Hydrogeology of the Intermediate Aquifer System and Upper Floridan Aquifer, Hardee and De Soto Counties, Florida

By A.D. Duerr and G.M. Enos

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ABBREVIATIONS AND CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric (International System) units by the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per day per foot [(ft/d)/ft]	1.000	meter per day per meter [(m/d)/m]
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
acre	0.4047	hectare (ha)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	3.785	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

°C = (°F - 32)/1.8

Sea level: In this report, "sea level" refers to the 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 Sea Level Datum of 1929.

Additional Abbreviations

µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
FDER = Florida Department of Environmental Regulation
µg/L = micrograms per liter
ROMP = Regional Observation and Monitor Well Program

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ABSTRACT

Hardee and De Soto Counties, a 1,371-square-mile area of west-central Florida, are underlain by three principal hydrogeologic units: the surficial aquifer, the intermediate aquifer system, and the Floridan aquifer system. The intermediate aquifer system includes all water-bearing units (aquifers) and confining units between the overlying surficial aquifer and the underlying Floridan aquifer system. The top of the intermediate aquifer system ranges from about 25 feet below sea level in northeastern De Soto County to about 100 feet above sea level in northwestern Hardee County. Thickness ranges from about 200 to 500 feet, and transmissivity ranges from 400 to 7,000 feet squared per day. The Floridan aquifer system consists of the Upper and Lower Floridan aquifers that are separated by a middle confining unit. Transmissivity of the Upper Floridan aquifer ranges from about 100,000 feet squared per day in western Hardee County to about 850,000 feet squared per day in northeastern De Soto County.

The altitude of the composite potentiometric surface of the intermediate aquifer system in September 1988 ranged from about 40 to 120 feet above sea level and was higher than the potentiometric surface of the Upper Floridan aquifer throughout the northern half of the study area. The altitude of the potentiometric surface of the Upper Floridan aquifer in September 1988 ranged from about 40 to 80 feet above sea level. Differences of as much as 70 feet between the potentiometric surfaces of the intermediate and Upper Floridan aquifers were measured in northwestern Hardee County.

The hydraulic connection between the intermediate aquifer system and the Peace River was defined by making discharge measurements at numerous points on the Peace River in April 1988 during a period of low flow. The measurements defined the reaches of the river that were gaining water from the intermediate aquifer system. The river gained about 4 cubic feet per second per river mile over a 6-mile reach upstream of Zolfo Springs.

Water in the intermediate aquifer system generally meets drinking-water standards throughout most of the study area, but water in the Upper Floridan aquifer does not meet the standards throughout southern Hardee County and all of De Soto County. For most dissolved constituents, highest concentrations occur in the Upper Floridan aquifer in southwestern De Soto County. In a large area of De Soto County, the potential exists for nonpotable water in the Upper Floridan aquifer to move upward to the overlying intermediate aquifer.

In 1987, an estimated 111.8 million gallons per day of fresh ground water was withdrawn for all uses in the study area. Of this total, an estimated 14.6 million gallons per day was withdrawn from the intermediate aquifer system and 97.2 million gallons per day was withdrawn from the Upper Floridan aquifer. The largest withdrawal was for irrigation, about 105.6 million gallons per day. Most irrigation wells are open to and pump water from both aquifer systems. Irrigated citrus acreage increased from about 57,000 acres in 1980 to more than 82,000 acres in 1987. Future increases in ground-water withdrawals and declines in ground-water levels are likely as citrus acreage increases.

INTRODUCTION

As a result of severe freezes between 1981 and 1984 in northern and central Florida, many citrus groves are being relocated from northern counties to southern counties. Central Florida's mild climate also is attracting tourists and residents from other parts of the country. As a result, population is increasing and industries are moving to the area. Hardee and De Soto Counties, a 1,371-mi^2 (square mile) area of west-central Florida (fig. 1), are among the counties most affected by this growth and development.

In Hardee and De Soto Counties, ground water is the principal source of freshwater because of the lack of adequate surface-water storage. Three hydrogeologic units serve as sources of freshwater: the surficial aquifer, the intermediate aquifer system, and the Floridan aquifer system. Because of low yield to wells and the potential for pollution, the surficial aquifer has limited use, generally for lawn and garden irrigation and for stock watering. The intermediate aquifer system is an important source of water in much of Hardee and De Soto Counties, although yields of individual wells and total withdrawals of water from the aquifer are

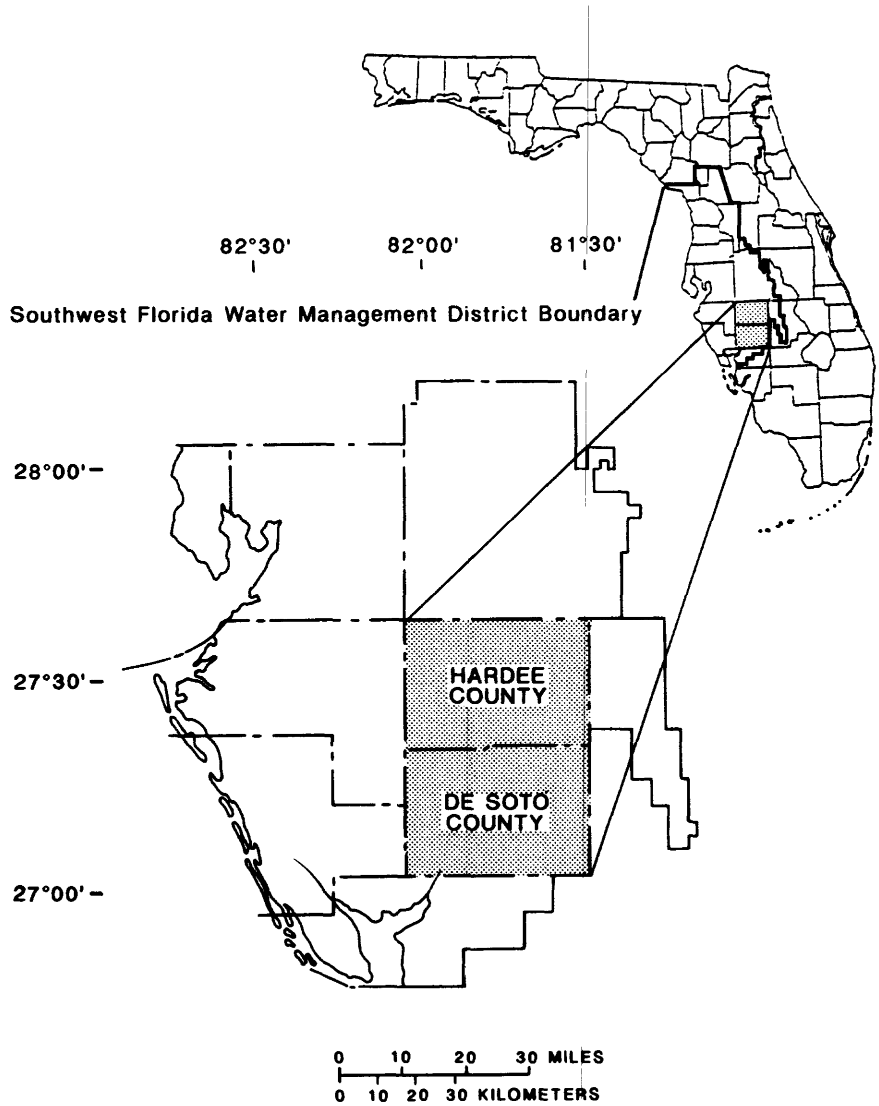


Figure 1. Location of Hardee and De Soto Counties.

generally much less than from wells open to the deeper Upper Floridan aquifer. The Upper Floridan aquifer is the principal source of water supply and yields large quantities of freshwater to wells in most areas. In the southern half of the study area, however, the Upper Floridan aquifer contains water with dissolved-solids concentrations that exceed limits for potable supply.

Because of the increase in population and water use, there is concern about the long-term effects of increased withdrawals from the intermediate aquifer system and Upper Floridan aquifer. There is a potential for degradation of high-quality (potable) water because many wells are open to multiple aquifers that contain water of varying quality.

As the demand for water in Hardee and De Soto Counties increases, more information about the aquifers is needed to develop and manage the aquifers effectively as water-supply sources. Thus, in 1986, the U.S. Geological Survey, in cooperation with the Southwest Florida Water Management District, began a project to study the hydrogeology of the intermediate aquifer system and the Upper Floridan aquifer in Hardee and De Soto Counties.

Purpose and Scope

This report defines the hydrogeologic framework of the intermediate aquifer system and the Upper Floridan aquifer in Hardee and De Soto Counties. The report contains potentiometric-surface maps, water-quality data, tables, and appendixes that present records of wells, ground-water withdrawal data, and streamflow data for the Peace River. The depth, thickness, and extent of the aquifers were determined from geologic and geophysical logs of wells drilled during the project and from the files of the U.S.

Geological Survey, the Florida Geological Survey, and the Southwest Florida Water Management District. A network of monitor wells was established and sampled to determine the water quality of the intermediate aquifer system and Upper Floridan aquifer.

Acknowledgments

The authors gratefully acknowledge the assistance provided by many organizations and individuals in conjunction with this study. Personnel from both Hardee and De Soto Counties were helpful in providing information and assistance. Southwest Florida Water Management District personnel also provided valuable information. The authors are 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. Special thanks is given to the well drillers whose cooperation allowed for the collection of extensive hydrogeologic data. Some of the well drillers included: Richard Ard, Scott Baker, Caesar Blackburn, Frank Bush, Harry Cannon, Jody Cannon, Joe Cannon, Carl Douglas, Thomas Edenfield, Earl Gaskins, John McDonald, J.D. McQuaig, Waldo Mishoe, Curtis Newberry, Thomas Prichard, and Darryl Wertz.

Previous Investigations

Hardee and De Soto Counties have been included in numerous statewide and regional hydrologic and geologic investigations, and several reports focused specifically on Hardee and De Soto Counties. Woodward (1964) provided background information on the geologic formations and their water-bearing characteristics. Kaufman and Dion (1967) mapped the distribution of various ground-water quality constituents in the southern Peace River basin. Kaufman and Dion (1968) also presented data on the ground-water resources of Charlotte, De Soto, and Hardee Counties. Wilson (1972) described the hydrogeology of a large citrus grove in De Soto County. Wilson (1977) described in detail the hydrology and water quality of Hardee and De Soto Counties. Hutchinson (1978) gave an appraisal of the shallow ground-water resources in the upper Peace River basin that included parts of Hardee County.

Buono and others (1979) presented the generalized thickness of the confining unit overlying the Upper Floridan aquifer throughout southwest Florida. Corral and Wolansky (1984) mapped the configuration of the top of the intermediate aquifer system in southwest Florida, but did not include the confining unit below the surficial aquifer system as part of the intermediate aquifer system. A report by Ryder (1985) described the hydrology of the Floridan aquifer system in west-central Florida. Franks (1982) presented summary information on the principal aquifers in Florida.

Miller (1986) presented a regional description of the Floridan aquifer system. Duerr and others (1988) described the hydrogeology and ground-water withdrawals of the aquifer systems in southwest Florida. Additional references, including several consultants reports, are listed in the "Selected References" section.

Description of the Area

Hardee and De Soto Counties lie entirely in the midpeninsular physiographic zone described by White (1970); included are three subdivisions, the Polk Upland, De Soto Plain, and Gulf Coastal Lowlands (fig. 2). These subdivisions correspond approximately to several marine plains or terraces that were formed by invasions of the sea during the Pleistocene Epoch. The Polk Upland is a broad, slightly dissected upland in northern Hardee County, generally at altitudes above 100 feet. The gently sloping, nearly undissected De Soto Plain lies between about 30 and 100 feet altitude, and the Gulf Coastal Lowlands proper consists of the poorly drained, low-lying land at altitudes below 30 to 40 feet in central and southwestern De Soto County. The land in these two subdivisions is poorly drained and has numerous marshes, many in shallow, saucer-like sinkhole depressions. The counties are nearly bisected, however, by one of the principal rivers of southwestern Florida, the southward flowing Peace River (fig. 2). Except for several square miles of southwestern Hardee County, the counties are entirely within the Peace River drainage basin. At times of high flow, water from the large, nearly flat marsh and grassland areas in eastern and southwestern De Soto County probably drains eastward into central Florida watersheds (Wilson, 1977).

Much of the land in Hardee and De Soto Counties remains undeveloped. Hardwood forests predominate in the bottom lands of the Peace River and its tributaries. Away from the river, most of the undeveloped land is pine flatwoods, saw palmetto, and, in eastern De Soto County, prairie grassland. The largest agricultural land use is pastureland, most of which is not irrigated. The second largest agricultural land use is citrus groves. In 1987, about 10 percent, or 82,200 acres, of the total land area within the two counties was citrus groves, with most of the groves requiring irrigation. This is a 44-percent increase from the 57,000 acres of citrus groves in the area in 1980 (Duerr and Trommer, 1981). Truck crop acreage totaled about 13,400 acres. The principal truck crops grown in the counties are watermelons, cucumbers, and tomatoes.

The rural aspect of the counties is reflected in the sparseness of the population and the absence of major urban centers. In 1987, the estimated population of Hardee County was 22,095, with 3,301 persons residing in the town of Wauchula, the county seat. The 1987 estimated population of De Soto County was 22,890, with 6,174 persons living in the county seat of Arcadia. Bowling Green (population 2,366)

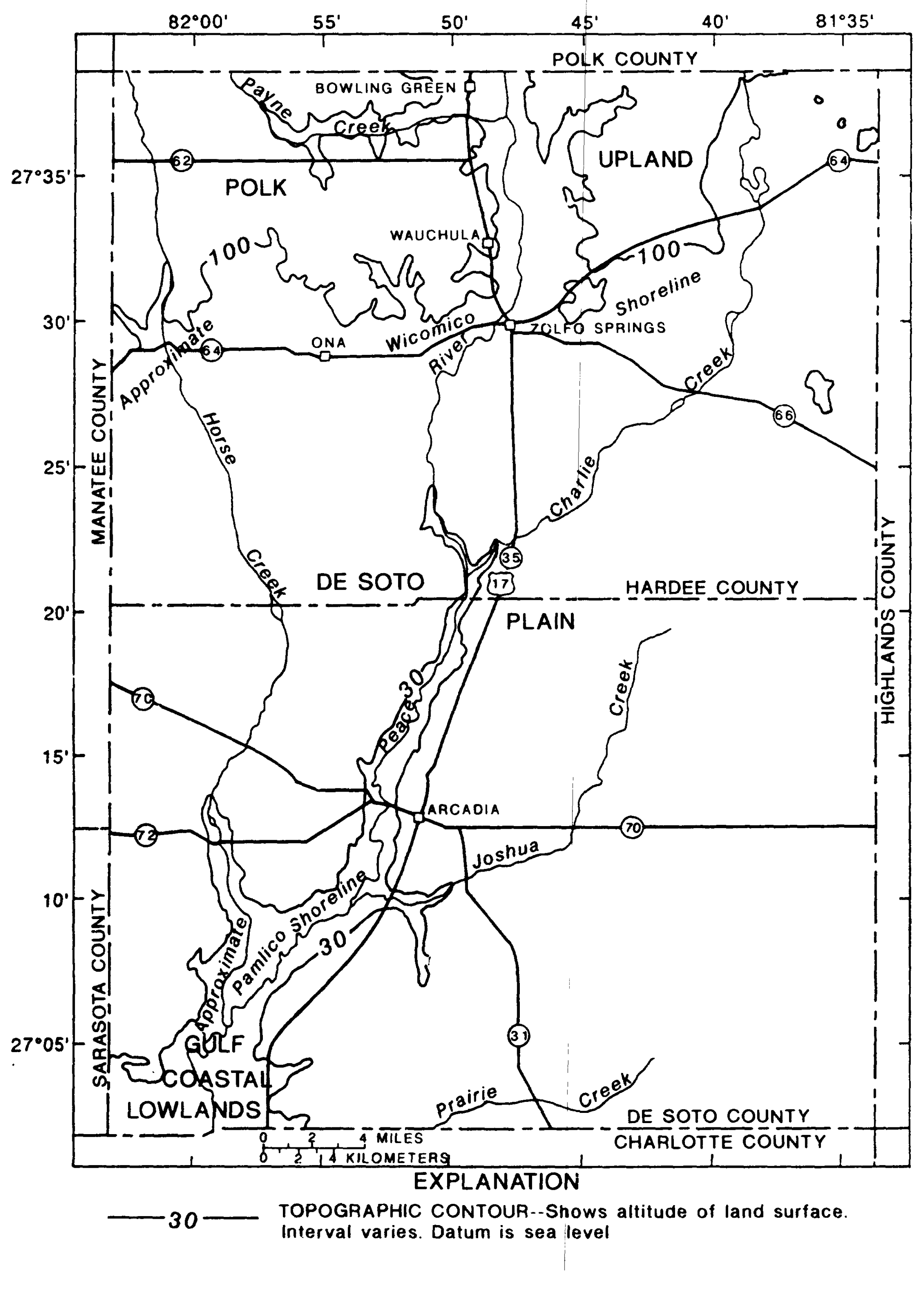


Figure 2. Physiographic subdivisions and topography.

Table 1. Hydrogeologic framework.
[Modified from Ryder, 1985, table 1.]

System	Series	Stratigraphic unit	General lithology	Major lithologic unit	Hydrogeologic unit
Quaternary	Holocene and Pleistocene	Surficial sand, terrace sand, phosphorite	Predominantly fine sand; interbedded clay, marl, shell, and phosphorite.	Sand	SURFICIAL AQUIFER
Tertiary	Pliocene	Undifferentiated deposits[1] Tamiami Formation	Clayey and pebbly sand; clay, marl, shell, phosphatic.	Clastic	Confining unit
	Miocene	Hawthorn Formation	Dolomite, sand, clay, and limestone; silty, phosphatic.	Carbonate and clastic	Aquifer
		Tampa Limestone	Limestone, sandy, phosphatic, fossiliferous; sand and clay in lower part in some areas.		Confining unit
	Oligocene	Suwannee Limestone	Limestone, sandy limestone, fossiliferous.	Carbonate	Upper Floridan aquifer
	Eocene	Ocala Limestone	Limestone, chalky, foraminiferal, dolomitic near bottom.		
		Avon Park Formation	Limestone and hard brown dolomite; intergranular evaporite in lower part in some areas.		Middle confining unit
	Paleocene	Oldsmar and Cedar Keys Formation	Dolomite and limestone, with intergranular gypsum and anhydrite.	Carbonate with evaporites	Lower Floridan aquifer
				Evaporites	Sub-Floridan confining unit

[1]Includes all or parts of Caloosahatchee Marl and Bone Valley Formation.

and Zolfo Springs (population 1,617), both in Hardee County, are the only other sizeable communities. Population estimates are from the University of Florida (1988).

The climate of Hardee and De Soto Counties is characterized by warm, humid summers and mild, moderately dry winters. The average July temperature at Wauchula is 81.5 °F (degrees Fahrenheit), and the average January temperature is 61.5 °F. Annual rainfall averages about 53 inches and varies seasonally with more than half the total occurring from June through September (Palmer and Bone, 1977).

HYDROGEOLOGIC FRAMEWORK AND HYDRAULIC PROPERTIES

The hydrogeologic system in the study area consists of a thick sequence of carbonate rocks overlain by clastic deposits. Principal hydrogeologic units are the surficial aquifer, the intermediate aquifer system, and the Floridan aquifer system (Southeastern Geological Society, 1986). The stratigraphic units, general lithology, and corresponding hydrogeologic units are given in table 1.

Surficial Aquifer

The surficial aquifer overlies the intermediate aquifer system and consists of Holocene and Pleistocene deposits containing sand, clayey sand, shell, shelly marl, and some phosphorite. The thickness of the deposits was mapped by Wolansky, Spechler, and Buono (1979). Thickness ranges from about 25 feet in Hardee County to about 100 feet in northeastern De Soto County. The surficial aquifer is unconfined. It is not a major source of water in Hardee and De Soto Counties, although some small diameter (2-inch) wells are used for lawn irrigation and stock watering. The surficial aquifer is a major source of recharge to the intermediate aquifer system.

The hydraulic properties of the surficial aquifer vary with saturated thickness and lithology. Wilson (1977, p. 28) estimated an average transmissivity of about 1,100 ft^2/d (feet squared per day) for the surficial aquifer in Hardee and De Soto Counties.

Intermediate Aquifer System

The intermediate aquifer system includes all water-bearing units (aquifers) and confining units between the overlying surficial aquifer and the underlying Floridan aquifer system. The water-bearing units of the intermediate aquifer system consist of discontinuous sand, gravel, shell, and limestone and dolomite beds in the Tamiami Formation of early Pliocene and late Miocene age and the Hawthorn Formation of late and middle Miocene age. The confining units consist of sandy clay, clay, and marl. When present, these confining units retard vertical movement of ground water between the water-bearing units and the overlying surficial aquifer and the underlying Upper Floridan aquifer. The confining units vary in thickness and are not consistent throughout the study area. The diversity in lithology reflects the variety of depositional environments during the Miocene Epoch, including open-marine, shallow-water, coastal-marine, and fluvial and estuarine processes (Gilboy, 1985).

The intermediate aquifer system thus consists of three or more hydrogeologic units (table 1): (1) a sandy clay and clayey sand confining unit in the lower part that lies directly on top of the Floridan aquifer system; (2) one, two, or three water-bearing units (aquifers) composed primarily of sand and carbonate rocks; and (3) a sandy clay, clay, and marl confining unit in the upper part that separates the aquifers in the intermediate aquifer system from the overlying surficial aquifer (Ryder, 1985). The water-bearing units (aquifers) of the intermediate aquifer system were defined by Wilson (1977) as the upper unit of the Floridan aquifer.

