GROUND-WATER RESOURCES OF COASTAL CITRUS, HERNANDO, AND SOUTHWESTERN LEVY COUNTIES, FLORIDA

By J. D. Fretwell

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JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Suite 3015
227 North Bronough Street
Tallahassee, Florida 32301

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ABBREVIATIONS AND CONVERSION FACTORS

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

Multiply	By	To obtain
	Length	
inch (in)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Transmissivity	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)
	Leakance	
foot per day per foot [(ft/d)/ft]	1.000	meter per day per meter [(m/d)/m]
	Specific Conductance	
micromho per centimeter at 25° Celsius (μmho/cm at 25°C)	1.000	microsiemen per centimeter at 25° Celsius (μS/cm at 25°C)
	Radiation	
picocurie (pCi)	0.037	becquerel (Bq)

* * * * * * * * * * * *

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. In the text of this report, NGVD of 1929 is referred to as sea level.

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ABSTRACT

Ground water in the coastal parts of Citrus, Hernando, and Levy Counties is obtained almost entirely from the Floridan aquifer. Water enters the aquifer as infiltration of precipitation or as ground-water flow from outside the area. Ground-water flow is toward the Gulf of Mexico in the limestone and dolomite of the Floridan aquifer, and natural discharge is through coastal springs and upward leakage in marshlands.

The aquifer is composed of one or more of the following Tertiary formations in order of increasing age: the Suwannee Limestone, Ocala Limestone, Avon Park Limestone, and that part of the Lake City Limestone above the evaporites. The aquifer increases in thickness from about 700 feet in the north to about 1,000 feet in the south. The Floridan aquifer is unconfined near the coast. In inland areas, where sands and clays are present, the aquifer is semiconfined.

Transmissivity of the Floridan aquifer was estimated to range from 20,000 feet squared per day in the northeast corner of the study area in Levy County, to 2,000,000 feet squared per day at several springs. Transmissivities are generally larger at springs and decrease radially away from them.

The potentiometric surface of the aquifer changes very little between the wet and dry seasons. This small change is related to seasonal variations in rainfall. The potentiometric surface has changed little from 1965 to 1980 due to relatively little ground-water development.

Chemical constituents increase in concentration toward the coast and with depth. Water quality is generally good except in areas adjacent to the coast where saltwater intrusion from the Gulf of Mexico poses a threat to the freshwater supply. Increased ground-water withdrawal associated with increased population and demand on water resources could lower the potentiometric surface, and seawater could move inland into the water supply. This threat can be lessened by placing well fields adequate distances from the saltwater-freshwater zone of transition so as not to reduce or reverse the hydraulic gradient adjacent to the coast.

INTRODUCTION

Coastal Citrus, Hernando, and Levy Counties lie within the Coastal Rivers and Withlacoochee Basins of the Southwest Florida Water Management District (fig. 1). This area has experienced rapid population growth from 1960-80 and the trend is expected to continue through the year 2020 (University of Florida, 1979; 1980a; 1980b). Growth is from increasing numbers of small communities and associated businesses and industry. At present (1982), the area does not have a regional water-supply system and each community or industry must develop its own. However, a regional water-supply system is being considered.

The principal source of water in the area is ground water from the Floridan aquifer. In 1980, an estimated 44 Mgal/d of ground water was used.

Conversations with well owners in the study area indicated problems related to ground water that they had encountered or suspected. Among these problems were high concentrations of chloride, sulfate, iron, and phosphorus, poor yields from some wells that had identical construction to nearby wells that had good yields, and sinkhole development.

Ground-water development in coastal areas presents special water management problems, primarily related to the threat of saltwater intrusion. Numerous wells in the area have shown increases in chloride concentrations in water. Increases in chloride, a major chemical constituent of saltwater, are used as an indicator of saltwater intrusion. Citizens and water managers have become concerned about increases in chloride concentrations in water from wells along the coast and are becoming aware of the threat of saltwater intrusion and the possible adverse effects on the quality and quantity of ground water available for development.

Purpose and Scope

In 1980, the U.S. Geological Survey, in cooperation with the Southwest Florida Water Management District, initiated an investigation to appraise the ground-water resources of coastal parts of Citrus, Hernando, and Levy Counties that are within the Southwest Florida Water Management District and to provide information necessary for the use and protection of the resource. The appraisal includes descriptions of the geography, geology, surface-water features, and ground-water resources, which include information on the water quality and hydraulic properties of the Floridan aquifer. Possible impacts from various ground-water development schemes were also evaluated. Information included in this report is based on data collected during the study (1980-81), historical data from the files of the U.S. Geological Survey and the Southwest Florida Water Management District, and from previously published reports. This report is intended to provide an understanding of the hydrogeology of the area and provide a basis for effective ground-water management.

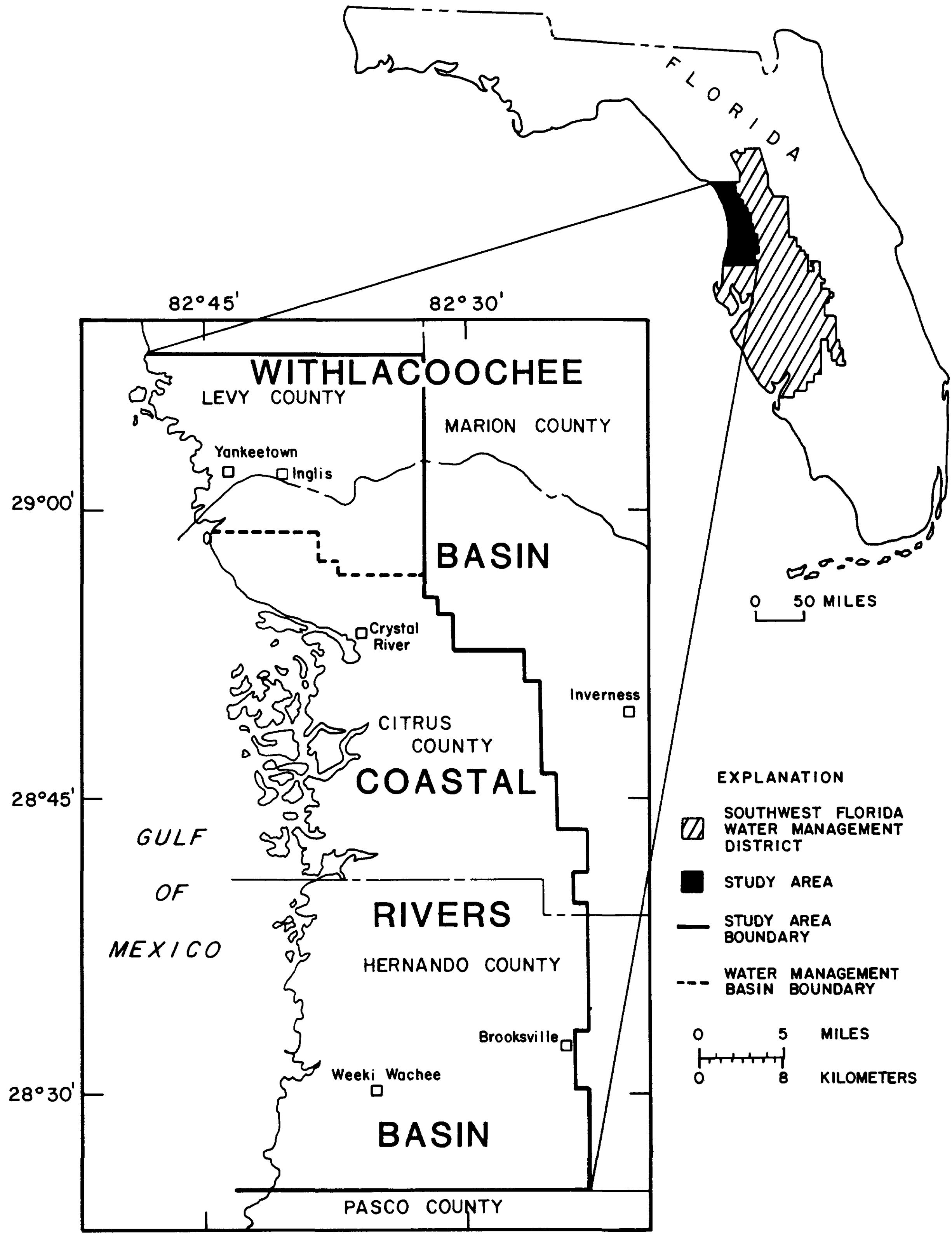

Figure 1.--Location of study area in west-central Florida.

Acknowledgments

The author gratefully acknowledges assistance provided by many organizations and individuals in conducting this investigation. Personnel of the Southwest Florida Water Management District provided valuable information. The author is grateful to the many well owners who permitted access to their land and allowed sampling of water and measuring of water levels in their wells.

DESCRIPTION OF THE STUDY AREA

The study area includes all parts of Citrus and Hernando Counties within the Coastal Rivers Basin and the coastal parts of Citrus and Levy Counties within the Withlacoochee Basin within about 15 miles of the coast, an area of about 720 mi^2 (fig. 1).

Rapid increases in population have occurred in Citrus, Hernando, and Levy Counties in the past 20 years, as shown on figure 2. This trend is expected to continue through the year 2020 (University of Florida, 1979; 1980a; 1980b). During the past decade, the population of Citrus County increased from more than 19,000 to more than 53,000 (177 percent); Hernando County showed an increase from 17,000 to almost 44,000 (158 percent); and Levy County, a rural area, increased from less than 13,000 to more than 19,000 (52 percent). The largest municipality in the area is Brooksville in Hernando County with a population of 5,600 in 1980. The second largest municipality is Crystal River in Citrus County with a population of 2,800 in 1980. Within the study area, the largest city in Levy County is Inglis with a population of 1,200 in 1980. Eighty-three percent of the population in the three counties live in unincorporated areas.

Physiography

The study area (fig. 3) lies within the Gulf Coastal Lowlands and Central Highlands physiographic divisions described by Puri and Vernon (1964). The lowlands are subdivisions of the Coastal Plain Province as described by Fenneman (1938). Land altitudes range from sea level at the Gulf Coast to more than 200 feet above sea level in the highlands.

The Central Highlands are characterized by the northwest-southeast trending Brooksville Ridge (White, 1970). This series of eroded ridges consists of limestone and clay hills of the Suwannee and Ocala Limestones, interbedded limestone and clay of the Hawthorn Formation, and sands and clays of the Alachua Formation. Local relief along the ridges is a result of numerous sinks and depressions characteristic of karst topography.

The dominant features of the Coastal Lowlands are two gently sloping Pleistocene terraces that consist of the Wicomico Formation and the Pamlico Sand, defined at their landward side by elevations of 100 and 25 feet. The Wicomico terrace slopes gently to the west between the western flank of the Brooksville Ridge and the eastern extent of the Pamlico terrace. The Pamlico terrace is submerged on its coastal side. The submerged part of the terrace retains many of the features of the emergent part, such as sinkholes and springs. This terrace supports salt marshes and swamps along the coast that give way to hardwood forests and sand ridges in a landward direction (Wetterhall, 1964).

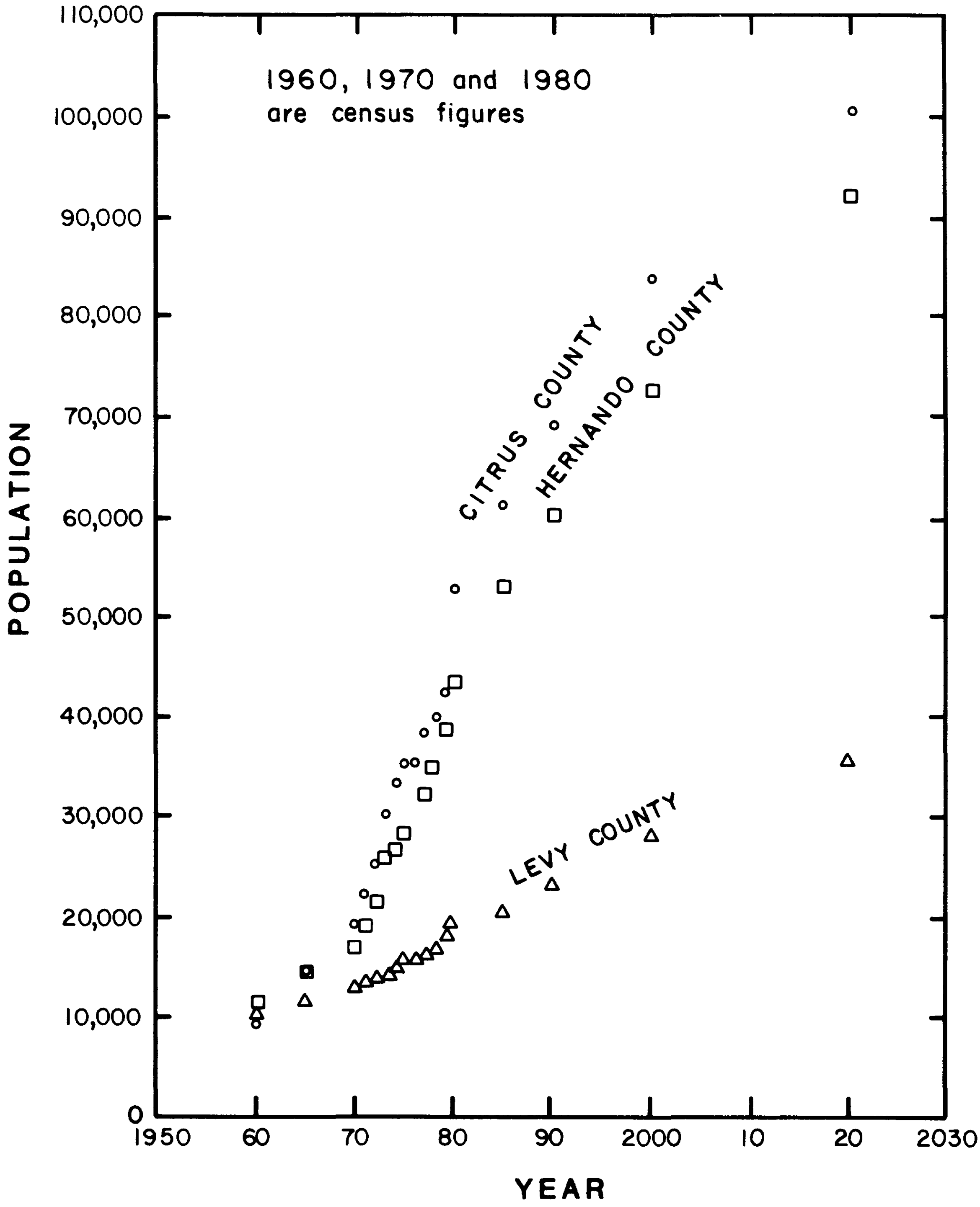

Figure 2.--Past and projected population in Citrus, Hernando, and Levy Counties (University of Florida, 1979; 1980a; 1980b).

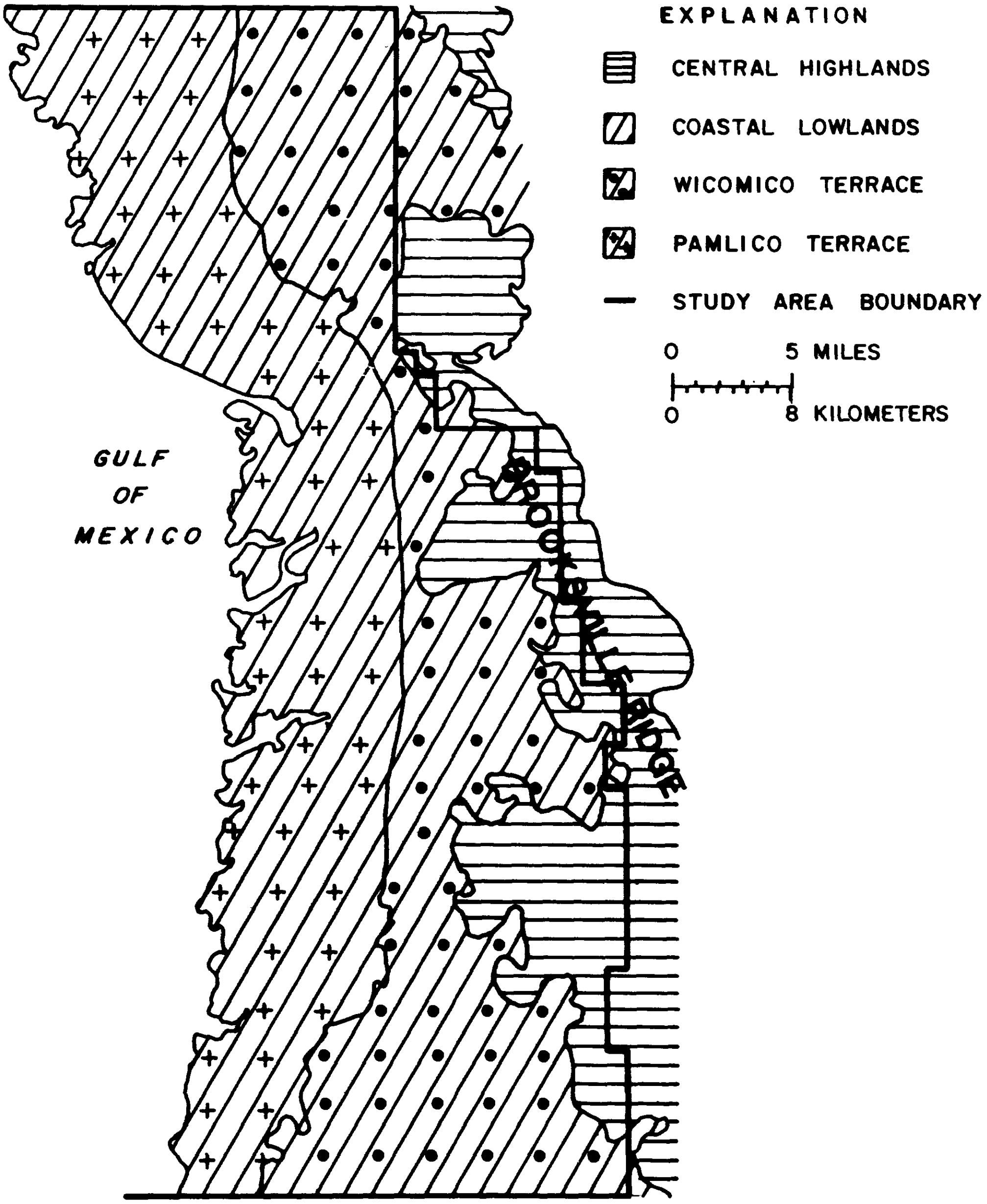

Figure 3.--Physiographic features (modified from Puri and Vernon, 1964).

Land Use

In 1975, major land-use classifications in the study area were wetlands made up of salt marshes and swamps along the coast and forest land interspersed with croplands and pasture in the east (Southwest Florida Water Management District, 1976). Urban land use, in the form of small housing developments and towns, occurs along the coastal fringe of the forest land and in the Brooksville area. Quarries represent a substantial amount of land use in north-central Hernando County and can be found throughout the study area. Projected changes in land use from 1975 to 1985 include expanded residential areas and related commercial growth along the coast (Southwest Florida Water Management District, 1976). Projections for the year 2035 indicate continued expansion of residential and commercial growth along the coast moving toward Brooksville in the south and along the Withlacoochee River in the north and some industrial expansion in the present forest land.

Surface-Water Features

Rivers, Streams, and Springs

Surface drainage is poorly developed landward of the coastal springs. The Withlacoochee River that separates Citrus and Levy Counties in the northern part of the study area (fig. 4) is the only major river that provides surface drainage from the interior of the study area. This river originates in the Green Swamp, about 20 miles east of the study area. Numerous springs and seeps along its course discharge water from the Floridan aquifer to the river. Near Lake Rousseau, the river and lake recharge the aquifer. The average river discharge at Inglis Dam, about 11 miles upstream from the coast, was 351 ft^3/s from 1969 to 1980. The river is affected by tides below the dam.

All other major rivers are in the coastal areas and discharge water from the Floridan aquifer. These include the Weeki Wachee, Chassahowitzka, Homosassa, and Crystal Rivers. Each of these rivers originates from a spring or group of springs. These springs represent 4 of the 27 first-order magnitude springs in Florida. A first-order magnitude spring has an average discharge of 100 ft^3/s or more. These springs are the Crystal River Springs (at least 30 known springs with a combined average discharge of approximately 916 ft^3/s) at the head of the Crystal River, Homosassa Springs (average discharge 175 ft^3/s) at the head of the Homosassa River, Chassahowitzka Springs (average discharge 139 ft^3/s) at the head of the Chassahowitzka River, and Weeki Wachee Springs (average discharge 176 ft^3/s) at the head of the Weeki Wachee River. The rivers are tidally affected as they flow through coastal marshlands toward the gulf.

Numerous smaller springs and spring-fed streams drain the coastal fringes of the mainland and marshes. Instantaneous discharge measurements for these are given in table 1. Combined springflow for some of these sites is greater than 100 ft^3/s; however, no single spring in this list is a first-order magnitude spring. Some streams begin from springs or seeps, flow overland some distance, and disappear into sinkholes. Hidden River near Homosassa is an example of this. It originates in seeps, flows about 2 miles, and then disappears underground. Water in streams within the marshes is a complex of saline and freshwater; the salinity varies with tide, depth of origin of the ground water, and proximity to the gulf. Flow is affected by the tide in many of the springs that are located near the coast.

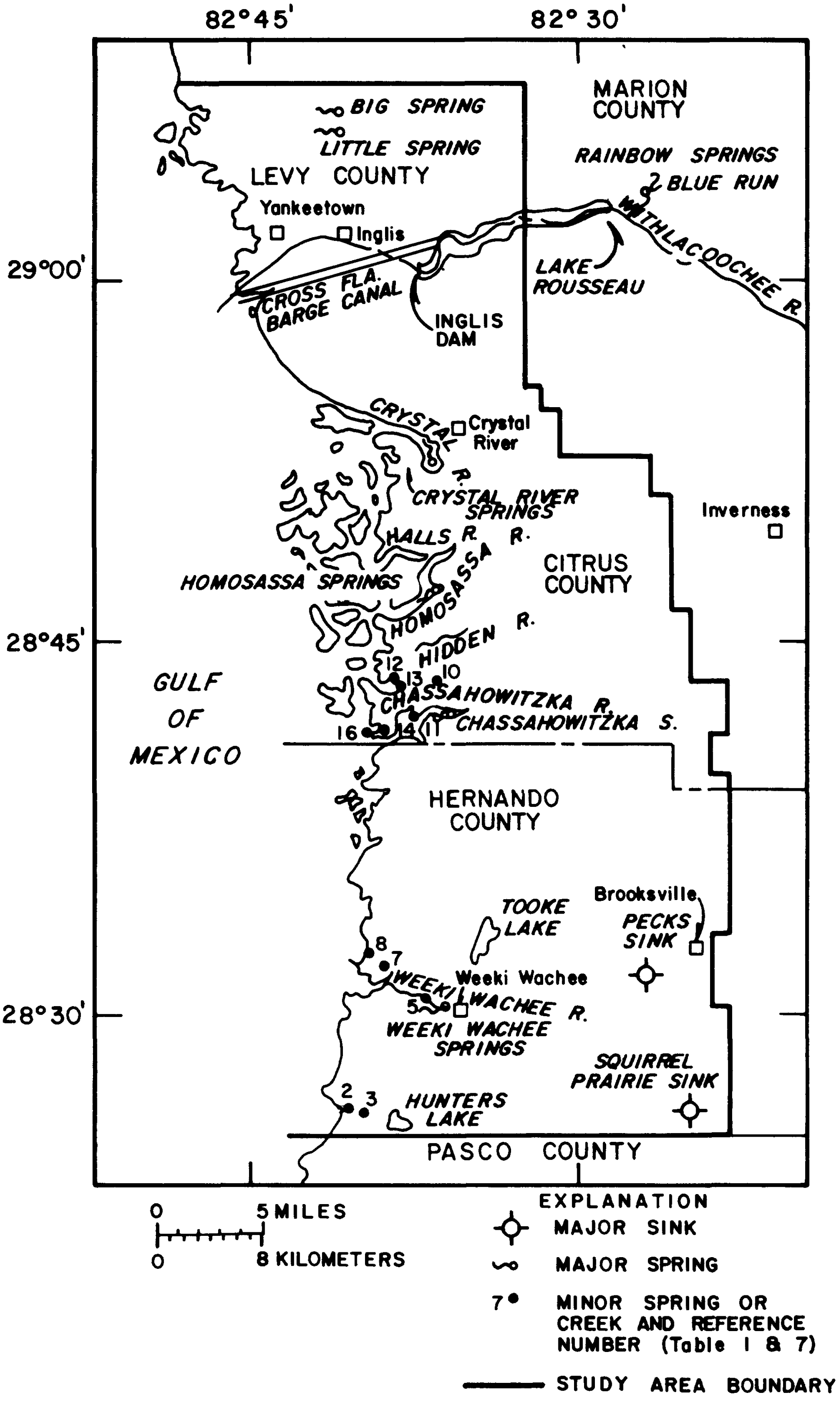

Figure 4.--Locations of major surface-water features.

Table 1.--Instantaneous discharge measurements for minor springs and spring-fed rivers

Site No.	Station name	Date of measurement	Streamflow, instantaneous (ft^3/s)
2	Boat Spring	4-30-64	1.5
3	Bobhill Springs	10-13-64	3.7
		8-06-65	4.3
		12-15-72	2.0
4	Magnolia Springs	10-13-64	9.1
		2-04-65	9.4
		8-05-65	10.0
		12-12-72	.9
5	Little Springs	3-03-61	18.0
		7-24-64	19.0
		10-14-64	38.0
		2-04-65	25.0
		8-06-65	33.0
		12-15-72	7.8
7	Salt Spring	1-18-61	25.0
		1-28-65	39.0
		1-30-66	28.0
		12-14-72	32.0
8	Mud River	1-18-61	128.0
10	Crab Creek	3-18-64	44.0
		7-21-64	49.0
		10-15-64	49.0
		1-27-65	43.0
		8-05-65	46.0
11	Baird Creek	4-10-64	22.0
		7-21-64	24.0
		10-14-64	53.0
		1-27-65	34.0
		8-05-65	44.0
12	Ruth Springs	4-14-64	6.6
		7-21-64	8.0
		10-15-64	7.4
		1-27-65	8.3
		8-05-65	12.0
		12-14-72	10.0
13	Potters Creek	11-29-61	32.0
		4-14-64	25.0
14	Crawford Creek	4-14-64	21.0
		7-22-64	35.0
16	Ryle Creek	11-29-61	.5
		4-16-64	26.0

Table 1.--Instantaneous discharge measurements for minor springs and spring-fed rivers--Continued

Site No.	Station name	Date of measurement	Streamflow, instantaneous (ft^3/s)
19	Halls River	3-27-64	168.0
		7-15-64	96.0
		10-08-64	227.0
		8-02-65	257.0
		9-08-65	120.0
		10-21-65	98.0
		11-23-65	291.0
		12-22-65	207.0
		1-19-66	191.0
		3-09-66	112.0
		6-14-66	59.0
20	Middle Springs	3-25-64	15.0
		2-03-65	15.0
		8-04-65	36.0
21	Saragassa Canal	3-25-63	179.0
		2-03-65	190.0
		8-03-65	218.0

Coastal marshes grade from saltwater habitats seaward and along marsh creeks to freshwater habitats at the landward side. Small creeks, usually less than 3 feet deep (Thom, 1967), flood the marshes during high tide, but may be dry during low tide. Large creeks and channels carry freshwater to the gulf and bring tidal waters into the marsh. The creeks and channels usually originate at springs or seeps where water is discharged from the aquifer.

Marshes behave very much like a diffuse spring (P. D. Ryder, U.S. Geological Survey, oral commun., 1982). The amount of upward leakage of freshwater to the marshes is dependent upon the amount of recharge to the aquifer. Marsh waters become saltier when freshwater discharge is reduced.

In this report, springs refer to a ground-water discharge site with a distinct orifice. Discharge from a seep represents a much smaller discharge rate than a spring.

Lakes

Few large lakes exist within the study area, although there are several small sinkhole lakes. The largest lake, Lake Rousseau, is formed by the Inglis Dam on the Withlacoochee River (fig. 4). Lake Rousseau is about 11 miles long and has a surface area of about 6.3 mi^2. The normal lake elevation is 27.5 feet above sea level (German, 1977). Water in the lake is derived predominantly from the Withlacoochee River and from Blue Run, the outlet of Rainbow Springs (fig. 4) that feeds into the Withlacoochee River. Rainbow Springs is a first-order magnitude spring in Marion County (Ferguson and others, 1947; Rosenau and others, 1977).

