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SURFICIAL AND INTERMEDIATE AQUIFERS

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INTRODUCTION

Aquifers that overlie the Floridan aquifer are becoming increasingly important as sources of water supply in the State, particularly in those areas where water in the underlying artesian aquifer is highly mineralized or has the potential of becoming highly mineralized. The principal sources of ground water used for drinking in parts of east coastal, southwest coastal, and south Florida are surficial and intermediate aquifers that overlie the Floridan aquifer. In 1977, these aquifers supplied 104 Mgal/d of water for public supply and 44 Mgal/d for rural domestic use in 16 counties. Together, these correspond to 10 percent of the total public supply and 38 percent of the total rural domestic use in the 12 counties in Florida in 1977. An estimated additional 28 Mgal/d was supplied for rural domestic use in 12 other counties (Healy, 1981).

Surficial and intermediate aquifers are the only source of ground water available for public supply in some areas where excessive depth to the Floridan or poor quality of water in the Floridan precludes its use for public supply without special and expensive water treatment. This summary includes only those counties where surficial and intermediate aquifers are currently being used to supply more than half of the drinking water for public supply (fig. 1).

TERMINOLOGY

About 12 percent of Florida's total public supply and rural domestic water needs are supplied by aquifers other than the Floridan, the Biscayne, and the sand-and-gravel. These "other aquifers" have been loosely identified by informal terminology, and consequently characterized by a number of local names. In various parts of the State, some of the terms used include shallow, surficial, secondary, water-table, semi-artesian, limestone, and shallow-rock. Especially in cases where several local names apply to essentially the same regional water source, this variability may lead to confusion.

No statewide consensus is presently available to clearly define or delineate these "other aquifers." For purposes of this discussion, the term "surficial aquifer" shall refer to any otherwise undefined aquifer whose top is contiguous with the land surface, and is a local source of supply for drinking water in a limited geographic area. "Intermediate aquifer" shall refer to any otherwise undefined, artesian aquifer that is below the surficial aquifer and above or within the unit confining the Floridan aquifer, and is a local source of supply for drinking water in a limited geographic area. The surficial and intermediate aquifers thus include those nonartesian (water-table) and artesian aquifers that overlie the Floridan aquifer with the exceptions of the sand-and-gravel aquifer in northwest Florida and the Biscayne aquifer in Broward and Dade Counties in the southeast. Although both are surficial, the sand-and-gravel and Biscayne aquifers have been extensively studied in the literature and are treated separately in this report.

HYDROGEOLOGY

Surficial aquifers include numerous surficial deposits of sand and shell that range from Miocene through Holocene in age. The intermediate aquifers include artesian beds and lenses of sand, shell, sandstone, clayey sand, dolomite, and limestone that are slightly deeper-lying and range from Miocene through Pleistocene in age (table 6). Pertinent geologic, hydrologic, and chemical characteristics of the surficial and intermediate aquifers are summarized for each county in the study area (table 7).

The surficial aquifers range in thickness from less than 1 foot in parts of Brevard, Duval, Highlands, Manatee, and Palm Beach Counties to more than 400 feet in Indian River and St. Lucie Counties. Contour maps of the top of the surficial aquifer in several counties and smaller areas have been prepared by Klein (1954, p. 24, 25); Brown and others, (1957, p. 71; 1962a, p. 86), Lichtler (1960, p. 25); Clark and others (1964a, p. 112); Hoy (1964); Fairchild (1972, p. 27), Miller (1978, p. 27), and Wolansky (1978, p. 18). Maps of the thickness of the surficial aquifer have been prepared by Fairchild (1972) for Duval County and by Wolansky (1978) for Charlotte County. Maps of the base of the surficial aquifer have been prepared for Martin and St. Lucie Counties by Miller (1980).

The intermediate aquifers consist mostly of shell beds and lenses of limestone in the Tamiami and Hawthorn Formations which are not in direct hydraulic contact with the underlying Floridan aquifer. Deposits in the Tamiami Formation contain water under nonartesian or artesian conditions in Charlotte County (Sutcliffe, 1975), Collier County (Klein, 1972), Glades and Hendry Counties (Klein and others, 1964), Highlands County (Bishop, 1956), and Lee County (Boggess and Missimer, 1975). Examples of water-bearing deposits in the Hawthorn Formation include artesian ground water supplies in Clay County (Clark and others, 1964a; Bentley, 1977) and Duval County (Fairchild, 1972).

