26E
R27E
T40S
T41S
Telegraph Swamp
1
2
3
5
6
7
8
9
10
11
13
EXPLANATION
Sand (Coarse)
Sand (Fine)
Marl
Shell
Clay
Limestone
Phosphatic limestone

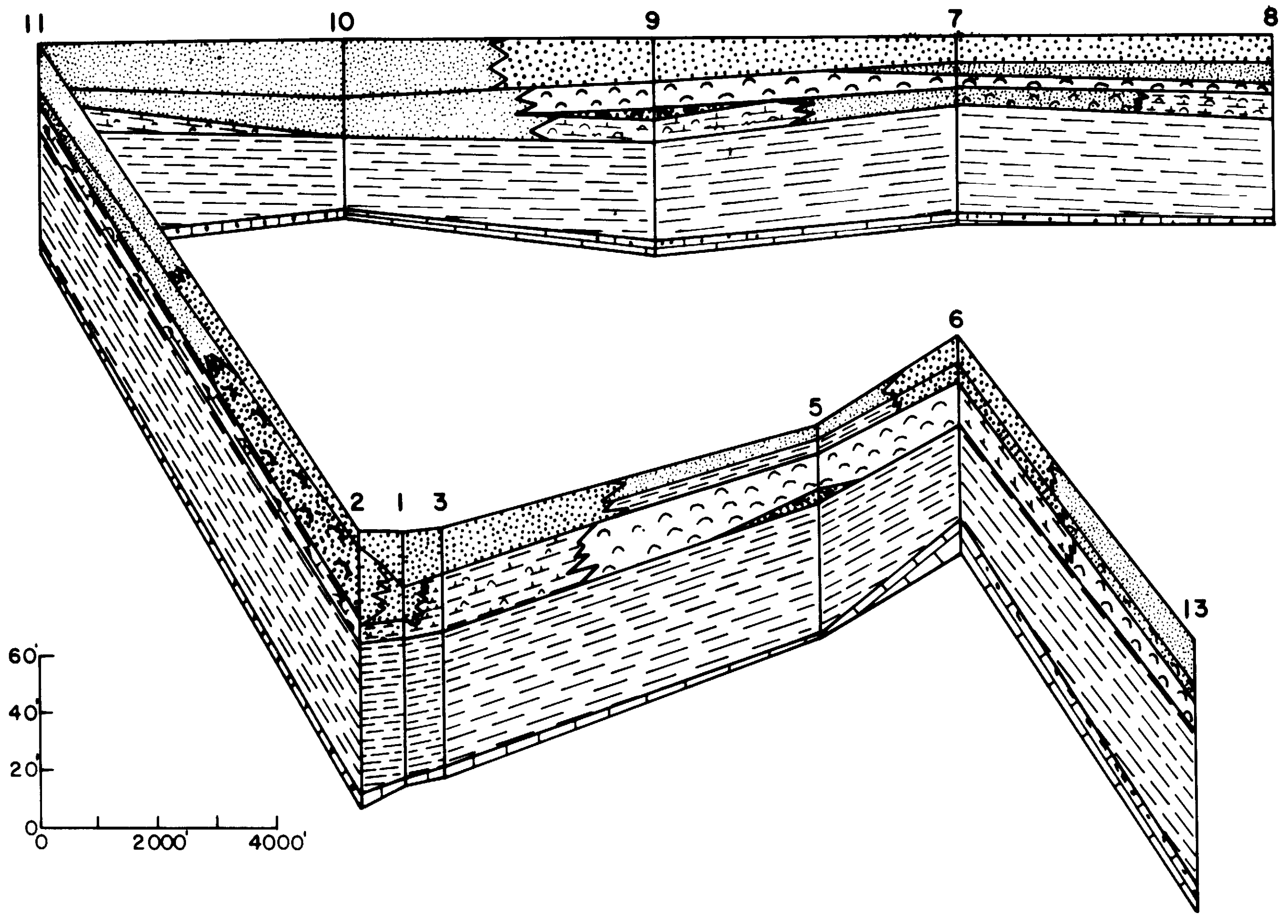


Figure 13. --Lithologic correlation of unconfined aquifer and clay confining bed in the Telegraph Swamp area

Table 3.--Estimated recharge to the unconfined aquifer and yields to wells in areas of different potential yields

Potential of area	Recharge (in)		Potential yield to wells (gal/min)	
	Maximum	Minimum	Maximum	Minimum
High	12	7	750	250
Medium	7	5	250	50
Slight	5	3	50	15
Low	3	1	15	1

The central part of the county is an area of generally low potential due to the predominance of low permeability marl and sandy marl in the aquifer. Areas of low potential will yield 1 to 15 gal/min to wells; yields satisfactory for most domestic needs.