Two other lakes in the study area are Hunter's Lake in southwest Hernando County and Tooke Lake in west-central Hernando County (fig. 4). The lakes have average surface areas of about 1 mi^2 and about 0.5 mi^2, respectively. Little is known about their interconnection with the aquifer, although they appear to be spring fed.

Climate

The climate in the coastal area of west-central Florida is characterized by long, warm, humid summers and mild, relatively dry winters. Average monthly temperatures range from the mid 50's in winter to the low 80's in summer.

About 60 percent of rainfall in the area occurs between June and September (fig. 5) in the form of intense, local thunderstorms of short duration and occasional severe storms associated with tropical depressions. The lowest monthly rainfall generally occurs in November with a normal at Inverness of 1.5 inches and at Brooksville of 1.8 inches. The highest monthly rainfall is in August with a normal of 9.8 inches at Inverness and 9.6 inches at Brooksville (National Oceanic and Atmospheric Administration, 1980). Deviations in precipitation from normal are frequent and extreme, as shown on figure 5.

Total annual rainfall was near normal during 1979-80 for both Inverness and Brooksville based on the 30-year period 1941 through 1970 (fig. 6). The Weeki Wachee station has not been operating long enough to establish records showing normal rainfall.

Evapotranspiration

Evapotranspiration is the discharge of water from the Earth's surface to the atmosphere by evaporation from surface-water bodies and land surface and by transpiration from plants. Potential evaporation is generally considered equal to lake evaporation and expresses the amount of evaporation that would occur from shallow surface-water bodies. This is generally higher than actual evapotranspiration that takes into account vegetative transpiration.

A "life zone" bioclimatic classification system that takes vegetative cover into account (Holdridge, 1967) was used by Dohrenwend (1977) to calculate actual evapotranspiration throughout Florida based on 5 years of record at 21 stations. Potential evapotranspiration was estimated to be about 43 inches in the study area. Values increased from 41 inches in the north to 45 inches in the south. Actual evapotranspiration was calculated to average about 37 inches annually.

To assess aquifer recharge and surface- and ground-water outflow from a basin, it is necessary to know the difference between rainfall and evaporative losses. According to Visher and Hughes (1969), the annual difference between rainfall and potential evaporation (lake evaporation) ranges from zero in marsh and swamp areas at the coast to as much as 10 inches near Brooksville (fig. 7). A difference of nearly 20 inches was calculated in Dohrenwend's (1977) study that takes into account vegetative cover. A study by Cherry and others (1970, p. 79) that included part of this study area showed precipitation exceeded evapotranspiration by 37 inches for the period June 1964 through May 1966, an average of 18.5 inches per year. Hence, an average of approximately 18 to 20 inches of water per year is available for recharge to the aquifer or surface runoff.

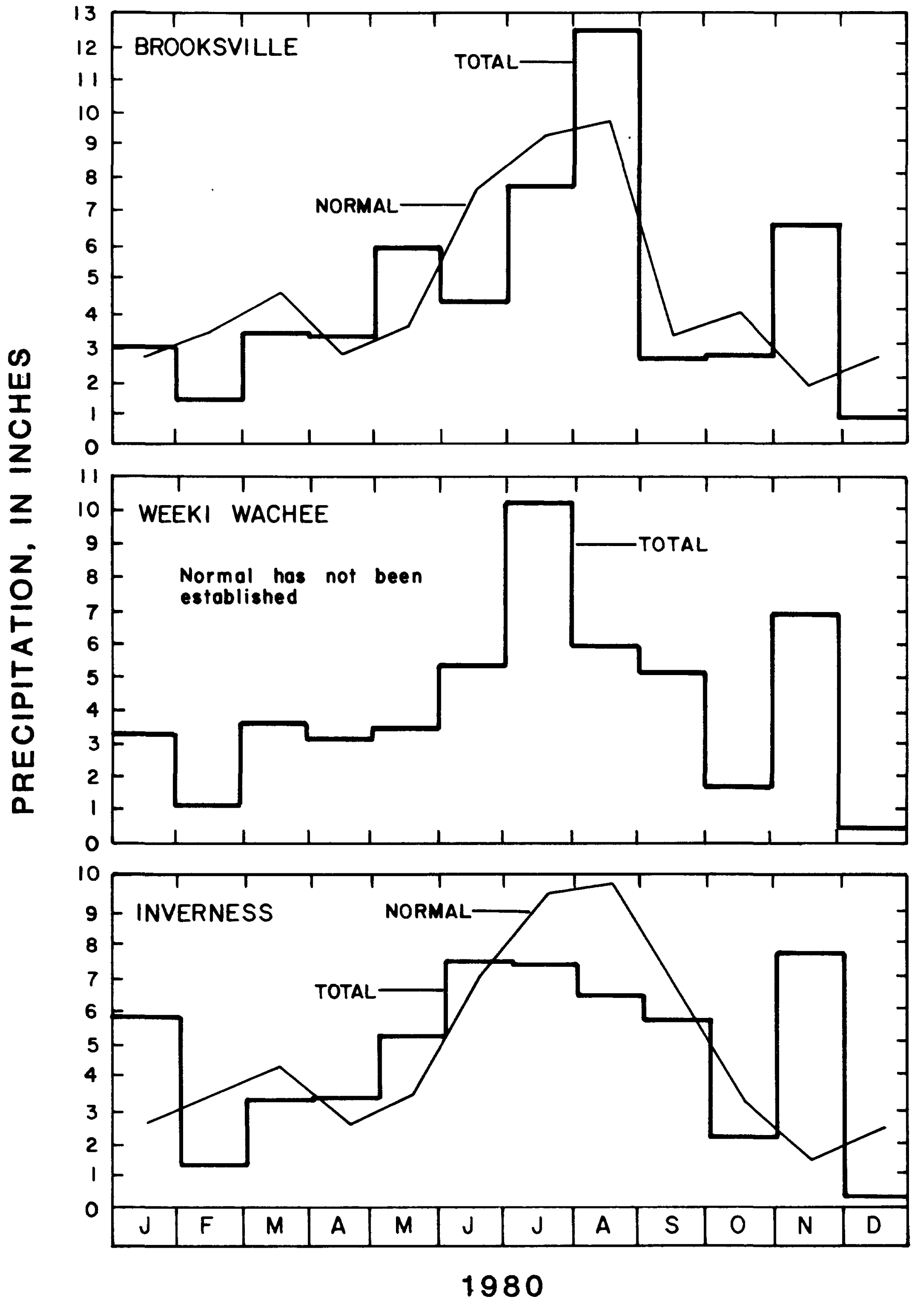

Figure 5.--Total monthly precipitation in 1980 at Brooksville, Weeki Wachee, and Inverness, and normal precipitation (1941-70) at Brooksville and Inverness.

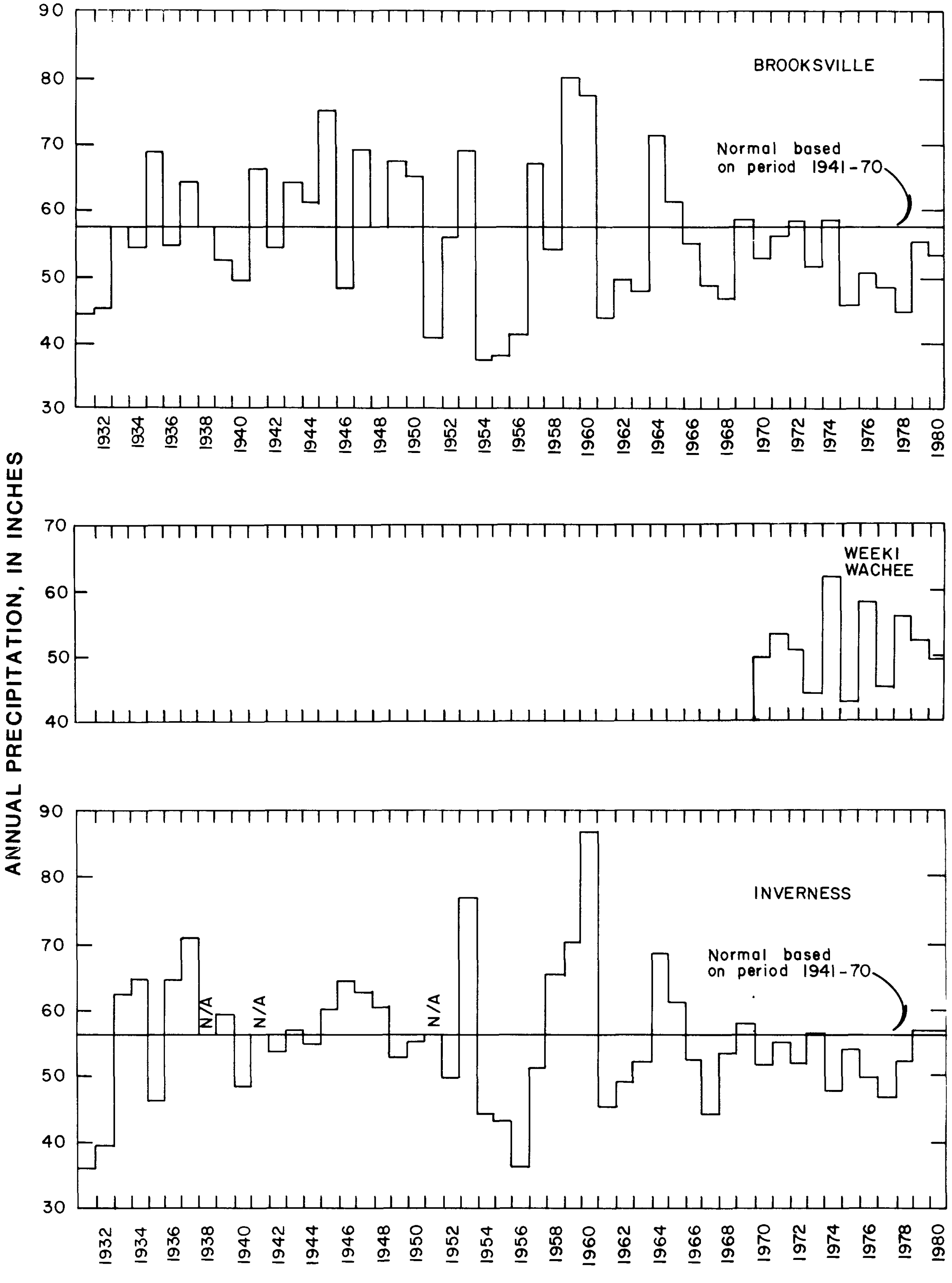

Figure 6.--Annual precipitation at Brooksville, Weeki Wachee, and Inverness.

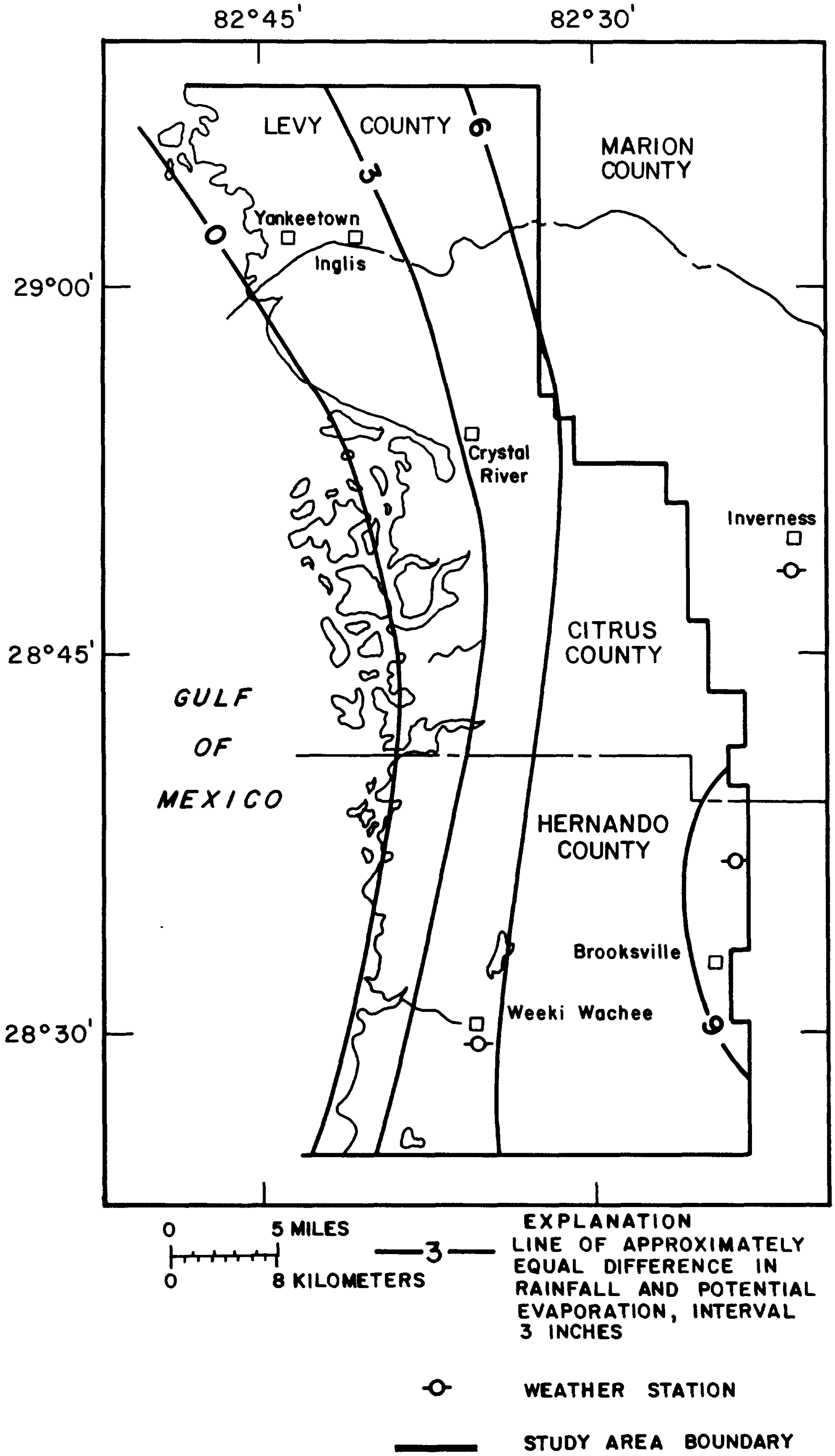

Figure 7.--Difference between rainfall and potential evaporation (modified from Visher and Hughes, 1969).

HYDROGEOLOGY

Citrus, Hernando, and Levy Counties are underlain by a thick sequence of sedimentary rock. Solution-riddled and fractured limestone and dolomite that range in age from Eocene to Oligocene comprise the following formations in ascending order: Oldsmar Limestone, Lake City Limestone, Avon Park Limestone, Ocala Limestone, and Suwannee Limestone. These formations generally dip from north to south. The Avon Park Limestone, the oldest rock exposed at land surface, crops out near the Withlacoochee River. The Ocala Limestone lies at or near land surface north and south of the Withlacoochee River. The Suwannee Limestone occurs above the Ocala Limestone in the southern part of Citrus County, increasing in thickness to the south through Hernando County. Sand and clays of the Alachua Formation and limestone and clays of the Hawthorn Formation fill depressions in these carbonates in some areas; mainly within the Brooksville Ridge (fig. 8). The geologic units and their water-supply properties are summarized in table 2. Figure 8 shows relative positions and thicknesses of the geologic formations as they change from north to south. Most formational contacts are unconformable.

Sinkholes

In the study area, sinkholes vary in size from several feet to several hundred feet in diameter. A few have well-developed drainage systems. Pecks Sink, about 2.5 miles southwest of Brooksville, drains about 15 mi^2 through a well-developed stream channel (fig. 4). The channel is dry except during times of heavy rainfall. The Squirrel Prairie Sink area about 8 miles south of Brooksville drains an area of about 20 mi^2 of the upper reaches of the Pithlachascotee River in Pasco County to the south. Both Pecks Sink and the Squirrel Prairie Sink are hydraulically connected to the Floridan aquifer (Cherry and others, 1970). Numerous other sinkholes that have poorly developed drainage systems also exist in the area and may be hydraulically interconnected through underground channels.

Occurrence of Ground Water

A distinct surficial sand aquifer, separate from the Floridan aquifer, does not occur as a continuous unit within the study area. Some perched water-table aquifers of limited extent occur in sands in parts of the study area along the western flank of the Brooksville Ridge, along the Levy-Marion County border just north of the Withlacoochee River (Hydrogage, Inc., 1980a; 1980b), and on the west side of Hunter's Lake in Hernando County. Differences between water levels in shallow wells or surface-water bodies and the potentiometric surface of the Floridan aquifer were used as indicators of a perched water table.

Table 2.--Generalized geologic column

System	Series	Stratigraphic unit	Thickness (feet)	Lithology	Water supply
Quaternary	Holocene	Unnamed deposits	0- 20	Soil, muck, sand, and alluvium.	Not used as a source of water.
	Pleistocene	Terrace deposits of Pamlico Sand and Wicomico Formation and other unnamed terrace deposits	0-100	Sand and clay, marine and estuarine terraces, alluvial, lake, and windblown deposits.	Generally not used as a source of water.
Tertiary	Pliocene	Alachua Formation	0-100	Interbedded sand and clay, residuum of limestone mixed with phosphatic clay, fine sand, silicified wood, and vertebrate remains.	Generally not used as a source of water.
	Miocene	Hawthorn Formation	0-100	Limestone, sandy, phosphatic finely crystalline, marly, calcareous sandstone, grayish-green, waxy clay.	Generally not used as a source of water.
	Oligocene	Suwannee Limestone	0-150	Limestone, cream to tan colored, fine-grained, fossiliferous, thin-bedded to massive, porous.	Many doemstic and irrigation wells produce water from the lower part of the formation.
	Eocene (upper)	Ocala Limestone[1/]	0-500	Upper member[2/]: Limestone, white to cream, soft, massive, friable, coquina, porous. Almost entirely composed of fossils in some places.	Yields large quantities of water to wells.

			Lower member[3/]: Limestone, cream to tan, granular to detrital, rarely pasty, fairly hard, porous. Lower part may be dolomitic, tan to brown, very porous, but poorly permeable.	
Eocene (middle)	Avon Park Limestone	200-400	Limestone, light- to dark-brown, highly fossiliferous, variable porosity in lower part of formation, dolomite, gray to dark-brown, very fine to finely crystalline, porous.	Yields large quantities of water to wells.
	Lake City Limestone	500-800	Dolomite, dark-brown to light-brown, very fine to microcrystalline; porous, fossil molds, thin beds of carbonaceous material and peat fragments. Generally gypsiferous in lower part of formation.	Yields large quantities of water to wells completed above evaporites.
Eocene (lower)	Oldsmar Limestone	400-700	Limestone, tan to brown, granular, porous, interbedded with chert, anhydrite, and dolomite, tan to brown, crystalline, porous.	Little is known about water supply of this formation.

1/ Ocala Group of Bureau of Geology, Florida Department of Natural Resources.

2/ Crystal River Formation of Ocala Group.

3/ Williston Formation and Inglis Formation of Ocala Group.

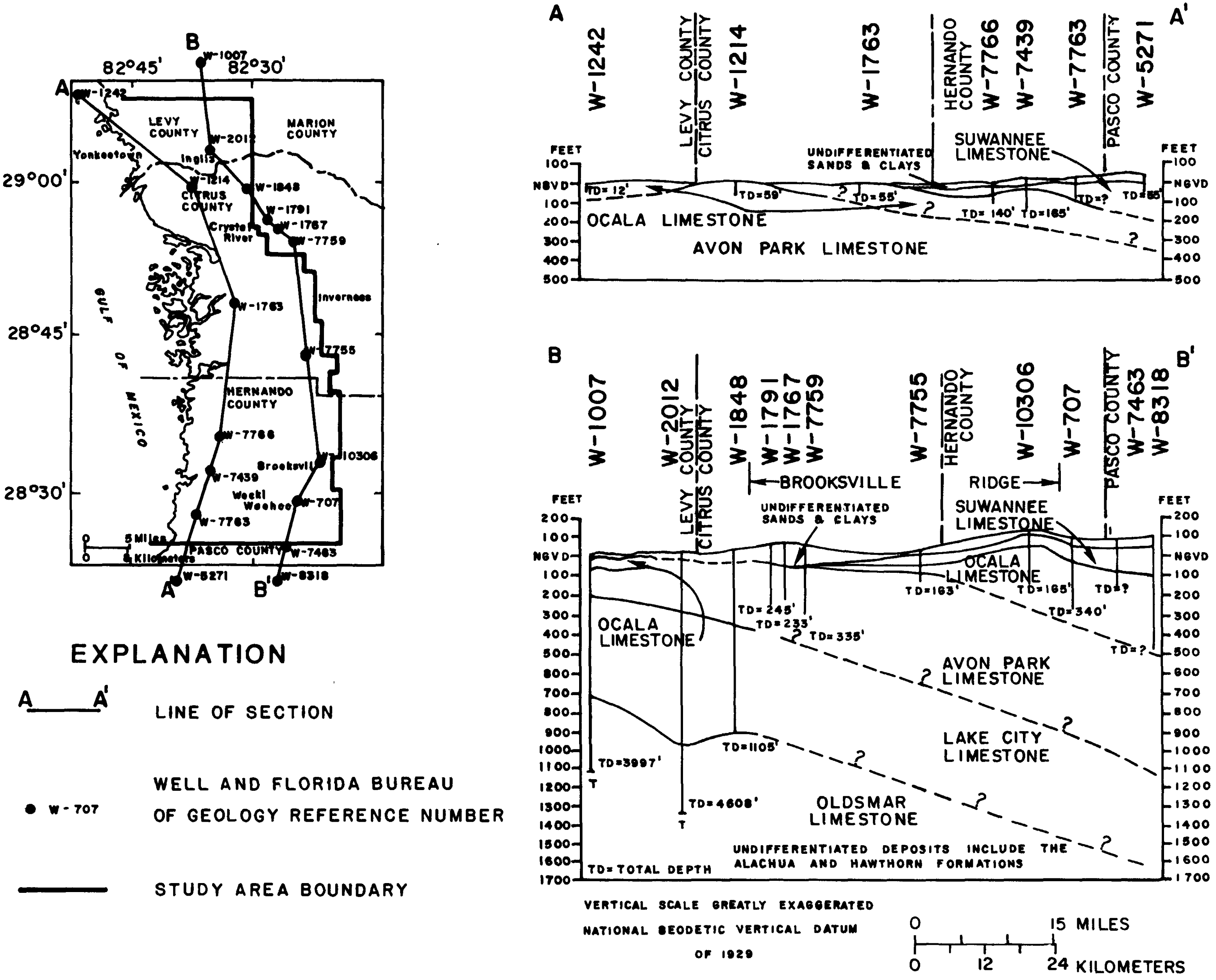

Figure 8.--Generalized geologic sections.

FLORIDAN AQUIFER

The principal aquifer in Florida, known as the Floridan aquifer (Parker and others, 1955), is the major source of water for domestic, agricultural, and industrial use in west-central Florida. The aquifer is composed predominantly of limestone and dolomite of Tertiary age that act as a single hydrologic unit (Parker and others, 1955). The Floridan aquifer in the study area comprises the following stratigraphic units in ascending order: the Lake City Limestone, Avon Park Limestone, and Ocala and Suwannee Limestones, where present.

The base of the Floridan aquifer is defined as that point in the aquifer where evaporites consistently fill pore spaces in the limestone and dolomite and restrict the flow of water. This generally occurs in the lower part of the Lake City Limestone in the study area. The top of the Floridan aquifer ranges from land surface near the coast to greater than 100 feet below land surface in the ridge area. Thickness of the aquifer ranges from less than 600 feet near the Withlacoochee River to almost 800 feet in southern Hernando County (Wolansky and Garbade, 1981).

Clastic sediments of sand, clay, and soil of varying thicknesses and varying degrees of permeability and some thin stringers of limestone overlie the Floridan aquifer. The Floridan is generally unconfined where these sediments are thin or missing, particularly seaward of the major springs and where clay content is relatively small compared to sand. As thickness of the clastic sedimentary layer increases, generally towards the ridge area, and as the clay content increases, vertical permeability in the sediments decreases causing local semiconfined conditions in the Floridan to exist.

Hydraulic Properties

Transmissivity is a measure of an aquifer's ability to transmit water and is usually expressed in units of feet squared per day (Lohman, 1979). Figure 9 shows locations where transmissivities have been determined by several investigators. Where pumping or aquifer tests have been performed, a point is located at the site of the pumping well. Hachured areas show where values from flow-net analyses have been used to estimate some averages. Values are given in table 3.

Transmissivities of the aquifer are high at springs and decrease away from the springs (Faulkner, 1973b). Weeki Wachee Springs has been estimated to have a transmissivity of between $1.2\text{x}10^6$ and $2.1\text{x}10^6$ ft^2/d (Sinclair, 1978). Faulkner (1973b) estimated the transmissivity of Silver Springs, about 25 miles east and slightly north of the study area, to average $2.1\text{x}10^6$ ft^2/d and suggested that Rainbow Springs (fig. 4) probably had a similar transmissivity. Transmissivities at the other large springs are probably on the same order of magnitude. Ryder (1981) used a transmissivity of more than $1\text{x}10^6$ ft^2/d for large areas surrounding major springs in a ground-water flow model of the Floridan aquifer that included the study area. The lowest reported transmissivity value is $2.0\text{x}10^4$ ft^2/d from an aquifer test in Levy County where the confining bed is thick.

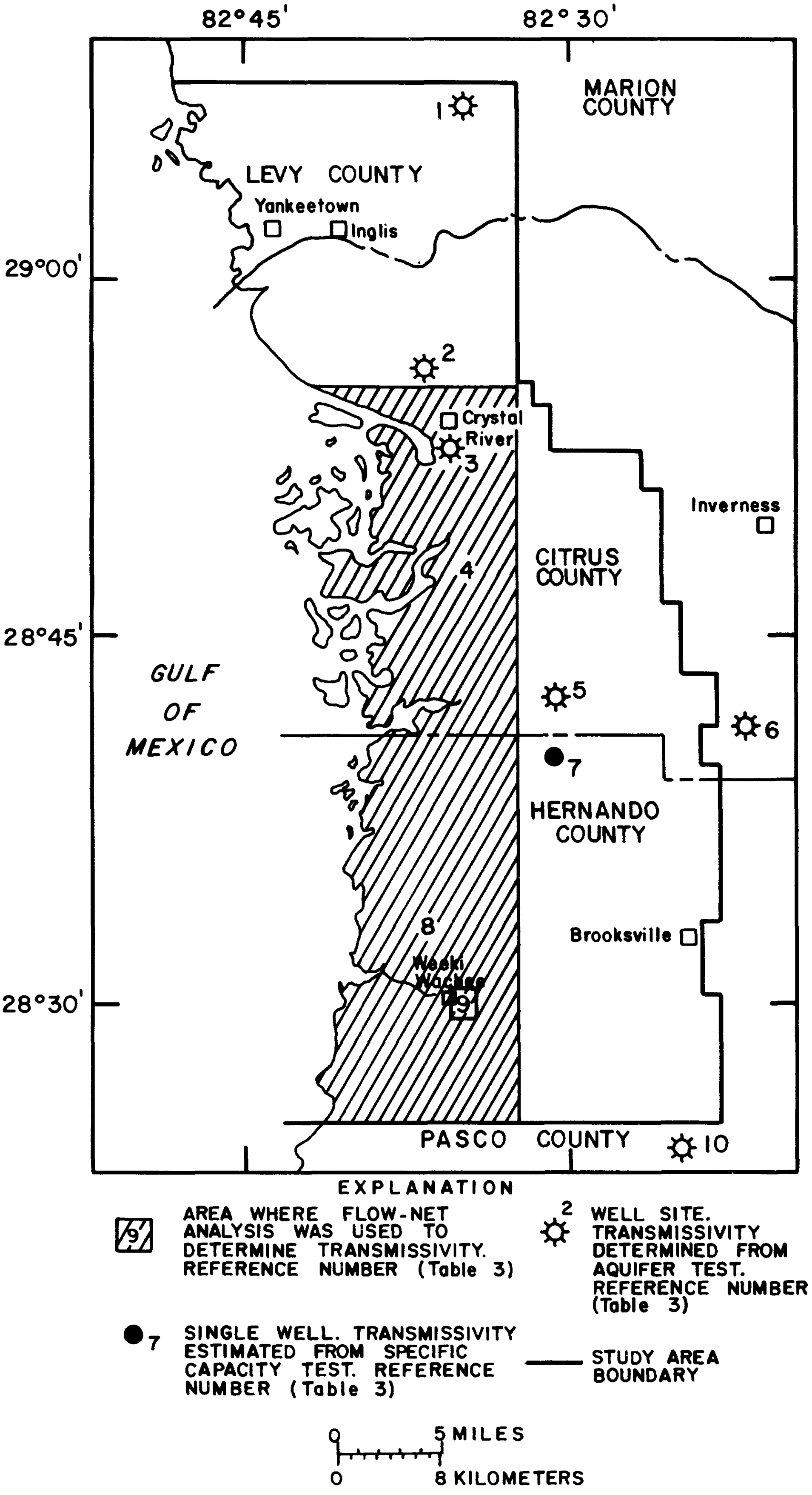

Figure 9.--Locations of aquifer-test sites.