The locations of seven hydrogeologic sections across the study area are shown in figure 3. The generalized sections, shown in figures 4 through 10, were constructed primarily from geologists' logs of test wells. Geophysical logs also were used for correlating aquifers in the sections. The sections show the relative positions of the surficial aquifer and the intermediate and Floridan aquifer systems. The sections also show the confining units and water-bearing units (aquifers) at specific test holes within the intermediate aquifer system. Rock-stratigraphic units are not included in the sections because of inconsistencies among interpretations. Data collected from newly drilled citrus irrigation wells also were used to define the hydrogeology of Hardee and De Soto Counties.

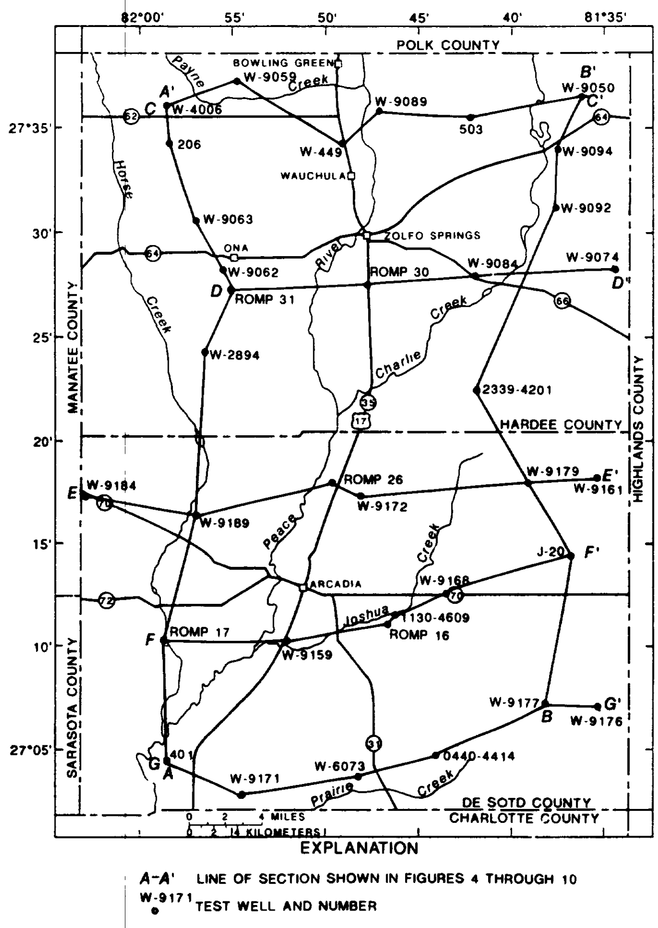


Figure 3. Locations of generalized hydrogeologic sections.

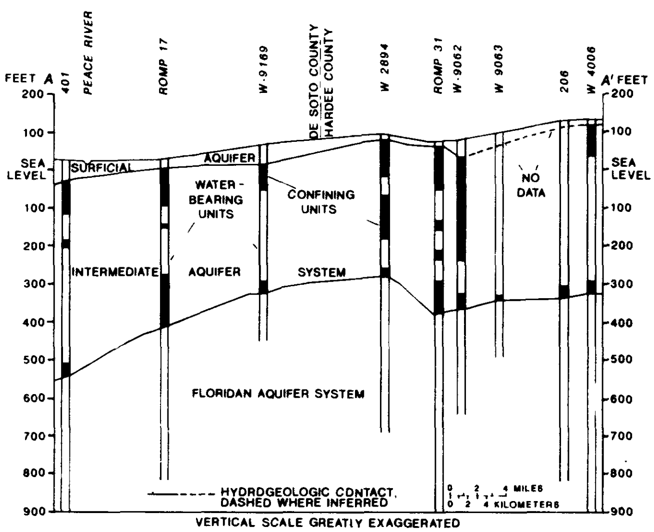


Figure 4. Generalized hydrogeologic section *A–A'*. (Line of section shown in fig. 3.)

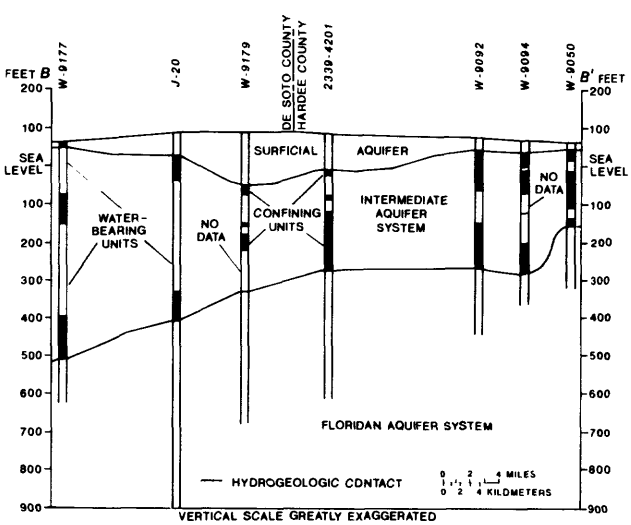


Figure 5. Generalized hydrogeologic section *B–B'*. (Line of section shown in fig. 3.)

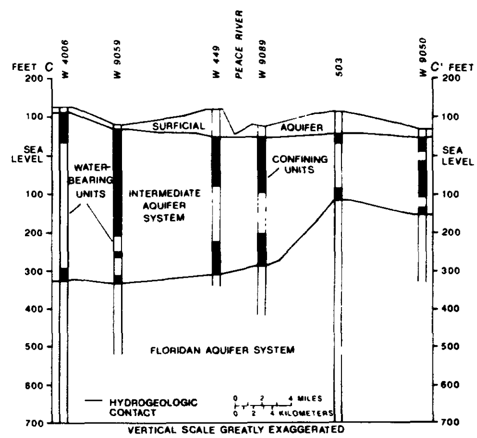


Figure 6. Generalized hydrogeologic section *C–C'*. (Line of section shown in fig. 3.)

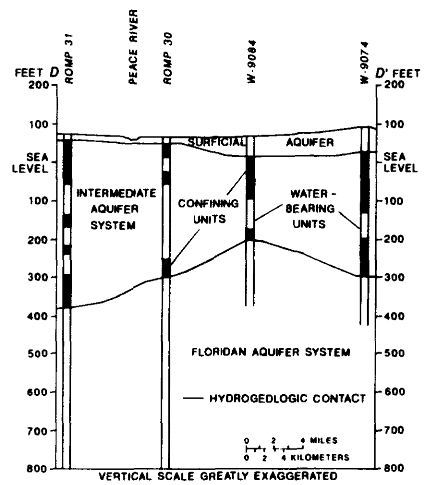


Figure 7. Generalized hydrogeologic section *D–D'*. (Line of section shown in fig. 3.)

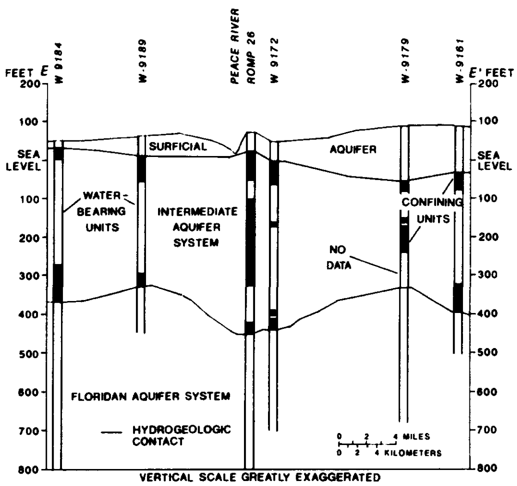


Figure 8. Generalized hydrogeologic section *E–E'*. (Line of section shown in fig. 3.)

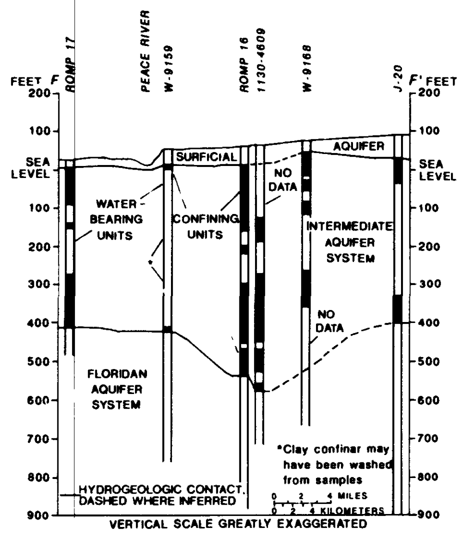


Figure 9. Generalized hydrogeologic section *F–F'*. (Line of section shown in fig. 3.)

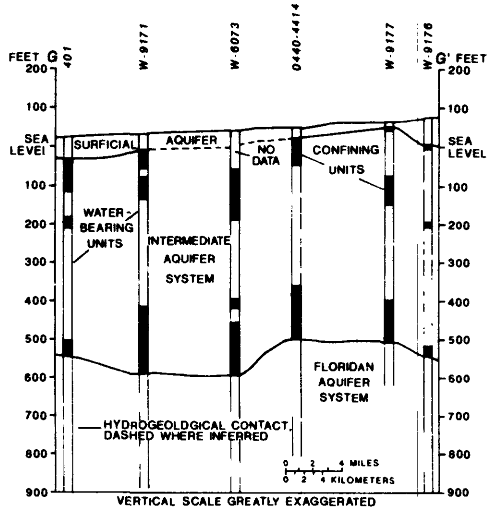
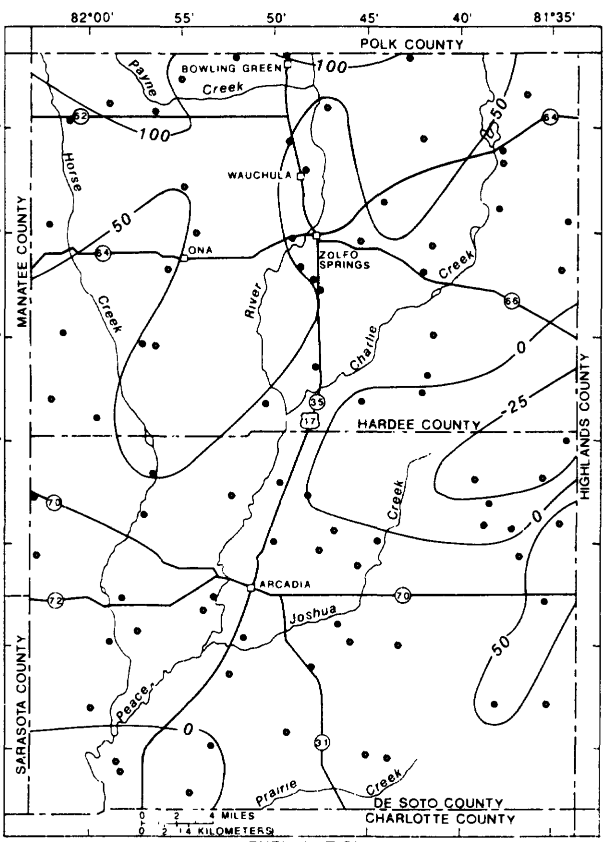


Figure 10. Generalized hydrogeologic section *G–G'*. (Line of section shown in fig. 3.)

The elevation of the top of the intermediate aquifer system ranges from about 25 feet below sea level in northeastern De Soto County to about 100 feet above sea level in northwestern Hardee County (fig. 11). Throughout most of the study area, the top of the aquifer system ranges from about 0 to 50 feet above sea level. The thickness of the intermediate aquifer system ranges from about 200 feet in northeastern Hardee County to about 500 feet in southern De Soto County (fig. 12). The bottom of the intermediate aquifer system (top of the Floridan aquifer system) ranges from about 200 feet below sea level in northeastern Hardee County to about 600 feet below sea level in southeastern De Soto County (fig. 13).

Ryder (1982) reported transmissivities of the water-bearing units of the intermediate aquifer system, as determined by field tests, ranging from 400 to 7,000 ft^2/d in Hardee and De Soto Counties. Near the Peace River, transmissivity is generally higher than 4,000 ft^2/d, indicating that perhaps a more active flow system exists in a carbonate section where ground water discharges to the river. Here, secondary porosity of the carbonate rocks has been enhanced by dissolution, thus providing greater permeability (Ryder, 1985, p. 23). The Southwest Florida Water Management District has drilled a network of monitor wells at Regional Observation and Monitor Well Program (ROMP) sites in Hardee and De Soto Counties. An aquifer test was conducted as part of this project at ROMP site 17 (fig. 3). Transmissivity of the intermediate aquifer system was calculated to be 7,000 ft^2/d at ROMP site 17.

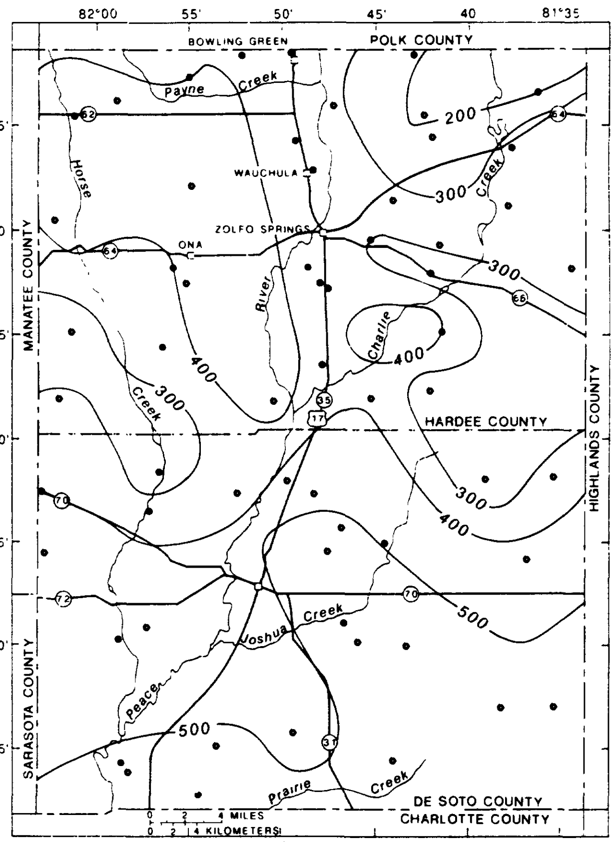


EXPLANATION

—50— TOP-OF-AQUIFER CONTOUR--Shows altitude of the top of the intermediate aquifer system Contour interval is 25 and 50 feet Datum is sea level

• DATA POINT

Figure 11. Altitude of the top of the intermediate aquifer system.



EXPLANATION

—400— LINE OF EQUAL THICKNESS OF THE INTERMEDIATE AQUIFER SYSTEM Contour interval is 100 feet

• DATA POINT

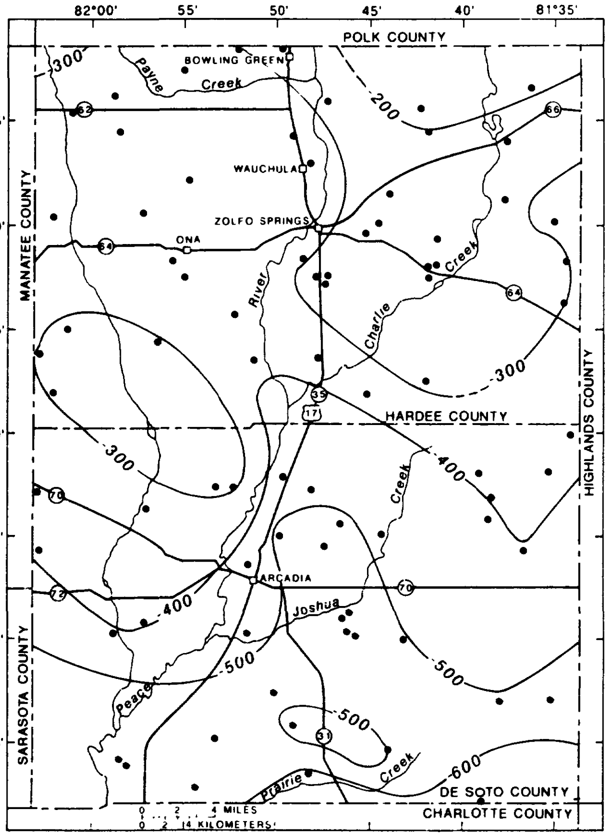
Figure 12. Thickness of the intermediate aquifer system.

Clay beds of limited lateral extent and variable thickness may occur within the water-bearing units of the intermediate aquifer system. These water-bearing units are confined above and below by less permeable material. Model-derived leakance of the lowermost confining unit used by Ryder (1985, p. 22) in a ground-water flow model of west-central Florida ranged from $3x10^{-5}$ to $7x10^{-5}$ (ft/d)/ft [(foot/day)/foot] over most of the study area. Ryder reported slightly lower leakance values in western Hardee and De Soto Counties.

The confining units have low hydraulic conductivity and consequently retard interaquifer ground-water flow and yield little water to wells. These confining units, however, do transmit, or leak, water from one aquifer to another, and the system is referred to as a leaky-aquifer system (Wilson, 1977, p. 37).

POTENTIOMETRIC SURFACE

The potentiometric surface is an imaginary surface connecting points to which water would rise in tightly cased wells from a given point in an aquifer (Lohman, 1972). The potentiometric surface reflects the hydraulic head distribution in an aquifer having predominantly lateral flow. Figure 14 shows the potentiometric surface of the intermediate aquifer system in May 1988 (Lewelling, 1989) near the end of the dry season when ground-water withdrawals are greatest and water levels are at their seasonal low. In areas where multiple aquifers exist in the intermediate aquifer system, wells open to all aquifers were selected for water-level measurements whenever possible. Thus, the potentiometric-surface maps of the intermediate aquifer system represent an average, or composite, pressure surface (Duerr and others, 1988). The altitude of the potentiometric surface ranges from about 30 feet above sea level in southwestern Hardee County and northwestern De Soto County to about 120 feet above sea level in extreme northwestern Hardee County.



EXPLANATION

—300— BOTTOM-OF-AQUIFER CONTOUR: Shows altitude of bottom of the intermediate aquifer system. Contour interval is 100 feet. Datum is sea level

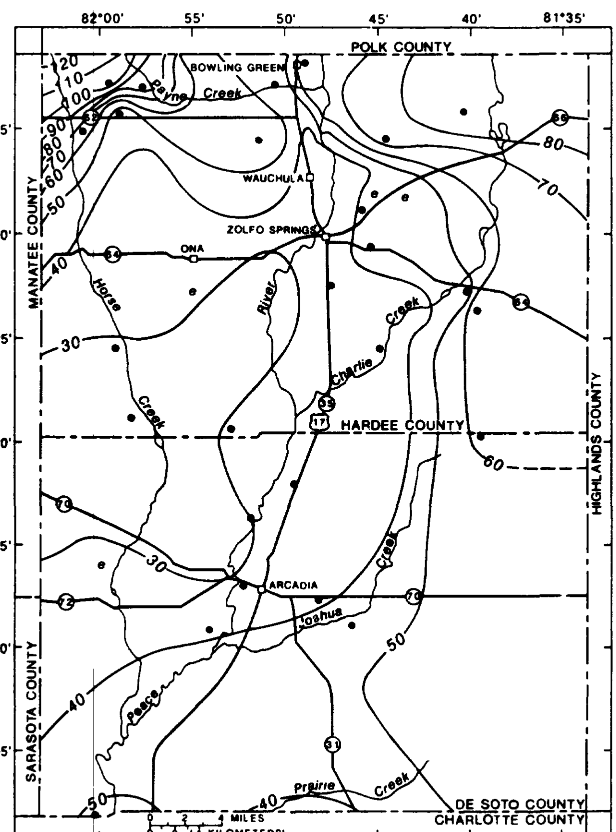
• DATA POINT

Figure 13. Altitude of the bottom of the intermediate aquifer system.

Floridan Aquifer System

The Floridan aquifer system is defined as a vertically continuous sequence of Tertiary age carbonate rocks (table 1) of generally high permeability that are hydraulically connected to each other in varying degrees, the permeability of which is several orders of magnitude greater than that of the rocks that bound the system above and below (Ryder, 1985). The Floridan aquifer system consists of the Upper and Lower Floridan aquifers that are separated by a middle confining unit (Miller, 1986). The middle confining unit and Lower Floridan aquifer generally contain saltwater (Ryder, 1985).

In most reports on the hydrology of southwest Florida, the term "Floridan aquifer" has been applied to the water-bearing rocks herein referred to as the Upper Floridan aquifer. It is the major source of fresh ground water for most of southwest Florida. Transmissivity of the Upper Floridan aquifer in the study area ranges from about 100,000 ft²/d in western Hardee County to about 850,000 ft²/d in northeastern De Soto County (Ryder, 1985).



EXPLANATION

—40— POTENTIOMETRIC SURFACE CONTOUR--Shows altitude of potentiometric surface. Contour interval is 10 feet. Datum is sea level

• WELL LOCATION

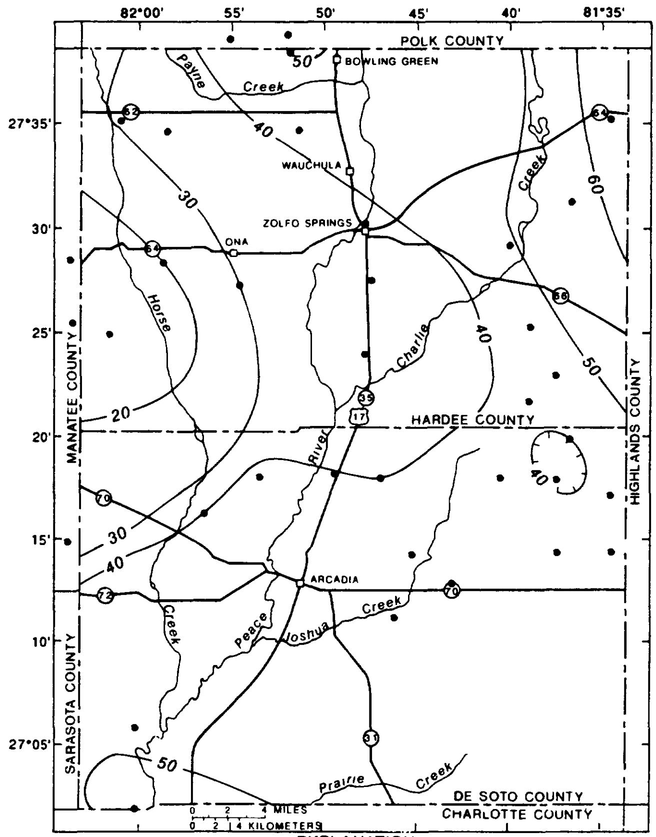
Figure 14. Composite potentiometric surface of the intermediate aquifer system, May 1988. (Modified from Lewelling, 1989.)