Water-bearing units of the lower part of the Hawthorn Formation and the underlying Tampa Limestone in parts of southwest Florida are also included under intermediate aquifers rather than under the Floridan aquifer. Because potable water in parts of southwest Florida is available only from the Hawthorn Formation and from the Tampa Limestone, these formations have been considered separately from the Floridan aquifer in most previous reports on water use in southwest Florida. Examples of reports discussing these units include Lee County (Boggess and Missimer, 1975) and Manatee County (Brown, 1981).

Water-Table Configuration and Potentiometric Surfaces

The configuration of the water table of the surficial aquifer is shown on the accompanying map (fig. 14). Figure 14 encompasses about 13,000 mi^2 and includes those areas where aquifers (other than the sand-and-gravel and the Biscayne) overlying the Floridan are significant sources of water for public supply. In most of the area, the contours represent generalized hydrologic conditions and do not represent any particular year or seasonal stage of ground-water levels. The potentiometric surfaces of selected intermediate aquifers are shown in figure 15. Contours include those of the minor artesian aquifer in Manatee, Sarasota, Charlotte, and Lee Counties, the upper Hawthorn aquifer in Lee County, and the secondary artesian aquifer in Clay County. The contours represent the altitude of the water surface of the aquifers with reference to sea level.

The base maps used to prepare the water-table surface of the surficial aquifer were U.S. Geological Survey 7½ minute series (topographic) quadrangles. Three types of control were used: topographic control from 172 quadrangles; control from elevations of water surfaces in about 75 lakes and streams, and ground-water level control from 233 observation wells. After completion of contouring using only topographic and water-surface control, wells that penetrate the surficial aquifers were located on the maps and the altitudes of the ground-water levels with reference to sea level were added to the contoured map as a final random check of the validity and accuracy of the contours. About 97 percent of the measured altitudes of water levels in wells closely matched the distribution of the contours, without adjustment of the contours.

The water-table configuration of the surficial aquifer is typically a subdued reflection of the topography, with relatively steep gradients adjoining stream courses and some lakes, and relatively gentle gradients existing in the broad interstream areas. In low, flat, poorly drained areas, the water table stands commonly at or within a few feet of the land surface. At higher elevations, 136 feet in western Clay County and 118 feet in southwest Highlands County, for example, the water table was 43.6 feet (Clark and others, 1964b, p. 86) and 35.1 feet (U.S. Geological Survey, 1977, p. 80), respectively, below land surface.

Contours of the potentiometric surfaces of the intermediate aquifers (fig. 15) were drawn exclusively from water levels in observation wells included in the 1977 water-data report for Florida (U.S. Geological Survey, 1977).

Rainfall is the principal source of recharge. According to Hughes and others (1971), the mean annual rainfall ranges from about 40 inches in the Keys to more than 64 inches in southeast and northwest Florida and exceeds 50 inches over most of the State. However, only a fraction of this amount is available for recharge (Stewart, 1980). Other sources of recharge are seepage from rivers, lakes, irrigated lands, surface and subsurface flow from artesian wells, and subsurface flow into the shallow aquifers from adjacent areas. Recharge from rivers and lakes occurs when lake and stream surfaces are higher than the water table because of topographic relief and irregular distribution of rainfall.

Discharge occurs as seepage into rivers, lakes, swamps, and manmade canals and ditches, as evapotranspiration losses from the soil zones, and as subsurface flow and draft from wells. Draft from wells has exceeded recharge, and water levels have declined, in two areas. Pumping for public supply at Stuart in Martin County and near Fort Myers in Lee County has caused ground-water levels to decline 15 feet (1952-77) in the surficial aquifer and 6 feet (1966-77) in the intermediate aquifer, respectively.

WATER QUALITY

Factors affecting the quality of water in the surficial and intermediate aquifers are: the quality and quantity of rainfall entering the aquifers as recharge, aquifer properties (including rock type and permeability), gradient of the water table, proximity of saltwater bodies, and permeability and thickness of confining beds overlying the Floridan aquifer in discharge areas of the Floridan. In some areas where the potentiometric surface of the underlying Floridan aquifer stands higher than water levels in the surficial aquifer, upward movement of the generally more mineralized water in the Floridan results in contamination of the overlying aquifers.