Table 3.--Transmissivity of the Floridan aquifer

[Locations shown on figure 9]

Site no.	Transmissivity (ft^2/d)	Reference
1	$2.0x10^4$	Unpublished data in the files of the U.S. Geological Survey.
2	$1.2x10^6$ to $1.9x10^6$	Geraghty and Miller, Inc. (1979).
3	$1.5x10^6$	Seaburn and Robertson (1980a).
4	$2.0x10^6$	Cherry and others (1970).
5	$9.0x10^4$ to $2.8x10^5$	Seaburn and Robertson (1980b).
6	$1.2x10^6$	Parker (written commun., 1980).
7	$9.4x10^5$	Estimated from unpublished data.
8	$6.7x10^5$	Cherry and others (1970).
9	$1.2x10^6$ to $2.1x10^6$	Sinclair (1978, p. 17).
10	$8.6x10^5$	Leggette, Brashears and Graham, Inc. (1978).

Potentiometric Surface

The potentiometric surface of an aquifer is defined by the level to which water will rise in a tightly cased well open within the aquifer (Lohman, 1979). The regional configuration of the potentiometric surface of the upper part of the Floridan aquifer is shown on figure 10. The potentiometric highs usually represent areas of recharge or potential recharge.

The major recharge area for the Floridan aquifer in southwest Florida is in the Green Swamp area about 20 miles east of the study area where the potentiometric surface in 1980 was greater than 120 feet above sea level. Another high exists a few miles southeast of the study area in Pasco County where the potentiometric surface is 70 feet above sea level. Still another high exists within the study area in the northeast corner. Recharge to the aquifer also occurs throughout the study area, generally through highly permeable sands and sinkholes.

Ground water flows downgradient at right angles to the potentiometric lines to areas of discharge (fig. 11). Most ground water flows toward the major coastal springs from areas to the southeast, east, and northeast.

Depressions in the potentiometric surface indicate areas of discharge along streams or near springs or ground-water withdrawal sites. Re-entrant of the contour lines, an indication of discharge, occurs along the Withlacoochee River and around the major spring areas. Total discharge through springs is approximately 1,500 ft^3/s. Seeps and upward leakage near the coast account for approximately 200 ft^3/s (P. D. Ryder, U.S. Geological Survey, oral commun., 1981).

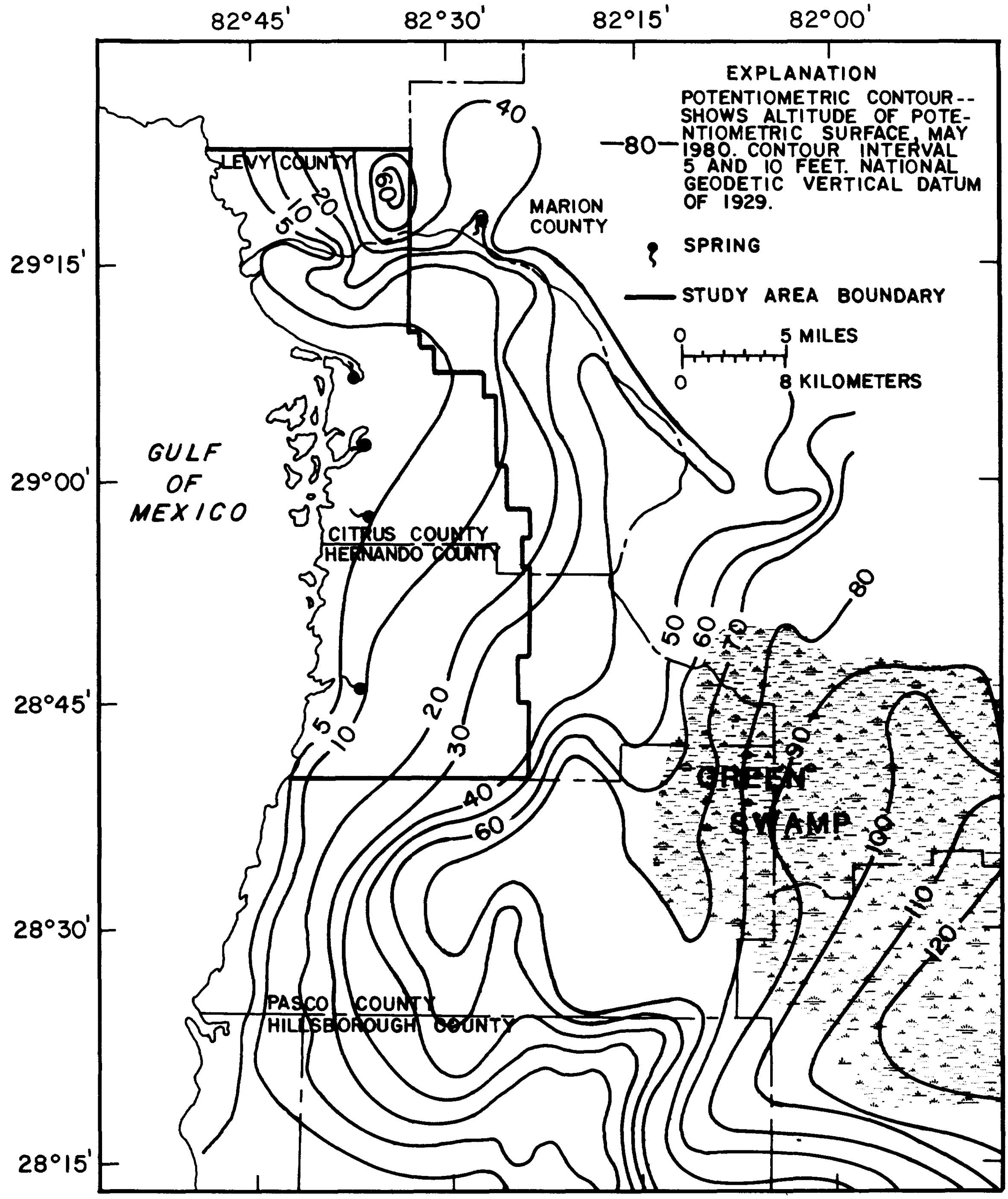

Figure 10.--Potentiometric surface of the Floridan aquifer in the study area and surrounding areas in May 1980 (from Yobbi and others, 1980a).

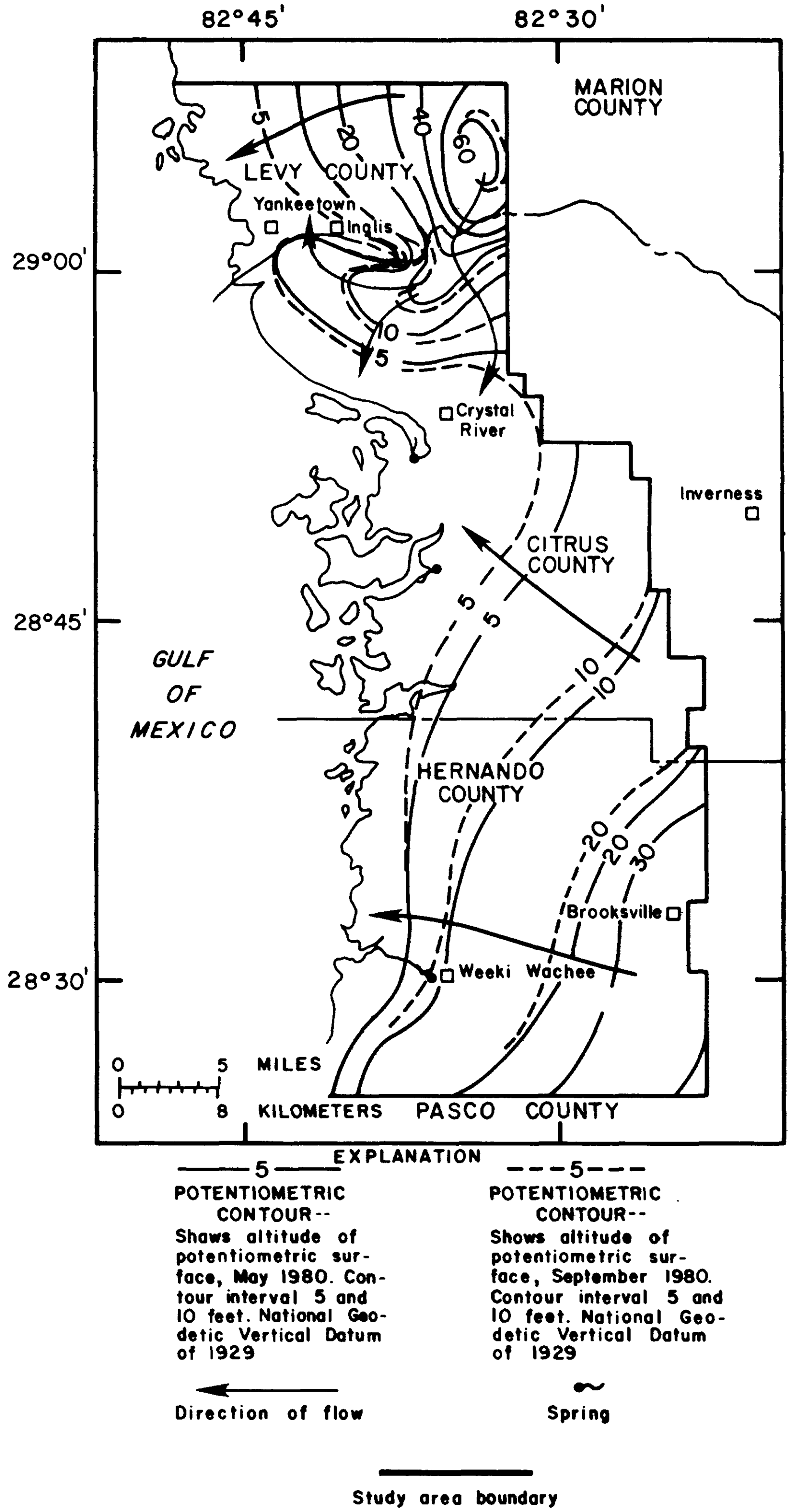

Figure 11.--Potentiometric surface of the Floridan aquifer in May and September 1980 (modified from Yobbi and others, 1980a; 1980b).

The potentiometric surface of the Floridan aquifer changes in response to variations in rainfall and pumpage and to tidal fluctuations near the coast. Figure 11 shows the potentiometric surface for May and September 1980, the end of the dry season and end of the wet season, respectively. More stress is placed on the aquifer in May than in September because seasonal rains have not yet begun and crop irrigation is heaviest. Also, tourism is at its peak in the spring, placing additional demands on the freshwater supply. The contours of the potentiometric surface shift slightly seaward between May and September as the aquifer is recharged by summer rains and pumpage is minimal.

Hydrographs for the available period of record for seven wells (locations on fig. 12) are shown on figure 13. Seasonal fluctuations tend to be greater than annual ones, with most peaks in water level occurring in the fall. Water levels are relatively constant over the 14-year period from 1966 through 1980, although a decline in peaks seems to have occurred in wells 3 and 20. Water-level peaks in 1974, 1976, and 1979 correspond with greater total annual rainfall (fig. 6). However, the peak early in 1970 at well 3 may reflect the higher than normal rainfall in 1969. Water levels are also relatively high for these same time periods--1970, 1974, 1976, and 1979--in well 20. Changes in the potentiometric surface from 1964 to 1980 indicate less than 5 feet of change in the potentiometric surfaces of the Floridan aquifer anywhere in the study area (D. K. Yobbi, U.S. Geological Survey, oral commun., 1982). The greatest decline in water level has occurred in the southeastern part of the area as is reflected in well 3. This is due in part to a decline in rainfall and possibly in part to well-field development southeast of the study area.

Along the coast, tidal changes influence water levels in wells. Tidal fluctuations are apparent in well 25 located 2.3 miles from the coast (figs. 12 and 14). Mixed semidiurnal and diurnal tidal patterns are apparent. Amplitude of the wave form is diminished as it travels inland from the shoreline. Water levels in well 20 (fig. 14), located 7.0 miles from the coast, do not show any apparent tidal influence. Table 4 lists all wells mentioned in this report along with well-identification number, depth, and casing depth.

Water Use

Ground water accounts for more than 99 percent of the 44 Mgal/d of water used for irrigation, industrial, public, and rural supply in the study area. Total pumpage varies from year to year and from season to season because of the amount and distribution of rainfall. This is especially true of pumpage for irrigation that is largest during the spring growing season when rainfall is least. As population continues to grow, pumpage for public and rural supply will increase.

The largest amount of fresh ground water withdrawn from the Floridan aquifer is used by industry. Estimated industrial use for 1980 in the study area was 32 Mgal/d (Duerr and Trommer, 1981) of which 99 percent was for rock-mining, mostly in Hernando County.

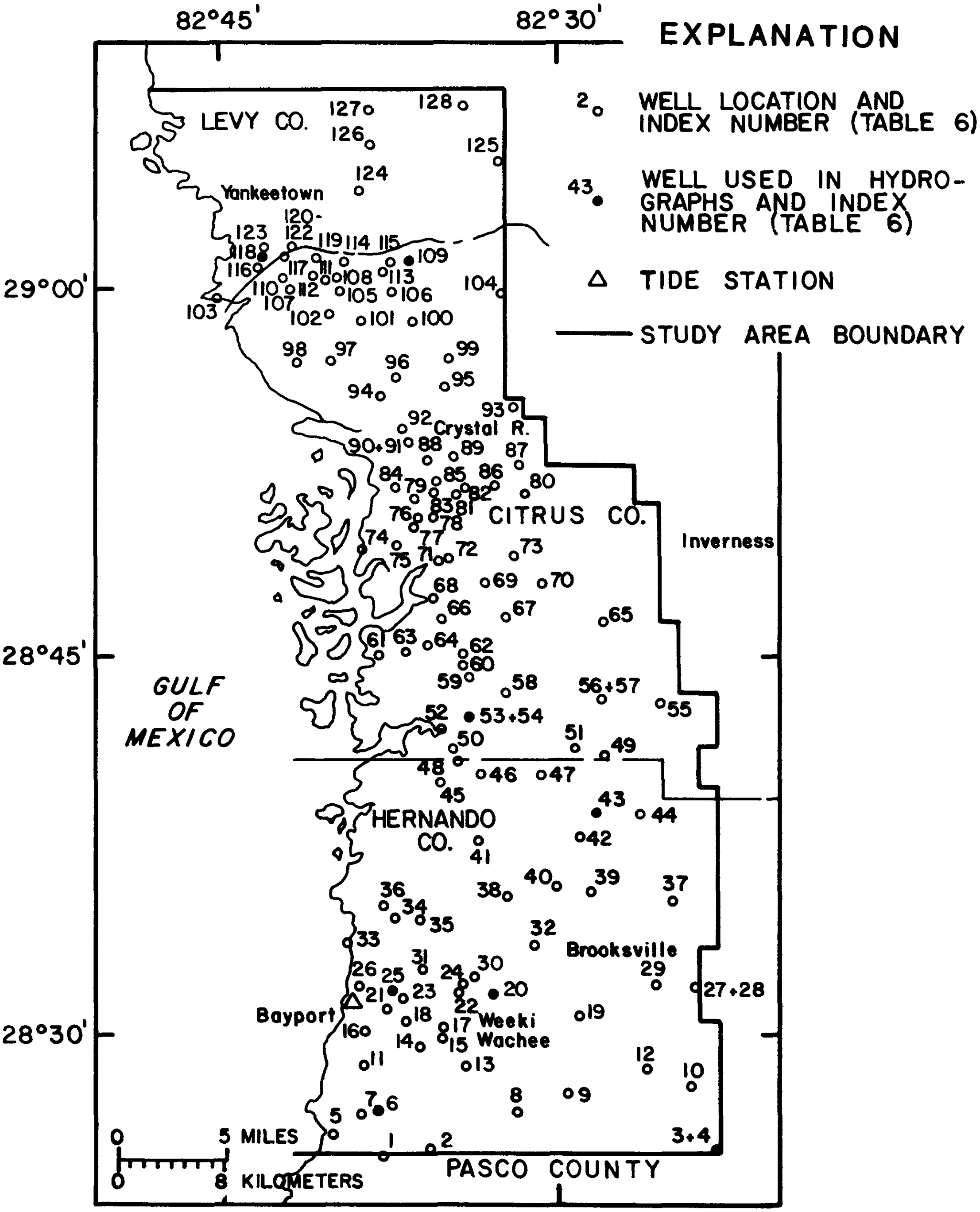

Figure 12.--Locations of wells.

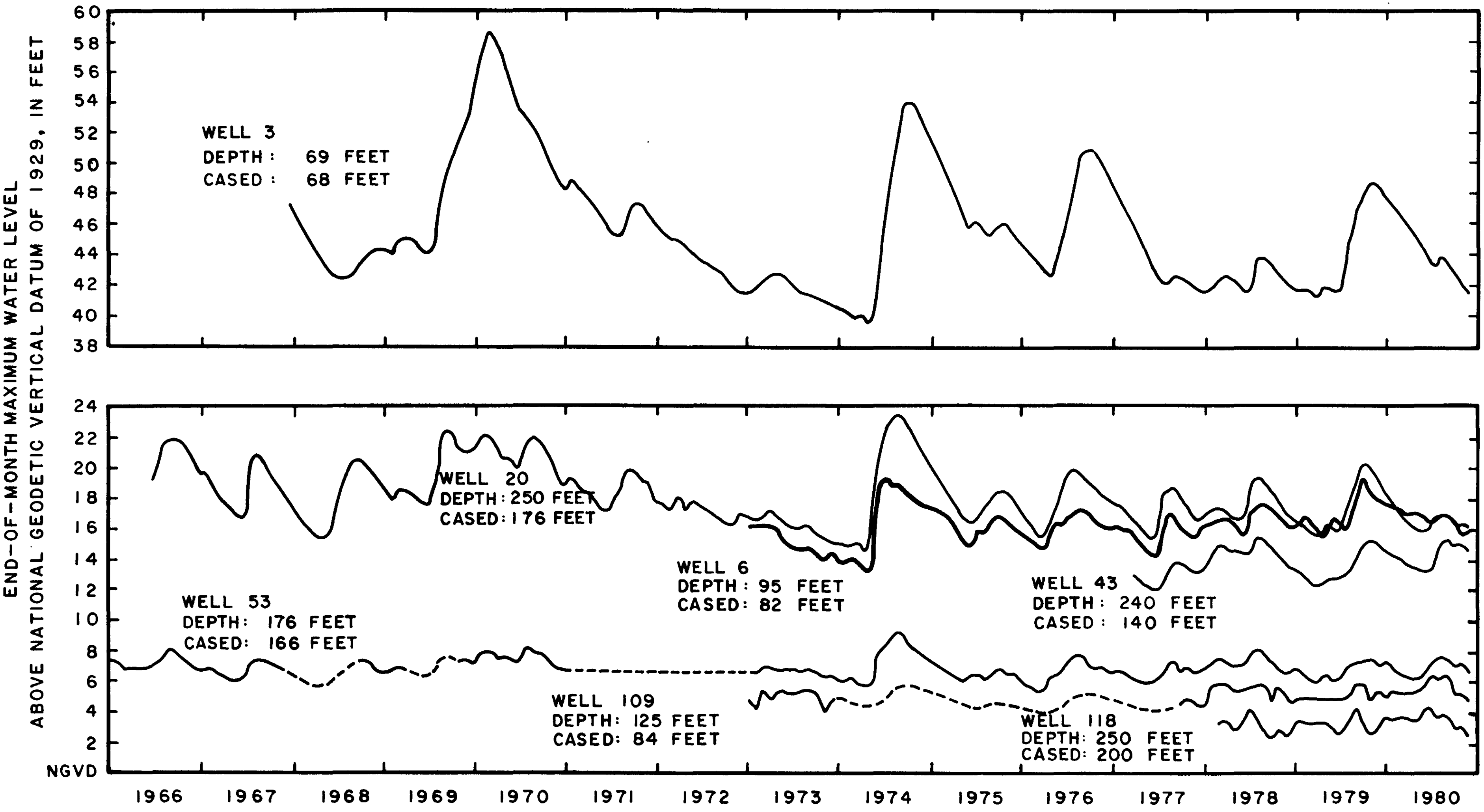

Figure 13.--Water levels of the Floridan aquifer. (Locations of wells are shown on figure 12.)

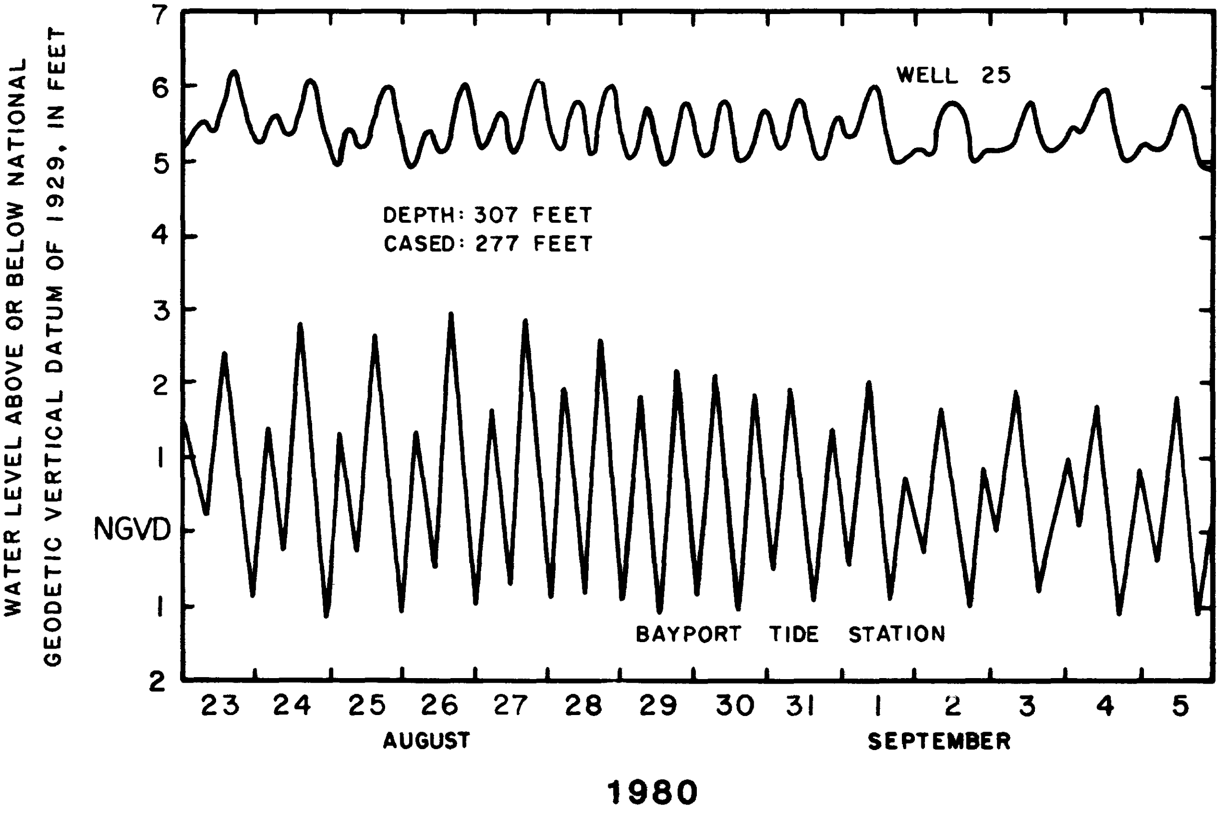

Figure 14.--Comparison of water levels in a well and tide levels. (Locations of tide station and wells are shown on figure 12.)

Table 4.--Wells used to compile water-level and water-quality information

Well No.	Station identification	Well name	Depth of well (feet)	Depth of casing (feet)
1	282553082370201	Brann	100	-
2	282605082345801	Romp 97 Deep	355	310
3	282636082221401	Weeki 11 Deep	69	68
4	282636082221402	Weeki 11 Shallow	16	6
5	282704082394301	Aripeka 1	195	176
6	282738082372501	Spring Hill	95	82
7	282742082375901	Romp TR 18-1	580	445
8	282756082311801	Deltona Corp. near Springhill	335	113
9	282838082284801	Florida Hills Memorial	400	-
10	282849082232201	Altizer	230	-
11	282923082380301	Hernando BH Supply	180	
12	282932082253301	Imperial Estates Deep	275	65
13	282938082332001	Deltona Corp. near Weeki Wachee	380	-
14	283038082352701	River County Estates	-	-
15	283057082342901	Holiday Inn	315	62
16	283105082380001	Smith	68	
17	283108082342301	Weeki Wachee Spring H Well	321	49
18	283127082355101	Weeki Wachee Campground	55	-
19	283143082281801		116	80
20	283201082315601	Weeki Wachee Well	259	176
21	283203082370201	Presbyterian Youth Camp	75	66
22	283227082335801	Royal Highlands No. 1	190	
23	283233082364101		165	126
24	283240082335801	Royal Palm Beach Deep	245	217
25	283243082365701	Whitehurst BM, Romp TR 19-2	302	277
26	283253082383701	Abbott	54	40
27	283258082231901	Brooksville #1	602	478
28	283258082232201	Brooksville #2	757	300
29	283259082250101	Paff Nursery	500	-
30	283308082331901	Barrett	125	-
31	283327082355001	S. Hernando Sportmans Club #2	101	
32	283433082303801	Groff	117	100
33	283433082391301	Plummer	33	32
34	283527082365701	Weeki Well 2	125	123
35	283529082355801	Weeki Well 3	140	133
36	283555082372901	Weeki Well 1	110	110
37	283607082241501	Seven Hills Nursery	-	-
38	283637082313301	Padgett	145	42
39	283648082275201	Community Church	250	-
40	283658082292001	Johnston	190	-
41	283808082324801	Nangel	127	-
42	283815082282201	Brooksville Rock Co. Deep	899	130
43	283924082272301	Romp Deep Well 107	240	140
44	283940082253201	Rivenbark	93	-
45	284040082342301	Lamar Chapman Hunting Camp		

Table 4.--Wells used to compile water-level and water-quality information--Continued

Well No.	Station identification	Well name	Depth of well (feet)	Depth of casing (feet)
46	284048082325001	Yellowbird	-	-
47	284102082295001	Radke	85	-
48	284125082333401	Hoppenmeyer	218	216
49	284142082272101	Harrell	136	134
50	284144082334501	Cason	100	
51	284152082281801	Coats	80	-
52	284247082343201	Strickland		
53	284317082330601	Chassahowitzka 1	176	166
54	284217082330602	Chassahowitzka 2	46	40
55	284334082245401	WSF-Tillis Hill Rec. Area	-	-
56	284339082270401	Lecanto 1	169	169
57	284339082270402	Lecanto 2	41	36
58	284412082313001	Sugarmill Woods	107	80
59	284455082331601	Homosassa Firetower	138	-
60	284501082331301	Chassahowtizka Wildlife Refuge 1	140	-
61	284532082371001	Homosassa 1	45	39
62	284537082331401	Chassahowitzka Wildlife Refuge 2	120	-
63	284547082361201	Homosassa 2	55	40
64	284551082345301	Homosassa 3	99	82
65	284705082270101	Lecanto 3	63	59
66	284720082345801	Homosassa Special Water Dist. #1		
67	284722082315001	Memorial Gardens	200	-
68	284803082351701	Norris	50	44
69	284840082325501	Heritage Hills	-	-
70	284922082291801	Forest Hills	96	84
71	284938082350301	Lee - Halls - Head	48	
72	284939082344701	Baptist Church Pastorium	60	
73	284947082311801	Lecanto 4	46	34
74	285010082384001	Ozello 2	55	49
75	285020082365301	Ozello 3	41	39
76	285102082361001	Ozello 4	75	60
77	285112082354401	Romp TR 21-2	111	-
78	285116082351401	Ozello Water #1	100	70
79	285220082361001	Palm Springs Water	85	82
80	285229082310501	Lewis	483	440
82	285234082341901	Romp TR 21-3 Deep	252	240
83	285238082352001	Plantation Paradise CC	119	89
84	285245082370101	Suncoast Development Co. 5	33	-
85	285248082351801	Plantation Hotel Deep	123	112
86	285254082323001	Lecanto 7	30	20
87	285342082312801		418	412
88	285356082352801	City of Crystal River	152	100
89	285413082343201	Crystal River Supply Well 2	175	92
90	285421082361601	Crystal River Shallow	53	3

Table 4.--Wells used to compile water-level and water-quality information--Continued

Well No.	Station identification	Well name	Depth of well (feet)	Depth of casing (feet)
91	285421082361602	Crystal River Deep	176	162
92	285508082365701	Indian Waters Subdivision No. 1	50	40
93	285548082313801	Pine Ridge No. 2	150	-
94	285610082374501	Lawn Ranger Nursery	38	-
95	285645082372101		68	-
96	285654082350101	Gerrits		
97	285737082400601	FPC Well 3	88	67
98	285737082413001	FPC Well 2	47	42
99	285749082342901	US Div. of Forestry	135	-
100	285900082361501	Whall	102	-
101	285918082381001	SCE 178	27	-
102	285935082410901	CE 87	28	20
103	290004082454101	SCE 186	20	-
104	290010082321601	Dolan	82	-
105	290023082393601	CE 89	30	21
106	290027082370701	Nichols	78	42
107	290047082414101	CE 86	30	8
108	290107082400501	CE 88	58	19
109	290112082371101	CE 5	125	84
110	290114082420901	CE 85	24	18
111	290115082401001	SCE 179 Haven Motel	40	-
112	290117082404501	Cocke	150	-
113	290118082364101	CE 70	67	62
114	290128082392801	Parcell	60	28
115	290138082371901	CE 4	64	47
116	290138082432001			
117	290145082421901	SCE 180 Logan	61	30
118	290200082432301	Romp 124		
119	290202082403901	FPC Well CE 62	155	-
120	290203082421301	Yankeetown Well 3	59	49
121	290203082421302		7	-
122	290205082421201	Yankeetown Well #2	52	49
123	290220082431501			
124	290402082384901	CE 3J	37	25
125	290503082323101	T & J Ranch	115	-
126	290551082380901	CE 2	32	14
127	290700082381001	Obert	121	-
128	290745082341501	Tidewater #1	788	298

Rural water use is the second largest use of water with an estimated 6.3 Mgal/d (Duerr and Trommer, 1981). This includes domestic and livestock freshwater use. Domestic water use includes self-supplied household water and water supplied by small public-supply systems and is based on an average per capita water use of 100 gal/d per person. This does not include population served by major public-supply systems. Water used by livestock, based on livestock population, includes drinking and washing water for commercially raised animals.