The potentiometric surface of the underlying Upper Floridan aquifer in May 1988 (Lewelling, 1988) is shown in figure 15. The altitude of the potentiometric surface ranges from about 20 feet above sea level in southwestern Hardee County to about 60 feet above sea level in northeastern Hardee County. Lateral flow from areas of high potential to areas of low potential is generally west toward the coast.

Head differences between the intermediate aquifer system and the Upper Floridan aquifer in May 1988 are shown in figure 16. In the northern part of the study area, heads in the intermediate aquifer system are higher than heads in the underlying Upper Floridan aquifer. In that area, there is a potential for water to move downward from the intermediate aquifer system to recharge the Upper Floridan aquifer. The head gradient reverses in the southern part of the study area where the underlying Upper Floridan aquifer has higher heads than the intermediate aquifer system. There, the potential is for water to move upward from the Upper Floridan aquifer to recharge the intermediate aquifer system.

Head differences between the intermediate aquifer system and the Upper Floridan aquifer ranged from more than 90 feet in northwestern Hardee County to less than 10 feet in west-central De Soto County in May 1988. The large head differences in the northern part of the study area were caused by large ground-water withdrawals from the Upper Floridan aquifer for irrigation during the dry season.

The potentiometric surface of the intermediate aquifer system in September 1988 (Barr, 1989a) is shown in figure 17. September is the end of the wet season when ground-water withdrawals are minimal and water levels are at their seasonal high. The altitude of the potentiometric surface ranges from about 40 feet above sea level in northwestern De Soto County and southwestern Hardee County to about 120 feet above sea level in northwestern Hardee County. The rise of the potentiometric surface from May to September 1988 ranged from about 1 to 20 feet and resulted from seasonal rainfall and a corresponding decrease in ground-water withdrawals during the summer months. Largest water-level increases were in central Hardee County.

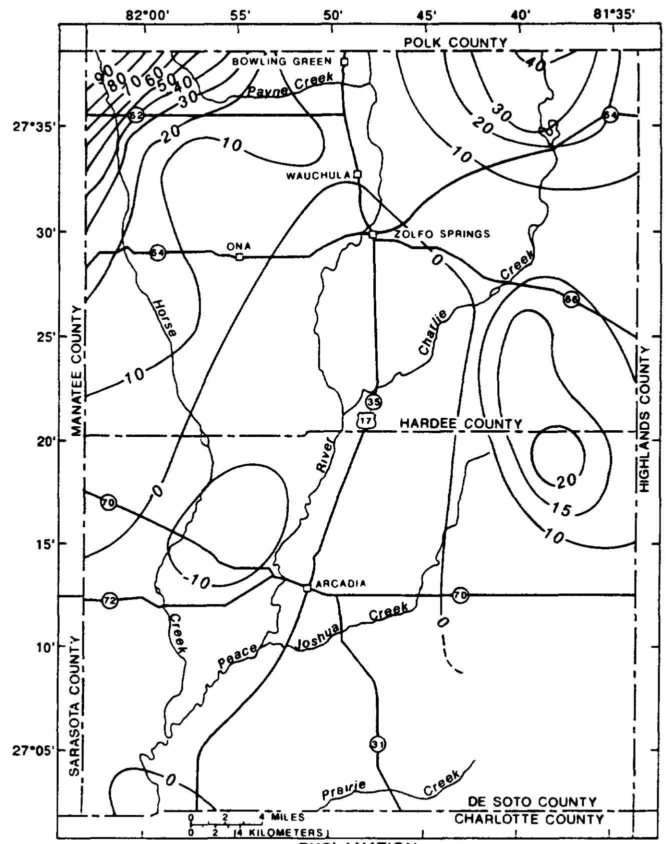


EXPLANATION

—30— POTENTIOMETRIC SURFACE CONTOUR--Shows altitude of potentiometric surface. Contour interval is 10 feet. Datum is sea level

• WELL LOCATION

Figure 15. Potentiometric surface of the Upper Floridan aquifer, May 1988. (Modified from Lewelling, 1988.)



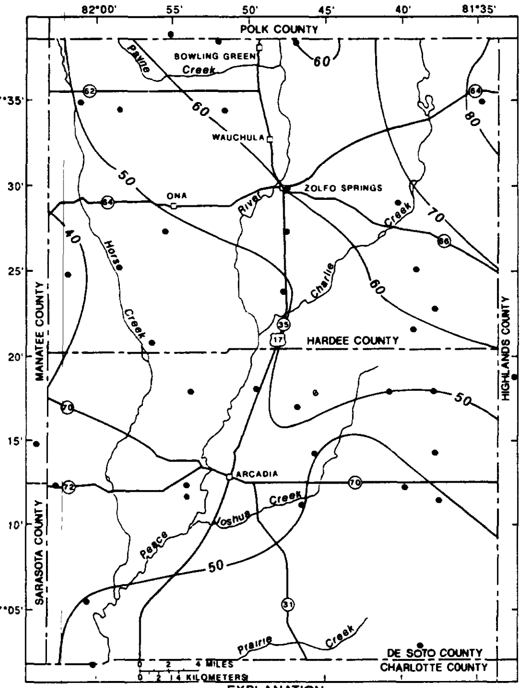
EXPLANATION

—10— LINE OF EQUAL HEAD DIFFERENCE--Shows amount potentiometric surface of the intermediate aquifer system is greater or less (-) than that of the Upper Floridan aquifer. Interval is 5 and 10 feet

Figure 16. Head difference between the intermediate aquifer system and the underlying Upper Floridan aquifer, May 1988.

The altitude of the potentiometric surface of the Upper Floridan aquifer in September 1988 ranges from about 40 to 80 feet above sea level (Barr, 1989b) and is shown in figure 18. Head differences between the two aquifers are shown in figure 19. As in May 1988, the potentiometric surface of the intermediate aquifer system in September 1988 was higher than the potentiometric surface of the underlying Upper Floridan aquifer throughout the northern half of the study area. Head differences were less in September 1988 than in May 1988. Also, th area where the Upper Floridan aquifer heads were higher than the intermediate aquifer system heads extended farther north. Head differences ranged from more than 70 feet in northwestern Hardee County to less than 7 feet in southwestern De Soto County.

Hydrographs of wells at ROMP sites 26 and 31 are shown in figures 20 and 21, respectively. Wells at these ROMP sites (fig. 3) are listed in appendix B as wells 56, 57, 69, and 70. The hydrographs show that small (1-4 feet) head differences and similar fluctuation patterns exist for wells in the intermediate aquifer system and wells in the Upper Floridan aquifer in the central part of the study area. The hydrographs also show larger fluctuations caused by seasonal rainfall and ground-water withdrawals.

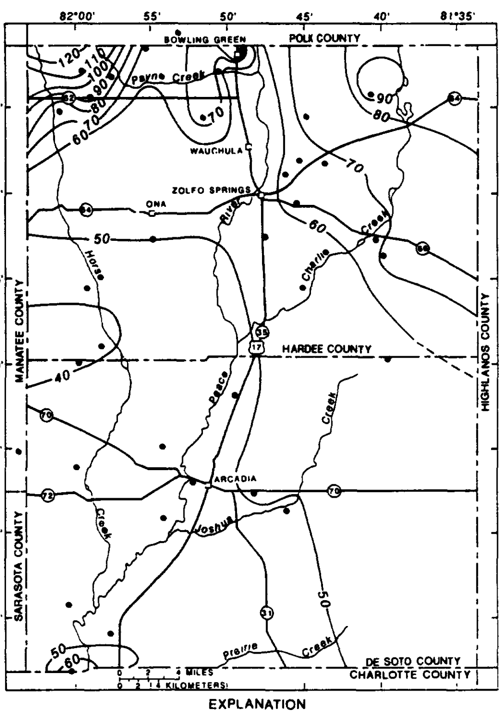


EXPLANATION

—50— POTENTIOMETRIC SURFACE CONTOUR--Shows altitude of potentiometric surface Contour interval is 10 feet Datum is sea level

• WELL LOCATION

Figure 18. Potentiometric surface of the Upper Floridan aquifer, September 1988. (Modified from Barr, 1989b.)

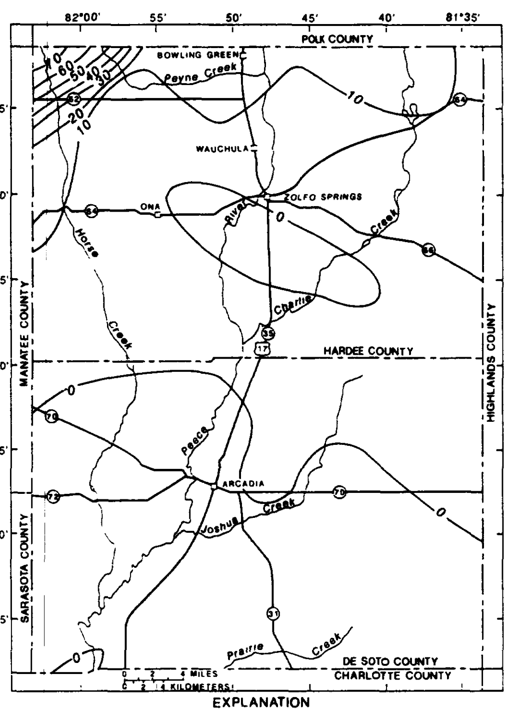


EXPLANATION

—60— POTENTIOMETRIC SURFACE CONTOUR--Shows altitude of potentiometric surface Contour interval is 10 feet Datum is sea level

• WELL LOCATION

Figure 17. Composite potentiometric surface of the intermediate aquifer system, September 1988. (Modified from Barr, 1989a.)



EXPLANATION

—10— LINE OF EQUAL HEAD DIFFERENCE--Shows amount potentiometric surface of the intermediate aquifer system is greater or less ( ) than that of the Upper Floridan aquifer Interval is 10 feet

Figure 19. Head difference between the intermediate aquifer system and the underlying Upper Floridan aquifer, September 1988.

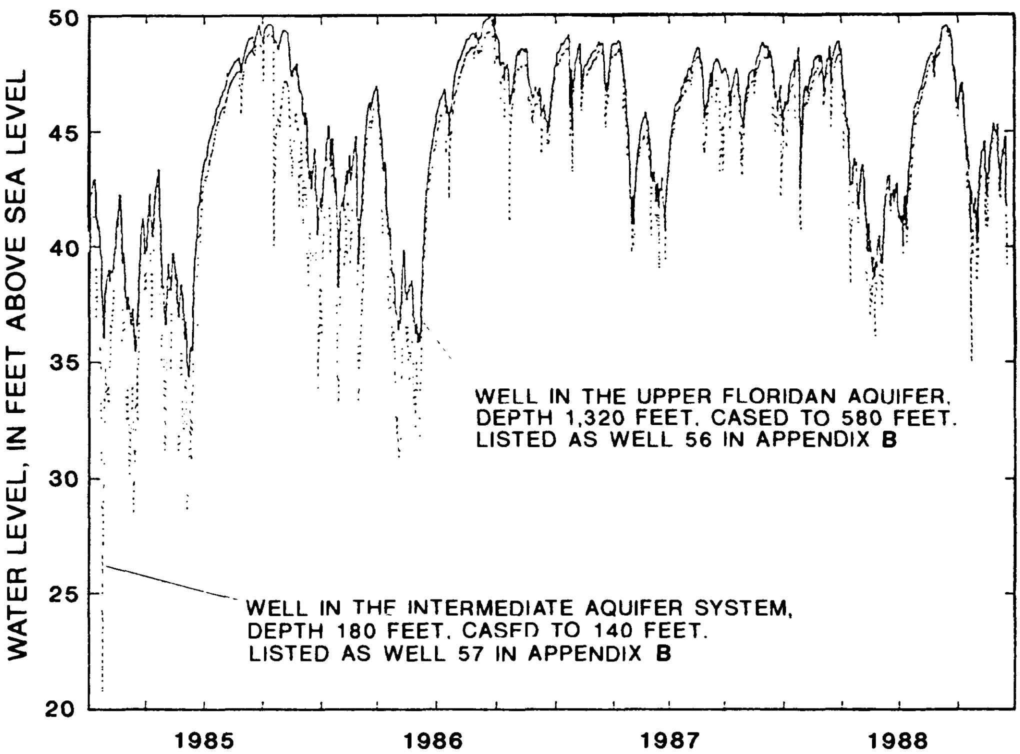


Figure 20. Daily maximum water levels, 1985–88, at Regional Observation and Monitor Well Program site 26. (Site location is shown in fig. 3.)

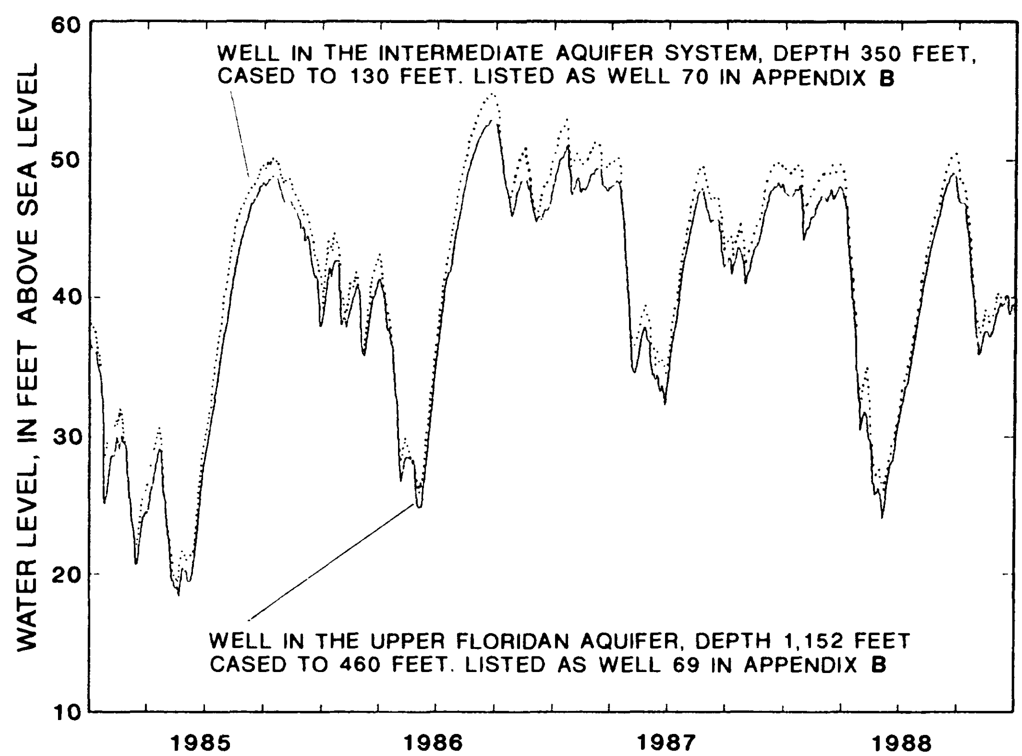


Figure 21. Daily maximum water levels, 1985–88, at Regional Observation and Monitor Well Program site 31. (Site location is shown in fig. 3.)

CONNECTION BETWEEN THE INTERMEDIATE AQUIFER SYSTEM AND THE PEACE RIVER

The potentiometric surface of the intermediate aquifer system is generally higher than the water level in the surficial aquifer in the low-lying areas near the Peace River. As a result, ground water in these areas moves upward from the intermediate aquifer system into the surficial aquifer and, in some areas, eventually discharges into the river. Along reaches of the river where the Hawthorn Formation crops out, as in parts of Hardee and northern De Soto Counties, ground water may discharge by spring flow directly from the intermediate aquifer system to the river (Wilson, 1977).

A series of streamflow measurements were made on the Peace River during a 3-day, low-flow period, April 26-28, 1988. The purpose of these measurements, commonly known as a "seepage run," was to define the reaches of the river, if any, that were gaining or losing water to the intermediate aquifer system. Discharge measurements were made at 30 sections along the river, as well as at 45 tributaries along a 53-mile reach of the river from the Polk-Hardee County line to an area just above the tidal reach near Nocatee (figs. 22 and 23). Temperature and specific conductance also were measured at most of the discharge measurement sites. Site descriptions, discharge, and water-quality data are presented in appendix A.

Continuous-record gaging stations are located at Zolfo Springs and Arcadia (fig. 22, sites 25 and 72B). During the time of measurement, the average flow of the study reach was approximately equal to a flow that is exceeded 85 percent of the time, based on the period of record (1933-88). River discharge measurements ranged from about 63 ft^3/s

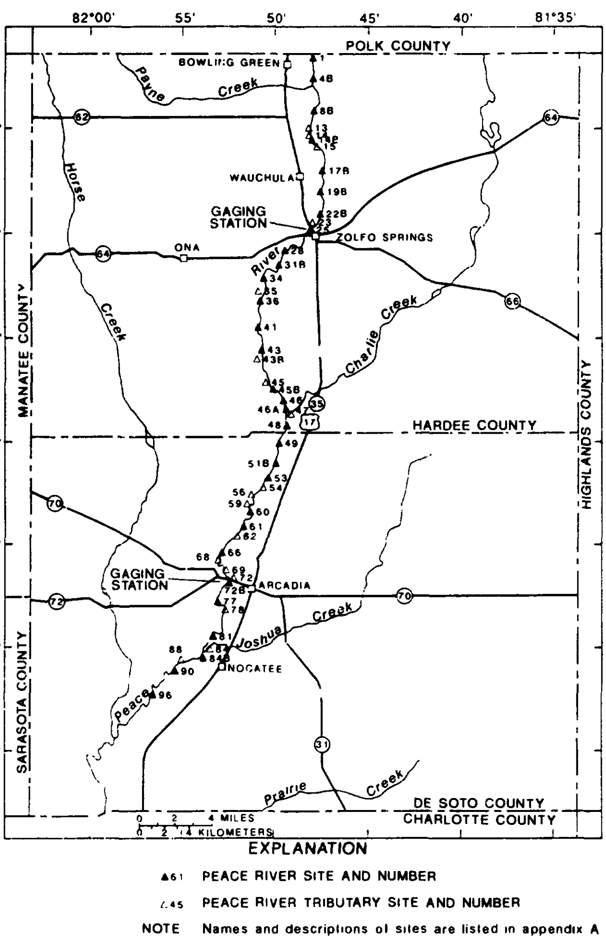


Figure 22. Measurement sites on the Peace River and its tributaries at which discharge on April 26–28, 1988, was equal to or greater than 0.5 cubic foot per second.

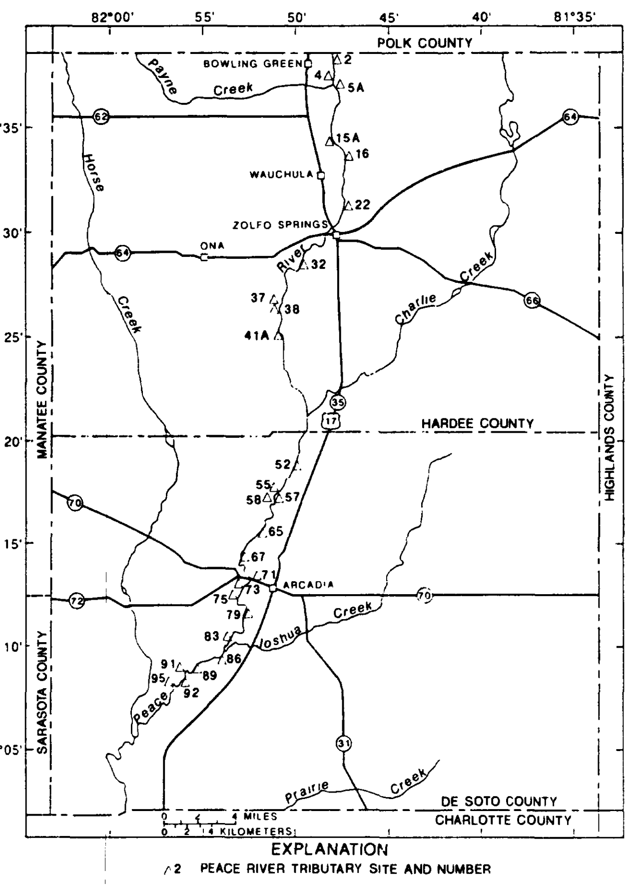


Figure 23. Measurement sites on the Peace River and its tributaries at which discharge on April 26–28, 1988, was less than 0.5 cubic foot per second.

(cubic feet per second) at site 4B near Bowling Green to about 199 ft^3/s at site 84B at Nocatee. Tributary flows ranged from 0 at numerous small tributaries to about 40 ft^3/s at Payne Creek (fig. 22, site 5) near Bowling Green (appendix A). No rainfall was recorded at gages in Arcadia and Wauchula for the week before or during the seepage run.

Generally, specific conductance and temperature of water in the Peace River were more consistent than the specific conductance and temperature of water in the tributaries. Specific conductance of the Peace River ranged from 430 μ/cm (microsiemens per centimeter) at site 8B to 525 μ/cm at site 17B (Wauchula, appendix A). Average specific conductance for 28 sites was 463 μ/cm. Specific conductance of the tributaries varied more than the values for the river itself. Values ranged from 168 μ/cm at a very small tributary at site 37 to 1,080 μ/cm at a small tributary at site 4. Average specific conductance for 39 tributaries was 454 μ/cm. The largest tributary, Payne Creek (site 5), had a specific conductance of 310 μ/cm.