Water in the surficial and intermediate aquifers normally contains low concentrations of dissolved solids. The maximum and minimum value measured for dissolved solids in the different hydrogeologic units are given in table 7, by counties. Dissolved solids concentrations range from less than 15 milligrams per liter (mg/L) in water from Holocene and Pleistocene deposits in Manatee County (Brown, 1981) to more than 7,000 mg/L in water from Pleistocene deposits in Palm Beach County (Land and others, 1973). Chloride concentrations range from near zero in numerous Pliocene and Holocene deposits to a maximum of more than 2,200 mg/L in the surficial aquifer in Glades County.

The highest concentrations of dissolved solids and chlorides are found in those areas where the water-bearing deposits have become contaminated by saltwater intrusion. In these areas. the maximum dissolved solids concentrations are well within the designation of freshwater, containing less than 10,000 mg/L dissolved solids.

Saltwater Intrusion

Declining water levels, particularly in coastal areas, frequently presage gradual deterioration in the quality of ground water. Such deterioration may occur from lateral or upward movement of saline water into a freshwater aquifer, impairing the usefulness of the aquifer as a present or future source of water supply.

Aquifers in coastal areas are particularly vulnerable to contamination from lateral movement of saltwater from the gulf and the Atlantic Ocean. Counties where saltwater intrusion of surficial and intermediate aquifers have been reported and described include: Charlotte County (Wolansky, 1978, p. 23), Collier County (McCoy, 1962, p. 53; 1972, p. 28), Flagler County (Bermes and others, 1963, p. 86), Glades County (Klein and others, 1964, p. 78), Lee County (Sproul and others, 1972; Boggess, 1973; Boggess and others, 1977), Martin County (Lichtler, 1960, p. 65), and Palm Beach County (Land, 1977; Scott and others, 1977). The areas of saltwater intrusion are described in table 7.

Intrusion has been hastened or initiated primarily by man's activities. These include increased pumping, construction of drainage ditches and canals that empty into the gulf or the Atlantic Ocean or bays connected to the ocean or gulf, urbanization with attendant increases in paving of recharge areas, and drilling of deep wells which may in time become the sources of saltwater contamination by upward leakage through corroded well casings.

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ABBREVIATIONS AND CONVERSION FACTORS

Factors for converting inch-pound units to International System (SI) and abbreviations of units.

Multiply inch-pound units	By	To obtain metric (SI) units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

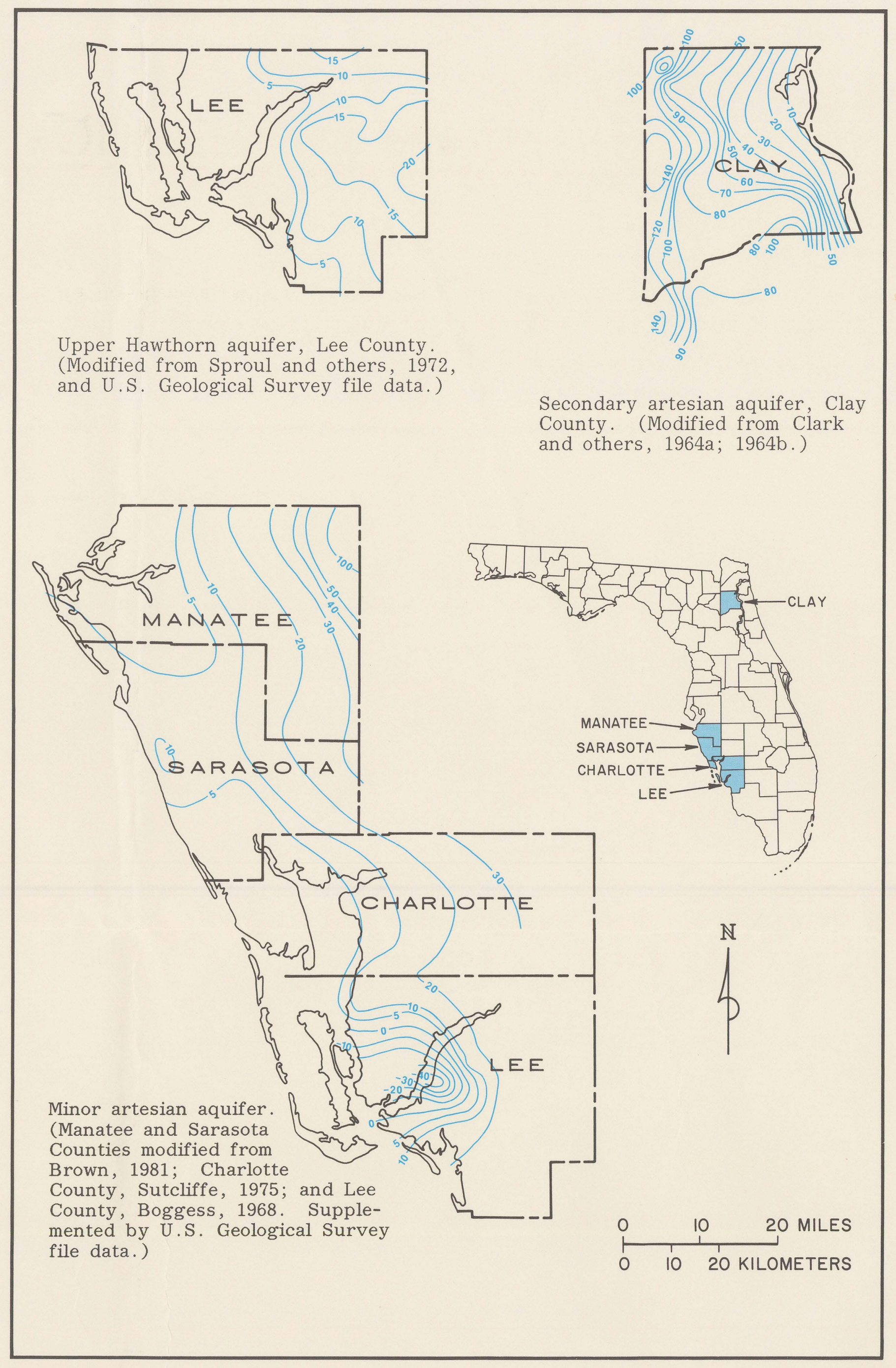
National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as "sea level" in the text of this report.