Estimates for irrigation water use are based on consumptive use permitted by the Southwest Florida Water Management District and from data collected at selected sites by the U.S. Geological Survey (fig. 15). Irrigation accounted for approximately 3.9 Mgal/d of ground water withdrawn in 1980 (Duerr and Trommer, 1981).

The public-supply water-use category includes all water supplied by public-supply systems in Crystal River, Brooksville, and Yankeetown and constitutes the smallest water-use category. In 1980, ground water used for public supply was 1.6 Mgal/d.

Since 1975, the Southwest Florida Water Management District has required that all new wells 6 inches in diameter or larger or wells producing greater than 0.1 Mgal/d must have a permit to withdraw ground water for consumptive use. Consumptive use means water that will be used and not returned directly to the aquifer. The permit sets limits on average and maximum daily pumpage. The permit system was developed to protect the environment, prevent depletion of water from the aquifer, and prevent interference with nearby wells.

The distribution of permitted pumpages in the study area is shown on figure 16 (R. G. Perry, Southwest Florida Water Management District, written commun., 1980). The amounts illustrated on figure 16 represent average daily rates of permitted pumpage and do not reflect seasonal variations that may occur. Figure 16 does not include irrigation wells drilled prior to 1975 that may still be in use. However, the data presented on figure 16 can serve as a guide to locations of major stress areas. At present, most demand on the aquifer is occurring northwest of Brooksville in Hernando County.

Water Quality

Many factors affect the chemical characteristics of ground water. Ions from atmospheric precipitation will concentrate on the land surface and contribute to the mineralization of ground water through recharge. The composition and solubility of soil and rocks through which precipitation passes in the study area, however, largely determine the degree of mineralization of ground water. In coastal areas, mineralization may result from mixing of freshwater with seawater within water-bearing formations.

Chemical characteristics of ground water may influence its use. The Florida Department of State (1977) has established primary drinking-water regulations. These regulations set minimum standards for the quality of drinking water distributed by public water systems for human consumption. Primary drinking-water standards relate solely to the safety of drinking water. A list of secondary recommendations (Florida Department of State, 1977) suggests limits on certain chemical constituents that are not directly related to health, but rather to the esthetic quality of water. Criteria have also been developed for evaluating water quality for industrial and irrigation purposes (McKee and Wolf, 1963). Knowledge of the quality of water may assist in development of the resource.

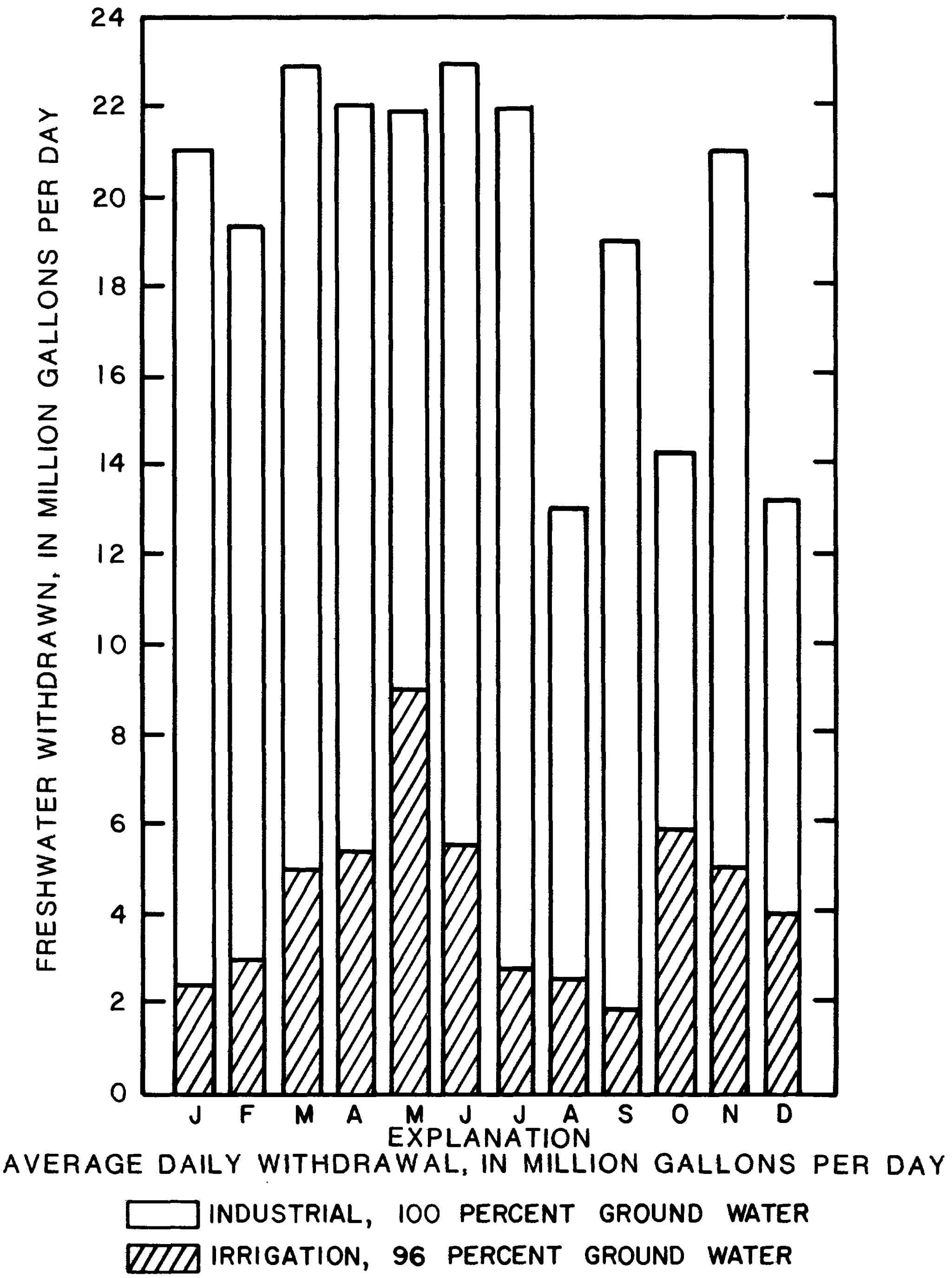

Figure 15.--Monthly industrial and irrigation freshwater use in the study area, 1980 (A. D. Duerr, written commun., 1982).

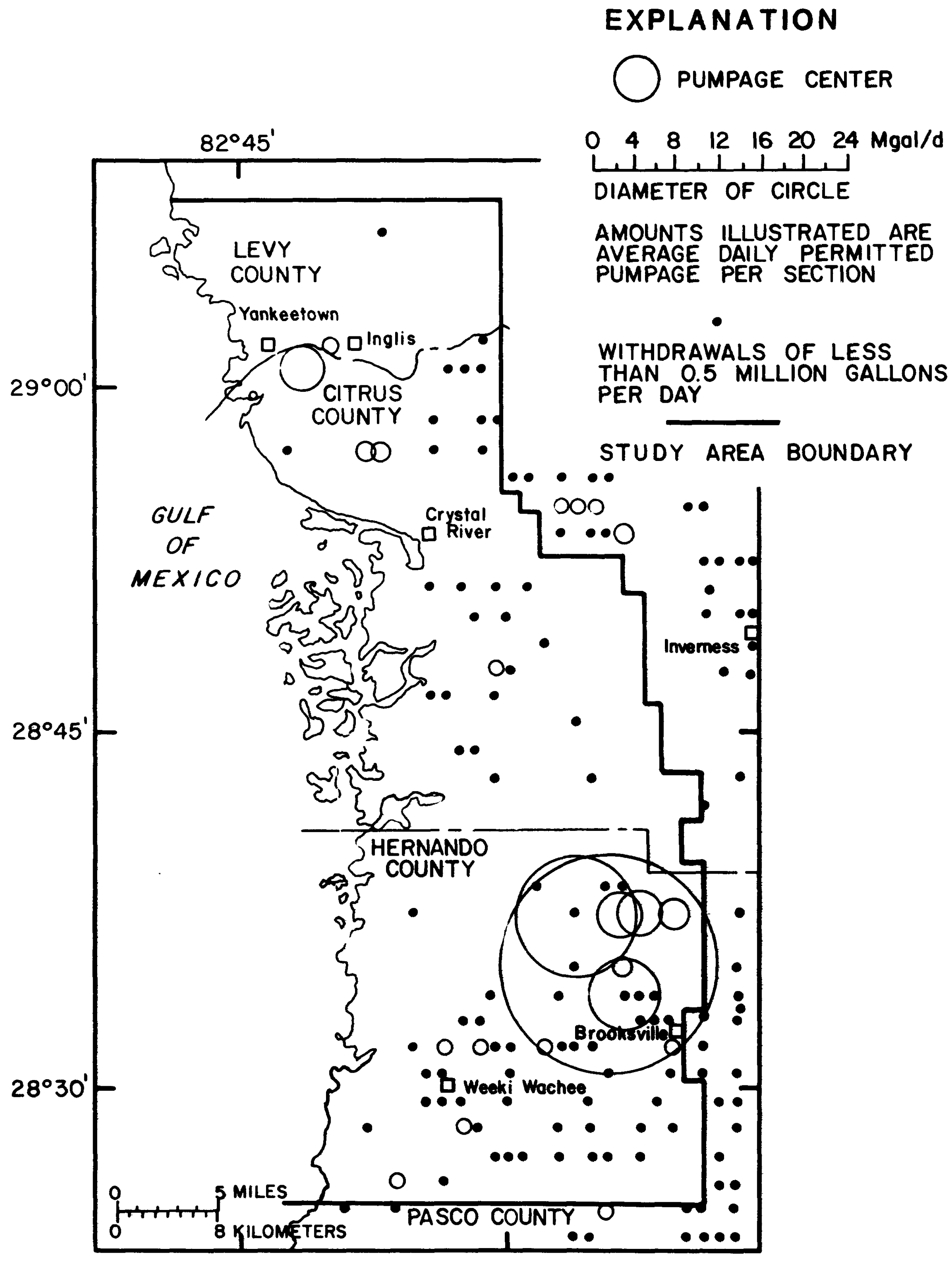

Figure 16.--Permitted daily withdrawals of ground water from the Floridan aquifer for consumptive use, 1980.

Table 5.--Selected chemical constituents

Constituent	Source or cause	Significance	Florida Department of State (1977) standards	
			Primary	Secondary
Alkalinity (mg/L)	Caused primarily by presence of bicarbonate and hydroxide. Borate, silicate, and phosphate or other weak acid radicals may also contribute to alkalinity.	Water with high alkalinity has the ability to neutralize strong acids.	Not established.	
Calcium (mg/L)	Dissolved from rock materials containing calcium carbonate (limestone, dolomite, marl, and shells) by water containing carbon dioxide.	Calcium is the principal cause of hardness in water.	Not established.	
Chloride (mg/L)	Dissolved from sedimentary rocks and in large quantities from mixing with seawater. Present in sewage and landfill leachate.	Chloride, when present with sodium, causes a salty taste to water.	Not established.	≤250
Dissolved solids[2] (mg/L)	Derived chiefly from soil and rocks as water flows through an aquifer.	Dissolved solids indicate the degree of salinity of water.	Not established.	
Fluoride (mg/L)	Dissolved from rocks and soil and is found in small amounts in most ground water.	Fluoride in drinking water reduces the incidence of tooth decay in children[3].	Not established.	1.8 (based upon mean air temperature)

Footnotes are at end of table.

and physical properties of water

Range of concentration		Median concentration		Industrial and domestic use[1/]
Wells	Springs and rivers	Wells	Springs and rivers	
0-810 80 of 89 samples: 50-300	75-784	130	130	Hardness and dissolved solids that are usually associated with high alkalinity can be undesirable for certain industrial and domestic uses.
4.9-418 83 of 104 samples: ≤90	24-180	48	50	Waters low in calcium are desirable in electroplating, tanning, dyeing, and in textile manufacturing.
0.3-9,200 89 of 101 samples: ≤25	4-6,100	7	210	Large quantities may affect the suitability of water for industrial use as it increases corrosiveness when combined with calcium or magnesium. It is also harmful to vegetation when present in large quantities.
17-10,100 3 of 96 samples: >500	113-11,000	177	555	Concentrations greater than 1,000 mg/L render water unsuitable for many purposes.
0-0.4	0-1.1	0.1	0.2	

Table 5.--Selected chemical constituents and

Constituent	Source or cause	Significance	Florida Department of State (1977) standards	
			Primary	Secondary
Hardness (mg/L)	Caused chiefly by ions of calcium and magnesium. Dissolved from the limestone ($CaCO_3$) and dolomite [$CaMg(CO_3)_2$] that compose the Floridan aquifer.	Classification[4] mg/L of $CaCO_3$: 0-60, soft; 61-120, moderately hard; 121-180, hard; >180, very hard.	Not established.	
Iron (µg/L)	Dissolved from many rock materials.	Leaves reddish-brown stain.	Not established.	≤300
Magnesium (mg/L)	Dissolved principally from dolomite, dolomitic limestone, and gypsum and is one of the principal mineral constituents of seawater.	Causes hardness in water.	Not established.	
Nitrogen, nitrate and nitrite (mg/L)	Derived from decaying organic matter, sewage, fertilizers, and nitrates in soil. Present in small amounts in most water. Found in sewage and other organic wastes.	Concentrations of nitrate greater than background levels may suggest pollution. Nitrate encourages growth of algae and other organisms that produce undesirable tastes and odors.	Nitrate ≤10	
pH (units)	pH=log(H+). Hydrogen ions derived from ionization of acids. Caused by the breakdown of gases such as SO_2 and CO_2 and organic acids.	Indicates the acidity or alkalinity of water: pH>7.0 is alkaline; pH<7.0 is acidic.	Not established.	Minimum 6.5

physical properties of water--Continued

Range of concentration		Median concentration		Industrial and domestic use[1]
Wells	Springs and rivers	Wells	Springs and rivers	
13-2,000 8 of 101 samples: >300	96-2,100	158	215	Forms scale in boilers, water heaters, and pipes. Consumes soap before a lather can form.
0-180,000	0-3,300	30	10	Water high in iron is objectionable for food processing, textile processing, beverages, ice manufacturing, brewing, and other processes.
0.1-590	2.4-400 3 of 21 samples: >100	5.3	22.0	Water having low magnesium and calcium concentrations is desirable for electroplating, tanning, dyeing, and textile manufacturing.
NO_2+NO_3 0-2.9	NO_2+NO_3 0-7.2	0.06	0.10	Nitrite is undesirable in water for some dyeing and brewing processes.
6.5-8.5	5.5-8.5	7.6	7.7	Corrosiveness of water generally increases with decreasing pH.

Table 5.--Selected chemical constituents and

Constituent	Source or cause	Significance	Florida Department of State (1977) standards	
			Primary	Secondary
Phosphorus[5/] (mg/L)	Prevalent in nature in organic forms. Results from leaching of soil and from fertilizer, decomposition of plants and animals, sewage, and industrial wastes.	Stimulates growth of algae which can result in odor and filtration problems.	Not established.	
Radionuclides (pCi/L)	Decay of radioactive elements, either naturally occurring or manmade.	Radium-226 is frequently found in ground water associated with phosphate ore. Manmade is associated with fallout from nuclear weapons testing. Levels may be increased by small releases from nuclear facilities.	Gross alpha ≤ 15	Gross alpha[6/] ≤ 0.5 Gross beta[6/] ≤ 5.0
Silica (mg/L)	Derived from decomposition and metamorphosis of silicate minerals rather than from the solution of quartz.		Not established.	
Sodium and potassium (mg/L)	Dissolved from most rock materials and are normally found in small amounts in ground water.	High concentration in seawater.	Not established.	
Specific conductance (μmho)	Measure of water's ability to conduct an electric current. The conductance is facilitated by free ions associated with dissolved constituents.	Specific conductance is generally proportional to total dissolved solids.	Not established.	

physical properties of water--Continued

Range of concentration		Median concentration		Industrial and domestic use[1]
Wells	Springs and rivers	Wells	Springs and rivers	
0-0.5 3 samples: >0.1	0-0.12 (orthophosphate)	0.01	0.02	
Gross alpha 1.4-11 Gross beta <1.8-16				
0.1-33 94 of 101 samples: ≤10	0.7-64 3 of 21 samples: >10	6.6	8.0	Undesirable for boiler water. Forms a hard coating on steam-turbine blades.
Sodium 1.6-4,200 Potassium 0-180	Sodium 1.2-3,500 Potassium 0-150	Sodium 4.7 Potassium 0.3	Sodium 120 Potassium 4.7	If sodium content is much higher than 100 mg/L, it may cause foaming in steam boilers.
1-26,600	186-19,000	386	755	

Table 5.--Selected chemical constituents and

Constituent	Source or cause	Significance	Florida Department of State (1977) standards	
			Primary	Secondary
Strontium (µg/L)	Occurs in water where strontium containing minerals are present.	It adds to the hardness of the water.	Not established.	
Sulfate (mg/L)	Dissolved from rocks containing gypsum, iron sulfide, and other sulfur compounds.	Third most common constituent of seawater. May give bitter taste to water and may produce undesirable laxative effects.	Not established.	≤250
Temperature (°C) 7/	Solar energy, heat from the Earth's core, and thermal loading from waste outfalls.	Affects usefulness of water for many purposes.	Not established.	

1/ McKee and Wolf, 1963.

2/ Dissolved solids are approximately equal to 0.52 times the specific conductance.

3/ Dean and others, 1942.

4/ Hem, 1970.

5/ Dissolved phosphorus is generally sampled for in ground water. The more specific oxided form of phosphorus, orthophosphorus, is generally sampled for in surface water.

6/ National Academy of Science and National Academy of Engineering, 1973.

7/ Shallow wells generally yield water that is near the mean annual air temperature of the area. In deep wells, the temperature increases on the average about 1°C per foot of depth.

The recommended limits for selected chemical constituents and physical properties of water for public water supplies and for some industrial and agricultural uses are listed in table 5.

Chemical analyses were made of water from 63 selected wells and one spring during this study. Wells selected for analysis ranged in depth from 20 to 899 feet and were distributed areally within the study area. Results of analyses from the 63 wells and the spring and from previous samplings at these and additional wells, springs, and spring-fed rivers are listed in tables 6 and 7.

physical properties of water--Continued

Range of concentration		Median concentration		Industrial and domestic use[1]
Wells	Springs and rivers	Wells	Springs and rivers	
1-7,280 Most samples: <1,000	60-4,800	150	270	
0-1,100 92 of 98 samples: <30	2.1-830	7.1	35	Some calcium sulfate beneficial to beer brewing process. May contribute to boiler scale.
21.0-28.0	21.0-29.0	24.0	24.0	For most purposes, water of uniformly low temperature is desired.

Water is generally of good quality for most purposes except near the coast where the transition from seawater to freshwater occurs. Stiff diagrams depict the quality of water from representative wells (fig. 17). Inland wells are of the calcium bicarbonate type. Several wells near the coast (wells 33, 77, and 103) have a significant amount of sodium and chloride due to the presence of seawater. In the set of wells (33, 35, and 39) from the coast inland, the transition from sodium chloride type to calcium bicarbonate type can be seen.

Ground-water quality in the vicinity of the Withlacoochee River may be altered by the river in areas where it recharges the aquifer, which results in lower amounts of dissolved constituents, for instance, near Lake Rousseau. Generally, dissolved constituents in the river are less than in the aquifer. During periods of low flow at most places along the river, concentrations of most chemical constituents may increase because of ground-water inflow.

Water-quality zones shown on figures 18 through 21 were constructed from point data and represent the quality of water at 100 feet below land surface. Most data used to construct the maps were collected in May 1980; however, data obtained between 1966 and 1980 were also used where 1980 data were not available. This is justified by the fact that concentrations of most chemical constituents remained relatively constant from year to year.

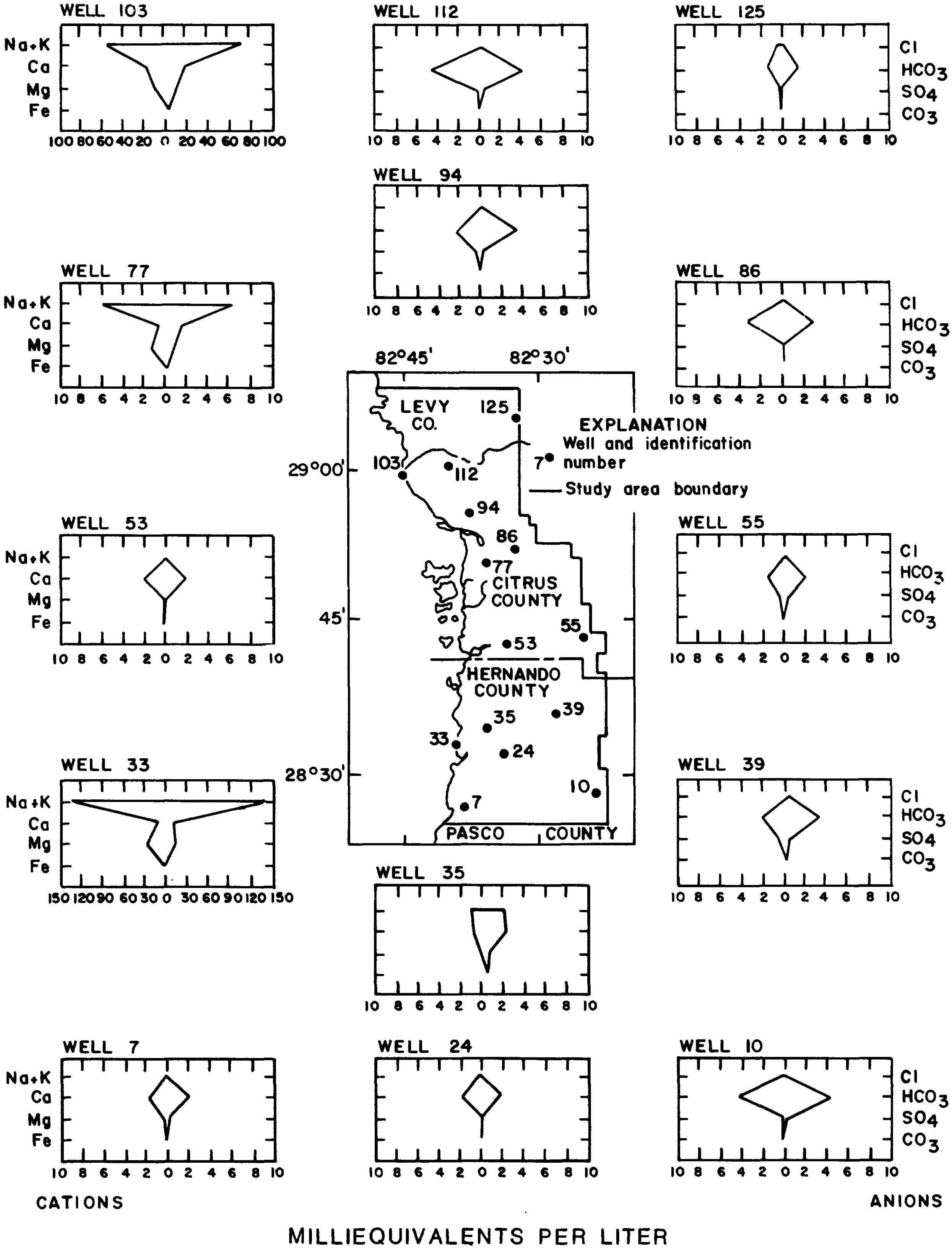

Figure 17.--Concentrations of major constituents in water from wells.