The temperature of the Peace River varied from 24.5 °C (degrees Celsius) at site 19B to 31.0 °C at site 72B (Arcadia). Tributary temperatures ranged from 20.5 °C at sites 86 and 89 to 30 °C at site 47 (Charlie Creek). Most of the temperature variations were probably a function of the local conditions at the stations when the temperatures were recorded.

Tributary flow was subtracted from concurrent Peace River discharge measurements to calculate seepage from ground water along various reaches of the river. No ground-water discharge was measured along a 6-mile reach beginning at the Polk-Hardee County line (fig. 24, reach A). The Peace River gained about 4 ft^3/s per river mile over the next 6-mile reach to Zolfo Springs in central Hardee County (reach B). The river gained flow from ground water at a lesser rate, 1.5 ft^3/s per mile, over an 18-mile section containing two reaches (C and D) from Zolfo Springs to the Hardee-De Soto County line. No gain or loss of flow was measured along the next 23-mile reach ending near Nocatee (reach E).

The seepage run was conducted during conditions of relatively low ground-water levels and low streamflow. Different results might be obtained under different conditions. It is estimated that the intermediate aquifer system would contribute more water to the Peace River under conditions when ground-water levels were high and streamflow was low. Such conditions could exist in the early fall, after several weeks of minimal or no rainfall, while ground-water levels were still high after recharge from the summer rains.

Decreases in ground-water levels caused by increased withdrawals from wells open to the intermediate aquifer system also could affect ground-water contributions to the Peace River. Decreases would be more significant during low streamflow when the river receives a greater percentage of its flow from ground water.

According to Hammett (1988, p. 47), over the period of record, there has been a statistically significant decrease in streamflow at the Peace River stations at Zolfo Springs and Arcadia that cannot be attributed solely to deficient rainfall. This decline in discharge is probably related to the decline in water levels in the underlying Upper Floridan aquifer (Hammett, 1988). Hammett also noted that the decline in the potentiometric surface of the Upper Floridan aquifer also can affect streamflow indirectly by increasing the potential for downward leakage from the intermediate aquifer system and surficial aquifer, which reduces the amount of water that is available to contribute to streamflow.

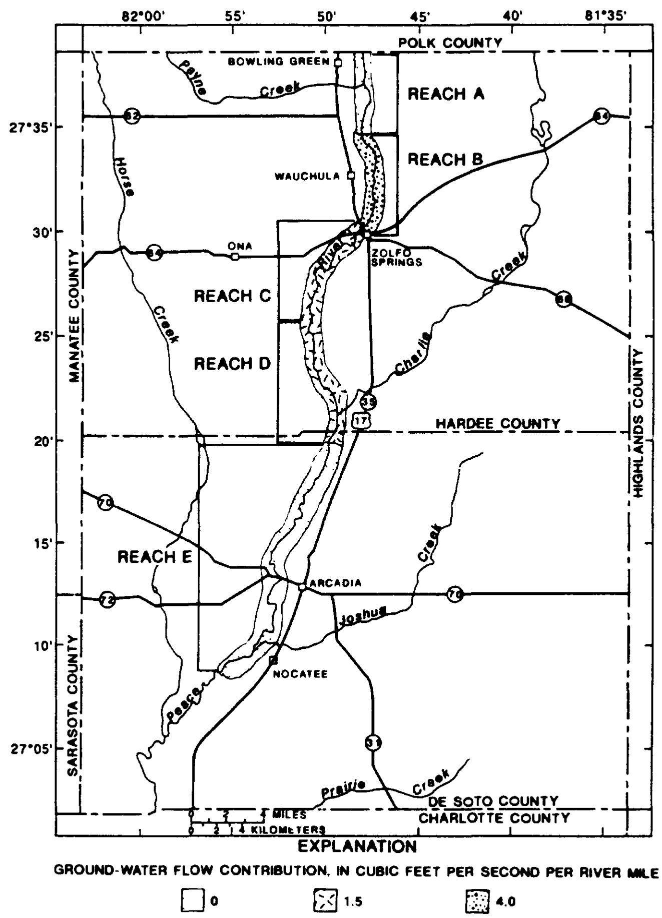


Figure 24. Ground-water discharge to the Peace River, April 26–28, 1988.

WATER QUALITY

Many factors affect the chemical characteristics of ground water, including the initial chemical character of the water when it recharges the aquifers, the types of rocks it is in contact with, and the length of time the water has been in circulation. Because potable water is usually available in the intermediate aquifer system in Hardee and De Soto Counties, most wells penetrating the more productive Upper Floridan aquifer are constructed so that they are also open to the intermediate aquifer system. Frequently, intermittent casings or liners are installed to case off zones of fine sand or clay in the intermediate aquifer system. Consequently, wells in Hardee and De Soto Counties are commonly constructed with tens to many hundreds of feet of open-hole section.

Water pumped from these wells may come from more than one aquifer or water-bearing zone and may have variable water-quality characteristics. Thus, the quality of water pumped from a well depends upon which zones are tapped and the proportion of water derived from each zone. In some areas, quality of water from nearby wells differs markedly, depending on well depth and length of casing (Wilson, 1977, p. 61). However, in recent years the implementation of either drip or jet irrigation systems for citrus has required well construction that often cases off the entire intermediate aquifer system in many areas. This is done to prevent clogging of the irrigation system by the fine sands.

According to Wilson (1977, p. 91), the practice of drilling irrigation wells with many hundreds of feet of borehole open to multiple aquifers facilitates interaquifer flow. The well bore provides an avenue for ground water to move from zones of higher head to zones of lower head, thus short-circuiting the slower route of leakage through intervening beds of lower permeability. Sutcliffe (1975) reported that, in Charlotte County, nonpotable ground water has moved up the boreholes of many abandoned irrigation wells from deep zones with high head and has intruded shallow zones with low head, thus resulting in a deterioration of water quality in the shallow zones. Similar conditions exist in southwestern De Soto County and may, in part, account for the nonpotability of water in the intermediate aquifer system in that area. Figure 25 illustrates how nonpotable water can move between aquifers through the open-hole sections of a well.

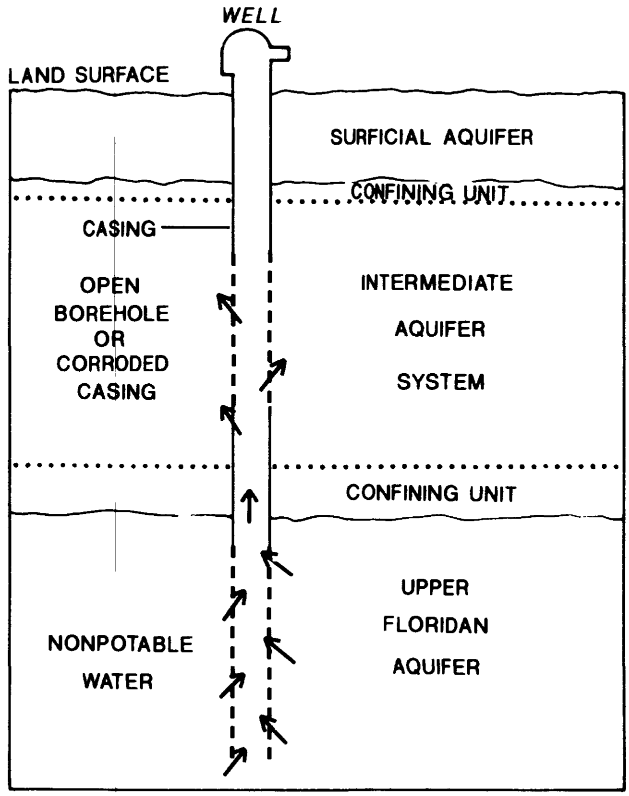


Figure 25. Diagram showing migration of nonpotable water by upward leakage through well boreholes. (Modified from Healy, 1978.)

Despite these complexities, broad water-quality characteristics of the intermediate aquifer system and Upper Floridan aquifer have been delineated and mapped from analyses of water samples from about 80 wells in the two counties. The results, described on the following pages, represent an expansion and revision of water-quality mapping by Wilson (1977). The results presented herein are based on additional sampling and a more detailed subdivision of aquifer units.

The figures presented later in this section show the vertical and areal distribution of several water-quality constituents that are significant in determining the quality characteristics and usefulness of ground water in the counties. Appendix B presents records of monitor wells in Hardee and De Soto Counties and includes well-construction data, as well as selected water-quality analyses. Well locations are shown in figure 26.

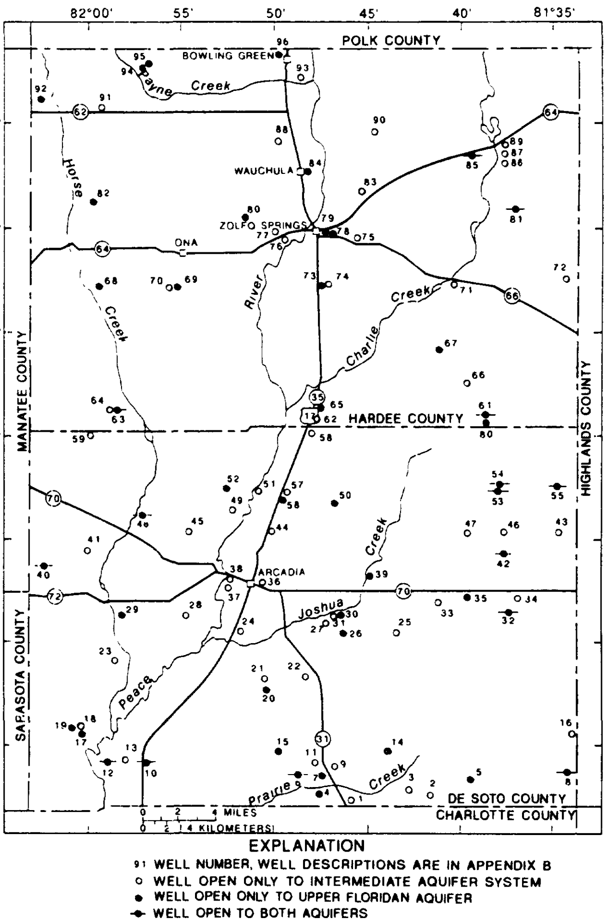


Figure 26. Locations of wells sampled for water-quality analyses.

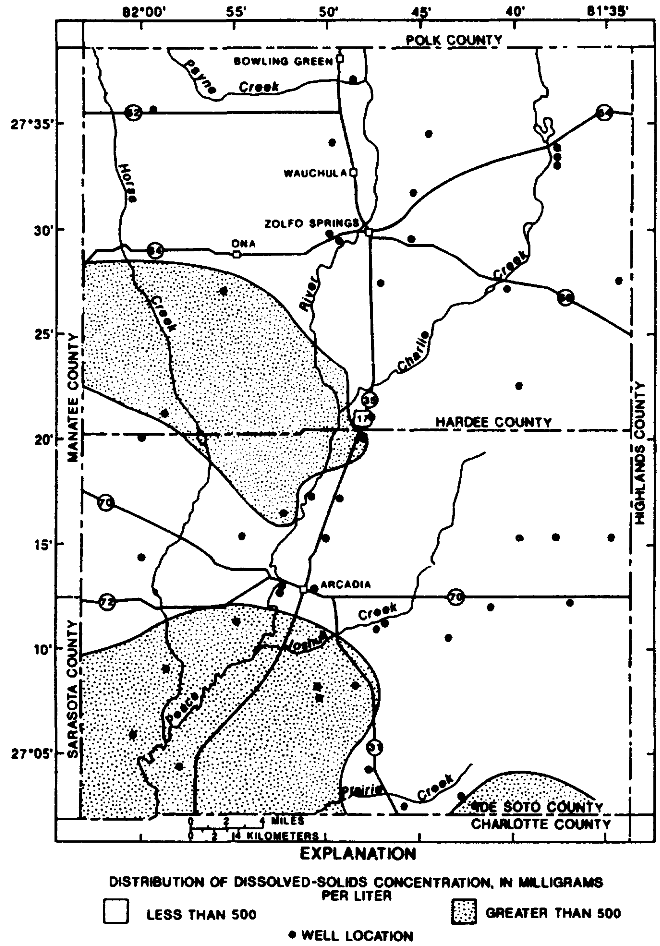


Figure 27. Distribution of dissolved solids in water in the intermediate aquifer system, 1985–89.

Dissolved Solids

Dissolved solids in water refers to all the dissolved mineral constituents contained in the water. Ground water derives some dissolved mineral matter from that contained in precipitation, the remainder is derived from soil and rocks as the water recharges and circulates through the aquifers. Dissolved-solids concentrations are determined from water samples as the residue of evaporation at 180 °C. The Florida Department of Environmental Regulation (FDER) has stipulated a maximum limit of 500 mg/L (milligrams per liter) dissolved solids for public drinking-water supplies, but has permitted use of water with concentrations up to 1,000 mg/L where no other source is available (Florida Department of Environmental Regulation, 1988).

Dissolved-solids concentrations generally increase toward the south and southwest and are greater in the Upper Floridan aquifer than in the overlying intermediate aquifer system (figs. 27 and 28). Figure 29 shows areas where significant differences in dissolved-solids concentrations exist between water in the two aquifers. Throughout most of De Soto County and in the southeastern part of Hardee County, the dissolved-solids concentrations of water in the intermediate aquifer system are less than 500 mg/L, and the dissolved-solids concentrations of water in the underlying Upper Floridan aquifer are greater than 500 mg/L.

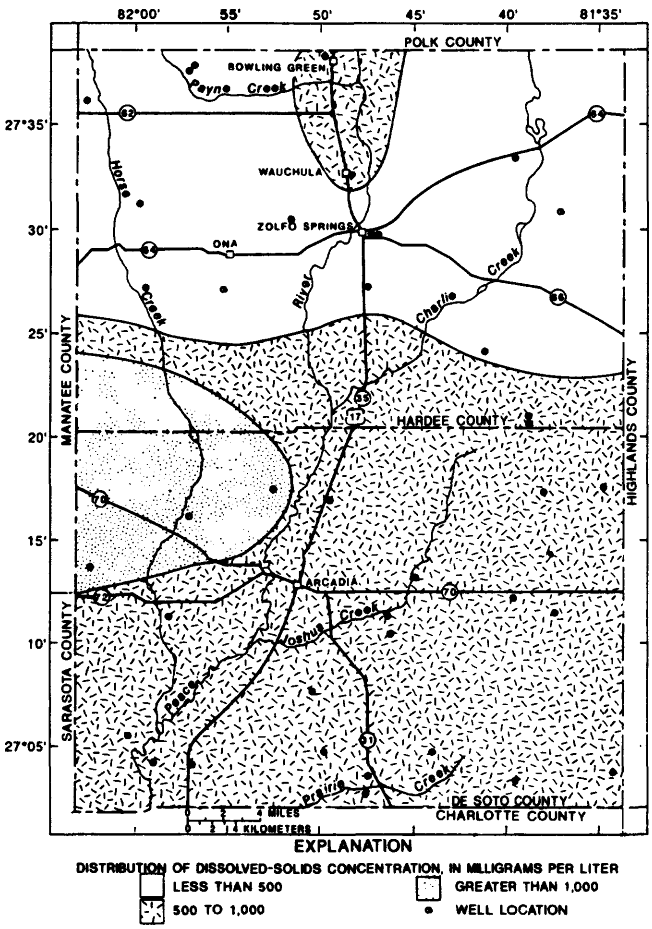


Figure 28. Distribution of dissolved solids in water in the Upper Floridan aquifer, 1985–89.

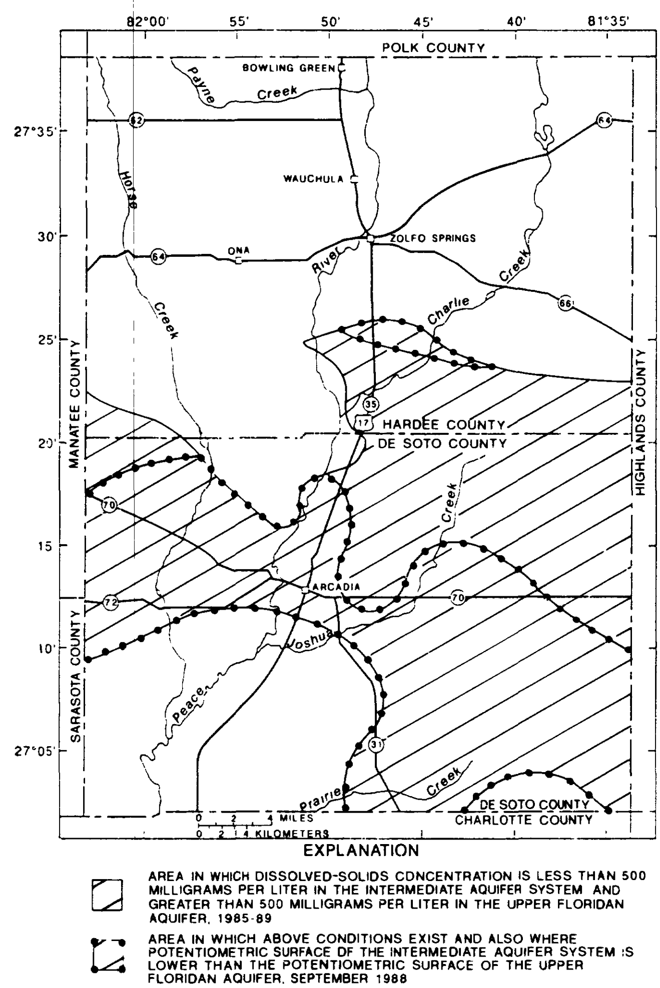


Figure 29. Area where potable water in the intermediate aquifer system is underlain by nonpotable water in the Upper Floridan aquifer, and area where there is potential for contamination of the intermediate aquifer system by upflow from the Upper Floridan aquifer.

Figure 29 also relates water-quality differences between the two aquifers to differences in their potentiometric surfaces in September 1988 at the end of the wet season when water levels were at their seasonal high. Figure 29 also indicates where there is potential for nonpotable water to move upward. In a large area of De Soto County where there is an upward gradient from the Upper Floridan aquifer to the intermediate aquifer system, the potential exists for nonpotable water to move upward and increase the dissolved-solids concentrations of water in the overlying aquifer. Movement of water could be through natural solution channels where confining beds are thin or absent, or through wells that are open to both aquifers.

Sulfate

In Hardee and De Soto Counties, most sulfate in ground water is probably derived from the solution of gypsum and anhydrite (calcium-sulfate minerals), found principally in the Avon Park Formation and deeper rocks (Wilson, 1977). The FDER limit for sulfate in drinking water is 250 mg/L. High sulfate concentrations are difficult to treat and may cause severe scaling problems on pipes and boilers and, in drinking water, may produce laxative effects.

In most of Hardee and De Soto Counties, sulfate concentrations in water in the intermediate aquifer system are less than 100 mg/L (fig. 30). In some parts of western De Soto County, sulfate concentrations exceed 100 mg/L, and in two small areas, concentrations exceed 250 mg/L. Sulfate concentrations exceed 100 mg/L in a small area in central Hardee County near the Peace River and in southwestern Hardee County near Horse Creek.

Water in the Upper Floridan aquifer contains sulfate concentrations greater than 100 mg/L in all of De Soto County and in central and southern Hardee County (fig. 31). Areas where differences in sulfate concentrations of 150 mg/L or more exist between water in the two aquifers are shown in figure 32. Throughout most of northern De Soto County, sulfate concentrations of water in the intermediate aquifer system are less than 100 mg/L, whereas sulfate concentrations of water in the underlying Upper Floridan aquifer are greater than 250 mg/L.

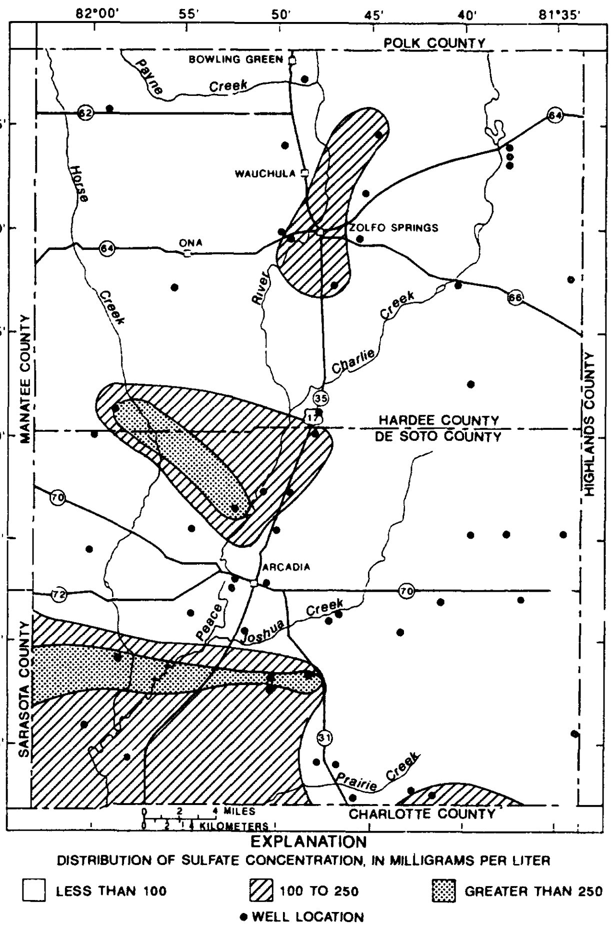


Figure 30. Distribution of sulfate in water in the intermediate aquifer system, 1985–89.