Water-Supply Withdrawals from the Unconfined Aquifer

The aggregate yield of the 1,000-1,500 wells that tap the unconfined aquifer in Charlotte County may be as much as 4 Mgal/d. Many of these wells are used to irrigate the 2,000 acres on which vegetables are grown. Others supply water to users on Gasparilla Island and at Cape Haze.

In 1974, 16 wells in the Gasparilla Island well field, in the east-central part of the western peninsula of Charlotte County (fig. 12), supplied 0.23 Mgal/d to about 1,000 persons through about 500 connections on Gasparilla Island. The yields of wells ranged from 5 to 20 gal/min. Although the peninsula is bounded on three sides by saltwater, the quality of the water in the aquifer seems not to have deteriorated. This is probably because the unconfined aquifer there receives recharge from Coral Creek northwest of the wells and also because pumping of the wells is carefully controlled.

The Cape Haze well field is in the west-central part of western peninsular Charlotte County. In 1953, the first well was drilled. In 1974, 32 wells in the field were in operation, yielding 6 to 38 gal/min with an aggregate daily production of about 0.2 Mgal. The wells supply part of the water requirements of the Rotonda development. The quality of the water from these wells has remained acceptable. This is probably due to recharge from Buck Creek located northwest of the well field, and to controlled pumping.

Methods of Water-Supply Development

Water can be removed from the unconfined aquifer by means of conventional wells, collector wells, and tile drains. Each method has advantages and disadvantages and in some situations, a combination of the above methods can be used.

Within areas of highly transmissive shell beds, conventional 6-in diameter, open-hole wells constructed through the shell beds have yielded as much as 600 gal/min. These unscreened wells are generally economical and trouble free. Wells of this type, adequately spaced, and with water control structures to retain runoff during the rainy season, provide the best method of developing the unconfined aquifer within this area.

In areas where the transmissivity is less, where fine sand and marl are found, wells are generally screened. Construction of screened wells requires careful choosing of well and screen diameter and length, and slot size of screen opening. Screened wells require careful development to remove clay, silt, and very fine sand from the immediate vicinity of the screen to optimize yield.

A commonly used collector well is constructed by installing a large diameter cylindrical concrete caisson to the bottom of the unconfined aquifer. The bottom of the caisson is sealed with a concrete plug, and perforated steel pipes are projected laterally into the aquifer. Collector wells are relatively more effective than other types of wells in unconfined aquifers near streams or swamps. A collector well with four 100-ft laterals spaced at 90 degree intervals has an effective radius equivalent to a conventional well with a 60-ft radius (Mikels and Klaer, 1956). The principal advantages of collector wells are: low pumping costs as a result, in part, of low maintainance; and the ability to create a cone of depression of large radius and of small depth.

In areas of the county where the aquifer is thin and the yield to wells that tap it, low, subsurface tile drains provide an alternate method of developing water supplies. Although tile drains are extensively used to drain wet lands, primarily for agircultural land use, their use to obtain water for public supply is not common. In an experiment intended to reduce evapotranspiration and to increase recharge to the Floridan aquifer, Sinclair (1976) installed about 1,000 ft of subsurface drain tile 5 ft below land surface. The drain consisted of 4-in perforated plastic tubing, laid in 0.25-in gravel at a gradient of 0.22 ft per 100 ft to a connector well. The transmissivity of the unconfined aquifer in the study area is about 430 ft^2/d and the specific yield is about 0.20. The experiment produced a yield of about 19 gal/min from the array, which drained 3 acres.

CONCLUSIONS

The unconfined aquifer in Charlotte County contains freshwater of potable quality, if treated, to provide the county with a reliable supply to help satisfy the increasing demands of development.

Recharge to the unconfined aquifer is primarily from rainfall, and averages about 12 in per year, however, it ranges from less than 1 in to 16 in per year, depending on the permeability and thickness of aquifer material and the topography. Long-term discharge equals recharge. Discharge occurs by evapotranspiration from the water table, ground-water seeps and outflow, downward leakage to the confined aquifer, and by wells.

In the 25-mi^2 area east of Telegraph Swamp in eastern Charlotte County, the unconfined aquifer has high water-supply potential (yield to wells of 250 to 750 gal/min). As much as 14 Mgal/d of a quality suitable for public supply and domestic use could be developed from the unconfined aquifer in this area. Throughout most of the county, the aquifer is of lesser potential. Although the yield to wells is much lower where the potential for development is slight to medium (yields to wells of 15 to 50 and 50 to 250 gal/min), a potential for development exists nonetheless. Areas of low potential (yields to wells of 1 to 15 gal/min), can support a fairly large number of domestic wells.

The program to cap unused flowing artesian wells that tap the deeper confined aquifers that yield water of poor quality will help prevent deterioration in quality of the water in the unconfined aquifer. A continuing program for monitoring the level and quality of water in wells open to the unconfined aquifer would help to detect and evaluate signs of deterioration of water quality or where flowing wells have been plugged, an improvement in water quality.

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