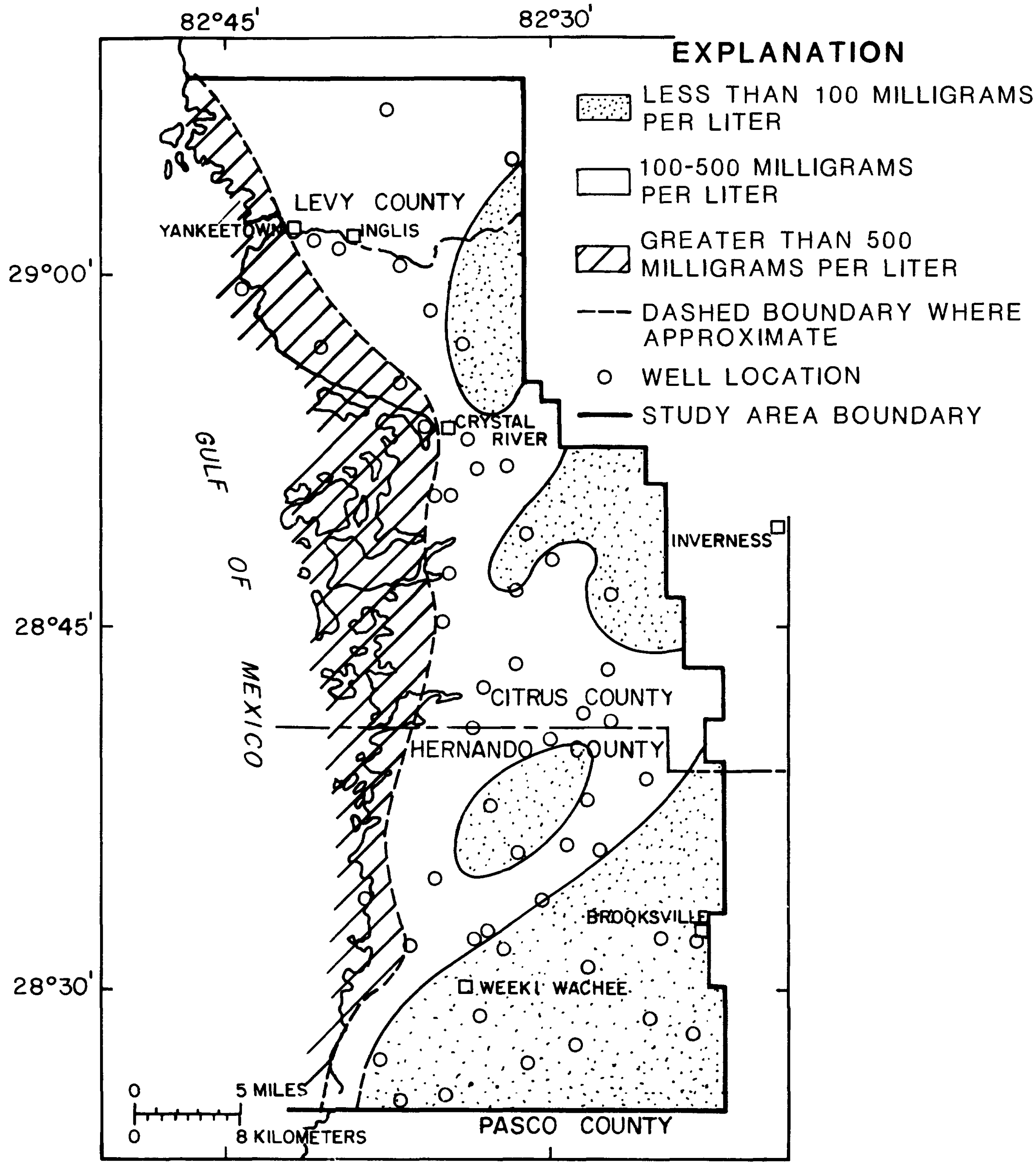

Figure 18.--Distribution of dissolved solids in ground water at a depth of 100 feet below land surface.

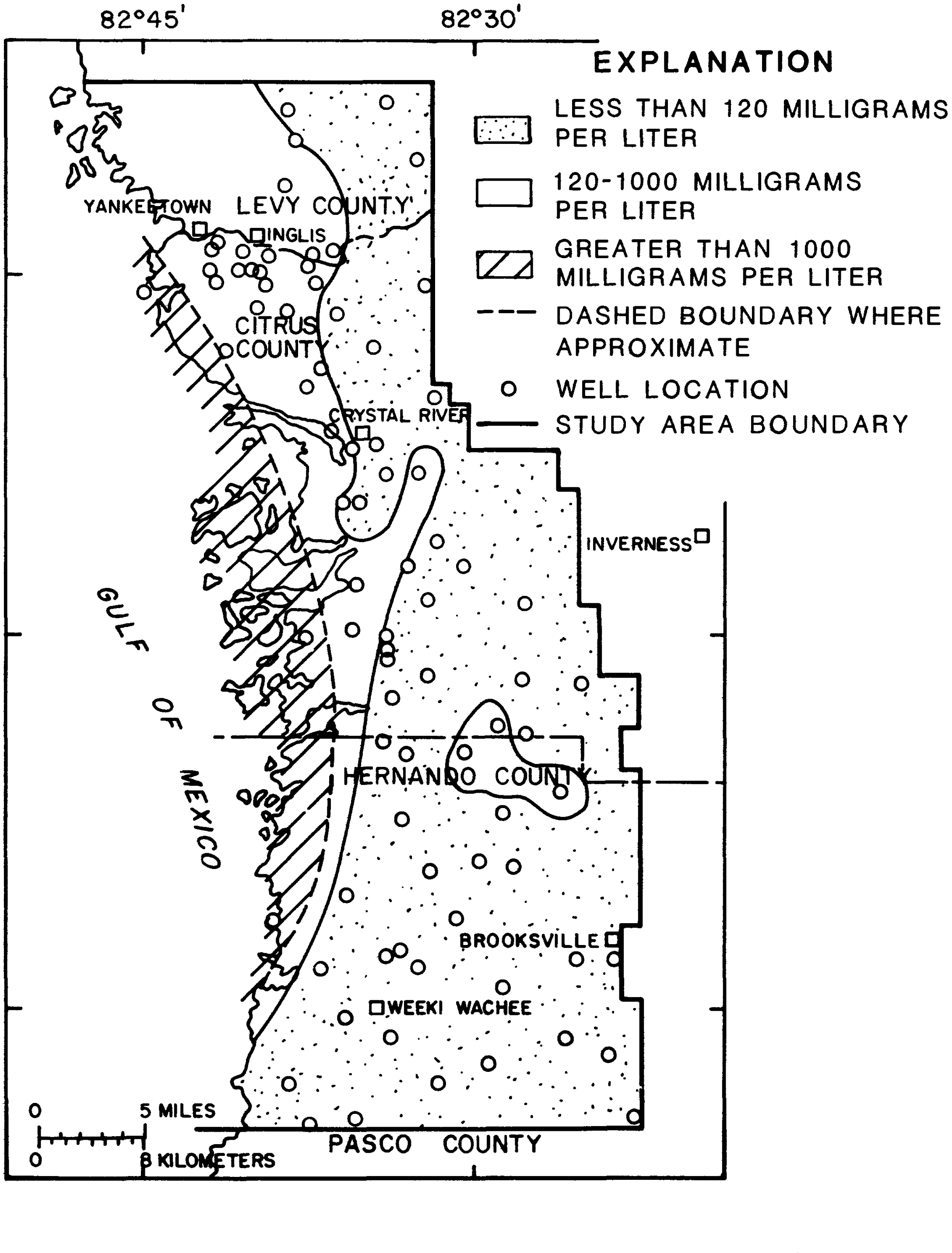

Figure 19.--Distribution of carbonate hardness in ground water at a depth of 100 feet below land surface.

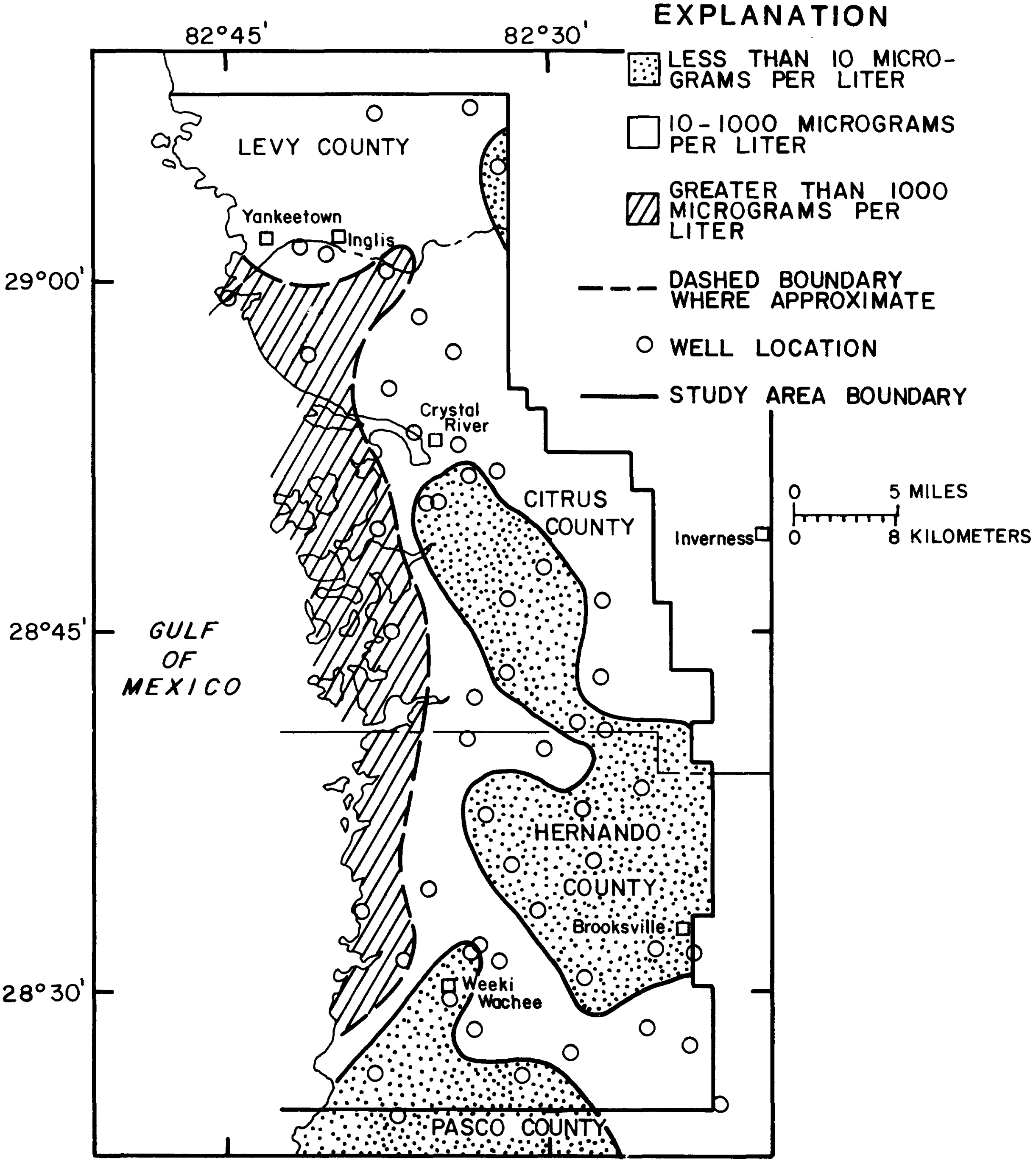

Figure 20.--Distribution of iron in ground water at a depth of 100 feet below land surface.

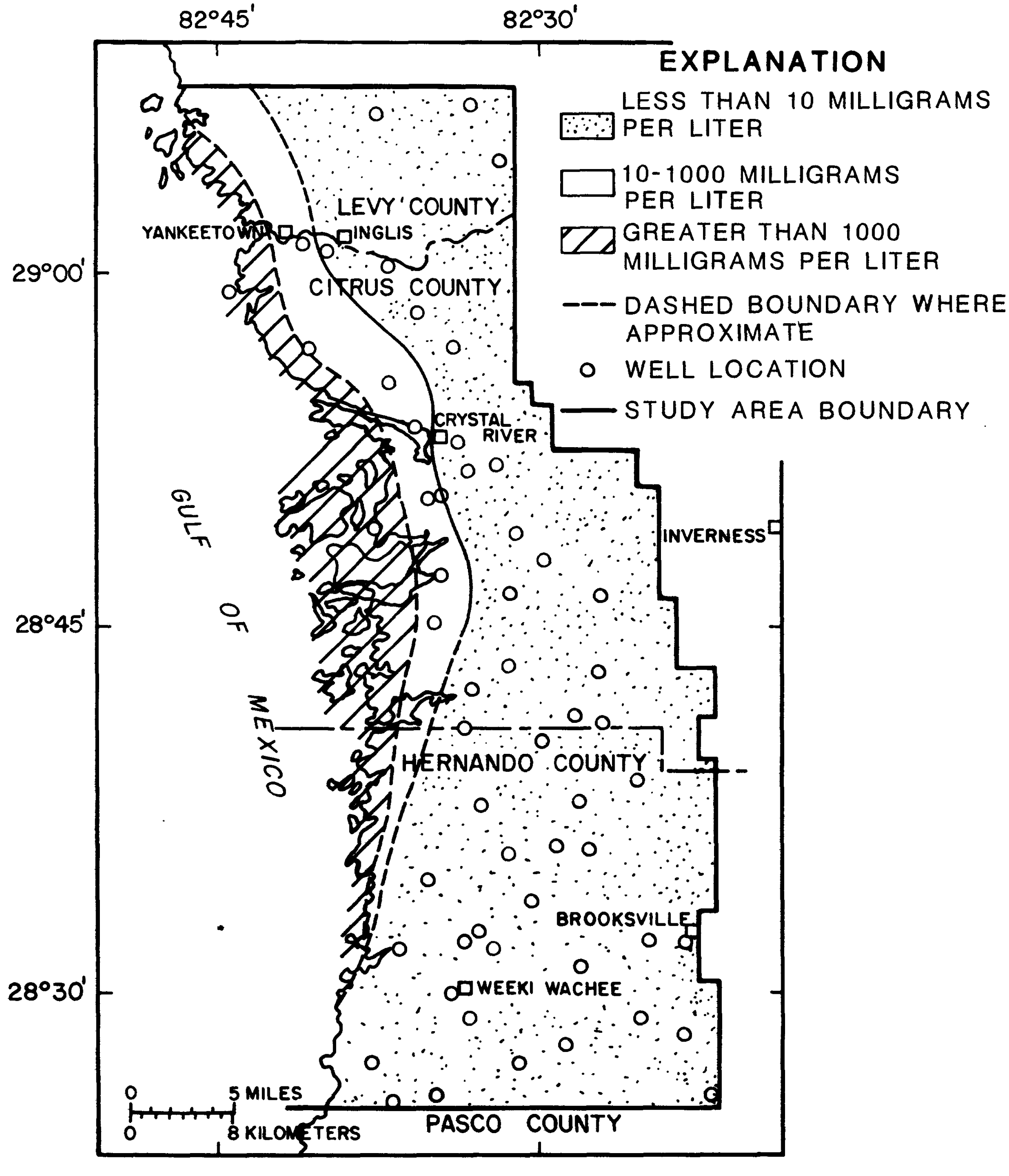

Figure 21.--Distribution of sulfate in ground water at a depth of 100 feet below land surface.

Concentrations of all constituents, except silica, listed in tables 6 and 7 increase toward the coast and with depth. Higher concentrations also occur along the lower reaches of the Withlacoochee River. These high concentrations are probably associated with deeper aquifer water moving up in the section to discharge to the river and freshwater mixing with seawater along the coast. Silica concentrations are generally higher in inland areas and are probably associated with recharge through the sands and clays that overlie the Floridan aquifer.

Median values of constituents were almost always higher for water from springs and rivers than for water from wells. This is due to the tidal influence in the rivers and the proximity of the springs to the coast.

Three wells (94, 97, and 98) located near the nuclear power plant at Crystal River were sampled for radionuclides. The well closest to the plant (98) had a gross alpha activity level of 11 pCi/L (picocuries per liter) and a gross beta activity of 15 pCi/L. The gross alpha activity level of 11 pCi/L is below the recommended limit of 15 pCi/L set by the Florida Department of State (1977). The elevated alpha and beta activities are probably related to the mixture of seawater and freshwater in the well.

Saltwater Encroachment

A major threat to quality of ground water in the study area is saltwater encroachment along the coast. As demonstrated by Cooper and others (1964), saltwater underlies freshwater along a coast in a wedge that diminishes in thickness landward. A zone of mixing between saltwater and freshwater, caused by mechanical dispersion and chemical diffussion, is referred to in this report as the zone of transition. Boundaries of the zone of transition from saltwater (19,000 mg/L chloride) to freshwater (25 mg/L chloride) can fluctuate with change in recharge and discharge to the aquifer.

The Ghyben-Herzberg theory (Davis and DeWiest, 1966) suggests that the position of the interface between saltwater and freshwater can be determined by knowing the head of freshwater above sea level. For every foot of head, the interface should be encountered 40 feet below sea level, or multiples thereof. For example, if the head were 3 feet, the interface would be at a depth of 120 feet. This would be true if the water were static and a sharp interface existed, which does not necessarily occur in nature. Theoretically, this relation between saltwater and freshwater would still apply in areas where the interface was very slightly sloped (Hubbert, 1940). In reality, freshwater flows toward the sea and seawater moves landward in a cyclic flow. This movement produces the zone of transition between saltwater and freshwater and reduces the inland extent that saltwater would reach under static conditions (Cooper and others, 1964).

Saltwater can be drawn into the freshwater aquifer by reduction in freshwater head (potentiometric surface) that could cause reduction or reversal in hydraulic gradient (slope of the potentiometric surface). The rate and extent of landward movement of saltwater is determined primarily by hydraulic gradient and hydraulic characteristics of the aquifer.

Water from wells open within or near the zone of transition will increase in chloride concentrations if freshwater head is reduced. If the natural balance of the system is not disturbed and mixing due to pumping does not occur, chloride may return to near its original concentration after the return of normal head. However, if mixing has occurred owing to pumping of water from the zone of transition, high concentrations of chlorides may continue for a long period of time.

The general shape of the zone of transition along the coast is shown on figure 22. Cross sections A and B were constructed using well depths and chloride concentrations for water from wells located within 5-mile wide bands that extend about 13 and 20 miles inland from the coast (fig. 23). The most recent chloride values available were used to construct this section. Most data are for 1980, but data as early as 1965 have been used to define the shape of the interface. The slope of the zone of transition is steeper in Hernando County (section B-B') than in Citrus County. This is due to the steeper hydraulic gradient in Hernando County that is reflected in the potentiometric surface (figs. 11 and 12).

The position of the 250-mg/L chloride line at a depth of 100 feet below sea level, based on data from 1964 through 1975, was mapped by Mills and Ryder (1977) and by Causseaux and Fretwell (1982) who added data through 1980. Figure 23 shows the position of the line as defined by Causseaux and Fretwell. A chloride concentration of 250 mg/L is the recommended limit for drinking water (Florida Department of State, 1977).

Changes in Chemical Quality

Because of problems of seawater intrusion, many wells in the coastal area have been sampled periodically for determination of chloride concentration and specific conductance. Figure 24 shows variations in chloride concentrations in several coastal wells from 1967 to 1980 as determined from samples taken bimonthly. Wells 21, 64, and 75 show increased chloride concentration with time that suggests possible inland movement of saltwater.

The wide range in values from near 400 to more than 900 mg/L chloride at well 21 may be associated with the time of sampling in relation to tides; however, the overall trend from 1970 to 1980 does appear to be in an upward direction. Well 64 fluctuates between 100 and 300 mg/L. The overall trend from 1969 to 1980 is in an upward direction. Well 75 also shows a definite upward trend between 1969 and 1980 from less than 2,000 to more than 3,000 mg/L chloride.

Wells located a few miles inland, such as wells 85 and 97, show fairly constant concentrations of chlorides in the freshwater range. Well 119 fluctuates, generally, between 5 and 30 mg/L but shows no apparent trend with time. Short-term fluctuations in concentrations are probably related to changes in rainfall. Plots of other wells (all within the zone of transition) show fairly constant average concentrations, although ranges vary considerably.

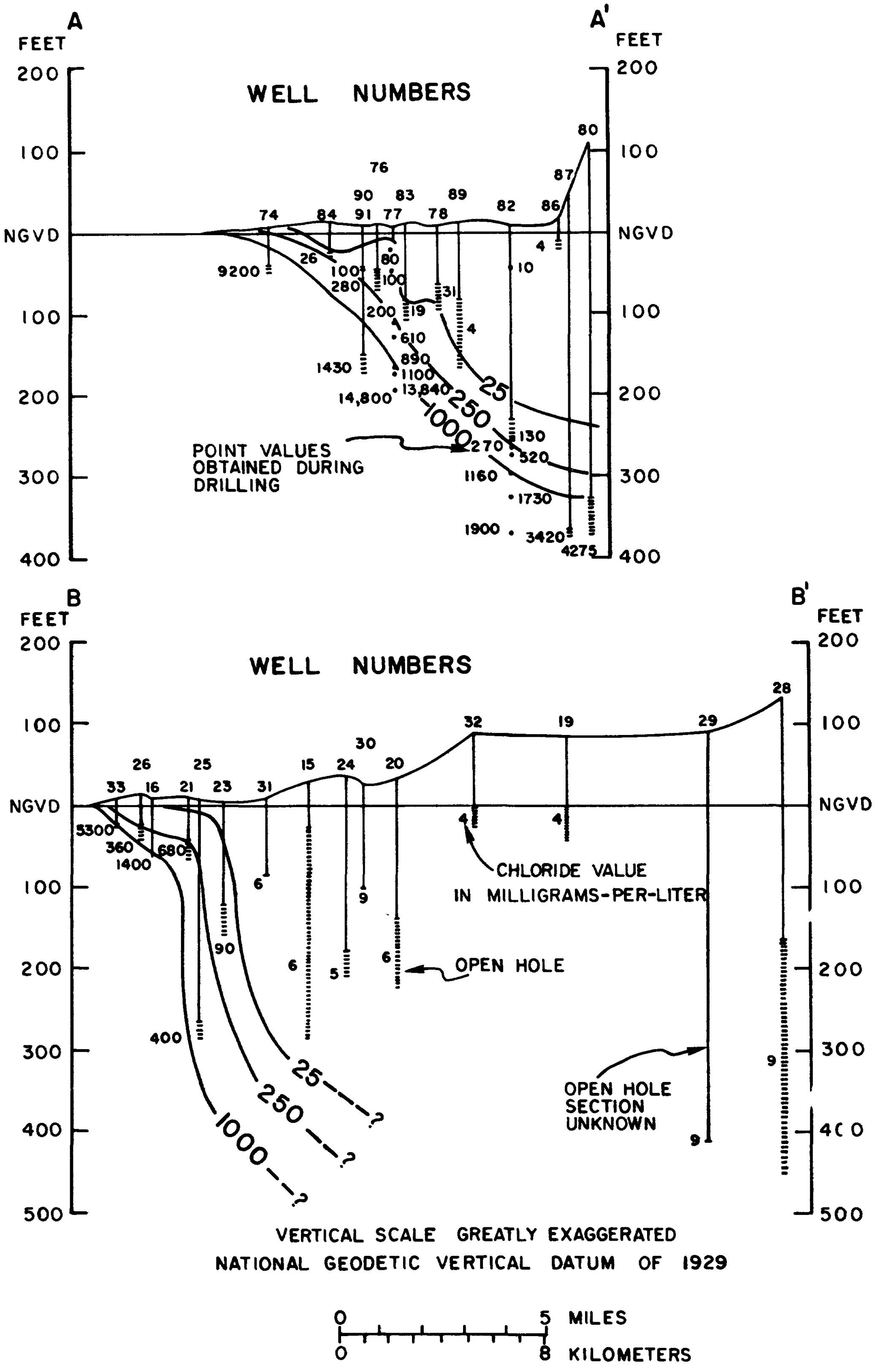

Figure 22.--Cross sections of the saltwater-freshwater zone of transition (modified from Causseaux and Fretwell, 1982).

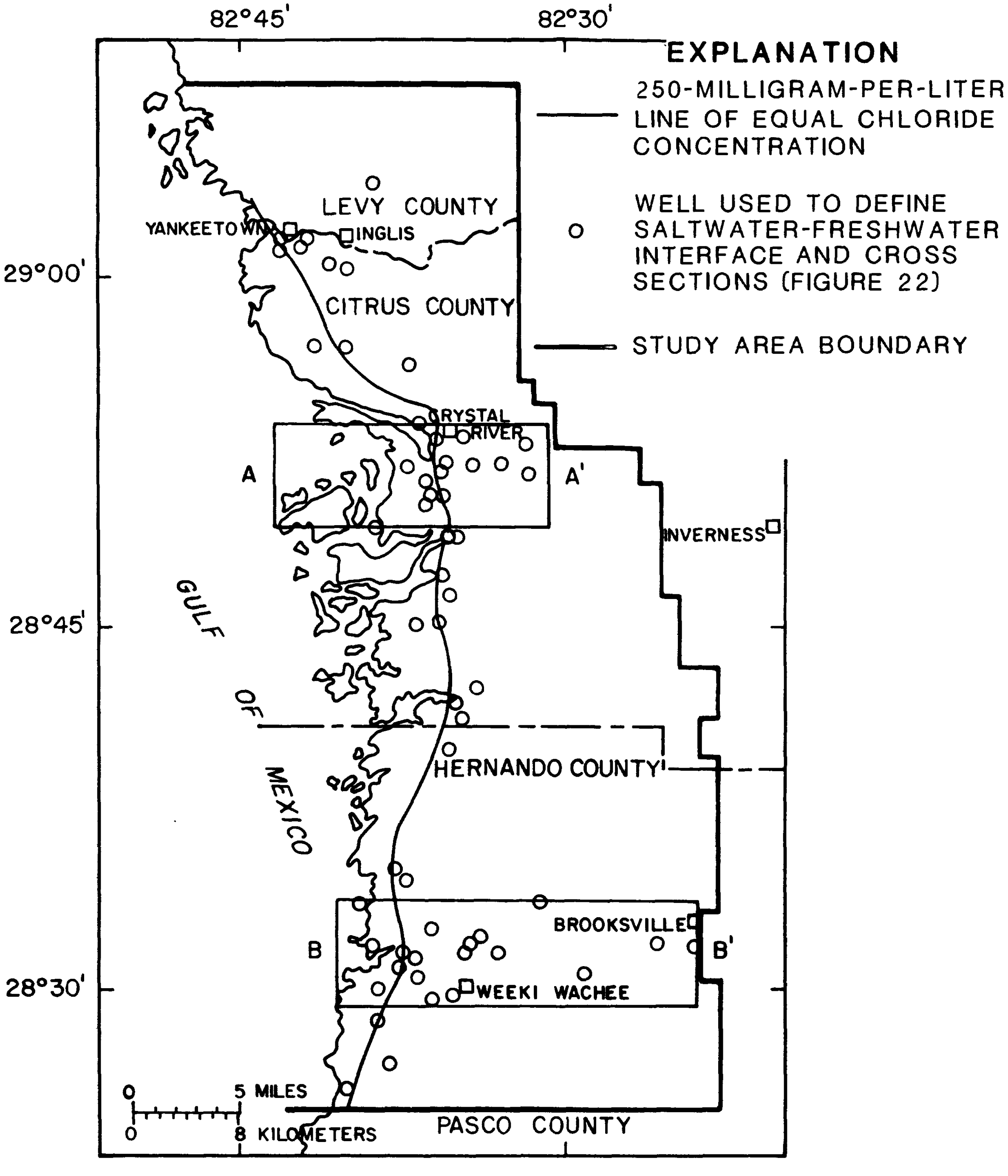

Figure 23.--Areal position of the 250-milligram-per-liter line of equal chloride concentration at 100 feet below sea level (modified from Causseaux and Fretwell, 1982).

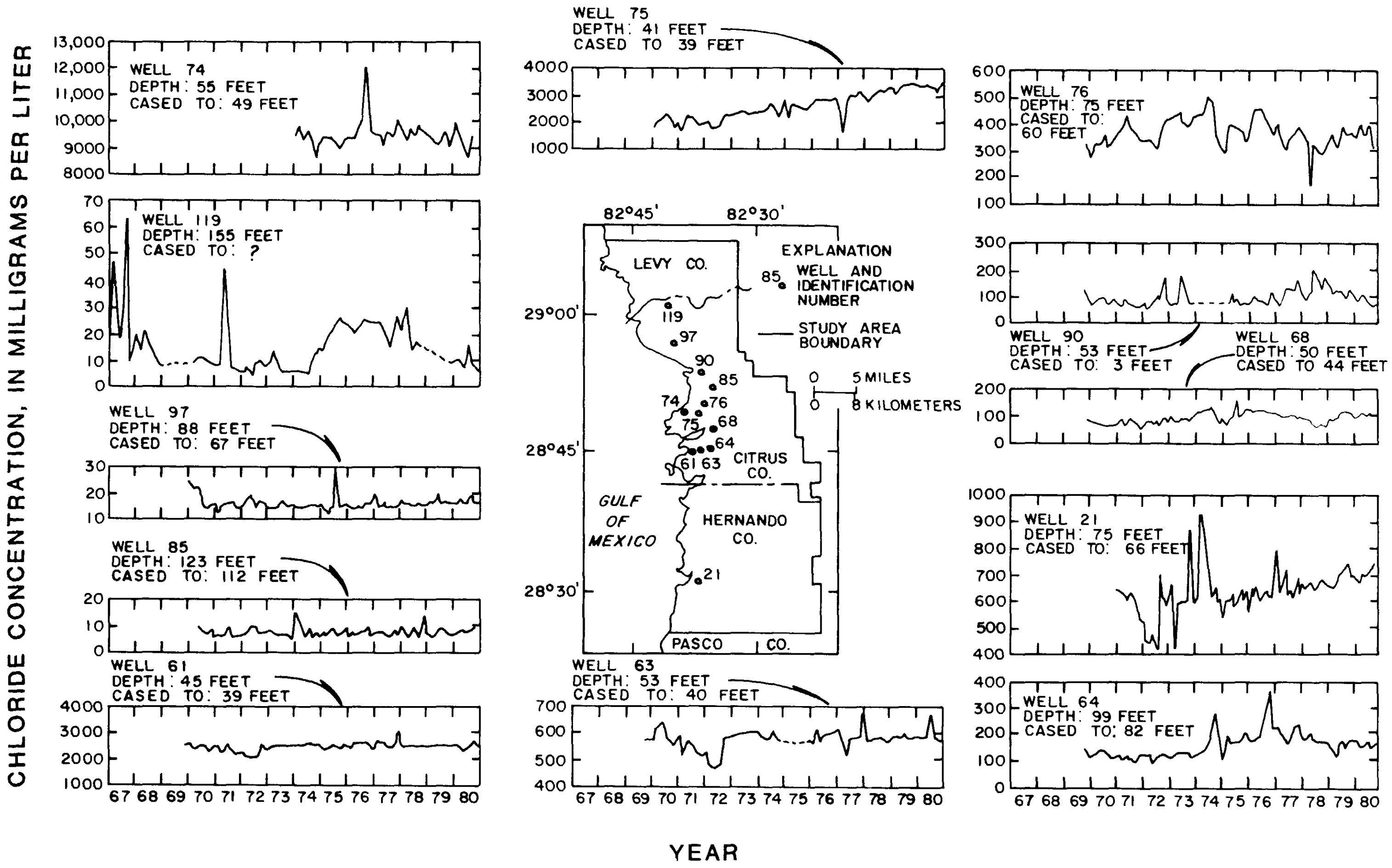

Figure 24.--Chloride concentrations in water from wells near the coast.