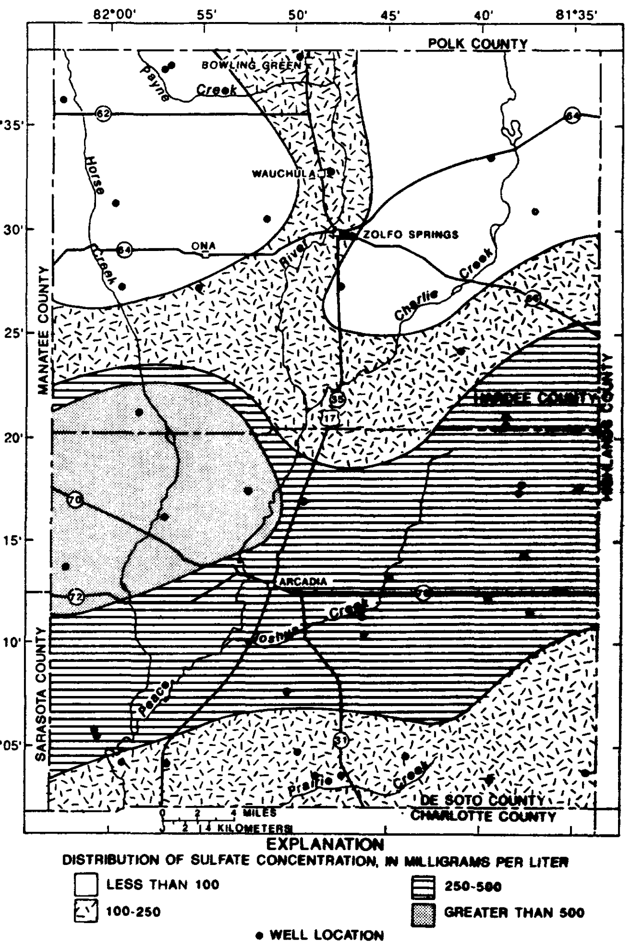
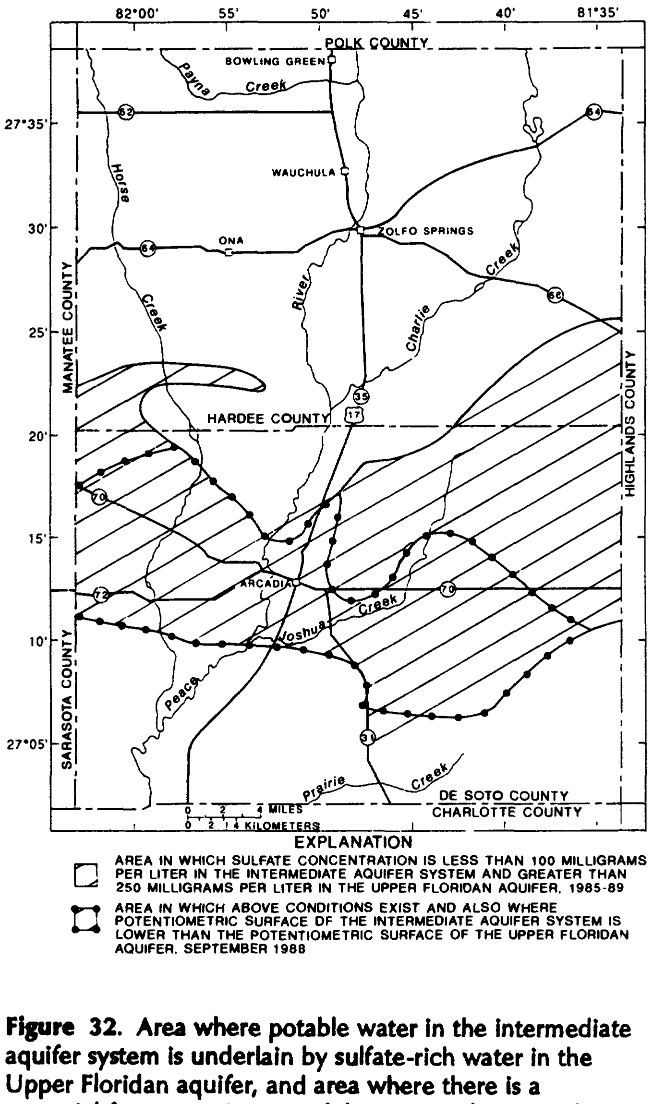


Figure 31. Distribution of sulfate in water in the Upper Floridan aquife, 1985–89.

Figure 32 also relates sulfate-concentration differences between the two aquifers to differences in their potentiometric surfaces in September 1988. Throughout most of central De Soto County where there is an upward gradient, the potential exists for water with higher sulfate concentrations in the underlying Upper Floridan aquifer to move upward and mix with water in the intermediate aquifer system that has sulfate concentrations less than 100 mg/L.



EXPLANATION

AREA IN WHICH SULFATE CONCENTRATION IS LESS THAN 100 MILLIGRAMS PER LITER IN THE INTERMEDIATE AQUIFER SYSTEM AND GREATER THAN 250 MILLIGRAMS PER LITER IN THE UPPER FLORIDAN AQUIFER, 1985-89

AREA IN WHICH ABOVE CONDITIONS EXIST AND ALSO WHERE POTENTIOMETRIC SURFACE OF THE INTERMEDIATE AQUIFER SYSTEM IS LOWER THAN THE POTENTIOMETRIC SURFACE OF THE UPPER FLORIDAN AQUIFER, SEPTEMBER 1988

Figure 32. Area where potable water in the intermediate aquifer system is underlain by sulfate-rich water in the Upper Floridan aquifer, and area where there is a potential for contamination of the intermediate aquifer system by upflow of sulfate-rich water from the Upper Floridan aquifer.

Chloride

Chloride in ground water may be derived from several sources, including recharging rainwater containing chloride ions; intrusion of saltwater into aquifers, either from below or laterally from nearby saline surface-water bodies; from solution of aquifer minerals containing chloride; and from pollution sources, such as sewage and industrial wastes. In southwest Florida, aquifers may contain salty water that, in part, is connate water (water of deposition) or water that was introduced during high stands of the sea subsequent to deposition. In either case, the aquifers in the study area have not been completely flushed of salty water by freshwater circulation (Wilson, 1977).

Small amounts of chloride are probably derived from phosphate minerals that occur only in the upper unit of the intermediate aquifer system and in younger rocks. The principal phosphate mineral, fluorapatite, commonly contains some chloride in place of some of the fluoride in the crystal structure (Toler, 1967, p. 13).

Water containing large amounts of chloride combined with sodium has a salty taste, and, when combined with calcium, such water is corrosive. The FDER limit for chloride in drinking water is 250 mg/L. Figures 33 and 34 show that, throughout most of the study area, chloride concentrations in water are less than 100 mg/L, generally increase toward the south, and are slightly higher in the intermediate aquifer system than in the Upper Floridan aquifer.

Ground water containing 100 mg/L or more of chloride in southern De Soto County may be largely a mixture of circulating low-chloride ground water and residual saltwater in aquifers and confining beds that has not been completely flushed. This source is suggested by the similarity in areal distribution of chloride concentration in the two aquifers and by the occurrence of ground water with high chloride concentrations even at considerable distances from possible saline surface-water sources (Wilson, 1977, p. 82).

In extreme southern De Soto County, chloride concentrations of water in the Upper Floridan aquifer exceed 250 mg/L and are greater than the concentrations in the intermediate aquifer system. Here, chloride concentrations of water in the intermediate aquifer system exceeding 100 mg/L may result in part from upward flow of water with high chloride concentration in well bores that are open to both aquifers (Wilson, 1977).

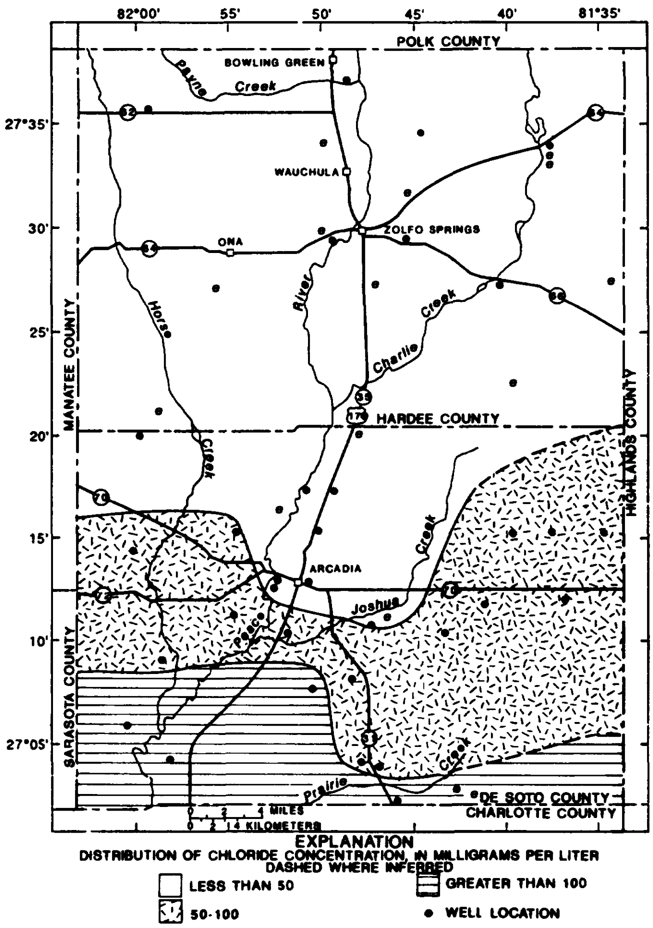


Figure 33. Distribution of chloride in water in the intermediate aquifer system, 1985–89.

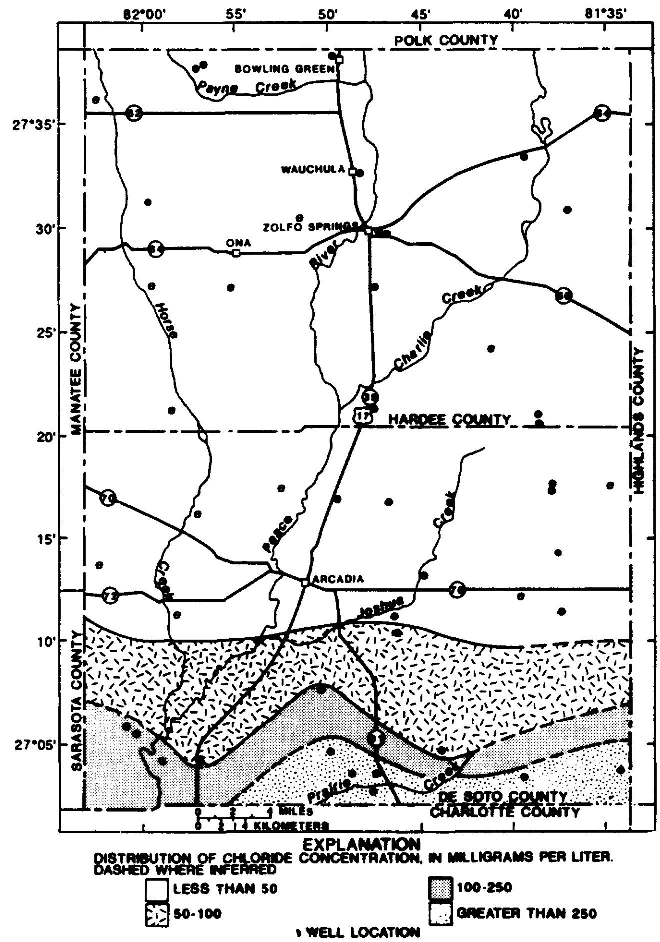


Figure 34. Distribution of chloride in water in the Upper Floridan aquifer, 1985–89.

Salty water, containing more than 1,000 mg/L chloride, underlies all of peninsular Florida at depths that generally increase from near sea level at the coast to more than 1,000 feet inland away from coastal areas. The depth to salty water in Hardee and De Soto Counties is unknown, because no known water wells are deep enough to tap it. The deepest wells in southern De Soto County, more than 1,500 feet deep, pump water with chloride concentrations of only a few hundred milligrams per liter. Elsewhere in the counties, the depth to salty water is probably greater than 2,000 feet (Wilson, 1977).

Some wells are close to the salty reaches of the Peace River in southwestern De Soto County, but high chloride concentrations have not been a significant problem in ground water near the river. This part of the county is a ground-water discharge area where the potentiometric surface of both the intermediate aquifer system and the Upper Floridan aquifer are above land surface, preventing downward leakage of salty water from the river.

Fluoride

Concentrations of fluoride in ground water in the study area are generally low, less than a few milligrams per liter. The presence of this ion is significant because fluoride in low concentrations is believed effective in reducing the incidence of tooth decay in children, and excessive amounts may cause mottled enamel on teeth. The FDER limit for fluoride in drinking water is 1.5 mg/L.

Table 2. Temperature of ground water collected from study area wells

Aquifer	County	Number of wells	Median depth (feet)	Temperature, in degrees Celsius		
				Median	Minimum	Maximum
Intermediate	Hardee	14	297	24.5	22.5	26.0
	De Soto	26	378	26.0	24.0	28.5
Upper Floridan	Hardee	13	1,205	28.0	25.0	30.0
	De Soto	11	1,315	31.0	27.5	32.0
Mixed (intermediate and Upper Floridan)	Hardee	3	1,119	28.0	24.0	28.0
	De Soto	9	1,450	29.0	28.0	32.0

The principal source of fluoride in waters in Hardee and De Soto Counties is fluorapatite, a mineral that is restricted to rocks of the intermediate aquifer system and younger deposits (Wilson, 1977). Fluorapatite also is the principal source mineral of phosphate in the land-pebble mining district of central Florida. The general form of fluorapatite is $Ca_5(PO_4)_3F$; in this form, the mineral contains about 3.8 percent fluoride. Geophysical logs of wells indicate that some phosphate minerals occur in the Hawthorn Formation and Tampa Limestone throughout the two counties. Younger deposits containing concentrated amounts of phosphorite are probably more extensive in Hardee County and the northern third of De Soto County than in southern De Soto County (Wilson, 1977).

Observed concentrations of fluoride in water ranged from 0.3 mg/L in well 81, an 849-foot deep well open to both the intermediate aquifer system and the Upper Floridan aquifer in eastern Hardee County, to 2.8 mg/L in well 80, a 1,280-foot deep well open to the Upper Floridan aquifer in central Hardee County (fig. 26, appendix B). Generally, fluoride concentrations were slightly greater in water in the intermediate aquifer system, especially near Arcadia in central De Soto County.

Woodard (1964) suggested that the fluoride distribution in central Florida is related to ground-water flow, with higher concentrations occurring downgradient and away from recharge areas. Although the concentration of fluoride in Hardee and De Soto Counties does fit the flow pattern in a general way, fluoride distribution probably is related also to other factors, including the vertical and areal distribution of fluoride source minerals. The interrelation of factors is undoubtedly complex, and more detailed knowledge of both flow patterns and geology is needed before a full understanding of areal variations in fluoride concentrations is possible (Wilson, 1977).

Temperature

Ground water is warmed as it circulates downward through aquifers because of the natural increase in temperature of rocks with depth. The FDER requirements for drinking water do not include limits for temperature. High temperatures, however, may severely restrict the usefulness of water for cooling purposes (Wilson, 1977), but may increase the effectiveness of using ground water for frost and freeze protection of agricultural crops, especially citrus. Table 2 indicates that temperature generally increases with depth. Water in the intermediate aquifer system is several degrees cooler than water in the underlying Upper Floridan aquifer. The median water temperature of 14 intermediate aquifer system wells, with a median depth of 297 feet, was 24.5 °C in Hardee County. In De Soto County, 26 intermediate aquifer wells, with a median depth of 378 feet, had a median water temperature of 26.0 °C. In the deeper Upper Floridan aquifer, 13 wells in Hardee County had a median water temperature of 28.0 °C, and 11 wells in De Soto County had a median water temperature of 31.0 °C (table 2).

Boron

Boron is an element that is important in agriculture. Small amounts are essential to plant growth; however, concentrations exceeding 1 mg/L in soil or in irrigation water can be toxic to citrus trees (Hem, 1985, p. 129). Appendix B shows that, of the 66 wells sampled for boron during this study, none had concentrations greater than 1 mg/L. Concentrations ranged from 20 µg/L (micrograms per liter) in eight wells to 170 µg/L in well 17 in southwest De Soto County. The median boron concentration for 33 intermediate aquifer system wells was 60 µg/L. The median concentration for 25 Upper Floridan aquifer wells was 40 µg/L.

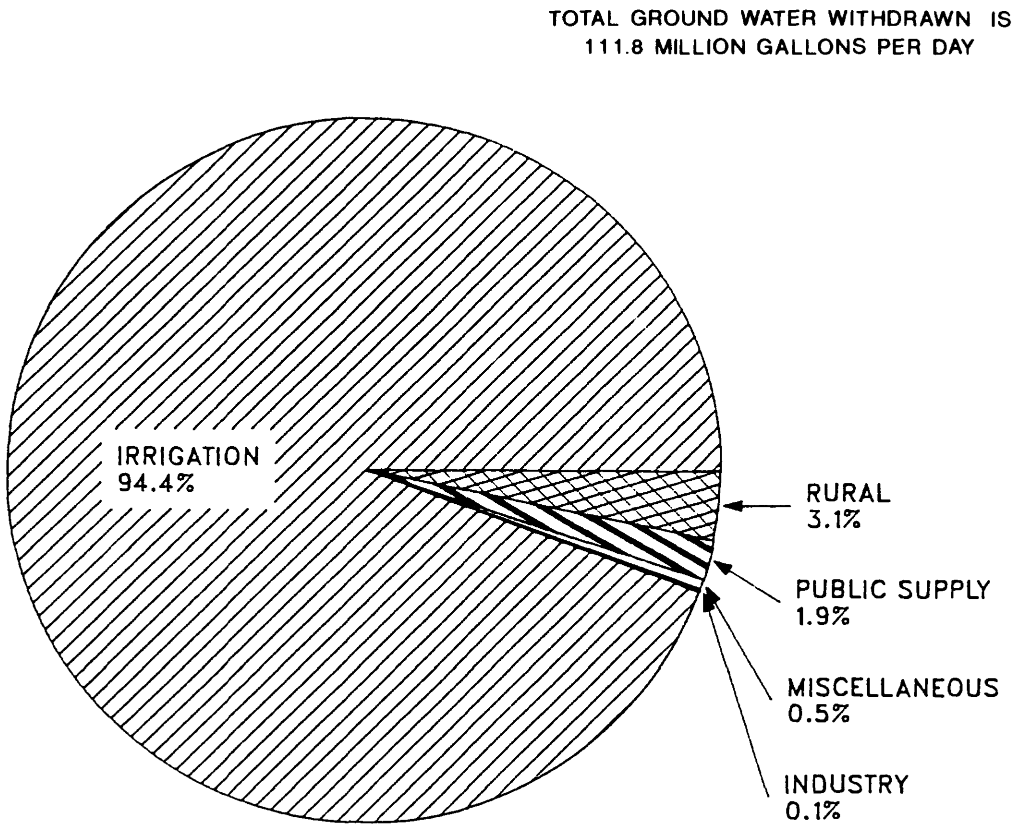


Figure 35. Percentage of ground water withdrawn in Hardee and De Soto Counties, by use category, 1987.

Nutrients

Water samples were collected from monitor wells in Hardee and De Soto Counties and were analyzed for nitrogen as total nitrite (NO_2) plus nitrate (NO_3). Sources of nitrogen in ground water include septic tanks, sewage-disposal plants, concentrated numbers of farm animals (livestock), and fertilizers used to grow plants (Hem, 1985, p. 125). The FDER requires that the nitrate-nitrogen concentration in public water-supply sources not exceed 10 mg/L and that the nitrite-nitrogen concentration not exceed 1 mg/L.

Data for 77 wells that were sampled for nitrogen, reported as the sum of nitrite plus nitrate, are presented in appendix B. Concentrations ranged from less than 0.02 mg/L for more than one-half of the wells to 2.04 mg/L for a 1,100-foot deep well (well 10) in southwestern De Soto County. Well 71, a 343-foot deep well in central Hardee County, had a nitrite plus nitrate concentration of 1.4 mg/L. All other wells had concentrations that were less than 0.6 mg/L.

WATER USE

Data on ground-water withdrawals within the Southwest Florida Water Management District were collected cooperatively by the Southwest Florida Water Management District and the U.S. Geological Survey. All ground-water withdrawal data summarized in this report were previously published by Tuttell and Sorensen (1989) in a Southwest Florida Water Management District report on water use; however, Tuttell and Sorensen did not delineate withdrawal data by aquifer.

Most wells that tap the intermediate aquifer system in Hardee and De Soto Counties are 2 to 6 inches in diameter and yield from 20 to 300 gal/min (gallons per minute) (Wilson, 1977). Wells that tap the deeper, more productive Upper Floridan aquifer can yield as much as 2,500 gal/min and are commonly 10 to 16 inches in diameter.

A combined total of about 111.8 Mgal/d (million gallons per day) of fresh ground water was withdrawn from the intermediate aquifer system and the Upper Floridan aquifer in 1987 in Hardee and De Soto Counties for public, rural, industrial, and irrigation supply and for miscellaneous use. Surface-water use totaled less than 5 Mgal/d in 1987. Following is an estimate of the amount of freshwater withdrawn from the intermediate aquifer system and Upper Floridan aquifer in 1987 in the study area and an explanation of the techniques used to make the estimate.

Water withdrawn from the surficial aquifer was minimal and was considered to be zero for this study. Delineation of water withdrawn from the intermediate aquifer system and the Upper Floridan aquifer was based upon: (1) Southwest Florida Water Management District well-construction and consumptive-use permitting files; (2) U.S. Geological Survey ground-water site inventory files; (3) specific capacity and transmissivity data for the aquifers; (4) data reported by previous investigators, such as Wilson (1977), Ryder (1985), and Duerr and others (1988); and (5) data provided by R.L. Marella, P.A. Metz, and J.L. Robinson (U.S. Geological Survey, written commun., 1989).