Table 6.--Generalized stratigraphic units for the surficial and intermediate aquifers of east and southwest coastal and south Florida

Series	Stratigraphic unit	Aquifer
Holocene	Undifferentiated alluvium and terrace deposits	Surficial
Pleistocene (Stratigraphic units are equivalent in part. Order does not necessarily reflect relative ages.)	Pamlico Sand Miami Oolite Fort Thompson Formation Anastasia Formation	Surficial
Pliocene	Caloosahatchee Marl Tamiami Formation Bone Valley Formation	Surficial Intermediate
Miocene	Choctawhatchee Formation Hawthorn Formation Tampa Limestone	Surficial (Choctawhatchee Formation) Intermediate

Table 7.--Geologic, hydrologic, and selected chemical data for surficial and intermediate aquifers of east and southwest coastal and south Florida

Local aquifer name	Hydrogeologic unit	Lithology	Approximate aquifer thickness (feet)	Yield to wells (gal/min)	Dissolved solids (DS) (mg/L)	Chloride (CL) (mg/L)
Brevard County						
Nonartesian	Holocene and Pleistocene deposits	Sand, sandy coquina, shell marl	1-110	30-50	21-2,420	4-1,270
	Pliocene or Upper Miocene deposits	Sand and shell	20-90	30-50	382	54
Artesian	Hawthorn Formation	Sand, shell marl, limestones	10-220			
Remarks: Dissolved solids in 25 of 30 samples less than 500 milligrams per liter (mg/L), chloride less than 250 mg/L in 24 samples. Formerly source of supply of Eau Gaille and Melbourne. Subject to contamination from salty water by upward flow from underlying aquifers. Sand and shell nonartesian aquifer supplies Titusville. References: Brown and others 1962a, 1962b; Healy 1977.						
Charlotte County						
Unconfined; water table	Holocene	Sand and alluvium			273-470	11-270
	Fort Thompson Formation	Terrace sand, shell marl		5-20		
	Caloosahatchee Marl	Shell beds, sandy shelly marl, beds of hard sandy limestone	10-50	600		
Nonartesian	Tamiami Formation	Sand in upper part of Formation	25-100	200		
Artesian	Hawthorn Formation, upper unit	Limestone		125-300	460	
Remarks: Estimated 748 billion gallons can be released from storage. Subject to saltwater intrusion by tidewater canals and upward leakage through open well bores and corroded casings. Water is saline west of Charlotte Harbor. Caloosahatchee Marl supplies Port Charlotte, Cape Haze, and Gasparilla Island. References: Sutcliffe, 1975; Wolansky, 1978.						
Clay County						
Water table	Holocene and Pleistocene undifferentiated deposits and coarse clastics	Sand, clayey sand and limestone	40-130	5-10	17-302	1.5-92
Water table	Choctawhatchee Formation	Thin layers of limestone and of sand	40			
Secondary	Hawthorn Formation	do.		15-32	29-363	4.5-84
Remarks: Generally source of small supplies--few domestic wells, sand points, and dug wells. Chloride was 10 mg/L or less in 35 of 71 samples from the water-table aquifers. Chloride 10 mg/L or less in 16 of 35 samples from secondary artesian aquifer. Reference: Clark and others, 1964a, 1964b.						
Collier County						
Shallow	Pamlico Sand	Terrace sand	60-130	10-1,000	412-1,370	8.5-558
Nonartesian	Anastasia Formation	Limestone, shelly and sandy marl			220-2,660	15-1,150
Shallow	Tamiami Formation	Limestone				
	Hawthorn Formation	Limestone		250-1,000		
Remarks: Saltwater contamination by recent and residual encroachment and by upward leakage. Anastasia Formation supplies Naples. References: Klein, 1954; McCoy, 1962; 1972; Klein and others, 1964; Leach and Healy, 1980.						
Duval County						
Shallow	Holocene and Pleistocene deposits	Sand and shell	<1-90	30-100		
Water table; shallow artesian	Deposits near base of Pliocene or upper Miocene deposits	Sand or shell, sandy clay, limestone within less permeable beds of clay and clayey sand	10-110	10-15 15-20 near base of Pliocene-Miocene	44-393	6-25
	Hawthorn Formation	Limestone beds (Upper Hawthorn Formation) Clay silty clay with beds of pebbly sand at 140-165 feet in east Duval County	250-500, 300-600			
Remarks: Samples from 31 wells. Two other wells: DS 2,550 and 2,560 mg/L; CL 12 mg/L each. Limestone section is the major source of water. Wells tap lenses of sand limestone in the upper part of the Hawthorn Formation. References: Fairchild, 1972; Causey and Phelps, 1978; Franks, 1980.						
Flagler County						
Nonartesian; artesian	Sand Anastasia Formation	Surficial sand and shell deposits coquina, shell and clay lenses	13-102	<200	380-780	70-258
Secondary artesian	Upper Miocene or Pliocene deposits	Sandy shell, limestone, shell and silty clay	15-77	375	377-400	10-95
Secondary artesian	Hawthorn Formation	Sandy clay and thin beds of sand, sandy limestone and shell	3-63			60-710