Wells 25, 82, 91, and 98, located near the coast (fig. 13) have wide ranges in chloride concentrations from sampling period to sampling period, which suggests a tidal effect on the wells. For example, chloride concentrations in well 25 fluctuated in an apparently random manner from 100 mg/L to 2,300 mg/L between 1976 and 1980. Chloride concentrations at well 82 fluctuated between 46 mg/L and 200 mg/L between July 1979 and November 1980. Fluctuations between 120 mg/L and 2,200 mg/L occurred in well 98 between 1965 and 1980. An even wider range of 520 mg/L to 5,000 mg/L has occurred in well 91 between 1970 and 1980.

Chloride concentration in water is generally proportional to specific conductance of water. Hence, fluctuations in specific conductance related to gulf tides, as shown on figure 25, are also reflected by variations in chloride concentrations. Peaks in specific conductance and temperature at well 25 correspond to peaks in tides at the Bayport tidal observation station approximately 2.3 miles west of the well. Fluctuations in specific conductance in water from the well ranged from about 1,400 to 9,600 μmho/cm (micromhos per centimeter) within a 30-minute period. This suggests that the well is finished within the transition zone between saltwater and freshwater. This may be true of many wells along the coast, especially wells that show large changes in chloride concentrations or specific conductance between times of sampling, but no general trend. Well 25 is an observation well where water levels are not affected by pumpage; therefore, the aquifer was not being stressed and mixing of saline water due to pumping was not occurring.

Surface resistivity methods can be used to define water-quality conditions by measuring changes in apparent resistivity with time and distance along a fixed traverse. Two electrical resistivity studies (Bisdorf and Zohdy, 1979; Fretwell and Stewart, 1981) were carried out in the area to test the feasibility of using this technique to locate saltwater at depth. Bisdorf and Zohdy (1979) mapped resistivities to depths of more than 1,000 feet. A geoelectric cross section on figure 26 shows variation in resistivity with depth for the upper 300 feet along a line near Homosassa Springs. Resistivities of 20 ohm-meters or less generally represent saltwater. The relation at depths greater than 300 feet is as yet inconclusive because well data are not available to verify the results.

Fretwell and Stewart (1981), using resistivity data, were able to nearly duplicate the location of the saltwater-freshwater interface defined from well data from north of Crystal River south to south of Homosassa (fig. 27). In addition to the position defined by Fretwell and Stewart (1981), lines defined by Causseaux and Fretwell (1982) and Mills and Ryder (1977) are shown. Discrepancies in the three lines are probably related in part to data being collected at varying tidal stages and dates and also to the fact that the resistivity study depicts water of a slightly higher chloride concentration than that depicted by well data defined by the other studies.

GROUND-WATER RESOURCE DEVELOPMENT

A quasi three-dimensional ground-water flow model for west-central Florida that includes the study area has been developed (Ryder, 1981). The quasi three-dimensional model is a sequence of two-dimensional ground-water flow models connected by vertical leakage through the confining beds. The model can be used to

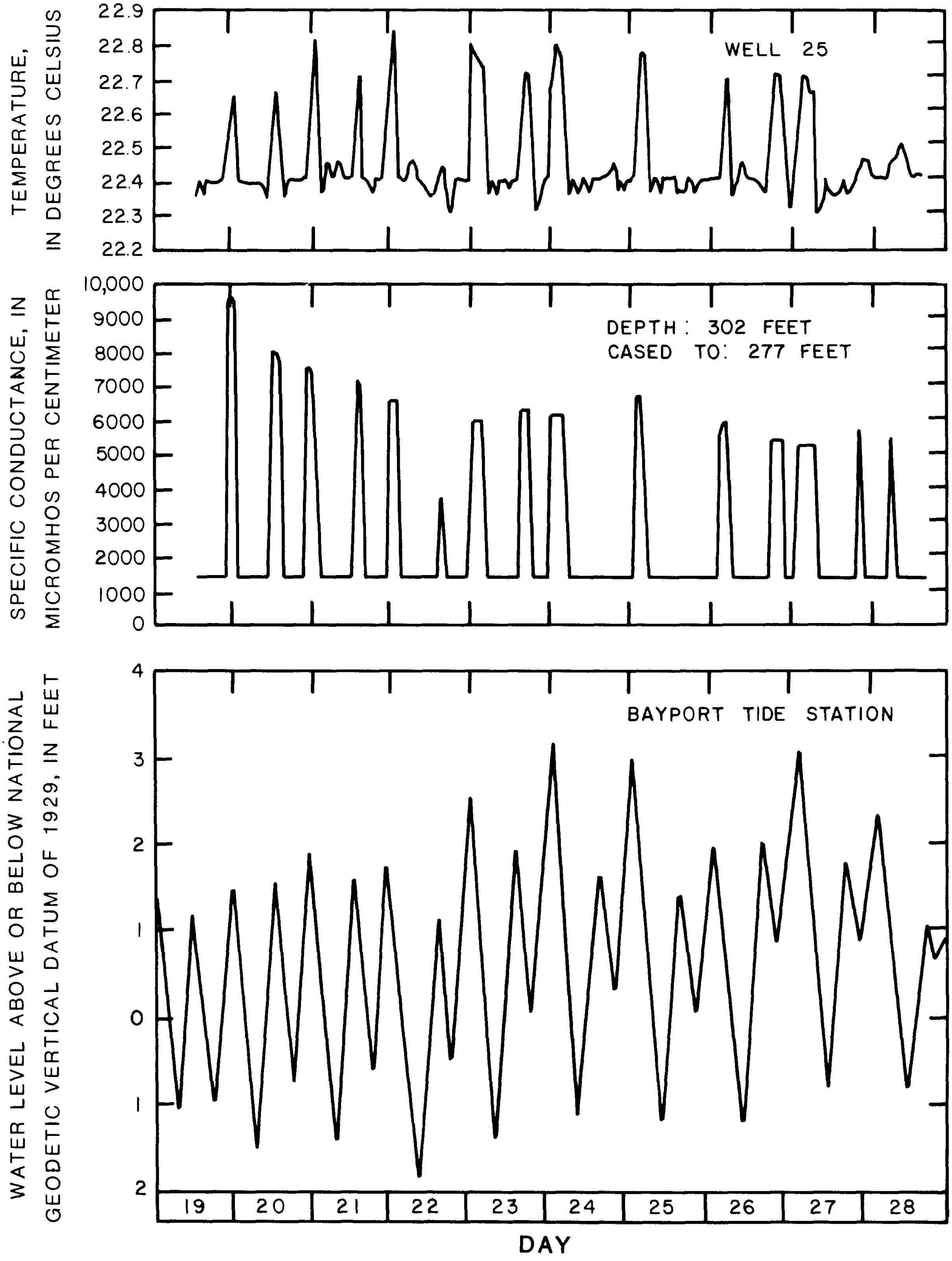

Figure 25.--Comparison of tidal fluctuations at Bayport with temperature and specific conductance of water from well 25, November 19 to 28, 1980.

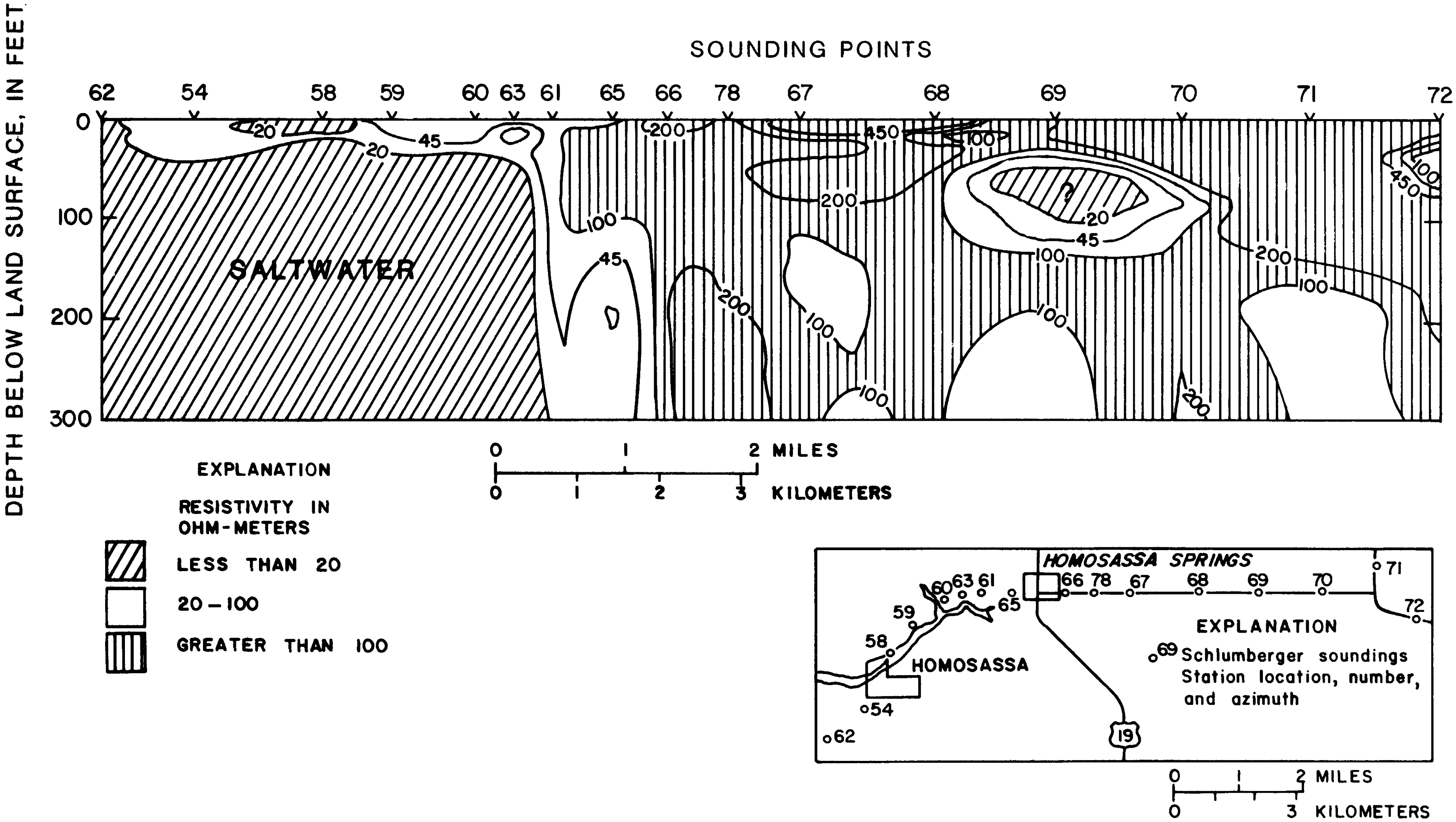

Figure 26.--Geoelectric cross section near Homosassa Springs (modified from Bisdorf and Zohdy, 1979).

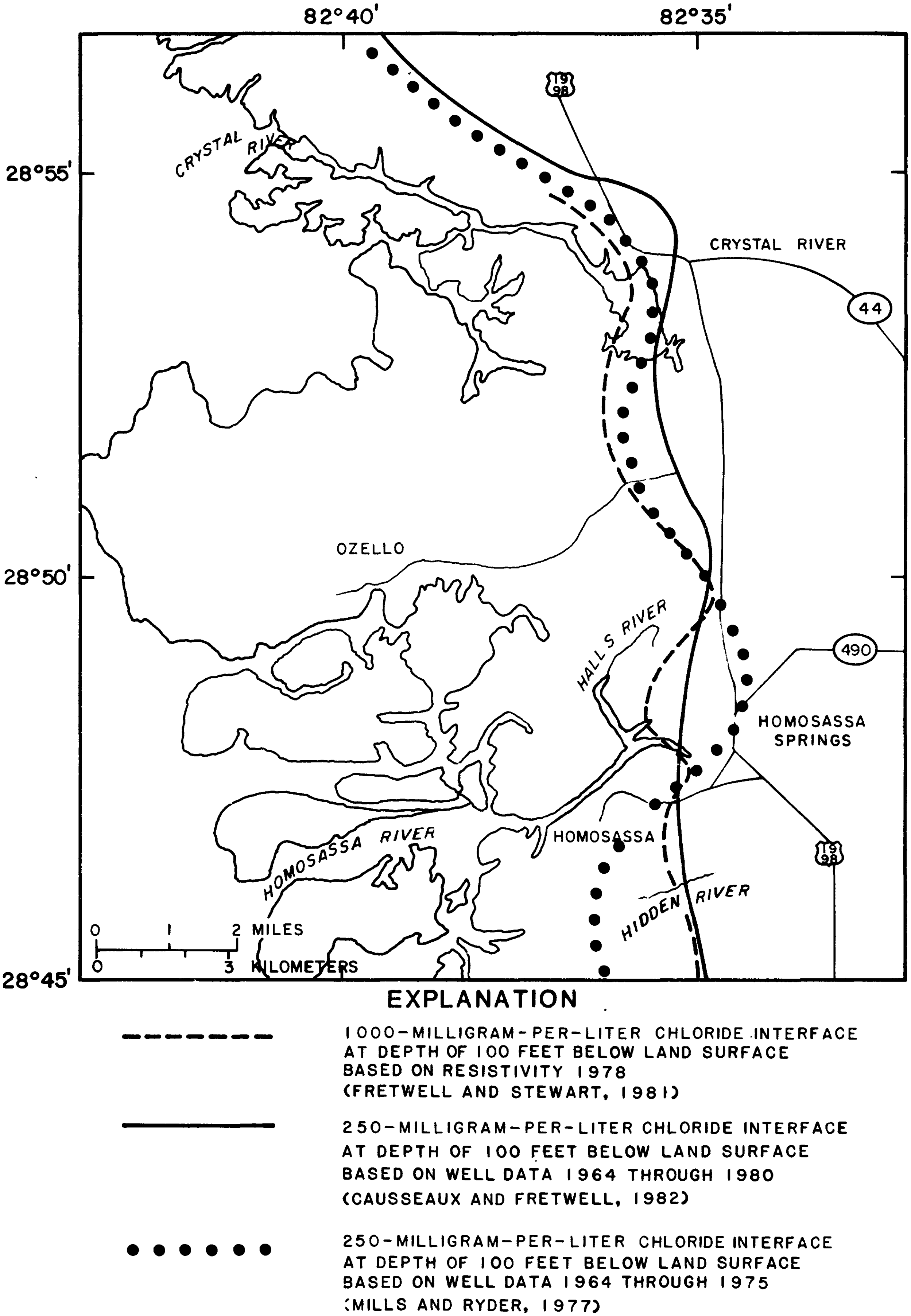

Figure 27.--Saltwater-freshwater interface in the Floridan aquifer based on electrical resistivity compared to that based on well data.

predict drawdowns resulting from pumpage, with reservation and qualification. Because no appreciable ground-water development has occurred in the study area, the distributions of aquifer properties derived from simulating predevelopment flow conditions have not been verified. Therefore, the results of predictive pumping simulations must be regarded as speculative at best. However, model-derived aquifer properties result from extensive calibration simulations and are within realistic limits based on available field data. With this deficiency, the model is still the best available tool at present for predicting drawodwns. For purposes of simulation, the aquifer is assumed to be homogeneous and isotropic. The aquifer is treated as a single layer. Another limitation of the model is that the coastal freshwater-saltwater interface was simulated as a no-flow boundary. This does not allow for potential inland movement of saltwater due to pumping. The model was used to estimate the impact of pumping from the Floridan aquifer at several points in the study area.

Input to the model includes: (1) estimated annual direct recharge to the limestone aquifer (net after subtracting evapotranspiration and surface runoff) when the aquifer is unconfined; (2) vertical leakage to the limestone aquifer from the surficial aquifer in confined areas; (3) estimated transmissivity; (4) spring-pool elevations at the larger springs; and (5) a hydraulic conductance that describes the linear relation between head difference and flow rate at each spring. The model has a grid spacing of 4 miles, which means that input values are averages over a 16-mi^2 area. No upward leakage is assumed from the base of the aquifer.

Five steady-state simulations were made, each with pumpage of 40 Mgal/d, from various hypothetical wells (figs. 28 through 30). A pumping rate of 40 Mgal/d was selected because this is generally the maximum permitted average daily pumpage from a well field at the present time (1982) in the Southwest Florida Water Management District. A single pumping well was used in the model at each selected site, although several wells would be used in an actual well field.

These particular sites were selected for various reasons. Sites 20:42 and 20:38 (fig. 28) show extreme variations in drawdowns that can result from placement of wells at different locations due primarily to differences in aquifer characteristics and in part to amount of recharge. Sites 17:31 (fig. 30), 18:31 (fig. 29), and 18:34 (fig. 28) were selected because they are near existing ground-water development sites.

As of 1980, the total ground-water withdrawal for the entire study area was 44 Mgal/d so that a pumping rate of 40 Mgal/d at any one site is an exaggeration of present demand and represents a worst case situation. The particular combinations of well location and pumping rate were selected to emphasize variations in response of the aquifer from site to site, rather than drawdown at a particular site.

Based on data shown in figures 28 through 30, a maximum radius of influence at a drawdown of 1 foot at the selected test sites from pumping 40 Mgal/d to steady-state is 18 miles inland and about 10 miles seaward from node 18:31 in Hernando County (fig. 29). The pumping center is located 10 miles inland from the saltwater-freshwater interface and 12 miles inland from the coast. This

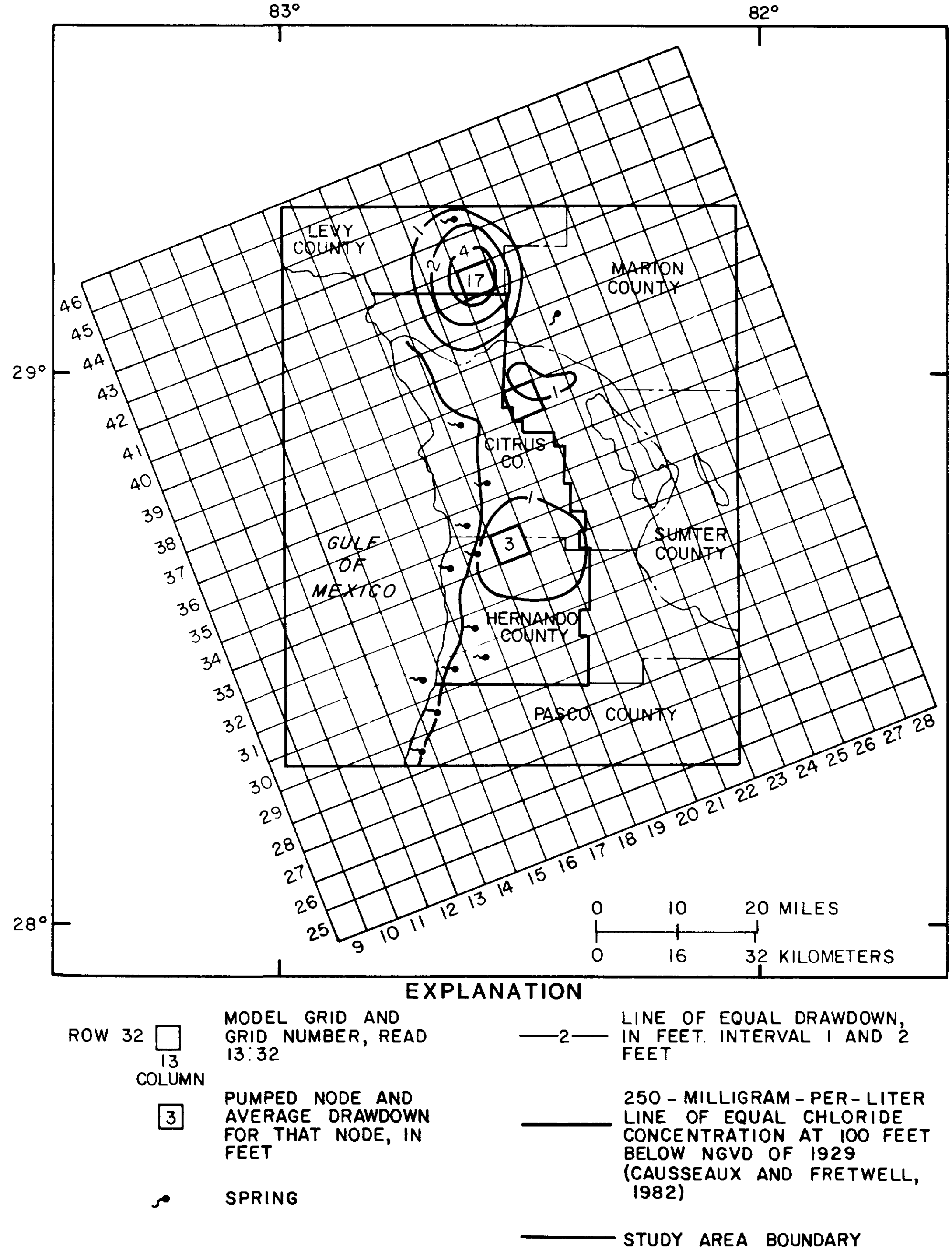

Figure 28.--Drawdown caused by pumping three hypothetical wells at different times to steady-state at a rate of 40 million gallons per day each.

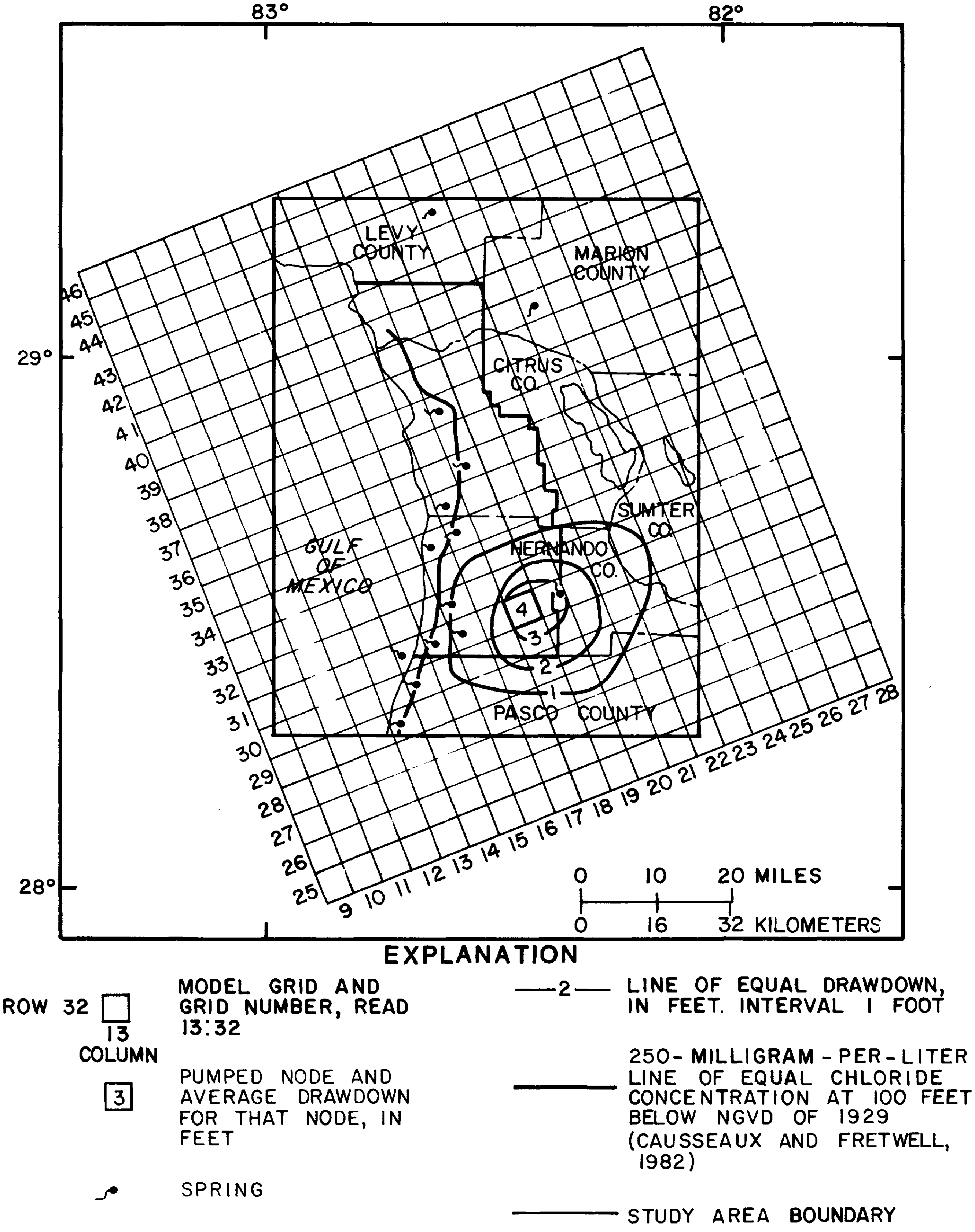

Figure 29.--Drawdown caused by pumping a hypothetical well in central Hernando County to steady-state at a rate of 40 million gallons per day.