Well construction information was the primary factor in estimating the relative amounts of water withdrawn from the two aquifers. The total depth of the well and cased interval were compared to aquifer boundaries to determine which aquifer or aquifers the well was tapping. In Hardee and De Soto Counties, it was estimated that 90 percent of the irrigation wells open to the Upper Floridan aquifer were also open to the intermediate aquifer system. For these wells, aquifer thickness, open hole interval of the well, and the ratio of transmissivities of the two aquifers were used to estimate the proportion of water withdrawn from each aquifer. Information on sources of withdrawals reported by previous investigators also was used to estimate withdrawals from the system.

The total ground water withdrawn in Hardee and De Soto Counties in 1987 and distribution by use category are shown in figure 35. Table 3 depicts water withdrawal by use as well as by aquifer for each county. (For a more detailed description of individual use categories see Tuttell and Sorensen, 1989.) An estimated 111.8 Mgal/d of ground water was withdrawn for all use categories in 1987 in Hardee and De Soto Counties (table 3). Of this 111.8 Mgal/d of water withdrawn, about 97.2 Mgal/d was withdrawn from the highly productive Upper Floridan aquifer.

Public supply includes all water distributed by public-supply water systems to households, industry, agriculture, and other purposes (Duerr and Sohm, 1983). A total of about 2.1 Mgal/d of ground water was withdrawn for public supply in the study area in 1987. Of this total, 0.8 Mgal/d was withdrawn from the intermediate aquifer system in De Soto County and 1.3 Mgal/d was withdrawn from the Upper Floridan aquifer in Hardee County (table 3).

Rural supply includes all water supplied to households that are not supplied by large (withdrawing more than 100,000 gal/d (gallons per day)) public-supply systems. This includes households that have their own water supply and households that are supplied by small public-supply systems.

Table 3. Ground water withdrawn from Hardee and De Soto Counties, 1987

[All values are in million gallons per day]

Water use	Hardee	De Soto	Total
Public supply			
Intermediate aquifer system	0	0.8	0.8
Upper Floridan aquifer	1.3	0	1.3
Total	1.3	.8	2.1
Rural			
Intermediate aquifer system	2.0	1.5	3.5
Upper Floridan aquifer	0	0	0
Total	2.0	1.5	3.5
Industrial			
Intermediate aquifer system	0	0	0
Upper Floridan aquifer	.1	0	.1
Total	.1	0	.1
Irrigation			
Intermediate aquifer system	4.3	5.5	9.8
Upper Floridan aquifer	39.2	56.6	95.8
Total	43.5	62.1	105.6
Miscellaneous			
Intermediate aquifer system	.2	.3	.5
Upper Floridan aquifer	0	0	0
Total	.2	.3	.5
Total (all uses)			
Intermediate aquifer system	6.5	8.1	14.6
Upper Floridan aquifer	40.6	56.6	97.2
Total	47.1	64.7	111.8

Well diameters generally range from 2 to 4 inches. Ground water withdrawn for rural use in the study area in 1987 averaged about 3.5 Mgal/d. All withdrawal was estimated to be from the intermediate aquifer system (table 3).

Industrial supply includes water used by industries that supply their own water. Data do not include water sold to industries by public-supply systems. Table 3 lists 0.1 Mgal/d of ground water withdrawn for industrial supply from the Upper Floridan aquifer in Hardee County. Tuttell and Sorensen (1989) reported an additional 7.4 Mgal/d of ground water withdrawn for industrial supply in Hardee County in 1987. The water was actually withdrawn in nearby Polk County. Similar averages also were published for 1982 and 1984-86 (Southwest Florida Water Management District, 1984; Stieglitz, 1985; 1986; and Stieglitz and Tomik, 1987).

Irrigation supply includes water withdrawn by irrigators from private wells and does not include water supplied by public-supply systems. Irrigation water use generally is not metered, and estimates of water use for irrigation are the least accurate of all water-use data. For a more complete discussion of irrigation water use see Duerr and Sohm (1983) and Tuttell and Sorensen (1989).

Total ground water withdrawn for irrigation in the study area in 1987 was 105.6 Mgal/d (table 3). Of this total, citrus irrigation accounted for 64.9 Mgal/d or 61 percent. Other major water-using crops included truck farming, 31.5 Mgal/d, and melons, 5.6 Mgal/d. Of the 105.6 Mgal/d of

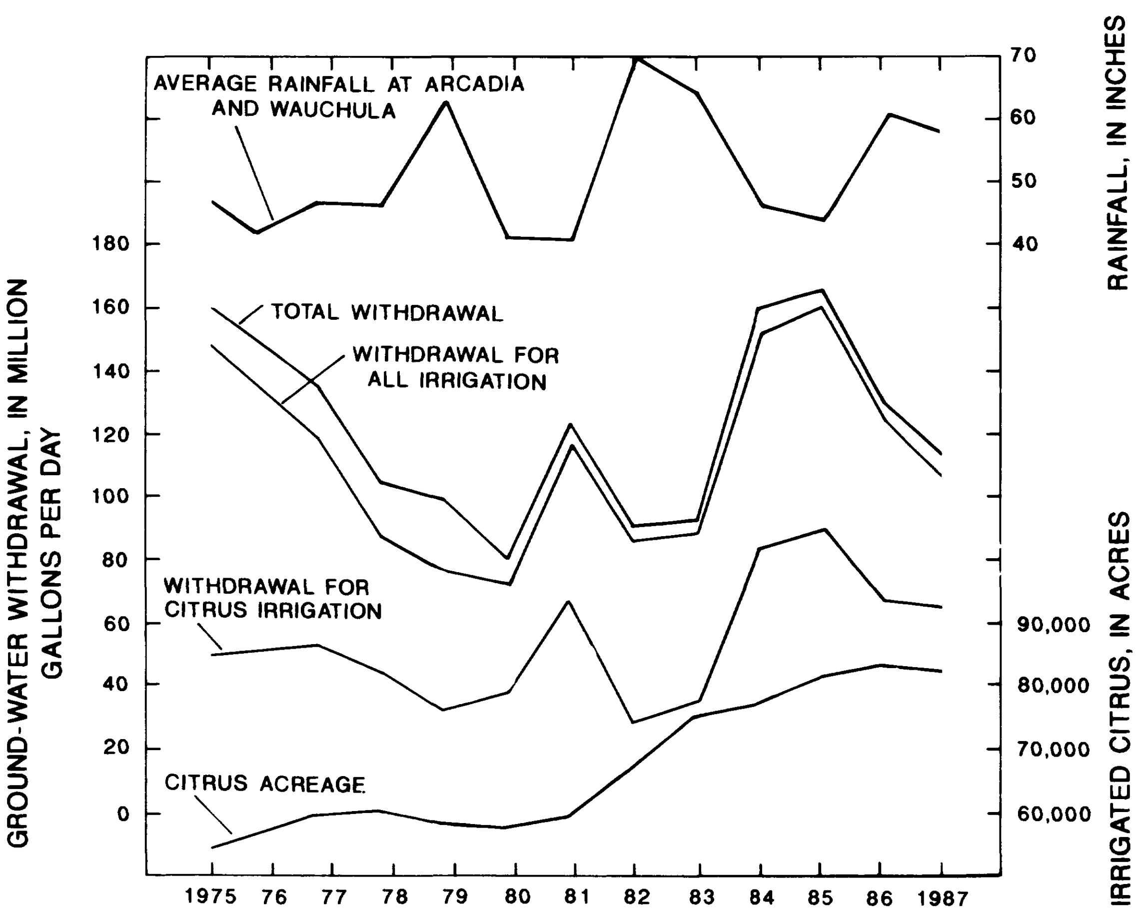


Figure 36. Rainfall, ground-water withdrawal, and irrigated citrus acreage in Hardee and De Soto Counties, 1975–87.

ground water withdrawn for irrigation in 1987, 95.8 Mgal/d was withdrawn from the highly productive Upper Floridan aquifer (table 3).

Southwest Florida Water Management District reported 0.5 Mgal/d of ground water withdrawn for miscellaneous use in Hardee and De Soto Counties in 1987. This water was withdrawn for hospital, institution, and small trailer park supply. All miscellaneous water was withdrawn from the intermediate aquifer system (table 3).

Trends of average annual rainfall at Arcadia and Wauchula, total ground water withdrawn for all uses, irrigation water use, citrus irrigation use, and irrigated citrus acreage for 1975-87 can be discerned from figure 36. Water withdrawn for industrial use (mostly phosphate mining) accounted for most of the larger differences between total water withdrawn and water withdrawn for irrigation. All of the water used for phosphate mining was in Hardee County.

Much of the decline in irrigation water use in the late 1970's can be attributed to increased fuel costs and reductions in pasture irrigation. Water withdrawn for irrigation increased in 1981 because of below normal rainfall (Duerr and Sohm, 1983).

Although citrus irrigation accounted for 61 percent of water withdrawn for irrigation in 1987, truck-farming crops (peppers, tomatoes, cucumbers, and so forth) and melons also used large quantities of ground water for irrigation in Hardee and De Soto Counties. In some years, depending on economic and climatic conditions, as much or more water has been withdrawn to irrigate truck-farming crops and melons as has been withdrawn to irrigate citrus. Since 1982, the number of irrigated acres of truck crops and melons has stabilized at about 12,000 to 15,000 acres. Conversely, the number of irrigated citrus acres has steadily increased from about 57,000 acres in 1980 to more than 82,000 acres in 1987 (fig. 36). Recent freezes in northern counties have caused growers to plant new citrus in the study area where the climate is warmer.

Since about 1980, the quantity of ground water withdrawn to irrigate citrus generally has shown an increasing trend (fig. 36). Annual fluctuations in withdrawals for irrigation were probably the result of rainfall variations. The increasing use by growers of efficient, low-volume irrigation systems most likely has helped deter the increase in water withdrawal from matching the steady increase in citrus acreage. These low-volume citrus irrigation systems have less tolerance to the fine sands from the Tampa Limestone and other sections of the intermediate aquifer system because the sands clog the tiny openings in the water distribution system. Consequently, newly-constructed wells have longer casings, and in many areas, the intermediate aquifer system is completely cased off to avoid the fine sands in that system.

If this trend continues, less water may be withdrawn for citrus irrigation from the intermediate aquifer system in the future, whereas water withdrawn from the Upper Floridan aquifer is likely to increase as growers continue to plant new citrus in the study area. As of October 30, 1989, active consumptive-use permits issued by the Southwest Florida Water Management District showed about 200 Mgal/d of water was permitted for agricultural uses in Hardee and De Soto Counties. Future phosphate production and power generation are proposed in the study area. If developed, each of these industries will require large quantities of freshwater for their operations.

SUMMARY

The principal hydrogeologic units that underlie Hardee and De Soto Counties in west-central Florida are the surficial aquifer, the intermediate aquifer system, and the Floridan aquifer system. The surficial aquifer overlies the intermediate aquifer system and consists of Holocene and Pleistocene deposits containing sand, clayey sand, shell, shelly marl, and some phosphorite. Thickness ranges from 25 to 100 feet, and transmissivity averages about 1,100 ft^2/d.

The intermediate aquifer system includes all water-bearing units and confining material between the overlying surficial aquifer and the underlying Floridan aquifer system. The intermediate aquifer system consists of three or more hydrogeologic units: (1) a sandy clay and clayey sand confining unit in the lower part that lies directly on the Floridan aquifer system; (2) one, two, or three aquifers composed primarily of sand and carbonate rocks; and (3) a sandy clay, clay, and marl confining unit in the upper part that separates the aquifers in the intermediate aquifer system from the overlying surficial aquifer. The top of the intermediate aquifer system ranges from more than 25 feet below sea level to about 100 feet above sea level. Thickness ranges from about 200 feet to about 500 feet, and transmissivity ranges from 400 to 7,000 ft^2/d.

The underlying Floridan aquifer system is defined as a vertically continuous sequence of Tertiary age carbonate rocks of generally high permeability that are hydraulically connected to each other in varying degrees, the permeability of which is several orders of magnitude greater than that of the rocks that bound the system above and below. The Floridan aquifer system consists of the Upper and Lower Floridan aquifers that are separated by a middle confining unit. The middle confining unit and Lower Floridan aquifer generally contain saltwater in the study area. Transmissivity of the Upper Floridan aquifer ranges from about 100,000 ft^2/d in western Hardee County to about 850,000 ft^2/d in northeastern De Soto County.

A comparison of the potentiometric surfaces of the intermediate aquifer system and the underlying Upper Floridan aquifer indicates that, in the northern part of the study area, heads in the intermediate aquifer system are higher than heads in the underlying Upper Floridan aquifer. In that area, there is a potential for water to move downward from the intermediate aquifer system to recharge the Upper Floridan aquifer. The position of the potentiometric surfaces reverse in the southern part of the study area where the underlying Upper Floridan aquifer has higher heads than the intermediate aquifer system. In that area, the potential is for water to move upward from the Upper Floridan aquifer to recharge the intermediate aquifer system.

The potentiometric surface of the intermediate aquifer system is generally higher than the water table in the surficial aquifer in the low-lying areas near the Peace River. As a result, in these areas, ground water moves upward from the intermediate aquifer system into the surficial aquifer.

A seepage run conducted on the Peace River in April 1988 during low flow defined reaches that were gaining water from the intermediate aquifer system. The river gained about 4 ft^3/s per river mile over a 6-mile reach upstream of Zolfo Springs and gained about 1.5 ft^3/s per river mile along an 18-mile reach downstream of Zolfo Springs.

Ground water with the lowest dissolved-solids concentration is in the intermediate aquifer system in northeastern Hardee County. For most dissolved constituents, highest concentrations occur in the Upper Floridan aquifer in southwestern De Soto County. In a large area of De Soto County, the potential exists for nonpotable water in the Upper Floridan aquifer to move upward and degrade the quality of water in the overlying aquifers. Movement of water could be through natural solution channels where confining beds are thin or absent, or through wells that are open to both aquifers.

An estimated 111.8 Mgal/d of fresh ground water was withdrawn for all uses in the study area in 1987. Of this total, an estimated 14.6 Mgal/d was withdrawn from the intermediate aquifer system and 97.2 Mgal/d from the Upper Floridan aquifer. Water withdrawn for irrigation totaled 105.6 Mgal/d; citrus irrigation accounted for 64.9 Mgal/d. Irrigated citrus acreage increased from 57,000 acres in 1980 to more than 82,000 acres in 1987.

Future increases in total ground-water withdrawals are likely as growers continue to plant new citrus in the warmer climate of the study area to escape the tree-killing freezes of recent years in northern counties. As of October 30, 1989, active consumptive-use permits issued by the Southwest Florida Water Management District showed that about 200 Mgal/d of water was permitted for agricultural uses in Hardee and De Soto Counties.

High-yielding wells that tap the productive Upper Floridan aquifer may be needed to irrigate new citrus crop acreage. If the overlying intermediate aquifer system is cased off in these wells, the potential for degradation of that aquifer by the upward movement of nonpotable water from the Upper Floridan aquifer can be minimized. Although the Upper Floridan aquifer contains nonpotable water in Hardee and De Soto Counties, the quality is suitable for most agricultural uses, and the aquifer is more productive than the intermediate aquifer system.

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APPENDIX A

APPENDIX A. Peace River and Tributary Discharge Measurements

[Site no., site numbers are shown in figures 22-23; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens per centimeter; Disch., discharge, in cubic feet per second; Lat., latitude; Long., longitude; number in parenthesis is the U.S. Geological Survey downstream order number; —, measurement not taken or unavailable; A, representative measurement used to calculate ground-water contribution to the river in reach A, shown in figure 24; B, representative measurement used to calculate ground-water contribution to the river in reach B, shown in figure 24; C, representative measurement used to calculate ground-water contribution to the river in reach C, shown in figure 24; D, representative measurement used to calculate ground-water contribution to the river in reach D, shown in figure 24; E, representative measurement used to calculate ground-water contribution to the river in reach E, shown in figure 24]

Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
1	Peace River at Bowling Green (02295194). Lat. 27°38'45" Long. 81°48'09" In Hardee County, at State Highway 664 bridge, 1.0 mile northeast of Bowling Green.	4-26-88 4-28-88	0816 1135	— —	480 78	75 A
2	Peace River Tributary No. 2 near Bowling Green. Lat. 27°38'28" Long. 81°48'07" In Hardee County, 80 feet above mouth, on left bank, 0.4 mile downstream from State Highway 664, and 1.3 miles east of Bowling Green.	4-26-88	0950	—	185	.05
4	Peace River Tributary No. 4 near Bowling Green. Lat. 27°37'27" Long. 81°48'12" In Hardee County, 30 feet above mouth, 200 feet downstream from State Highway 664A (upper), 1.6 miles southeast of Bowling Green.	4-26-88	1136	—	1,080	.12
4B	Peace River at State Highway 664A near Bowling Green (02295203). Lat. 27°37'28" Long. 81°48'10" In Hardee County, at State Highway 664A (upper), 1.6 miles southeast of Bowling Green.	4-26-88 4-28-88	1308 1035	— —	491 —	63 73
5	Payne Creek at State Park near Bowling Green. Lat. 27°37'09" Long. 81°48'09" In Hardee County, at a boat ramp 0.2 mile above mouth, 1.8 miles southeast of Bowling Green.	4-26-88 4-28-88	1443 0950	— —	310 —	40 44
5A	Peace River Tributary No. 5A near Bowling Green. Lat. 27°36'45" Long. 81°47'47" In Hardee County, at mouth, 0.6 mile downstream from Payne Creek, on left bank, 2.4 miles southeast of Bowling Green.	4-26-88	1520	—	—	.1
8B	Peace River below Hog Branch near Wauchula. Lat. 27°36'04" Long. 81°47'59" In Hardee County, 0.1 mile downstream from confluence with Hog Branch, 2.0 miles upstream from State Highway 664A (lower), 3.7 miles north of Wauchula.	4-26-88 4-28-88	1635 1220	— —	430 —	98 B 120

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

[Site no., site numbers are shown in figures 22-23; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens per centimeter; Disch., discharge, in cubic feet per second; Lat., latitude; Long., longitude; number in parenthesis is the U.S. Geological Survey downstream order number; —, measurement not taken or unavailable; A, representative measurement used to calculate ground-water contribution to the river in reach A, shown in figure 24; B, representative measurement used to calculate ground-water contribution to the river in reach B, shown in figure 24; C, representative measurement used to calculate ground-water contribution to the river in reach C, shown in figure 24; D, representative measurement used to calculate ground-water contribution to the river in reach D, shown in figure 24; E, representative measurement used to calculate ground-water contribution to the river in reach E, shown in figure 24]

Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
13	Peace River Tributary No. 13 near Wauchula. Lat. 27°34'34" Long. 81°48'17" In Hardee County, at mouth, 0.1 mile upstream from State Highway 664A (lower), on right bank, 2.0 miles north of Wauchula.	4-26-88	—	22.0	400	.7
14	Peace River Tributary No. 14 near Wauchula. Lat. 27°34'33" Long. 81°48'17" In Hardee County, at mouth, 20 feet upstream from State Highway 664A (lower), on right bank, 1.9 miles north of Wauchula.	4-26-88 4-28-88	0826 0815	26.0 —	329 —	.7 .6
14B	Peace River at State Highway 664A near Wauchula (02295440). Lat. 27°34'32" Long. 81°48'17" In Hardee County, at bridge on State Highway 664A (lower), 2.0 miles north of Wauchula.	4-26-88 4-28-88	0932 0900	25.0 —	469 —	115 A 122
15	Little Charlie Creek at mouth below State Highway 664A near Wauchula. Lat. 27°34'27" Long. 81°48'10" In Hardee County, at mouth, 0.1 mile downstream from State Highway 664A, 1.9 miles north of Wauchula.	4-26-88	1134	23.0	430	2.7
15A	Peace River Tributary No. 15A near Wauchula. Lat. 27°34'20" Long. 81°48'11" In Hardee County, at mouth, on right bank, 0.2 mile downstream from State Highway 664A, 1.8 miles north of Wauchula.	4-26-88	1242	—	520	.3
16	Max Branch at mouth near Wauchula. Lat. 27°33'20" Long. 81°47'24" In Hardee County, at mouth, 0.5 mile upstream from State Highway 64A, 1.5 miles east of Wauchula.	4-26-88	1439	25.0	440	.02
17B	Peace River at Wauchula (02295607). Lat. 27°33'01" Long. 81°47'38" In Hardee County, at State Highway 64A, 1.1 miles east of Wauchula.	4-26-88	1607	—	525	113 B

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
19B	Peace River below State Highway 652 near Wauchula. Lat. 27°32'03" Long. 81°47'38" In Hardee County, 0.4 mile downstream from State Highway 652, 1.4 miles southeast of Wauchula.	4-26-88	0940	24.5	470	135
22	Hickory Branch at mouth near Zolfo Springs. Lat. 27°30'51" Long. 81°47'28" In Hardee County, at mouth, 1.1 miles upstream from U.S. Highway 17, 1.5 miles north of Zolfo Springs.	4-26-88	1055	—	517	.01
22B	Peace River below Hickory Branch near Zolfo Springs. Lat. 27°30'48" Long. 81°47'34" In Hardee County, 1.0 mile upstream from U.S. Highway 17, 200 feet below Hickory Branch, 1.4 miles north of Zolfo Springs.	4-26-88	1155	26.0	484	130
23	Thompson Branch at mouth near Zolfo Springs. Lat. 27°30'32" Long. 81°47'52" In Hardee County, at mouth, 0.5 mile upstream from U.S. Highway 17, 0.5 mile downstream from Hickory Branch, about 0.6 mile downstream from where confluence with Peace River was shown on 1955 Wauchula Quadrangle, 1.1 miles north of Zolfo Springs.	4-26-88	1338	25.0	490	.5
25	Peace River at Zolfo Springs (02295637). Lat. 27°30'15" Long. 81°48'04" In Hardee County, at U.S. Highway 17, 0.8 mile north of Zolfo Springs.	4-26-88	1510	—	517	130 B,C
28	Peace River below State Highway 64 near Zolfo Springs. Lat. 27°29'32" Long. 81°49'16" In Hardee County, 1.7 miles downstream from State Highway 64, 1.5 miles west of Zolfo Springs.	4-26-88	0902	25.0	493	141
31B	Peace River above Alligator Branch near Zolfo Springs. Lat. 27°28'30" Long. 81°49'56" In Hardee County, 100 feet above Alligator Branch, 3.4 miles downstream from State Highway 64, 2.5 miles southwest of Zolfo Springs.	4-26-88	1054	25.0	473	140