Remarks: Deposits of high average permeability attain maximum thickness of 100 feet in coastal portions of Flagler and St. Johns Counties between St. Augustine and Flagler Beach. Deposits thin toward the west. Saltwater encroachment in Flagler County near Flagler Beach and south of Bunnell. Anastasia Formation supplies Bunnell and St. Augustine. References: Bermes, 1958; Bermes and others, 1963; Healy, 1977.						
Glades County						
Shallow	Pamlico Sand Anastasia Formation Fort Thompson Formation	Terrace sands Sand, shell and marl Shells, limestone	10->300	200-1,400	40-4,100	7-2,280
Shallow	Tamiami Formation	Beds of shell, limestone, marl, mixtures of sand and gravel		100	674	71
	Upper Hawthorn Formation	Sand and pebble beds, discontinuous limestone beds		<250-2,000		
Remarks: Saltwater intrusion by upward leakage in some areas. Tamiami Formation supplies Moore Haven. References: Klein and others, 1964; Healy, 1977.						
Hendry County						
Shallow	Tamiami Formation	Limestone in thin layers	33	115-250	290-2,900	11-1,040
	Hawthorn Formation	Gravel beds within Hawthorn Formation	36	<250-2,000	702	28
Remarks: Limestone of the Tamiami Formation most productive. Wells reported to yield over 1,000 gal/min. Some contamination of shallow aquifer occurring by upward and lateral leakage from open-well bores southwest of La Belle. Tamiami Formation supplies La Belle. References: McCoy, 1962; Klein and others, 1964; Healy, 1977.						
Highlands County						
Water table; non-artesian	Pleistocene sand deposits	Terrace sands	1-100	Small to moderate		14-20
Shallow artesian	Tamiami Formation	Coarse sand, gravel, shell beds	<-100 300-650	Flows as much as 50		6-330
	Upper Hawthorn Formation	Sand, gravel (deltaic beds)		1,800		0.6-57
Remarks: Reference: Bishop, 1956.						
Indian River County						
Shallow	Pamlico Sand	Sand	100-150	<100-1,000	<500	
	Anastasia Formation	Shell, sand, coquina	>400			
	Fort Thompson Formation	Clay and sand				
Shallow artesian, secondary artesian	Hawthorn Formation	Thin limestone lenses, discontinuous shell beds, lenses of sand and gravel	10-20			
Remarks: Estimated 76 Mgal/d available for public supply and domestic use. Saltwater contamination on southern part of barrier beach. Recharge estimated at 16 inches annually. Anastasia Formation supplies Vero Beach. References: Snell and Anderson, 1970; Crain and others, 1975.						
Lee County						
Water table	Undifferentiated deposits	Sand	5-100	300-750	150-400	10-50
Sandstone aquifer		Sand, limestone, sandy limestone marly, limestone, shell beds				
Tamiami (artesian)	Tamiami Formation	Sand, sandstone, gravel limestone	150-250	30-50	200-600	30-80
Upper Hawthorn (artesian)	Hawthorn	Sandy limestone Formation	75-200	55-125	450-700	80-150
Remarks: Saltwater intrusion primarily related to well construction and decline in water levels caused by pumping. Intrusion of saline water from underlying artesian sources by upward leakage from deep wells. Water-table and sandstone aquifers supply Fort Myers, North Fort Myers. Tamiami aquifer supplies Bonita Springs, Lehigh Acres. Upper Hawthorn aquifer supplies Cape Coral, South Fort Myers, Fort Myers Beach, and Pine Island. References: Boggess, 1968; Boggess and Missimer, 1975.						
Manatee County						
Surficial	Undifferentiated deposits Caloosahatchee Marl Bone Valley Formation	Alluvium, sand, terrace deposits, beds of sand and shell, limestone	<1-100	30-75	13-508	4.5-18
Minor artesian	Hawthorn Formation Tampa Limestone				170-1,870	3-570
Remarks: Minor artesian aquifer supplies Sarasota. References: Brown, 1981; Peek, 1958.						
Martin County						
Shallow	Pamlico Sand	Sand		7-500	96-1,660	5-626
Nonartesian	Anastasia deposits Formation	Sand, thin layers of sandy limestone and shell beds (coquina), sandstone	<150			
	Fort Thompson Formation	Shell marl and limestone				
	Caloosahatchee Marl	Sandy and shelly marl				
	Tamiami Formation	Sand and shell				
Confining layer	Hawthorn Formation	Occasional thin layer of limestone	350-550	Not significant as source		
Remarks: Saltwater intrusion a problem in some coastal areas, that is, Sewall Point, Hutchinson and Jupiter Islands. Residual Pleistocene seawater remains trapped in lower part of shallow aquifer in parts of western Martin County. Shallow sand aquifer supplies Stuart. Reference: Lichtler, 1960.						
Orange County						
Nonartesian	Holocene through Pliocene undifferentiated	Sand, clay, hardpan, shell beds	30-40	5-10, 30	16-389	
Secondary	Hawthorn Formation	Lenses of sand and gravel, thin limestone lenses, discontinuous shell beds	80-100	300-1,000	100-400	