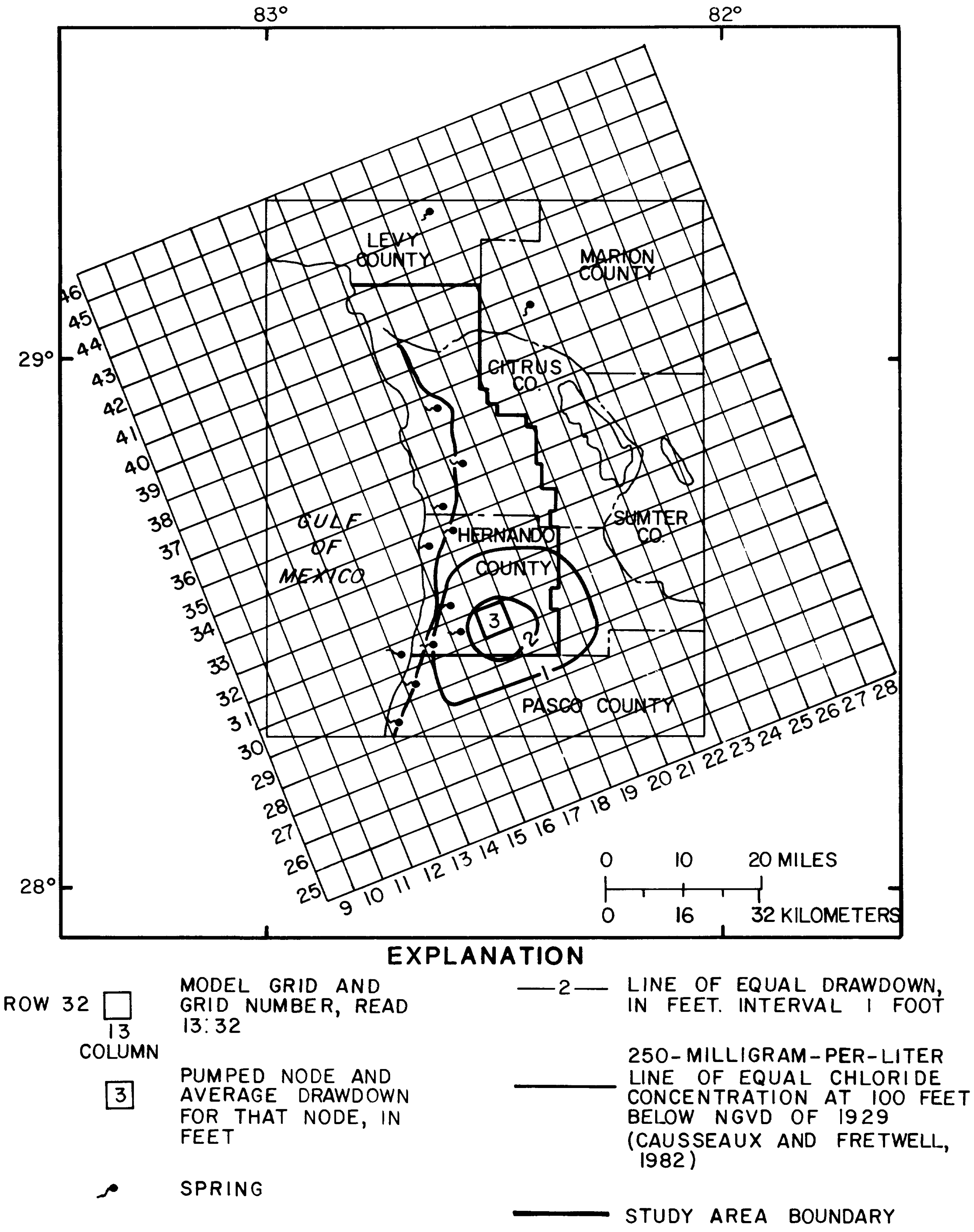

Figure 30.--Drawdown caused by pumping a hypothetical well in south-central Hernando County to steady-state at a rate of 40 million gallons per day.

suggests a minimum safe distance of 12 miles inland for locating a 40 Mgal/d well field to maintain a drawdown of 1 foot or less at the interface. A smaller rate of pumpage would result in less drawdown. Theoretically, any amount of drawdown will allow the interface to move inland. However, a drawdown of 1 foot at the interface could potentially cause upconing of approximately 40 feet. The minimum radius of influence of a drawdown of 1 foot at the selected test sites is about 8 miles at node 20:38 (fig. 28) in northern Citrus County. Each site is unique and potential well-field sites need to be studied in detail to determine effects of pumping. Major variables affecting the radius of influence are transmissivity, storativity, and overlapping cones of influence (nearby wells).

Maximum drawdown at any of the sites was at node 20:42 (fig. 28) of 17 feet (which is an average for the 16-mi^2 node) that theoretically could result in upconing of 680 feet of saltwater if saltwater is present near the base of the aquifer. A deep monitor well would be advisable in any well field in the coastal area to monitor for any upward movement of saltwater. The minimum average drawdown for any of the selected nodes is 1 foot at node 20:38 (fig. 28) inland from the coast about 12 miles.

Ground-water development in the study area will lower the potentiometric surface which could induce upconing or lateral intrusion of saltwater, reduce flow of water from coastal springs, and increase the likelihood of sinkhole development (Sinclair, 1982). Lateral intrusion of saltwater can be minimized by placing well fields inland from the coast so that their drawdowns have little or no measurable effect on the saltwater-freshwater interface. Reduced flow to springs can also be avoided by placing well fields so that drawdown is minimized at the springs (Sinclair, 1978).

SUMMARY AND CONCLUSIONS

Dominant features of the karstic terrain of coastal Citrus, Hernando, and Levy Counties are the Brooksville Ridge, a series of eroded ridges at the eastern edge of the study area, and two well-defined Pleistocene beaches and their associated terraces west of the Brooksville Ridge. Many square miles of saltwater marshes occur near the gulf.

Most nonmarsh land is forest interspersed with cropland and pasture. Rock mining is the major industry and accounts for most of the present (1982) water use. The number of small housing developments is increasing rapidly along the coast in the study area. Population is expected to continue growing rapidly for the next few years, resulting in increased demands on the area's ground-water resources.

The Floridan aquifer, composed of many hundreds of feet of carbonate rock of Tertiary age, occurs at or near land surface throughout the study area. Some of the oldest exposed aquifer rock in Florida crops out in the northern part of the area. There is no evidence of a continuous water-table aquifer in surficial deposits. The Floridan aquifer is generally unconfined or semiconfined by sands and clays throughout most of the area.

Most of the water discharged from the study area each day occurs through coastal springs. This water is derived from rainfall within or outside the area. Water entering the area from outside is almost entirely ground-water flow. Water enters the Floridan aquifer in recharge areas to the southeast, east, and northeast and flows generally coastward toward coastal springs. Surface runoff is virtually nonexistent except seaward of the springs and in the Withlacoochee River that traverses the northern part of the study area.

Transmissivities of the Floridan aquifer are estimated to range from 2.0×10^4 ft^2/d in Levy County to 2.1×10^6 ft^2/d at Weeki Wachee Springs. Transmissivity in general increases toward the springs.

The potentiometric surface of the Floridan aquifer changes in response to variations in rainfall, pumpage, and tidal fluctuations near the coast. Contours of the potentiometric surface shift slightly seaward between the dry and wet seasons (May and September). Hydrographs for seven wells showed seasonal fluctuations in water levels to be greater than annual ones from the period 1966 through 1980 for most wells. The greatest declines in water-level over the 14-year period have occurred in the southeastern part of the study area.

Ninety-nine percent of the 44 Mgal/d of water used for irrigation, industrial, public, and rural supply in the study area is ground water. About 32 Mgal/d of water is withdrawn from the Floridan aquifer for industrial use. Ninety-nine percent of this is used for rock mining. Rural water use accounts for 6.3 Mgal/d. Water withdrawn for irrigation is estimated at 3.9 Mgal/d. In 1980, water used for public supply was 1.6 Mgal/d.

Water in the Floridan aquifer is generally of good quality except near the coast where saltwater is present. Concentrations of all constituents, except silica, increase toward the coast and with depth. Median values of constituents were generally higher for water from springs and rivers than for water from wells due to the tidal influence in the rivers.

Although values vary considerably, most wells sampled for chloride showed no apparent trend with time. However, a few wells located near the coast showed an upward trend in chloride concentrations with time suggesting saltwater encroachment; the only major threat to freshwater supplies. Surface resistivity measurements have been used to locate the saltwater-freshwater interface in Citrus County.

A quasi three-dimensional model was used to predict drawdowns resulting from a hypothetical pumping rate of 40 Mgal/d at various sites throughout the study area. The radius of influence ranged from about 8 miles in northern Citrus County to about 18 miles in central Hernando County. Average drawdowns for each pumping node ranged from 1 foot in northern Citrus County to 17 feet in southern Levy County. These variations are due to different aquifer characteristics and in part to differences in amount of recharge at each site. A reduction in head near the saltwater-freshwater interface could cause upconing or lateral intrusion of saltwater, reduction in flow of water to the coastal springs, or sinkhole development. Lateral intrusion of saltwater could be minimized by placing well fields inland from the coast so that their drawdowns do not intersect the saltwater-freshwater interface. Placing well fields inland from the springs would also minimize drawdown at the springs.

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Table 6.--Chemical analyses of water from wells

[For location, see figure 12]

Well No.	Station no.	Date of sample	Depth of well (feet)	Depth of casing (feet)	Elevation of land surface (feet)	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (µg/L as Fe)
1	282553082370201	6-25-80	100	-	40	5.2	10
2	282605082345801	5-21-80	355	310	32	7.9	--
4	282636082221402	5-05-80	16	6	103	5.0	460
7	282742082375901	7-17-80	580	445	15	6.4	10
8	282756082311801	6-18-80	335	113	60	5.2	0
9	282838082284801	5-30-80	400	-	72	7.7	70
10	282849082232201	5-30-80	230	-	190	8.5	20
12	282932082253301	5-30-80	275	65	80	8.7	520
13	282938082332001	5-31-80	380	-	32	5.9	230
14	283038082352701	5-31-80	-	-	30	8.1	0
15	283127082355101	11-19-80	55	-	-	8.5	0
19	283143082281801	6-20-80	116	80	84	7.1	0
20	283201082315601	5-21-80	259	176	36	6.6	50
24	283240082335801	6-25-80	245	217	30	6.8	10
25	283243082365701	5-07-80	302	277	7	10	2,800
27	283258082231901	3-09-62	602	478	133	11	--
		2-19-80	-	-	-	11	--
		5-30-80	-	-	-	10	10
28	283258082232201	9-01-71	757	300	133	10	--
29	283259082250101	5-30-80	500	-	89	11	10
30	283308082331901	6-18-80	125	-	25	5.3	630
32	283433082303801	5-31-80	117	100	-	6.6	1
33	283433082391301	6-18-80	33	32	3	7.6	8,100
35	283529082355801	5-16-80	140	133	8	1.5	50
37	283607082241501	5-30-80	-	-	90	-	--
38	283637082313301	5-31-80	145	42	45	7.3	0
39	283648082275201	5-30-80	250	-	126	13	10
40	283658082292001	5-23-80	190	-	60	9.3	--
41	283808082324801	6-18-80	127	-	24	5.4	0
42	283815082282201	6-26-80	899	130	115	9.7	0
44	283940082253201	5-30-80	93	-	80	11	0
46	284048082325001	5-31-80	-	-	18	7.8	10
47	284102082295001	6-19-80	85	-	60	7.1	20
48	284125082333401	6-26-80	218	218	10	9.0	280
49	284142082272101	5-30-80	136	134	65	7.1	0
51	284152082281801	5-30-80	80	-	70	7.8	10
53	284317082330601	5-05-80	176	-	9	8.3	20
*54	284317082330602	5-05-80	46	40	9	.2	310
55	284339082245401	9-21-78	-	-	232	7.6	10
56	284339082270401	5-20-80	169	168	33	.8	30

*Wells not in the Floridan aquifer.

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Station no.	Date of sample	Depth of well (feet)	Depth of casing (feet)	Elevation of land surface (feet)	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (µg/L as Fe)
*57	284339082270402	5-20-80	41	36	33	6.4	26
58	284412082313001	5-31-80	107	80	70	7.9	10
59	284455082331601	1-12-71	138	-	10	7.9	--
		5-02-73	-	-	-	6.6	--
60	284501082331301	5-17-67	140	-	-	12	--
		5-02-73	-	-	-	10	--
61	284532082371001	5-05-80	45	39	4	7.4	3,400
62	284537082331401	1-12-71	120	-	-	7.1	--
		5-02-73	-	-	-	6.9	--
64	284551082345301	5-05-80	99	-	6	7.2	--
65	284705082270101	5-20-80	63	59	58	1.7	30
67	284722082315001	6-19-80	200	-	38	7.2	0
68	284803082351701	5-05-80	50	44	5	7.4	--
69	284840082325501	6-25-80	-	-	10	7.6	10
70	284922082291801	6-26-80	96	84	70	7.5	0
73	284947082311801	5-05-80	46	34	21	.1	--
74	285010082384001	5-06-80	55	49	3	6.4	180,000
77	285112082354401	7-17-80	111	-	3	5.2	10
78	285116082351401	6-19-80	100	70	4	6.4	10
82	285234082341901	7-17-80	252	240	6	9.7	0
86	285254082323001	5-05-80	30	20	8	5.4	950
88	285356082352801	3-10-62	152	100	4	7.4	--
89	285413082343201	5-25-80	175	92	10	5.6	250
90	285421082361601	5-06-80	53	3	5	4.4	70
91	285421082361602	5-06-80	176	162	5	1.0	70
93	285548082313801	9-22-78	150	-	90	6.8	10
94	285610082374501	5-24-80	38	-	9	6.3	10
96	285654082350101	2-01-79	109	-	11	5.4	40
97	285737082400601	5-06-80	88	67	7	4.5	30
98	285737082413001	5-06-80	47	42	5	5.6	2,900
99	285749082342901	5-24-80	135	-	27	5.8	150
100	285900082361501	5-23-80	102	-	28	4.7	270
101	285918082381001	6-30-70	27	-	25	38	--
102	285935082410901	6-22-71	28	20	10	3.6	--
103	290004082454101	6-19-80	20	-	2	24	640
104	290010082321601	10-19-78	82	-	86	7.1	30
105	290023082393601	6-22-71	30	21	18	3.3	--
106	290027082370701	7-13-71	78	42	25	6.4	--
		10-19-78	-	-	-	6.0	360
107	290047082414101	6-21-71	30	8	10	6.4	--

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Station no.	Date of sample	Depth of well (feet)	Depth of casing (feet)	Elevation of land surface (feet)	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (μg/L as Fe)
108	290107082400501	6-22-71	58	19	16	9.2	--
109	290112082371101	2-24-66	125	-	25	7.8	--
110	290114082420901	6-23-71	24	18	9	3.3	--
111	290115082401001	7-13-71	40	-	16	5.1	--
		10-19-78	-	-	-	4.9	50
112	290117082404501	10-19-78	150	-	12	4.1	80
113	290118082364101	2-28-66	67	62	29	6.8	--
		5-25-76	-	-	-	-	--
		9-28-76	-	-	-	-	--
		5-25-77	-	-	-	-	--
		9-14-77	-	-	-	-	--
		7-18-80	-	-	-	6.1	5,100
114	290128082392801	12-16-70	60	-	16	4.8	--
115	290138082371901	2-15-66	64	-	31	8.1	--
117	290145082421901	7-03-71	61	30	10	5.0	--
119	290202082403901	7-13-71	155	-	13	5.0	--
		7-18-80	-	-	-	4.5	160
120	290203082421301	6-24-71	59	49	10	5.5	--
		6-20-80	-	-	-	4.9	310
121	290203082421302	7-18-80	7	-	6	4.5	160
122	290205082421201	6-24-71	52	-	10	5.5	--
		11-01-78	-	-	-	5.2	280
124	290402082384901	2-11-66	37	-	42	3.4	--
125	290503082323101	5-24-80	115	-	81	6.2	0
126	290551082380901	2-10-66	32	-	37	5.4	--
127	290700082381001	5-24-80	121	-	40	3.3	170
128	290743082541501	9-17-81	780	299	74	11	--

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)
1	28	1.1	3.0	0.3	64	4.7	4.5	0.1
2	9	.8	10	3.8	36	8.9	3.9	.1
4	24	3.6	7.8	.2	82	4.0	6.3	.2
7	35	3.9	2.6	.3	92	5.9	4.7	.1
8	16	.7	2.1	.1	43	1.8	3.4	.1
9	54	5.1	15	.5	160	9.3	6.5	.1
10	86	1.7	4.0	.2	210	1.6	6.5	.1
12	77	1.6	4.8	.3	180	.8	6.4	.2
13	48	2.6	2.8	.2	130	1.5	4.8	.1
14	51	7.3	3.1	.4	130	7.3	4.9	.1
15	39	6.6	4.0	.2	-	7.1	6.0	.1
19	29	1.5	2.8	.1	69	.8	3.8	.1
20	35	8.2	5.5	.5	140	4.5	5.6	.1
24	36	2.5	3.1	.2	100	3.6	4.6	.1
25	38	23	52	9.9	130	19	100	.2
27	66	11	6.2	.4	-	12	11	.3
	60	9.8	5.6	.3	180	13	9.2	.2
	58	8.2	5.3	.2	180	16	10	.2
28	61	10	5.4	.3	-	11	9.0	.2
29	70	7.8	5.1	.2	190	9.8	9.2	.2
30	41	5.2	4.8	1.5	120	--	8.8	0
32	37	2.7	2.7	.1	90	3.9	4.2	.1
33	270	310	3,100	91	520	670	5,300	.1
35	25	6.5	35	.8	85	.1	52	.1
37	76	--	--	--	-	--	--	-
38	35	4.1	2.8	.1	96	4.1	4.8	.1
39	48	11	3.7	.2	150	7.8	5.4	.3
40	41	7.3	5.2	.3	120	0	6.0	.1
41	26	2.2	3.1	.1	65	1.1	5.0	.1
42	76	9.7	6.2	--	210	7.9	.4	.2
44	55	14	6.0	.3	170	8.7	11	.2
46	31	2.7	3.0	.3	95	1.5	4.8	.1
47	29	4.5	3.7	.2	86	3.8	4.6	.1
48	42	9.6	3.3	--	140	4.9	5.7	-
49	39	2.5	4.1	.1	93	2.0	5.0	.1
51	42	5.2	3.1	.2	110	8.6	4.7	.1
53	38	8.3	4.7	.2	130	7.5	8.0	.2
*54	13	.4	3.5	1.2	49	1.0	3.7	.1
55	32	5.3	3.0	.2	90	10	4.6	.1
56	9	2.3	3.7	.4	30	1.2	5.6	.1

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)
*57	34	3.2	3.6	0.2	110	2.4	4.2	0.1
58	37	4.8	3.2	.1	100	5.1	5.4	.1
59	36	5.1	2.6	.3	107	0	4.1	0
	39	4.4	2.4	.3	110	2.4	4.1	.2
60	35	14	4.3	.9	-	9.2	6.0	.2
	36	14	4.2	.9	135	10	5.2	.3
61	160	160	1,400	44	-	--	2,300	.1
62	80	1.5	7.0	.3	197	5.6	14	.1
	88	2.4	6.2	.3	208	5.6	7.8	.1
64	37	15	91	3.1	120	27	150	.1
65	21	2.3	4.7	.5	73	.1	4.4	0
67	31	5.0	3.1	.2	90	4.1	5.5	.1
68	42	9.3	53	1.4	110	15	100	.1
69	28	3.5	2.8	.2	73	3.1	4.4	.1
70	35	3.1	2.9	.1	93	2.2	.3	.1
73	5	.1	1.6	.7	16	0	.3	.1
74	--	590	4,200	180	0	1,100	9,200	.2
77	17	16	130	29	68	28	220	.1
78	28	6.1	18	.7	96	9.6	31	.1
82	14	6.7	37	11	63	9.0	49	.3
86	70	1.6	3.0	.3	170	5.7	4.2	.1
88	26	6.1	2.8	.1	-	16	3.0	.2
89	27	4.4	2.8	.1	64	15	4.4	.1
90	75	14	57	2.3	200	22	100	.1
91	59	--	--	--	89	--	1,430	.1
93	29	4.5	3.0	.2	81	9.8	3.8	.1
94	80	5.5	7.8	.3	200	8.6	11	.1
96	44	6.4	2.7	.2	110	11	4.9	.1
97	--	--	--	--	-	--	16	-
98	140	36	230	8.0	240	140	500	.1
99	25	7.3	4.0	.2	90	2.7	4.8	.1
100	31	6.4	3.1	.1	100	2.0	4.4	.2
101	42	9.8	3.6	1.0	136	4.8	8.0	.3
102	83	4.3	4.8	.1	220	2.8	9.0	.1
103	418	140	1,300	44	810	220	2,300	-
104	33	6.5	2.6	.2	80	22	3.7	.1
105	114	6.3	3.2	0	269	45	7.0	.1
106	52	17	6.7	.2	197	4.8	14	.1
	59	20	6.7	.5	190	13	12	.1
107	96	27	15	.4	317	12	33	.3

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)
108	77	12	3.4	0.5	239	4.8	7.0	0.2
109	91	3.8	5.2	.1	-	0	11	.1
110	73	34	4.8	.1	318	9.6	8.0	.4
111	69	15	4.5	.2	226	8.0	9.0	.3
	83	18	9.6	.3	240	21	16	.2
112	90	2.7	6.5	.1	240	16	4.3	.2
113	90	2.7	6.5	.1	-	2.8	12	.2
	94	2.6	--	--	-	--	11	-
	92	2.6	--	--	-	--	10	-
	91	2.7	--	--	-	--	11	-
	85	2.6	--	--	-	--	11	-
	92	2.9	5.8	.1	238	.3	12	0
114	135	2.4	7.4	.7	277	68	10	.2
115	101	8.8	7.8	2	-	18	11	.1
117	101	3.2	4.9	.2	269	2.4	9.0	.1
119	96	7.1	3.8	.3	262	7.6	7.0	.2
	100	6.4	7.1	.4	273	14	10	.2
120	91	4.3	7.9	.3	236	16	17	.2
	97	5.2	11	.5	250	11	16	.1
121	100	6.4	7.1	.4	273	14	10	.2
122	106	3.8	9.7	.4	267	8.4	18	.2
	100	4.0	10	.3	250	16	19	.1
124	55	28	1.8	0	-	0	6.0	.2
125	27	2.5	7.5	.2	86	3.0	10	.1
126	66	18	4.3	.2	-	3.6	10	.2
127	40	8.9	3.1	.4	130	6.1	4.6	.1
128	59	18	4.0	.4	230	2.2	7.2	.1

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmhos)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
1	1.00	0.01	90	75	11	184	7.0	26.5	60
2	.01	.02	67	26	0	112	-	25.5	1,100
4	.50	.03	103	75	0	187	-	21.5	30
7	.02	.02	115	100	12	225	-	25.5	210
8	.47	.01	57	43	0	113	7.6	25.5	2
9	.09	.01	195	160	0	347	7.2	24.0	150
10	.02	.03	235	220	12	408	7.4	25.5	80
12	.05	.01	193	200	0	378	7.2	25.5	170
13	0	0	133	130	0	265	7.6	25.5	140
14	.02	.01	148	160	0	304	7.6	24.0	190
15	.02	.01	--	--	--	284	8.0	24.0	160
19	.06	.02	87	79	10	160	7.4	26.0	70
20	.01	0	151	120	0	300	-	25.0	530
24	12	.01	118	100	0	229	7.7	25.0	90
25	0	.01	334	190	60	620	-	21.0	660
27	--	--	233	210	20	410	7.8	--	--
	--	--	218	190	10	385	7.3	23.0	230
	.43	.03	218	180	0	402	7.5	26.0	200
28	--	--	220	193	6	389	6.5	--	--
29	.34	.02	218	210	0	398	7.6	26.0	210
30	0	.01	140	120	4	274	7.8	25.0	90
32	.80	.01	114	100	14	205	7.7	25.0	100
33	.04	.50	10,100	2,000	1,400	19,600	6.5	27.5	2,500
35	0	.01	173	90	5	368	-	24.0	450
37	--	--	--	--	--	421	-	--	--
38	.36	.02	113	100	0	219	7.8	26.5	100
39	.20	.02	172	170	0	321	7.6	26.0	120
40	.05	.01	142	130	12	400	7.5	23.0	30
41	.53	.01	84	74	9	171	7.8	28.0	50
42	.33	--	239	230	20	456	7.3	23.5	270
44	.79	0	201	200	0	388	7.6	25.5	120
46	.05	0	109	89	0	206	7.6	27.5	70
47	.32	.02	100	91	0	200	7.4	25.0	80
48	--	--	160	140	5	297	7.6	24.5	120
49	2.90	.02	122	110	0	228	7.8	24.5	50
51	.22	.01	129	130	0	250	7.7	24.0	100
53	.26	.01	155	130	0	331	8.1	23.5	130
*54	.02	0	53	34	0	90	-	23.0	40
55	--	--	117	100	12	222	7.8	25.0	180
56	0	0	39	34	9	78	-	24.5	60

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmhos)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
*57	0.14	0.04	121	98	0	245	-	25.5	90
58	.75	.02	121	110	0	231	7.9	26.0	80
59	--	--	121	110	4	215	8.4	--	100
	--	--	125	120	6	225	7.5	--	80
60	--	--	164	150	9	308	8.1	--	250
	--	--	162	150	13	290	7.0	--	250
61	.23	0	--	1,100	830	8,320	-	21.5	1,400
62	--	--	238	210	10	435	8.2	--	1,100
	--	--	242	230	21	415	7.4	--	20
64	.07	.01	403	150	34	785	-	23.5	170
65	.01	.01	79	62	0	167	-	25.0	60
67	.26	.03	106	98	0	210	7.5	25.0	80
68	.14	.03	295	140	33	581	-	23.0	120
69	.10	--	94	84	11	175	8.0	23.0	70
70	.06	--	112	100	7	207	7.8	23.5	80
73	0	0	17	13	0	35	-	24.5	20
74	.02	.01	--	--	--	26,600	-	24.0	3,300
77	.01	.01	487	110	41	912	-	24.5	300
78	.14	.02	158	95	0	328	7.7	24.5	110
82	.01	.01	177	65	2	302	-	25.0	2,000
86	.03	.02	186	180	0	344	-	23.5	60
88	--	--	105	90	18	80	7.9	23.0	--
89	.13	.02	99	86	22	100	-	--	100
90	.06	.01	396	250	45	809	-	22.0	150
91	0	--	--	--	--	4,800	-	22.0	380
93	--	.02	106	91	10	192	7.6	24.0	160
94	.06	--	240	220	23	500	7.6	25.0	80
96	--	--	151	140	30	280	7.2	24.0	7,200
97	0	0	--	--	--	459	-	21.0	140
98	.21	.01	1,080	500	460	2,140	-	21.5	800
99	0	.02	104	93	3	201	7.4	24.0	40
100	0	.02	112	100	4	216	7.7	24.0	40
101	--	--	184	158	9	278	7.9	24.0	60
102	--	--	240	230	5	430	7.9	23.0	90
103	0	--	4,700	1,000	220	8,500	6.6	22.0	1,400
104	--	--	124	110	29	214	7.5	25.0	130
105	--	--	341	310	42	580	8.1	22.5	110
106	--	--	220	200	3	392	8.0	--	90
	--	--	231	230	41	402	7.2	23.0	90
107	--	--	380	350	34	700	8.1	22.5	90

Table 6.--Chemical analyses of water from wells--Continued

Well No.	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmhos)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
108	--	--	259	240	2	448	8.2	24.0	170
109	--	--	262	242	5	466	8.0	22.0	--
110	--	--	324	320	4	590	8.0	21.5	90
111	--	--	248	230	8	442	8.1	22.5	110
	--	--	296	280	44	520	7.1	23.0	130
112	--	--	275	280	45	469	6.9	24.0	140
113	--	--	255	236	12	424	7.9	22.0	--
	--	--	--	250	--	472	7.1	21.0	--
	--	--	--	240	--	454	6.9	21.5	--
	--	--	--	240	--	447	7.1	23.5	--
	--	--	--	220	--	452	6.8	21.0	--
	--	0.01	267	240	4	475	7.0	21.0	160
114	--	--	395	350	70	663	7.4	22.0	2
115	--	--	307	288	37	497	7.8	23.0	--
117	--	--	287	270	0	510	8.1	23.0	100
119	--	--	285	270	6	498	7.5	23.0	1
	--	.03	307	280	3	525	7.3	23.0	160
120	--	--	284	250	9	483	8.1	23.0	1
	0	.29	296	260	14	500	7.3	25.0	110
121	.20	.03	307	280	3	525	7.3	23.0	160
122	--	--	313	280	13	540	8.2	23.0	1
	--	--	308	270	12	625	7.5	23.5	130
124	--	--	241	252	8	459	7.9	24.0	--
125	.17	.05	109	78	0	191	7.4	24.0	90
126	--	--	245	288	10	449	8.2	26.0	--
127	.14	.07	145	140	7	267	7.5	23.5	40
128	--	--	--	220	0	431	7.5	--	40

Table 7.--Chemical analyses of water from springs and spring-fed rivers

[For location, see figure 4]