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
32	Alligator Branch at mouth near Zolfo Springs. Lat. 27°28'29" Long. 81°49'54" In Hardee County, at mouth, 3.5 miles downstream from State Highway 64, 2.5 miles southwest of Zolfo Springs.	4-26-88	1015	24.5	330	.02
34	Peace River near Mud Lake near Zolfo Springs. Lat. 27°27'56" Long. 81°50'59" In Hardee County, 4.5 miles downstream from State Highway 64, 0.4 mile east of Mud Lake, 2.0 miles below Alligator Branch, 3.8 miles southwest of Zolfo Springs.	4-26-88	1210	—	—	139
35	Troublesome Creek at mouth near Zolfo Springs. Lat. 27°26'48" Long. 81°51'01" In Hardee County, 100 feet above mouth, 6.7 miles downstream from State Highway 64, 0.6 mile above confluence of Hickory Creek and the Peace River, 4.6 miles southwest of Zolfo Springs.	4-26-88	1340	—	—	1.6
36	Peace River below Troublesome near Zolfo Springs. Lat. 27°26'44" Long. 81°51'00" In Hardee County, 6.8 miles downstream from State Highway 64, 0.1 mile downstream from the confluence of Troublesome Creek and the Peace River, 4.7 miles southwest of Zolfo Springs.	4-26-88	1050	—	442	143
37	Peace River Tributary No. 37 near Zolfo Springs. Lat. 27°26'26" Long. 81°51'08" In Hardee County, on right bank, 0.1 mile upstream from confluence of Hickory Creek with the Peace River, 7.3 miles downstream from State Highway 64, 5.0 miles southwest of Zolfo Springs.	4-26-88	1133	—	168	.12
38	Hickory Creek at mouth near Zolfo Springs. Lat. 27°26'24" Long. 81°51'10" In Hardee County, 50 feet above mouth, 7.4 miles downstream from State Highway 64, 5.1 miles southwest of Zolfo Springs.	4-26-88	1157	—	208	.27

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
41	Peace River above Peace River Ranch Bridge near Gardner. Lat. 27°25'24" Long. 81°51'09" In Hardee County, 1.0 mile upstream from Peace River Ranch Bridge, 5.5 miles northwest of Gardner.	4-26-88	1440	—	448	147 C
41A	Peace River Tributary No. 41A near Gardner. Lat. 27°25'22" Long. 81°51'11" In Hardee County, 150 feet above mouth, on right bank, 0.9 mile above Peace River Ranch Bridge, 5.5 miles northwest of Gardner.	4-26-88	1510	—	462	.02
43	Peace River above Oak Creek near Gardner. Lat. 27°24'16" Long. 81°50'57" In Hardee County, above confluence with Oak Creek, 1.3 miles below Peace River Ranch Bridge, 4.6 miles northwest of Gardner.	4-27-88	0938	26.5	457	122 D
43B	Oak Creek at mouth near Gardner. Lat. 27°24'15" Long. 81°50'58" In Hardee County, 150 feet above confluence with Peace River, 4.6 miles northwest of Gardner.	4-27-88	1014	25.0	518	.61
45	Limestone Creek at mouth near Gardner. Lat. 27°22'45" Long. 81°50'37" In Hardee County, 400 feet above mouth, 3.2 miles northwest of Gardner.	4-27-88	1154	24.5	405	.58
45B	Peace River below Limestone Creek near Gardner. Lat. 27°22'44" Long. 81°50'34" In Hardee County, 400 feet below mouth of Limestone Creek, 3.1 miles northwest of Gardner.	4-27-88	1248	28.0	450	121
46	Peace River in section 8 near Gardner. Lat. 27°22'00" Long. 81°49'56" In Hardee County, 1.9 miles upstream from Gardner boat ramp, 1.6 miles above Charlie Creek, 2.1 miles northwest of Gardner.	4-27-88 4-28-88	1357 1040	28.5 —	457 —	126 137
46A	Peace River above Charlie Creek near Gardner. Lat. 27°21'12" Long. 81°49'34" In Hardee County, 0.3 mile above mouth of Charlie Creek, 0.7 mile above boat ramp, 1.5 miles west of Gardner.	4-28-88	1221	—	—	132

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
47	Charlie Creek at mouth near Gardner. Lat. 27°20′58" Long. 81°49′34" In Hardee County, 400 feet above confluence with Peace River, 0.3 mile above Gardner boat ramp, 1.5 miles west of Gardner.	4-27-88 4-28-88	1543 1336	30.0 —	282 —	11.9 11.4
48	Peace River below Charlie Creek near Gardner (02296525). Lat. 27°20′46" Long. 81°49′37" In Hardee County, 15 feet below boat ramp, 0.6 mile above county line, 1.5 miles west of Gardner.	4-27-88 4-27-88 4-27-88 4-28-88	0938 1700 1745 1456	— — — —	440 — — —	144 128 129 141
49	Peace River in section 20 near Brownville. Lat. 27°19′56" Long. 81°50′13" In De Soto County, 1.4 miles downstream from boat ramp, 0.7 mile below county line, 2.4 miles northwest of Brownville.	4-27-88	1139	—	435	146 D,E
51B	Peace River in section 29 near Brownville. Lat. 27°18′45" Long. 81°50′20" In De Soto County, 200 feet below power lines, 0.4 mile below Bear Branch, 1.1 miles above Brownville Road, 1.3 miles west of Brownville.	4-27-88	1414	—	440	150
52	Sand Gully at mouth near Brownville. Lat. 27°18′21" Long. 81°50′27" In De Soto County, 100 feet above mouth, 0.5 mile upstream from Brownville Road, 0.5 mile downstream from location of mouth on 1956 Gardner quadrangle map, 1.1 miles northwest of Brownville.	4-27-88	1524	—	262	.11
53	Peace River near Brownville (02295977). Lat. 27°18′08" Long. 81°50′47" In De Soto County, at Brownville Road, 1.3 miles west of Brownville.	4-27-88 4-27-88	0910 1662	26.0 —	445 430	156 140
54	Mare Branch at mouth near Brownville. Lat. 27°17′47" Long. 81°50′53" In De Soto County, at mouth, 0.4 mile downstream from Brownville Road, 1.4 miles west of Brownville.	4-27-88	0950	24.0	471	2.2

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
55	Peace River Tributary No. 55 near Brownville. Lat. 27°17'28" Long. 81°51'24" In De Soto County, at mouth, on right bank, 0.1 mile above Hampton Branch, 1.1 miles below Brownville Road, 1.9 miles southwest of Brownville.	4-27-88	1035	23.5	574	.16
56	Hampton Branch at mouth near Brownville. Lat. 27°17'23" Long. 81°51'30" In De Soto County, at mouth, 1.2 miles below Brownville Road, 2.0 miles southwest of Brownville.	4-27-88	1110	25.0	650	1.1
57	Peace River Tributary No. 57 near Brownville. Lat. 27°16'55" Long. 81°51'23" In De Soto County, at mouth, on left bank, 0.6 mile below Hampton Branch, 1.8 miles below Brownville Road, 2.2 miles southwest of Brownville.	4-27-88	1200	25.5	350	.13
58	Peace River Tributary No. 58 near Brownville. Lat. 27°16'58" Long. 81°51'40" In De Soto County, at mouth, on right bank, 300 feet above Walker Branch, 2.4 miles southwest of Brownville.	4-27-88	1315	28.0	1,000	.03
59	Walker Branch at mouth near Brownville. Lat. 27°16'56" Long. 81°51'43" In De Soto County, at mouth, 2.2 miles downstream from Brownville Road, 2.5 miles southwest of Brownville.	4-27-88	1305	26.0	985	.51
60	Peace River below Walker Branch near Brownville. Lat. 27°16'46" Long. 81°51'34" In De Soto County, 0.2 mile below Walker Branch, 2.5 miles southwest of Brownville.	4-27-88	1405	29.5	462	152
61	Peace River above McBride Branch near Arcadia. Lat. 27°15'47" Long. 81°52'04" In De Soto County, 0.5 mile above new mouth of McBride Branch, 2.5 miles above railroad bridge, 3.2 miles north of Arcadia.	4-27-88	1042	27.0	460	154
62	McBride Branch near Arcadia. Lat. 27°15'24" Long. 81°52'14" In De Soto County, at mouth, 2.0 miles above railroad, about 1.0 mile upstream from old mouth, near center of section 13, 2.7 miles north of Arcadia.	4-27-88	1141	24.0	—	.57

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
65	Peace River Tributary No. 65 near Arcadia. Lat. 27°14'54" Long. 81°52'50" In De Soto County, at mouth, on left bank, 1.2 miles above railroad, near or at former mouth of McBride Branch, may actually be part of McBride Branch, 2.4 miles northwest of Arcadia.	4-27-88	1244	26.0	470	.05
66	Peace River above railroad near Arcadia. Lat. 27°14'14" Long. 81°53'12" In De Soto County, 0.1 mile above railroad, 2.0 miles northwest of Arcadia.	4-27-88	1404	29.5	450	155
67	Peace River Tributary No. 67 near Arcadia. Lat. 27°14'10" Long. 81°53'09" In De Soto County, at mouth, on left bank, 200 feet above railroad, 1.9 miles northwest of Arcadia.	4-27-88	1430	—	—	.02
68	Peace River Tributary No. 68 near Arcadia. Lat. 27°14'03" Long. 81°53'21" In De Soto County, at mouth, on right bank, 0.2 mile below railroad, 1.9 miles northwest of Arcadia.	4-27-88	1509	27.0	375	1.54
69	Peace River Tributary No. 69 near Arcadia. Lat. 27°13'42" Long. 81°52'56" In De Soto County, at mouth, on left bank, 0.9 mile above State Highway 70, 1.5 miles northwest of Arcadia.	4-27-88	1625	27.5	540	1.50
71	Peace River Tributary No. 71 at Arcadia. Lat. 27°13'21" Long. 81°52'35" In De Soto County, at mouth, on left bank, 300 feet above State Highway 70, 1.0 mile west of Arcadia.	4-27-88	1700	27.0	412	.02
72	Peace River Tributary No. 72 at Arcadia. Lat. 27°13'20" Long. 81°52'34" In De Soto County, at mouth, on left bank, 200 feet above State Highway 70, between old and new bridges, 1.0 mile west of Arcadia.	4-27-88	1730	—	—	1.50

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
72B	Peace River at Arcadia (02296750). Lat. 27°13'19" Long. 81°52'34" In De Soto County, gage is on left bank 500 feet upstream from bridge on State Highway 70, 1.0 mile west of post office in Arcadia, 6.1 miles upstream from Joshua Creek.	4-27-88	1705	31.0	450	184
73	Peace River Tributary No. 73 near Arcadia. Lat. 27°12'55" Long. 81°53'13" In De Soto County, 50 feet above mouth, on right bank, 0.8 mile downstream from State Highway 70, 1.6 miles west of Arcadia.	4-27-88	0915	26.0	330	.18
75	Peace River Tributary No. 75 near Arcadia. Lat. 27°12'24" Long. 81°53'24" In De Soto County, at mouth, on right bank, 1.5 miles below State Highway 70, 1.9 miles southwest of Arcadia.	4-27-88	0959	26.0	330	.26
77	Peace River near Arcadia. Lat. 27°12'05" Long. 81°53'21" In De Soto County, 1.9 miles below State Highway 70, 2.0 miles southwest of Arcadia.	4-27-88	1112	27.0	460	171
78	Peace River Tributary No. 78 near Arcadia. Lat. 27°12'00" Long. 81°53'02" In De Soto County, 50 feet above mouth, on left bank, 2.4 miles below State Highway 70, 1.8 miles southwest of Arcadia.	4-27-88	1210	26.5	323	.57
79	Peace River Tributary No. 79 near Arcadia. Lat. 27°11'31" Long. 81°52'51" In De Soto County, 5 feet above mouth, on left bank, 3.0 miles below State Highway 70, 2.1 miles southwest of Arcadia.	4-27-88	1250	27.5	545	.03
81	Peace River near Nocatee. Lat. 27°10'38" Long. 81°53'47" In De Soto County, 1.4 miles above State Highway 760, 1.5 miles northwest of Nocatee.	4-27-88	1500	29.0	465	175 E

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

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Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
83	Peace River Tributary No 83 near Nocatee. Lat. 27°10'32" Long. 81°53'49" In De Soto County, at mouth, on right bank, 1.2 miles above State Highway 760, 1.4 miles northwest of Nocatee.	4-27-88	1524	29.0	375	.05
84	Joshua Creek at mouth at Nocatee. Lat. 27°09'44" Long. 81°54'06" In De Soto County, 300 feet above mouth, 400 feet above State Highway 760, 1.0 mile west of Nocatee.	4-27-88	1640	27.0	570	22.8
84B	Peace River at Nocatee (02297105) Lat. 27°09'43" Long. 81°54'06" In De Soto County, 500 feet below State Highway 760, 1.0 mile west of Nocatee.	4-27-88	1810	29.0	463	199
86	Peace River Tributary No. 86 near Nocatee. Lat. 27°09'21" Long. 81°54'19" In De Soto County, 50 feet above mouth, on left bank, 0.4 mile below State Highway 760, 1.4 miles southwest of Nocatee.	4-28-88	0825	20.5	200	.04
88	Bee Gum Lake at mouth near Nocatee. Lat. 27°09'10" Long. 81°55'36" In De Soto County, 100 feet above mouth, 1.9 miles below State Highway 760, 2.7 miles southwest of Nocatee.	4-28-88	0900	24.5	455	2.18
89	Peace River Tributary No. 89 near Nocatee. Lat. 27°08"57" Long. 81°55'37" In De Soto County, 100 feet above mouth, on left bank, 2.1 miles below State Highway 760, 2.8 miles southwest of Nocatee.	4-28-88	0903	20.5	549	.02
90	Peace River above Johnson Lake near Nocatee. Lat. 27°08'54" Long. 81°55'46" In De Soto County, 2.2 miles below State Highway 760, 0.6 mile above Johnson Lake, 2.9 miles southwest of Nocatee.	4-28-88	0950	27.0	455	173 E

APPENDIX A. Peace River and Tributary Discharge Measurements—Continued

[Site no., site numbers are shown in figures 22-23; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens per centimeter; Disch., discharge, in cubic feet per second; Lat., latitude; Long., longitude; number in parenthesis is the U.S. Geological Survey downstream order number; —, measurement not taken or unavailable; A, representative measurement used to calculate ground-water contribution to the river in reach A, shown in figure 24; B, representative measurement used to calculate ground-water contribution to the river in reach B, shown in figure 24; C, representative measurement used to calculate ground-water contribution to the river in reach C, shown in figure 24; D, representative measurement used to calculate ground-water contribution to the river in reach D, shown in figure 24; E, representative measurement used to calculate ground-water contribution to the river in reach E, shown in figure 24]

Site No.	Site name and location	Date	Time	Temp.	Cond.	Disch.
91	Johnson Lake at mouth near Nocatee. Lat. 27°08'37" Long. 81°56'11" In De Soto County, 100 feet above mouth, 2.8 miles below State Highway 760, 3.4 miles southwest of Nocatee.	4-28-88	0943	25.5	300	.12
92	Peace River Tributary No. 92 near Nocatee. Lat. 27°08'08" Long. 81°56'30" In De Soto County, at mouth, on left bank, 3.5 miles below State Highway 760, 3.9 miles southwest of Nocatee.	4-28-88	1020	23.0	592	.26
95	Peace River Tributary No. 95 near Fort Ogden. Lat. 27°08'14" Long. 81°56'55" In De Soto County, at mouth, on right bank, 4.0 miles below State Highway 760, 3.5 miles northwest of Fort Ogden.	4-28-88	1130	—	—	.08
96	Peace River above Grass Lake near Fort Ogden. Lat. 27°07'49" Long. 81°56'51" In De Soto County, 1.2 miles above Grass Lake, 2.9 miles above Hancock Lake, 1.6 miles below Johnson Lake, 3.1 miles northwest of Fort Ogden.	4-28-88 Note:	1215 Flow is probably tidally affected.	—	460	182

APPENDIX B

APPENDIX B. Water-Quality Analyses of Water from Selected Wells in Hardee and De Soto Counties

[Well No., well number as shown in figure 26; Depth, depth of well below land surface, in feet; Csg., casing depth below land surface, in feet; Di., diameter of casing, in inches; Aqu., aquifer, UF is Upper Floridan, IA is intermediate, BA is both; Alt. lsd, altitude of land surface, in feet; Lab, water-quality laboratory where analysis was made, USGS is U.S. Geological Survey, SWF is Southwest Florida Water Management District; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens at 25 degrees Celsius; Dis., dissolved solids, in milligrams per liter; Cl, chloride, in milligrams per liter; SO_4, sulfate, in milligrams per liter; Hrd., hardness as $CaCO_3$, in milligrams per liter; Fl, fluoride, in milligrams per liter; B, boron, in micrograms per liter; Nut., nutrients (NO_2+NO_3), in milligrams per liter. NOTE: * indicates uncertain well depth; — indicates no analysis performed]

Well No.	I.D. number	Name	Depth	Csg.	Di.	Aqu.	Alt. lsd.	Date sampled	Lab	Temp.	Cond.	Dis.	Cl	SO_4	Hrd.	Fl	B	Nut.
1	270201081460201	D.T. Brown 6	450	—	6	IA	40	9-15-88	USGS	26.5	890	477	150	34	250	1.0	120	0.19
2	270225081415701	D.T. Brown 10 (25-57)	404	71	8	IA	48	9-13-70	USGS	28.5	1,200	—	—	—	—	—	—	—
2								9-15-88	USGS	28.5	1,400	834	250	170	360	.4	60	.19
3	270246081424301	D.T. Brown 15 (46-43)	408	62	8	IA	46	9-15-88	USGS	26.0	795	488	130	62	250	.6	70	<.02
4	270256081472801	Hancock and Lawrence	900	700	12	UF	36	7-09-87	USGS	30.0	1,710	954	340	180	390	.7	60	—
5	270313081391001	Emerald Island Farms C	1,500	610	12	UF	54	9-13-88	USGS	29.0	1,690	954	290	190	390	.4	70	.10
6	270325081484701	Nat Wolf	1,600	—	12	BA	38	12-15-71	USGS	27.0	1,300	874	270	170	350	.8	—	—
6								5-17-88	USGS	29.0	1,750	—	370	200	—	—	—	—
7	270333081473101	Smith (Aborgia) W-6073	1,211	685	12	UF	42	10-04-62	USGS	28.0	846	507	82	160	310	1.0	—	—
7								7-30-80	USGS	28.5	920	600	110	160	350	1.0	—	—
7								6-16-87	USGS	31.0	2,040	1,240	460	190	500	.6	60	.17
7								5-17-88	USGS	30.0	1,800	—	420	220	—	—	—	—
7								9-20-88	USGS	33.5	2,120	—	380	200	—	—	—	—
8	270347081342901	NAFCO Groves FLRD	1,520	150	12	BA	73	3-08-89	USGS	29.0	1,450	889	290	130	430	.7	—	—
8		liner	450-750		10													
9	270359081464401	Nichols Ranch (35)	377	44	6	IA	44	9-15-87	USGS	—	570	—	55	25	—	—	—	—
10	270410081565201	Morgan	1,100	—	6	BA	39	7-24-85	SWF	28.0	950	660	96	218	—	1.2	—	2.04
11	270412081474901	Bill Athey (Foster)	460	112	6	IA	47	6-19-62	USGS	27.0	605	—	60	56	220	—	—	—
11								9-13-63	USGS	25.0	341	—	71	.4	—	—	—	—
11								9-03-87	USGS	26.0	590	361	60	58	220	1.0	90	<.02
12	270414081584701	Lettuce Lake	1,190	105	16	BA	21	8-05-85	SWF	28.0	1,150	729	161	207	—	1.2	—	.02
13	270417081575601	Rob Lane (Russell)	411	70	8	IA	35	8-12-70	USGS	27.5	1,000	—	—	—	—	—	—	—
13								9-03-87	USGS	27.5	—	813	220	190	440	1.0	60	.14
13								9-15-87	USGS	—	1,330	—	54	180	—	—	—	—
14	270440081434401	Cromwell No. 1	1,500	666	12	UF	51	9-13-88	USGS	27.5	800	447	92	72	250	.7	70	.59
15	270442081494301	Roper Groves	1,189	640	12	UF	47	4-29-63	USGS	30.0	981	710	110	150	310	—	—	—
15								8-20-80	USGS	31.0	1,520	1,030	310	190	460	.8	—	—
15								6-16-87	USGS	31.0	1,370	864	260	160	420	.7	60	.02
16*	270540081335101	NAFCO Groves Intermed.	300	100	—	IA	75	3-08-89	USGS	—	1,520	1,090	360	19	500	.5	—	—
17	270540082001101	Gen. Development M-2	897	605	12	UF	30	9-12-88	USGS	24.5	1,300	915	68	450	460	1.1	170	<.02
18	270540082001102	Gen. Development T-2	496	393	4	IA	30	9-12-88	USGS	25.5	1,140	737	140	230	400	1.3	130	<.02
19	270554082003601	General Development	1,411	1,326	2	UF	33	8-19-80	USGS	30.5	1,420	1,090	200	310	540	1.6	—	—
19								5-17-88	USGS	25.5	1,220	—	160	270	—	—	—	—
20	270725081500701	Dees—while drilling UF	430	254	12	IA	43	2-26-88	USGS	25.0	735	472	69	130	—	1.1	60	—
20	270725081500701	Dees (C. Harrison)	1,280	645	12	UF	43	2-23-89	USGS	30.0	1,120	793	120	260	460	1.2	—	—