Remarks: Base of the nonartesian aquifer generally 40 feet below land surface. In highlands region base may be deeper. Water table ranges from 0 to 20 feet below land surface. Nonartesian aquifer polluted in some areas with high nitrates, sulfates and potassium. References: Lichtler and others, 1968.						
Osceola County						
Surficial	Unconsolidated deposits	Sand, shell material, limey sand, silt and clay	25-70	15-300	<70-<100	<10
Remarks: Surficial aquifer yields 10 percent of domestic and municipal water supplies. Water occurs under confined and semiconfined conditions. Base of aquifer at sea level in northwest and 200 feet below sea level southeast with maximum thickness of 300 feet. Reference: Frazee, 1980.						
Palm Beach County						
Nonartesian	Pamlico Sand	Sand	1-50	50-1,460	245-7,210	33-1,890
Unconfined shallow	Anastasia Formation	Sand, shell beds, limestone, coquina, sandstone	40-200			
	Miami Oolite	Limestone				
	Fort Thompson Formation	Marls, limestone, sandstone	20-50			
	Caloosahatchee Marl	Shell sands and shell marls	7-70	Low permeability		
	Tamiami Formation	Limestone, clay and marl	70-100	Low permeability		
Remarks: Yield decrease northward are highest in coastal areas. Saltwater intrusion in northeast near Jupiter, Tequesta, and along lower reach of Loxahatchee River caused by land drainage and drought. Supplies 21 municipalities. References: Land and others, 1973; Rodis, 1973; Healy, 1977; Scott, 1977.						
Putnam County						
Nonartesian Artesian	Holocene and Pleistocene sand deposits	Sand, coquina, shell and clay lenses and hardpan sand beneath hardpan	<10->125 (Leve, 1958, p. 9)	10-100		15-1,080
Secondary artesian	Upper Miocene or Pliocene deposits	Thin, lenticular beds of sand and shell within Miocene or Pliocene clay	1-15		130	0
	Hawthorn Formation	Lenses of sand and shelly sand	1-15			
Remarks: In areas of artesian flow, chloride concentration in water from the shallow aquifer ranged from 170-1,080 mg/L. Contamination by upward flow from underlying saline aquifers is postulated. References: Leve, 1958; Bermes and others, 1963.						
St. Johns County						
Nonartesian		Sand				
	Anastasia Formation	Shell beds, sand, coquina	28-77	10-250	372-644	14-30
	Undifferentiated Pliocene and Upper Miocene deposits	Sand, marl, shell, and sandy limestone	21-93			20-55
Secondary artesian	Hawthorn Formation	Thin lenses of sand, shell, and limestone	1-15			1,160
Remarks: Shallow aquifer contaminated in some areas by upward leakage of saline water, lateral encroachment from the ocean and rivers and by inundation of land by sea water. Contamination is occurring in central and coastal areas of the county. Nonartesian aquifer supplies St. Augustine. References: Bermes and others, 1963; Hayes, 1981.						
St. Lucie County						
Shallow nonartesian	Anastasia Formation	Sand, shell beds, thin discontinuous layers of sandy limestone or sandstone	30->400	300-695	480	<100
Remarks: Supplies Fort Pierce. References: Bearden, 1972; Healy, 1977.						
Sarasota County						
Water table; nonartesian Artesian	Undifferentiated deposits Caloosahatchee Marl. Bone Valley Formation	Sand, shell, sandy limestone		30-100	84-1,330 (546, public supply)	8-1,300 (130, public supply)
Minor artesian	Tamiami Formation Upper Hawthorn Formation	Limestone		200-600	(730, public supply) 300-4,150	(25, public supply) 34-1,500
Remarks: Hawthorn Formation and Tampa Limestone in part of southwest Florida are the only sources of potable water. From the Floridan aquifer--the Floridan contains highly mineralized water below the Tampa Limestone in most areas in southwest and south Florida and because of this, the Hawthorn and Tampa are included here. Upper Hawthorn Formation supplies Venice; water-table aquifer supplies Englewood. References: Clark, 1964; Healy, 1977; Brown, 1981.						
Seminole County						
Nonartesian	Undifferentiated deposits	Sand, with some clay	10-75		50	
Nonartesian artesian	Undifferentiated deposits	Shell beds and clay	<1-83	Small to moderate		
Secondary artesian	Hawthorn Formation	Sandy limestone beds	<1-150	5-500		
Remarks: Reference: Barraclough, 1962.						
Volusia County						
Nonartesian	Undifferentiated deposits	Sand	25-80			
Clastic		Sand, shell, clay	75			
	Caloosahatchee Marl	Basal shell bed overlain by sand, silty shell beds, clay				
Remarks: Saltwater encroachment into aquifer immediately adjacent to the St. Johns River and ocean. Aquifer not used to any great extent in county. Estimated water in storage 300 billion gallons. References: Wyrick, 1960; Knochenmus and Beard, 1971.						