Site No.	Station name	Date of sample	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (µg/L as Fe)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
1	Unnamed spring	5-12-69	7.2	10	72	20	155
		8-04-69	4.1	--	69	29	245
		9-15-69	6.8	130	72	25	249
		10-27-69	5.4	--	74	30	240
		3-02-70	6.3	--	76	28	240
		4-13-70	4.5	--	69	24	207
		6-01-70	6.4	--	68	22	188
2	Boat Springs	4-30-64	6.8	0	44	4.1	11
		10-13-65	6.6	60	45	3.8	8.0
3	Bobhill Springs	7-23-64	6.4	30	38	3.9	3.1
		10-13-64	6.8	160	37	2.8	3.2
		2-14-65	6.0	20	37	2.8	4.6
		8-06-65	6.4	0	40	2.4	2.9
4	Magnolia Springs Run	4-30-64	5.6	--	43	5.2	29
		7-24-64	6.6	--	42	7.5	36
		10-13-64	7.5	240	42	6.6	30
		2-04-65	7.2	170	39	6.9	25
		8-05-65	6.5	60	42	5.6	29
5	Little Springs	7-24-64	8.7	60	47	5.0	3.0
		8-06-65	7.0	0	48	4.5	3.0
6	Weeki Wachee Springs	6-20-61	8.2	--	50	3.6	3.2
		3-16-62	8.2	--	47	5.0	3.2
		4-25-62	8.3	--	46	6.1	3.1
		3-08-63	8.6	--	47	5.2	2.9
		3-28-63	-	--	46	6.1	2.4
		1-14-64	7.9	--	46	7.1	3.0
		3-02-64	7.9	--	47	5.5	2.7
		4-16-64	8.1	0	44	7.8	3.0
		9-24-64	8.4	0	48	3.9	2.8
		10-14-64	8.7	20	48	3.9	3.1
		5-01-68	8.0	10	46	5.6	3.0
		5-13-69	9.0	10	48	5.0	3.2
		5-13-69	7.9	10	49	8.3	2.7
		6-02-70	8.3	60	41	5.3	2.9
		10-01-70	8.0	10	45	5.1	2.9
		4-19-71	-	--	--	--	--
		4-28-71	8.0	0	43	5.6	2.7
		5-10-72	7.2	10	45	5.0	3.0
		5-10-72	-	--	--	--	--
		4-04-74	8.2	10	50	6.0	4.0

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Station name	Date of sample	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (µg/L as Fe)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
6	Weeki Wachee Springs	10-17-74	8.1	10	40	8.4	3.3
		10-24-75	8.3	10	50	5.7	3.6
		6-03-76	8.3	20	47	5.0	3.3
		9-17-76	8.1	10	50	5.5	3.2
		5-03-77	8.1	10	51	5.6	3.0
		10-13-77	8.1	10	48	5.4	3.2
		5-10-78	7.9	10	47	5.4	4.5
		10-25-78	8.0	20	47	5.4	--
		10-17-79	8.4	10	46	5.0	3.3
		6-26-80	8.3	0	49	5.6	3.3
7	Salt Springs	4-23-64	8.5	0	62	49	375
		1-26-65	8.1	0	52	46	264
		8-06-65	6.6	10	56	43	260
9	Chassahowitzka River	9-24-64	7.1	30	47	10	25
		9-01-67	8.2	--	70	76	605
		9-14-67	8.2	--	64	58	449
		9-19-67	8.3	--	50	22	138
		5-01-68	7.1	90	53	27	165
		5-13-69	8.3	0	51	15	64
		8-05-69	5.7	--	65	44	305
		9-16-69	6.6	--	47	15	54
		10-27-69	8.5	--	50	13	1.4
		4-14-70	5.9	--	48	12	1.4
		6-02-70	8.4	60	46	11	1.2
		9-30-70	8.4	20	48	16	2.4
		4-28-71	7.8	20	49	16	76
		10-05-71	8.2	30	48	13	40
		8-21-73	8.7	80	52	22	150
		4-03-74	8.2	30	54	29	--
		10-17-74	7.9	10	44	15	66
		4-18-75	8.5	10	54	19	100
		10-24-75	8.6	20	52	22	120
		9-17-76	8.6	20	50	13	42
		5-03-77	7.8	10	53	18	85
		10-13-77	8.3	10	55	21	120
10	Crab Creek	10-15-64	10	140	60	43	310
		1-27-65	8.8	0	60	51	360
		8-05-65	8.2	10	67	70	560
11	Baird Creek	10-14-64	64	230	88	88	610
		1-27-65	8.8	0	76	83	660
		8-05-65	5.3	110	74	126	988

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Station name	Date of sample	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (µg/L as Fe)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
12	Ruth Springs Run	7-21-64	9.2	60	54	28	162
		10-15-64	9.9	280	56	24	122
13	Potter Creek	7-21-64	8.2	140	72	55	450
		1-27-65	8.3	0	48	18	114
		8-05-65	8.7	30	49	22	115
14	Crawford Creek	7-22-64	8.9	--	65	38	245
15	Crawford Creek Tributary	7-22-64	9.1	--	59	25	124
		10-15-64	12	--	60	24	128
		1-27-65	9.0	--	60	27	152
		8-05-65	7.7	--	55	24	115
16	Ryle Creek	7-21-64	8.5	300	140	224	1,850
		10-15-64	11	3,300	116	156	1,162
17	Homosassa Springs	5-01-56	8.1	--	54	56	--
		11-10-60	8.5	--	50	37	292
		3-02-64	8.3	0	52	61	425
		3-27-64	8.2	10	60	78	505
		8-04-65	-	0	44	38	300
		5-19-66	8.2	10	55	57	--
		6-05-67	8.0	0	53	52	399
		5-02-68	8.2	--	50	45	322
		5-12-69	8.4	10	53	59	438
		6-01-70	8.3	--	54	60	410
		4-20-71	8.4	--	--	--	--
		4-21-72	8.2	10	48	48	340
		9-19-72	8.1	--	--	--	--
		10-11-72	7.2	--	65	86	600
		1-08-75	8.2	10	47	35	320
		6-05-75	8.2	10	51	45	330
		5-04-76	-	--	--	--	--
		9-17-76	-	--	--	--	--
		5-03-77	-	--	--	--	--
		9-01-77	-	--	--	--	--
		6-29-78	-	--	--	--	--
		9-06-78	-	--	--	--	--
18	Southeast Fork Homosassa Springs	5-19-66	7.2	0	34	8.0	27
		6-05-67	8.0	0	35	8.8	28
		5-02-68	7.5	0	37	9.2	24
		5-12-69	8.8	10	36	8.3	--
		6-01-70	7.4	--	38	8.6	--
		4-20-71	5.6	--	--	--	--
		5-09-72	-	--	--	--	--

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Station name	Date of sample	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (μg/L as Fe)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
18	Southeast Fork Homosassa Springs	11-14-72	-	--	--	--	--
		5-01-73	-	--	--	--	--
		12-13-73	-	--	--	--	--
		5-28-74	-	--	--	--	--
		9-17-74	-	--	--	--	--
		4-28-75	-	--	--	--	--
		9-02-75	-	--	--	--	--
		5-04-76	-	--	--	--	--
		9-17-76	-	--	--	--	--
		5-03-77	-	--	--	--	--
		9-02-77	-	--	--	--	--
		6-29-78	-	--	--	--	--
		9-06-78	-	--	--	--	--
19	Halls River	8-03-65	4.2	100	24	27	168
		5-19-66	7.3	0	54	51	400
20	Middle Springs	3-25-64	7.9	10	33	4.0	8.0
		10-16-64	7.5	0	33	3.3	4.7
		8-04-65	7.7	20	34	3.2	6.0
21	Saragassa Canal	10-16-64	8.5	--	34	6.6	25
		8-03-65	7.4	--	35	8.4	38
22	Crystal River	5-18-66	-	--	105	235	1,910
		5-19-67	7.2	0	49	13	288
		5-02-68	5.3	20	60	90	726
		5-31-68	5.6	0	62	83	633
		5-12-69	7.7	10	50	34	242
		6-13-69	.7	--	105	228	1,950
		6-08-70	7.3	--	46	44	340
		10-13-70	-	--	--	--	--
		4-28-71	5.6	10	48	40	320
		10-05-71	6.4	30	120	210	1,400
		5-10-72	5.2	--	92	180	1,400
		9-20-72	6.6	--	180	400	3,500
		4-30-73	6.3	--	63	70	560
		10-18-73	5.1	--	63	110	580
		4-04-74	4.5	--	54	41	370
		10-17-74	4.8	--	38	34	250
		4-18-75	6.7	--	54	45	410
		10-24-75	6.2	--	66	85	700
		9-17-76	5.4	--	51	46	330
		5-03-77	6.6	--	52	48	380
		5-10-78	7.2	10	47	42	320

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Nitrogen, nitrate, total (mg/L as N)	Phosphate, ortho, dissolved (mg/L as PO_4)
1	5-12-69	5.2	156	42	299	0.1	0.00	--
	8-04-69	8.2	154	57	445	.2	.50	--
	9-15-69	8.9	161	62	420	0	.10	--
	10-27-69	8.1	161	61	430	.2	.40	0.03
	3-02-70	8.3	158	62	434	.1	1.30	--
	4-13-70	7.5	154	49	370	.2	.70	--
	6-01-70	6.8	162	29	340	.1	1.00	--
2	4-30-64	.5	112	7.5	18	.1	0	--
	10-13-65	1.1	120	7.6	12	0	0	--
3	7-23-64	.2	102	5.6	6.4	0	0	--
	10-13-64	.4	102	4.8	5.0	0	.10	--
	2-14-65	.2	102	5.6	5.0	.2	.40	--
	8-06-65	0	100	5.2	4.0	.1	.20	--
4	4-30-64	1.2	109	13	52	.1	.20	--
	7-24-64	1.0	108	17	66	.1	.10	--
	10-13-64	1.2	108	14	54	.2	.20	--
	2-04-65	.6	105	12	42	.1	0	--
	8-05-65	1.8	108	13	53	.1	1.10	--
5	7-24-64	.3	131	6.4	4.0	.1	0	--
	8-06-65	.4	131	6.8	5.0	.1	.10	--
6	6-20-61	.2	133	5.6	--	-	.10	--
	3-16-62	-	130	7.2	4.5	0	.20	--
	4-25-62	-	130	6.4	4.5	.2	0	--
	3-08-63	.4	133	6.8	5.5	.4	0	.01
	3-28-63	.3	131	6.0	6.0	-	0	0
	1-14-64	.2	133	6.4	4.0	.1	0	.07
	3-02-64	0	130	6.4	4.8	.2	0	--
	4-16-64	.3	130	6.4	4.0	0	.10	--
	9-24-64	.1	133	6.4	4.0	.2	0	--
	10-14-64	.3	131	6.8	4.0	0	0	--
	5-01-68	.2	139	6.5	6.0	.2	1.10	.03
	5-13-69	5.0	131	9.6	8.0	.1	.10	--
	5-13-69	1.1	131	14	46	.1	.10	.03
	6-02-70	.4	133	4.8	6.0	.2	.10	--
	10-01-70	.2	127	--	7.4	.1	.30	.03
	4-19-71	-	--	--	--	-	--	--
	4-28-71	.3	126	--	8.0	.1	.20	.11
	5-10-72	.2	128	8.0	5.0	.1	--	--
	5-10-72	-	137	--	--	-	--	--

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Nitrogen, nitrate, total (mg/L as N)	Phosphate, ortho, dissolved (mg/L as PO_4)
6	4-14-74	0.6	--	7.4	4.6	0.1	--	--
	10-17-74	.1	131	7.5	5.2	.2	0.09	0.01
	10-24-75	.3	130	6.9	5.7	.1	.11	.01
	6-03-76	.3	130	8.5	5.2	.2	.13	.02
	9-17-76	.3	130	7.7	5.1	.1	.21	.02
	5-03-77	.3	130	7.4	5.2	.1	.09	.01
	10-13-77	.4	130	6.8	5.2	.1	.10	.01
	5-10-78	.4	130	9.0	9.0	.1	--	.01
	10-25-78	.5	130	7.6	5.4	.1	--	--
	10-17-79	.2	120	6.4	5.0	.1	--	--
	6-26-80	.2	130	6.6	5.0	.1	--	--
7	4-23-64	14	125	112	680	.2	.10	--
	1-28-65	9.2	124	72	490	.2	1.40	--
	8-06-65	9.8	128	73	490	.1	.50	--
9	9-24-64	.9	132	10	46	.2	.20	--
	9-01-67	22	--	154	1,050	.3	--	--
	9-14-67	16	--	116	790	.3	2.10	--
	9-19-67	4.8	--	38	242	.2	1.00	--
	5-01-68	5.4	139	43	302	.4	0	--
	5-13-69	2.5	144	22	121	.2	.10	.01
	8-05-69	13	141	82	510	.3	0	--
	9-16-69	2.2	138	12	93	.2	0	--
	10-27-69	1.7	139	--	75	.2	.90	--
	4-14-70	1.6	141	--	74	.2	.60	--
	6-02-70	1.6	141	--	870	.2	.70	.06
	9-30-70	3.0	139	--	135	0	.60	.06
	4-28-71	2.9	139	24	140	0	.60	.07
	10-05-71	1.8	144	169	79	.3	.10	.07
	8-21-73	4.5	143	34	270	.2	.20	--
	4-03-74	11	146	50	340	.1	--	--
	10-17-74	2.3	139	22	120	.1	.17	.03
	4-18-75	3.8	143	13	800	.3	.24	.01
	10-24-75	4.2	144	35	210	.7	.21	.02
	9-17-76	1.8	138	16	82	.1	.17	.02
	5-03-77	3.6	140	27	160	.1	.16	.02
	10-13-77	4.4	140	35	220	.1	.18	.02
10	10-15-64	11	138	78	560	.3	--	--
	1-27-65	12	141	94	680	.3	--	--
	8-05-65	21	144	148	1,040	.2	--	--

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as CaCO$_3$)	Sulfate, dissolved (mg/L as SO$_4$)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Nitrogen, nitrate, total (mg/L as N)	Phosphate, ortho, dissolved (mg/L as PO$_4$)
11	10-14-64	125	784	2.1	960	1.0	0.70	--
	1-27-65	22	139	164	1,160	.3	.30	--
	8-05-65	37	95	272	810	.3	.70	--
12	7-21-64	5.8	141	46	301	.2	.10	--
	10-15-64	5.2	135	36	235	.2	.30	--
13	7-21-64	16	144	124	790	.1	.10	--
	1-27-65	3.3	138	129	176	1.1	.10	--
	8-05-65	4.3	136	32	210	.2	.20	--
14	7-22-64	9.2	166	66	452	.2	.60	--
15	7-27-64	4.7	167	37	232	.2	.40	--
	10-15-64	5.5	162	35	248	0	.10	--
	1-27-65	5.2	164	41	275	.3	.60	--
	8-05-65	4.2	151	35	215	.2	.40	--
16	7-21-64	67	182	460	3,350	.3	4.80	--
	10-15-64	42	180	298	2,300	.4	.10	--
17	5-01-56	10	113	95	680	-	.14	--
	11-10-60	--	103	80	500	.1	1.20	--
	3-02-64	16	108	109	784	.2	--	--
	3-27-64	19	108	120	976	.1	--	--
	8-04-65	12	112	84	532	.2	--	0.12
	5-19-66	18	107	111	780	.3	--	0
	6-05-67	14	105	96	720	-	--	--
	5-02-68	12	112	84	580	.4	--	--
	5-12-69	16	108	124	780	.2	--	--
	6-01-70	16	105	105	750	.3	.70	.07
	4-20-71	--	--	--	--	-	.60	.08
	4-21-72	12	118	84	640	.2	.20	.02
	9-19-72	--	--	--	850	-	.02	.02
	10-11-72	20	107	150	1,100	.2	.30	--
	1-08-75	12	101	75	520	.2	.31	--
	6-05-75	13	108	91	600	.2	.19	.02
	5-04-76	--	--	--	580	-	--	--
	9-17-76	--	--	--	1,100	-	--	--
	5-03-77	--	--	--	820	-	--	--
	9-01-77	--	--	--	800	-	--	--
	6-29-78	--	--	--	820	-	--	--
	9-06-78	--	--	--	700	-	--	--
18	5-19-66	.9	107	10	46	.3	.10	.10
	6-05-67	1.1	108	11	50	.3	.50	--
	5-02-68	.9	123	9.8	45	.2	.20	--
	5-12-69	.7	108	9.6	34	-	0	.10

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Potassium, dissolved (mg/L as K)	Alkalinity, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Nitrogen, nitrate, total (mg/L as N)	Phosphate, ortho, dissolved (mg/L as PO_4)
18	6-01-70	1.1	110	11	47	0.2	0.40	0.05
	4-20-71	--	--	--	--	-	.30	--
	5-09-72	--	--	--	46	-	--	--
	11-14-72	--	--	--	47	-	--	--
	5-01-73	--	--	--	34	-	--	--
	12-13-73	--	--	--	51	-	--	--
	5-28-74	--	--	--	73	-	--	--
	9-17-74	--	--	--	120	-	--	--
	4-28-75	--	--	--	49	-	--	--
	9-02-75	--	--	--	77	-	--	--
	5-04-76	--	--	--	59	-	--	--
	9-17-76	--	--	--	89	-	--	--
	5-03-77	--	--	--	130	-	--	--
	9-02-77	--	--	--	59	-	--	--
	6-29-78	--	--	--	48	-	--	--
	9-06-78	--	--	--	35	-	--	--
19	8-03-65	7.4	75	443	302	.2	.20	--
	5-19-66	16	113	103	710	.3	1.40	--
20	3-25-64	.4	92	3.8	17	.2	0	--
	10-16-64	.3	89	3.2	6.0	0	0	--
	8-04-65	.4	90	4.4	10	.1	0	--
21	10-16-64	1.2	95	9.2	46	0	0	--
	8-03-65	1.8	95	13	73	.1	.10	--
22	5-18-66	79	112	469	3,490	.5	7.20	.12
	5-19-67	9.7	102	64	455	.3	0	.05
	5-02-68	27	112	175	1,300	.6	0	--
	5-31-68	24	107	162	1,160	.3	0	--
	5-12-69	9.1	105	72	440	.1	0	--
	6-13-69	71	105	450	2,150	.7	2.40	.07
	6-08-70	13	103	83	600	-	0	.08
	10-13-70	--	104	--	--	-	.10	.07
	4-28-71	13	113	76	570	.2	0	.07
	10-05-71	74	--	380	2,800	.3	0	.01
	5-10-72	30	104	340	2,600	.3	0	.02
	9-20-72	150	112	830	6,100	.7	0	--
	4-30-73	23	112	150	920	.2	0	.02
	10-18-73	1.0	109	220	1,100	.1	0	.02
	4-04-74	14	109	83	600	.1	0	.02
	10-17-74	11	103	67	450	.1	--	.02
	4-18-75	16	107	110	780	.1	--	--
	10-24-75	26	111	170	1,200	.2	--	--
	9-17-76	15	99	84	620	.1	.10	.02
	5-03-77	16	--	89	670	.1	0	.03
	5-10-78	11	98	98	590	.1	--	--

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmho)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
1	5-12-69	--	262	106	1,280	8.0	22.0	--
	8-04-69	686	292	138	1,800	7.6	24.5	--
	9-15-69	951	283	123	1,800	7.7	24.0	490
	10-27-69	946	308	148	1,800	7.9	24.5	--
	3-02-70	951	305	147	1,710	7.8	21.5	--
	4-13-70	825	271	130	1,550	8.5	22.0	--
	6-01-70	760	260	98	1,420	8.1	24.0	--
2	4-30-64	--	127	16	353	8.5	--	--
	10-13-65	156	128	8	268	7.7	--	--
3	7-23-64	125	111	10	240	6.9	--	--
	10-13-64	121	104	2	210	8.0	--	--
	2-14-65	123	104	2	200	7.5	--	--
	8-06-65	121	110	10	215	7.3	--	--
4	4-30-64	221	129	20	388	8.2	--	--
	7-24-64	196	136	28	440	7.5	--	--
	10-13-64	217	132	24	393	7.8	--	--
	2-04-65	--	126	21	348	7.5	--	--
	8-05-65	--	128	20	395	7.5	--	--
5	7-24-64	154	138	7	265	8.0	24.0	--
	8-06-65	154	146	8	260	7.7	--	--
6	6-20-61	155	140	7	270	8.2	--	--
	3-16-62	153	130	8	278	7.9	23.0	--
	4-25-62	153	140	10	278	7.8	--	--
	3-08-63	157	139	6	186	7.8	23.0	--
	3-28-63	155	140	9	265	7.9	--	--
	1-14-64	152	144	11	265	7.9	24.0	--
	3-02-64	152	140	10	258	8.0	24.0	--
	4-16-64	154	142	12	262	7.9	--	--
	9-24-64	154	136	3	260	7.2	--	--
	10-14-64	--	136	5	260	7.9	--	--
	5-01-68	161	138	0	282	7.5	24.0	170
	5-13-69	167	141	10	275	8.0	24.0	--
	5-13-69	233	157	26	423	8.3	24.0	--
	6-02-70	155	140	7	272	8.2	24.0	100
	10-01-70	150	136	9	282	8.2	23.5	200
	4-19-71	--	--	--	282	-	22.5	--
	4-28-71	147	130	5	270	7.9	--	200
	5-10-72	--	130	6	280	7.8	23.5	240
	5-10-72	--	--	--	272	7.4	23.5	--
	4-14-74	163	150	13	284	7.7	21.5	150
	10-17-74	152	130	3	267	7.4	24.0	180
	10-24-75	159	150	18	268	6.7	25.0	300

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmho)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
6	6-03-76	157	140	8	230	7.5	25.0	340
	9-17-76	158	150	18	290	7.4	26.5	200
	5-03-77	160	150	19	300	7.6	25.0	250
	10-13-77	--	140	11	277	-	23.0	130
	5-10-78	--	140	9	300	7.9	24.0	170
	10-25-78	157	140	9	292	7.1	24.5	210
	10-17-79	147	140	16	276	7.6	24.0	170
	6-26-80	157	150	16	275	7.6	23.5	170
7	4-23-64	--	355	230	3,050	6.1	--	--
	1-28-65	--	282	158	1,500	7.5	--	--
	8-06-65	1,020	315	187	1,800	7.3	--	--
9	9-24-64	225	160	28	419	7.4	--	--
	9-01-67	2,079	487	343	--	7.5	--	--
	9-14-67	1,590	398	254	2,820	7.9	--	--
	9-19-67	521	216	72	1,100	7.6	--	--
	5-01-68	687	244	105	1,330	7.5	25.0	280
	5-13-69	371	189	45	721	7.9	25.0	--
	8-50-69	1,090	343	215	2,150	-	24.0	--
	9-16-69	321	179	55	590	8.4	24.0	--
	10-27-69	290	179	39	545	7.7	24.0	--
	4-14-70	287	170	32	550	8.3	24.0	--
	6-02-70	272	160	19	500	8.2	26.0	200
	9-30-70	394	189	49	735	8.2	25.0	220
	4-28-71	401	190	49	755	8.0	24.5	200
	10-05-71	294	170	30	530	8.1	24.5	200
	8-21-73	627	220	78	1,000	7.9	25.5	240
	4-03-74	770	250	110	1,420	7.7	24.5	300
	10-17-74	361	170	32	668	7.5	24.0	210
	4-18-75	1,110	210	71	875	5.5	24.5	250
	10-24-75	539	220	77	975	7.2	23.5	270
	9-17-76	297	180	41	555	-	26.0	200
	5-03-77	439	210	67	850	7.7	23.0	250
	10-13-77	548	220	85	990	-	21.0	200
10	10-15-64	1,160	325	188	2,080	7.7	--	--
	1-27-65	1,350	360	219	2,100	7.5	--	--
	8-05-65	2,000	455	311	3,550	7.8	--	--
11	10-14-64	2,410	582	0	4,000	7.4	--	--
	1-27-65	2,260	530	392	3,100	7.8	--	--
	8-05-65	3,370	702	608	6,000	7.2	--	--
12	7-21-64	691	248	107	300	7.4	23.0	--
	10-15-64	564	240	80	1,000	7.8	--	--
13	7-21-64	1,602	405	261	--	-	--	--

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmho)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
13	1-27-65	481	196	58	2,820	7.7	--	--
	8-05-65	523	214	78	770	7.5	--	--
14	7-22-64	986	318	152	1,780	7.6	--	--
15	7-27-64	591	248	81	1,050	7.7	--	--
	10-15-64	555	250	88	1,050	7.9	--	--
	1-27-65	669	260	96	1,080	7.7	--	--
	8-05-65	548	234	83	988	7.8	--	--
16	7-21-64	6,210	1,270	1,090	9,700	7.0	--	--
	10-15-64	4,480	930	750	6,500	7.5	--	--
17	5-01-56	1,330	365	254	2,590	7.6	--	--
	11-10-60	1,050	277	174	1,940	-	--	--
	3-02-64	1,500	380	272	2,750	7.4	--	--
	3-27-64	1,830	470	362	3,390	7.3	--	--
	8-04-65	1,100	266	155	1,920	7.2	--	--
	5-19-66	1,520	372	265	2,900	7.5	--	--
	6-05-67	1,410	346	242	2,600	7.3	23.0	500
	5-02-68	1,170	310	198	2,220	7.4	24.0	440
	5-12-69	1,540	375	267	2,900	7.5	24.0	--
	6-01-70	1,470	382	277	2,550	8.0	--	--
	4-20-71	--	--	--	2,100	-	23.0	--
	4-21-72	1,250	320	200	2,370	6.9	23.5	490
	9-19-72	--	--	--	3,100	-	24.0	--
	10-11-72	2,100	480	370	3,740	7.9	23.5	500
	1-08-75	1,100	260	160	2,530	-	22.5	460
	6-05-75	1,200	310	200	2,260	7.8	25.0	440
	5-04-76	--	--	--	2,300	-	24.0	--
	9-17-76	--	--	--	3,650	-	25.5	--
	5-03-77	--	--	--	1,220	-	25.0	--
	9-01-77	--	--	--	3,200	-	25.5	--
	6-29-78	--	--	--	3,000	7.6	23.5	--
	9-06-78	--	--	--	1,500	7.7	23.0	--
18	5-19-66	199	118	10	351	8.0	--	--
	6-05-67	208	124	16	386	7.2	25.5	--
	5-02-68	208	130	7	368	7.5	24.0	60
	5-12-69	183	124	16	335	7.9	25.0	--
	6-01-70	206	131	21	375	8.4	24.0	--
	4-20-71	--	--	--	371	-	24.0	--
	5-09-72	--	--	--	372	-	24.0	--
	11-14-72	--	--	--	380	-	23.0	--
	5-01-73	--	--	--	332	-	22.0	--
	12-13-73	--	--	--	400	-	21.0	--

Table 7.--Chemical analyses of water from springs and spring-fed rivers--Continued

Site No.	Date of sample	Solids, sum of constituents, dissolved (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Specific conductance (µmho)	pH (units)	Temperature (°C)	Strontium, dissolved (µg/L as Sr)
18	5-28-74	--	--	--	478	-	25.0	--
	9-17-74	--	--	--	630	-	25.5	--
	4-28-75	--	--	--	384	-	24.0	--
	9-02-75	--	--	--	450	-	27.0	--
	5-04-76	--	--	--	420	-	25.0	--
	9-17-76	--	--	--	520	7.4	25.5	--
	5-03-77	--	--	--	700	-	25.0	--
	9-02-77	--	--	--	468	-	24.0	--
	6-29-78	--	--	--	395	7.8	25.0	--
	9-06-78	--	--	--	342	7.5	23.0	--
19	8-03-65	621	170	94	1,150	7.0	--	--
	5-19-66	1,410	344	232	2,730	7.0	--	--
20	3-25-64	--	99	7	225	7.2	--	--
	10-16-64	113	96	8	192	7.9	--	--
	8-04-65	120	98	8	215	7.2	--	--
21	10-16-64	188	112	17	338	7.8	--	--
	8-03-65	234	122	27	440	7.3	--	--
22	5-18-66	--	1,230	1,120	--	7.4	--	--
	5-19-67	920	176	75	1,720	7.8	24.0	330
	5-02-68	2,450	520	408	4,480	7.4	25.0	640
	5-31-68	2,190	496	389	4,010	7.5	27.0	610
	5-12-69	918	265	160	1,750	7.7	26.0	--
	6-13-69	6,020	1,200	1,100	10,400	7.8	29.0	--
	6-08-70	1,200	296	193	2,240	7.9	26.0	--
	10-13-70	--	--	--	6,300	-	29.0	--
	4-28-71	1,140	290	186	2,160	7.9	25.5	440
	10-05-71	5,060	1,200	1,100	7,600	7.8	24.5	1,300
	5-10-72	4,710	970	870	8,100	8.2	27.0	870
	9-20-72	11,000	2,100	2,000	19,000	7.9	29.5	4,800
	4-30-73	1,860	450	340	3,500	8.2	23.5	600
	10-18-73	2,140	610	500	3,130	7.7	23.0	--
	4-04-74	1,230	300	200	2,230	7.4	25.5	370
	10-17-74	917	240	130	1,560	7.5	25.0	310
	4-18-75	1,490	320	210	--	-	23.5	490
	10-24-75	2,320	520	410	4,100	-	23.0	760
	9-17-76	1,210	320	220	2,340	-	26.0	410
	5-03-77	1,320	330	230	1,200	8.1	23.0	490
	5-10-78	1,180	290	190	2,310	8.0	26.5	450