APPENDIX B. Water-Quality Analyses of Water from Selected Wells in Hardee and De Soto Counties—Continued

[Well No., well number as shown in figure 26; Depth, depth of well below land surface, in feet; Csg., casing depth below land surface, in feet; Di., diameter of casing, in inches; Aqu., aquifer, UF is Upper Floridan, IA is intermediate, BA is both; Alt. lsd, altitude of land surface, in feet; Lab, water-quality laboratory where analysis was made, USGS is U.S. Geological Survey, SWF is Southwest Florida Water Management District; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens at 25 degrees Celsius; Dis., dissolved solids, in milligrams per liter; Cl, chloride, in milligrams per liter; SO_4, sulfate, in milligrams per liter; Hrd., hardness as $CaCO_3$, in milligrams per liter; Fl, fluoride, in milligrams per liter; B, boron, in micrograms per liter; Nut., nutrients (NO_2+NO_3), in milligrams per liter. NOTE: * indicates uncertain well depth; — indicates no analysis performed]

Well No.	I.D. number	Name	Depth	Csg.	Di.	Aqu.	Alt. lsd.	Date sampled	Lab	Temp.	Cond.	Dis.	Cl	SO_4	Hrd.	Fl	B	Nut.
21*	270803081502401	Hancock Groves (Brantly)	418	77	6	IA	40	12-02-57	USGS	26.0	—	—	76	—	—	—	—	—
21								8-16-88	USGS	26.5	1,160	805	120	290	470	1.0	60	< 0.02
22	270810081481201	G.P. Wood Hospital	565	70	12	IA	54	6-10-65	USGS	28.0	791	—	—	—	—	1.4	—	—
22								9-19-85	SWF	28.0	950	644	71	281	—	1.2	—	< .02
23	270858081582201	Red Hawk Ranch (Nunez)	428	63	6	IA	21	5-21-71	USGS	25.0	1,050	678	87	270	450	1.9	—	—
23								9-12-88	USGS	25.5	1,040	717	90	260	440	1.6	90	.12
24*	271010081515301	Blocker	450	420	6	IA	35	9-15-88	USGS	26.0	675	408	57	60	270	2.4	80	.02
25	271015081432101	Bright Hour Ranch 15-21	396	96	6	IA	61	12-16-71	USGS	24.5	860	546	110	14	260	1.4	—	—
25								8-19-88	USGS	26.0	720	431	89	15	260	1.4	70	.16
26	271023081462301	Carlton 2 by 4 No. 5	1,500	540	16	UF	64	8-17-88	USGS	31.0	1,050	784	54	360	490	1.1	50	< .02
27	271058081471601	Vance Stansel	335	110	4	IA	62	8-18-88	USGS	26.0	600	365	49	31	230	1.1	60	.02
28	271113081543301	Minute Maid (44) D-69	384	99	6	IA	54	6-17-87	USGS	27.5	790	548	88	87	320	2.4	90	.04
28								5-17-88	USGS	27.5	820	—	84	93	—	—	—	—
29	271113081574801	D.L. Cullifer	1,315	511	8	UF	45	2-23-89	USGS	27.5	1,030	792	40	340	530	2.0	—	—
30	271115081462701	ROMP 16 Floridan	942	757	7	UF	64	8-08-85	SWF	29.5	900	606	40	373	—	1.1	—	.02
30								6-17-87	USGS	29.0	900	686	39	320	420	1.1	40	—
31	271115081462702	ROMP 16 Hawthorn	340	300	6	IA	64	7-24-85	SWF	25.5	410	214	41	20	—	1.4	—	.02
32*	271135081372501	Bright Hour Ranch 35-25	1,478	180	12	BA	81	8-19-88	USGS	28.0	660	429	35	110	280	.8	50	< .02
32		liner	338-518		10													
32		liner	504-612		8													
33	271151081410801	Bright Hour Ranch 51-08	335	105	4	IA	73	9-26-85	SWF	27.0	600	369	70	14	—	1.3	—	< .02
33								8-19-88	USGS	25.0	565	396	70	3	210	1.1	60	< .02
34	271228081371101	Bright Hour Ranch 28-11	291	126	4	IA	85	12-16-71	USGS	23.0	600	384	7	2	250	.6	—	—
34								8-19-88	USGS	26.5	575	347	14	2	240	.5	60	< .02
35	271232081392201	ROMP 15 Floridan	1,360	575	10	UF	77	10-09-85	SWF	27.0	900	658	39	329	—	.9	—	< .02
36	271244081504201	City of Arcadia No. 4	353	112	10	IA	65	8-16-88	USGS	27.0	620	380	46	15	250	2.1	60	.04
37	271308081522601	City of Arcadia No. 2	372	263	8	IA	29	10-12-64	USGS	25.5	690	—	34	190	360	1.8	—	—
37								7-25-85	SWF	25.0	525	344	47	16	—	2.1	—	< .02
38	271310081522701	City of Arcadia No. 1	250	84	10	IA	28	12-29-64	USGS	—	630	—	36	140	320	2.0	—	—
38								7-25-85	SWF	26.0	800	547	30	253	—	1.5	—	< .02
38								2-24-89	USGS	24.5	550	375	45	25	230	2.3	—	—
39	271314081445901	Avant Groves	1,412	630	16	UF	68	7-09-64	USGS	31.5	871	620	34	320	430	1.2	—	—
39								6-16-87	USGS	32.0	975	754	35	320	460	1.2	40	.03
40	271355082021301	Treadwell and Flint	1,450	200	12	BA	51	12-13-68	USGS	32.0	1,700	1,470	13	850	980	1.6	50	.10
40		liner	220-450		10													

APPENDIX B. Water-Quality Analyses of Water from Selected Wells in Hardee and De Soto Counties—Continued

[Well No., well number as shown in figure 26; Depth, depth of well below land surface, in feet; Csg., casing depth below land surface, in feet; Di., diameter of casing, in inches; Aqu., aquifer, UF is Upper Floridan, IA is intermediate, BA is both; Alt. lsd, altitude of land surface, in feet; Lab, water-quality laboratory where analysis was made, USGS is U.S. Geological Survey, SWF is Southwest Florida Water Management District; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens at 25 degrees Celsius; Dis., dissolved solids, in milligrams per liter; Cl, chloride, in milligrams per liter; SO_4, sulfate, in milligrams per liter; Hrd., hardness as $CaCO_3$, in milligrams per liter; Fl, fluoride, in milligrams per liter; B, boron, in micrograms per liter; Nut., nutrients (NO_2+NO_3), in milligrams per liter. NOTE: * indicates uncertain well depth; — indicates no analysis performed]

Well No.	I.D. number	Name	Depth	Csg.	Di.	Aqu.	Alt. lsd.	Date sampled	Lab	Temp.	Cond.	Dis.	Cl	SO_4	Hrd.	Fl	B	Nut.
41	271407082000401	AMAX (Hollingsworth 716)	430	60	6	IA	49	8-16-88	USGS	25.0	750	465	57	79	320	1.2	70	0.03
42	271416081374601	Joshua J-14 (TRG)	1,492	193	12	BA	86	2-11-71	USGS	29.5	1,000	—	—	—	—	—	—	—
42								8-18-88	USGS	30.0	950	728	33	330	460	1.1	50	<.02
42		liner	269-514		10													
43	271512081344701	Joshua Tier Barn 3	300	90	4	IA	90	10-26-71	USGS	25.5	920	600	150	9	290	1.2	—	—
43								8-18-88	USGS	28.0	730	488	35	170	320	.9	50	<.02
44	271517081502201	Carl Regan	327	84	4	IA	62	9-10-87	USGS	27.0	532	322	42	27	190	2.0	50	<.02
45	271517081542201	Allen Burtscher (704)	320	130	8	IA	59	8-16-88	USGS	25.0	775	496	53	74	320	1.7	80	.17
46	271520081394201	Joshua Tier Barn 1 (TRG)	294	105	4	IA	86	10-26-71	USGS	—	670	398	97	5	210	2.0	—	—
46								5-23-73	USGS	—	650	448	86	6	210	2.0	—	—
46								9-18-73	USGS	26.0	650	403	94	5	200	1.2	—	—
46								5-13-74	USGS	25.5	760	496	130	7	190	2.0	80	—
46								9-04-74	USGS	26.0	620	—	84	12	210	1.9	80	—
46								8-18-88	USGS	26.0	630	360	76	17	210	1.7	80	<.02
47	271521081374301	Joshua Tier Barn 2 (TRG)	300	150	4	IA	89	10-26-71	USGS	—	740	454	81	81	190	2.6	—	—
47								8-18-88	USGS	26.0	725	424	83	42	190	2.3	140	<.02
48	271610081565401	Cunningham AMAX NPFO 4	1,040	350	8	BA	60	8-01-85	SWF	26.1	1,400	1,240	30	693	—	1.2	—	.02
49	271624081520001	Camp Chanyatah No. 3	208	80	4	IA	20	9-03-87	USGS	24.0	860	631	24	260	430	1.7	60	.02
50*	271653081464701	W.F. Underhill (Conger)	1,300	460	10	UF	80	5-20-71	USGS	30.0	760	540	17	240	340	1.4	—	—
50								6-17-87	USGS	27.0	620	384	29	86	250	1.5	50	<.02
51	271713081504901	J.H. Brock (50) (D-122)	257	47	4	IA	34	10-27-71	USGS	24.0	700	474	34	140	300	2.1	—	—
51								6-17-87	USGS	24.5	680	454	35	110	300	1.8	60	<.02
52	271717081522601	Sorrell Groves 17-26	893	511	12	UF	62	6-24-64	USGS	—	1,230	910	19	610	830	1.8	—	—
52								6-17-87	USGS	31.0	1,490	1,460	16	820	980	1.6	40	<.02
53	271743081374601	Joshua J-18.1 (TRG)	698	137	12	BA	89	8-21-85	SWF	26.0	800	672	12	216	—	.8	—	.02
53		liner	261-389		10													
53		liner	430-482		8													
54	271743081374602	Joshua J-18.2 (TRG)	1,343	137	12	BA	89	8-01-72	USGS	—	900	605	75	150	350	1.5	—	—
54		liner	262-390		10			5-17-88	USGS	30.0	1,060	—	28	430	—	—	—	—
55	271748081345101	Joshua J-36 (TRG)	1,361	180	12	BA	93	8-18-88	USGS	31.0	920	717	16	360	470	.8	40	<.02
55		liner	352-594		10													
56	271757081493002	ROMP 26 Floridan	1,320	580	12	UF	75	8-07-85	SWF	30.5	950	701	16	357	—	.8	—	.03
56								5-05-86	USGS	31.5	—	662	14	340	490	1.0	50	.01
57	271757081493003	ROMP 26 Hawthorn	180	140	12	IA	76	7-31-85	SWF	22.5	430	325	3	109	—	1.1	—	<.01
58	272012081482501	D.E. Marshall	478	137	5	IA	63	7-31-85	SWF	25.0	700	525	21	197	—	.9	—	<.02

APPENDIX B. Water-Quality Analyses of Water from Selected Wells in Hardee and De Soto Counties—Continued

[Well No., well number as shown in figure 26; Depth, depth of well below land surface, in feet; Csg., casing depth below land surface, in feet; Di., diameter of casing, in inches; Aqu., aquifer, UF is Upper Floridan, IA is intermediate, BA is both; Alt. lsd, altitude of land surface, in feet; Lab, water-quality laboratory where analysis was made, USGS is U.S. Geological Survey, SWF is Southwest Florida Water Management District; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens at 25 degrees Celsius; Dis., dissolved solids, in milligrams per liter; Cl, chloride, in milligrams per liter; SO_4, sulfate, in milligrams per liter; Hrd., hardness as $CaCO_3$, in milligrams per liter; Fl, fluoride, in milligrams per liter; B, boron, in micrograms per liter; Nut., nutrients (NO_2+NO_3), in milligrams per liter. NOTE: * indicates uncertain well depth; — indicates no analysis performed]

Well No.	I.D. number	Name	Depth	Csg.	Di.	Aqu.	Alt. lsd.	Date sampled	Lab	Temp.	Cond.	Dis.	Cl	SO_4	Hrd.	Fl	B	Nut.
59	272014081595701	Hollingsworth 751	430	144	—	IA	81	2-24-89	USGS	25.0	495	326	13	17	230	1.3	—	—
60	272036081384701	Davis 10 Mi Grade 2	1,250	450	12	UF	95	12-14-88	USGS	28.0	815	637	12	330	430	1.0	30	0.45
61	272043081384701	Davis 10 Mi Grade 1	1,200	200	12	BA	95	12-14-88	USGS	28.0	790	598	13	290	400	1.0	30	.08
61		liner	400-600		10													
62	272103081480701	Hazel Williams	199	129	4	IA	74	2-24-89	USGS	24.0	470	307	14	4	240	.7	—	—
63	272107081580601	Hollingsworth	—	147	10	BA	76	2-24-89	USGS	31.0	2,460	2,460	17	1,500	1,700	1.7	—	—
63		liner	230-560		8													
64	272108081582601	Hollingsworth 620	335	146	6	IA	79	2-24-89	USGS	25.5	770	593	20	250	390	1.3	—	—
65*	272118081473401	Circle 5 Ranch (Bowen)	1,345	580	8	UF	75	6-30-88	USGS	24.5	475	271	14	3	230	.4	40	.19
66	272225081395101	D.C. Brown Ranch	300	—	—	IA	94	3-08-89	USGS	26.0	560	376	17	120	270	1.1	—	—
67	272403081410501	Schoonover	1,261	425	10	UF	80	12-14-88	USGS	29.0	640	485	7	240	320	.8	20	.02
68	272709081591701	Edwin Sasser	1,280	479	8	UF	86	6-30-88	USGS	28.0	420	297	15	65	220	.7	20	<.02
69	272714081545901	ROMP 31 Floridan	1,152	460	8	UF	78	11-21-78	USGS	25.5	700	—	14	—	—	—	—	—
69								5-23-79	USGS	24.5	640	—	35	—	—	—	—	—
69								5-22-80	USGS	25.5	518	—	27	—	—	—	—	—
69								4-27-82	USGS	27.5	505	—	13	—	—	—	—	—
69								8-14-85	SWF	29.5	465	359	12	101	—	.4	—	<.01
69								4-05-88	USGS	25.0	540	—	12	—	—	—	—	—
69								10-11-88	USGS	25.5	550	—	11	—	—	—	—	—
70	272714081545902	ROMP 31 Hawthorn	350	130	8	IA	78	11-21-78	USGS	25.0	940	—	110	—	—	—	—	—
70								5-23-79	USGS	26.0	1,210	—	120	—	—	—	—	—
70								5-28-80	USGS	24.5	1,110	—	140		—		—	—
70								4-27-82	USGS	25.0	1,040	—	130	—	—	—	—	—
70								8-01-85	SWF	25.0	750	537	109	70	—	1.6	—	.14
70		pumped at 240 gallons per minute						3-29-88	USGS	25.5	870	550	87	76	310	2.2	160	—
70								4-05-88	USGS	24.5	1,080	—	110	—	—	—	—	—
70								10-11-88	USGS	25.0	1,060	—	110	—	—	—	—	—
71	272715081401601	Wilbur Robertson (20)	343	103	6	IA	75	12-14-71	USGS	23.0	422	280	10	100	160	1.7	—	—
71								11-23-87	USGS	23.0	385	217	9	40	180	1.1	20	1.40
72	272718081342401	Thomas Spuckler	372	231	4	IA	85	3-08-89	USGS	22.5	362	229	9	53	150	1.5	—	—
73	272728081474701	ROMP 30 Floridan	1,266	380	8	UF	67	8-14-85	SWF	26.0	700	485	18	2	—	.8	—	.02
74	272728081474702	ROMP 30 Tampa	316	280	8	IA	67	8-14-85	SWF	25.0	500	388	25	142	—	1.2	—	.03
75	272917081453901	William Anderson	140	42	4	IA	83	12-14-71	USGS	23.5	315	204	8	16	140	1.0	—	—
75								9-09-87	USGS	23.5	328	198	14	15	150	1.3	30	<.02
76	272932081492001	Jeff Surrency (Martens)	177	34	4	IA	55	9-09-87	USGS	25.5	490	369	14	110	260	1.4	30	<.02

APPENDIX B. Water-Quality Analyses of Water from Selected Wells in Hardee and De Soto Counties—Continued

[Well No., well number as shown in figure 26; Depth, depth of well below land surface, in feet; Csg., casing depth below land surface, in feet; Di., diameter of casing, in inches; Aqu., aquifer, UF is Upper Floridan, IA is intermediate, BA is both; Alt. lsd, altitude of land surface, in feet; Lab, water-quality laboratory where analysis was made, USGS is U.S. Geological Survey, SWF is Southwest Florida Water Management District; Temp., temperature, in degrees Celsius; Cond., specific conductance, in microsiemens at 25 degrees Celsius; Dis., dissolved solids, in milligrams per liter; Cl, chloride, in milligrams per liter; SO_4, sulfate, in milligrams per liter; Hrd., hardness as $CaCO_3$, in milligrams per liter; Fl, fluoride, in milligrams per liter; B, boron, in micrograms per liter; Nut., nutrients (NO_2+NO_3), in milligrams per liter. NOTE: * indicates uncertain well depth; — indicates no analysis performed]

Well No.	I.D. number	Name	Depth	Csg.	Di.	Aqu.	Alt. lsd.	Date sampled	Lab	Temp.	Cond.	Dis.	Cl	SO_4	Hrd.	Fl	B	Nut.
77	272942081495701	Scott (T.C. Hart) 604	321	82	6	IA	90	12-08-71	USGS	—	370	246	6	24	180	1.2	—	—
77								9-10-87	USGS	26.0	473	302	11	60	220	2.0	30	0.02
78	272944081474001	Zolfo Springs No. 1	1,002	350	10	UF	65	12-09-71	USGS	29.5	700	486	19	200	320	1.1	—	—
78								8-21-74	USGS	29.5	706	507	18	190	340	1.1	—	—
78								2-05-86	USGS	30.0	—	456	17	180	340	1.0	50	.01
78								12-09-87	USGS	30.0	645	464	18	170	340	1.0	30	<.02
79	272945081474101	Zolfo Springs No. 2	933	350	8	UF	65	12-09-87	USGS	30.0	650	466	18	180	340	1.0	30	.12
80	273033081513801	Albert Carlton	1,280	680	8	UF	102	12-13-88	USGS	23.0	500	314	22	22	200	2.8	50	.12
81	273103081363701	M.A. Smith	849	66	6	BA	70	10-04-62	USGS	25.5	236	126	7	20	100	.4	—	—
81								4-03-73	USGS	—	229	—	5	—	—	—	—	—
81								9-19-77	USGS	—	239	—	6	—	—	—	—	—
81								9-25-85	SWF	28.0	210	136	6	19	—	.3	—	<.01
82	273112081595601	Doyle Carlton, Jr.	1,360	900	10	UF	110	3-30-66	USGS	26.5	490	—	12	47	190	1.0	—	—
82								12-13-88	USGS	25.5	430	271	39	22	190	1.6	40	.08
83	273156081451401	Rowell	267	39	6	IA	98	8-15-85	SWF	24.0	270	194	8	9	—	1.5	—	<.01
84	273254081480601	City of Wauchula No. 4	1,152	420	14	UF	69	9-xx-68	PRIV	—	623	—	18	236	376	—	—	—
84								12-09-87	USGS	28.0	730	535	10	250	390	.5	20	<.02
85	273337081393301	Floyd Smith	1,119	178	10	BA	91	1-10-64	USGS	25.0	—	—	14	—	—	—	—	—
85								2-23-89	USGS	24.0	317	206	10	20	150	.7	—	—
86	273345081371701	Charlie Stevens	225	100	4	IA	77	2-24-89	USGS	21.0	167	111	3.1	1.3		80	.5	—
87	273356081371701	Ed McClelland	226	110	4	IA	80	2-24-89	USGS	19.0	170	138	7	22	83	.7	—	—
88	273403081494701	Ed Jernigan (26)	298	83	4	IA	122	12-09-71	USGS	—	343	226	7	0	140	1.2	—	—
88								11-23-87	USGS	—	340	191	7	1	150	1.1	30	.26
89	273423081371701	Harold McClelland	210	100	—	IA	73	2-24-89	USGS	24.0	275	169	9	3	140	.6	—	—
90	273435081444001	Henderson (Geiger) (624)	293	105	6	IA	110	11-12-87	USGS	24.5	585	393	21	110	250	1.5	50	.02
91	273543081590301	Dewey Waters	400	90	4	IA	125	3-15-66	USGS	—	372	—	—	20	—	—	1.7	—
91								12-09-87	USGS	25.0	410	251	27	14	170	1.8	30	.04
92	273608082023001	Peace Valley Groves	1,160	450	12	UF	131	12-14-88	USGS	25.5	440	283	14	64	190	.9	20	.06
93	273714081483101	Paynes Cr. Historical	130	119	—	IA	62	9-09-87	USGS	24.5	522	304	39	32	180	1.8	40	.02
94	273744081565301	C.F. Industries A	1,205	600	16	UF	122	12-09-87	USGS	28.0	390	258	7	70	200	.4	20	<.02
95	273749081564701	C.F. Industries C	950	600	8	UF	122	12-09-87	USGS	27.0	420	271	9	79	210	.4	20	<.02
96	273821081493901	City of Bowling Green 4	1,218	418	16	UF	118	12-09-87	USGS	29.0	840	646	10	330	450	.5	20	.12