Upper Hawthorn aquifer, Lee County. (Modified from Sproul and others, 1972, and U.S. Geological Survey file data.)

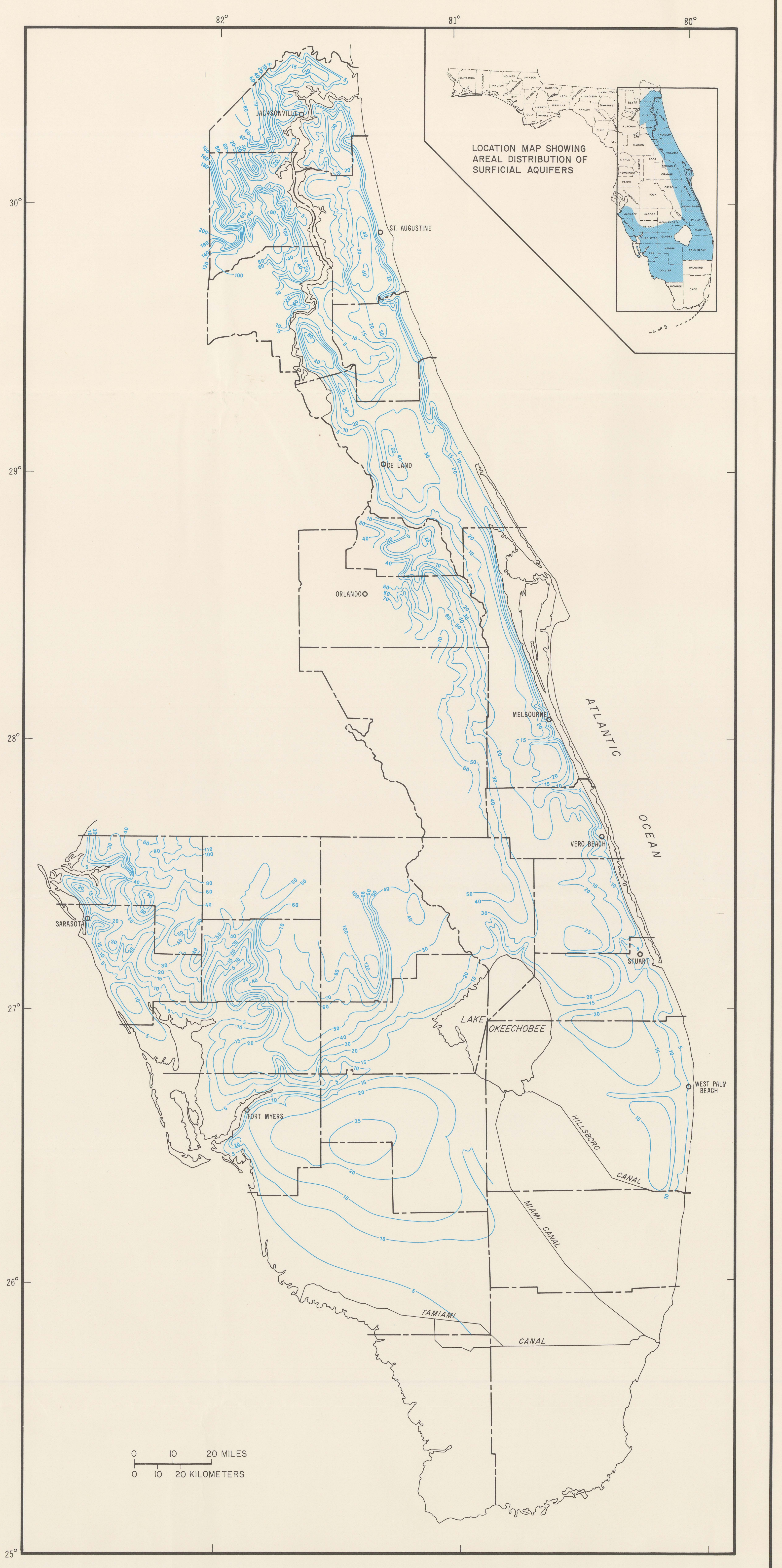
Secondary artesian aquifer, Clay County. (Modified from Clark and others, 1964a; 1964b.)

Minor artesian aquifer. (Manatee and Sarasota Counties modified from Brown, 1981; Charlotte County, Sutcliffe, 1975; and Lee County, Boggess, 1968. Supplemented by U.S. Geological Survey file data.)

EXPLANATION

POTENTIOMETRIC CONTOUR--Indicates the altitudes of the potentiometric surfaces of selected intermediate aquifers, with reference to NGVD of 1929. Contour intervals 5, 10, and 20 feet.

Figure 15.--Generalized potentiometric surfaces of selected intermediate aquifers.



EXPLANATION

WATER-LEVEL CONTOUR--Indicates the altitudes of water levels in the surficial aquifers, with reference to NGVD of 1929. Contour intervals 5, 10, and 20 feet.

Figure 14.--Generalized altitudes of the water-table surfaces of the surficial aquifers, with inset location map.

PRINCIPAL AQUIFERS IN FLORIDA

By

Bernard J. Franks (ed.)

1982