DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

WATER-RESOURCES INVESTIGATIONS 82-4086

INTRODUCTION

The Floridan aquifer is the principal source of freshwater in west-central Florida (fig. 1). The aquifer, in ascending stratigraphic order, includes the Lake City Limestone, Avon Park Limestone, Ocala Limestone, Suwannee Limestone, Tampa Limestone, and permeable parts of the Hawthorn Formation that are in hydraulic connection with the rest of the aquifer. Recharge to the Floridan is from local rainfall and from infiltration from overlying aquifers. Recharge occurs wherever geologic and hydrologic conditions are favorable for water to move into the aquifer.

The altitude of the potentiometric surface is the level, referenced to sea level, to which water will rise in tightly cased wells that tap the Floridan aquifer. The surface is mapped by determining the altitude of water levels in a network of wells and is represented on maps by lines that connect points of equal altitude.

This report describes the long-term and short-term trends and fluctuations of the potentiometric surface of the Floridan aquifer. Data shown include: (1) annual rainfall and departure from average rainfall at St. Leo and Arcadia from 1961 through 1980, and hydrographs of selected wells; and (2) maps that show change in the potentiometric surface of the Floridan aquifer from January 1964 to May 1969, from May 1969 to May 1975, from May 1975 to May 1980, from September 1975 to September 1980, and from January 1964 to May 1980. A map that shows seasonal change of the potentiometric surface of the Floridan aquifer from May 1980 to September 1980, graphs that show water levels, pumpage, and rainfall at Lakeland, Polk County, from 1975 through 1980, and a table that shows ground-water withdrawals of selected counties are also included.

FLUCTUATIONS AND LONG-TERM TRENDS OF THE POTENTIOMETRIC SURFACE

Fluctuations and long-term trends of water levels in wells that tap the Floridan aquifer and the relation to annual rainfall are shown by hydrographs in figure 2. The graphs show irregular patterns, but generally indicate that water levels in the northern half of the area, where water use is small, have remained nearly unchanged from year to year and during each year, whereas water levels in the southern half, where water use is large, have large annual and year-to-year fluctuations. Generally, the highest water levels occur in September or October, following the rainy season, when water use is at a minimum. The lowest levels occur in May, when water use is generally at a maximum, shortly before the rainy season.

In general, water levels in the northern area changed little from 1961 to 1980. Graphs of water levels in the North Lecanto, Weeki Wachee, SR577, and Pasco 13 wells (fig. 2) show that water levels in the north follow a cyclic pattern of rise and fall that, in general, corresponds with the wet and dry seasons each year. The graphs do not show a significant decline in water levels or progressive trends, although rainfall was below the 1941-70 normal (56.49 inches) during the period. In northwest Hillsborough and northeast Pinellas Counties, where pumpage of ground water for municipal use was heavy, water levels during 1961-74 decline at an average annual rate of less than 1 foot per year (Healy, 1975). Graphs of water levels in Hillsborough deep well 13 near Citrus Park and Pinellas well 665 near Clearwater (fig. 2) illustrate the long-term decline. Water levels in the Hillsborough deep well 13 recovered considerably from 1973 to 1980, primarily in response to decreased municipal pumpage, but water levels remain below 1961 levels.

Water levels in the southern area fluctuated widely during 1961-80. Hydrographs of Tampa well 15 near Dover, Mulberry deep well at Mulberry, Marshall deep well near Gardner, and Sarasota well 9 near Sarasota (fig. 2) show that water levels during any year undergo large amplitudes of decline and rise. Steep water-level declines occur during spring when rainfall is small and irrigation pumpage is large and almost equally large and rapid rises occur at the end of spring when pumpage for irrigation generally ceases at the start of the rainy season, usually in late May or early June.

Hydrographs of southern area wells show an overall small downward trend in annual high levels and a wide range of seasonal low levels. From 1961 to about 1975, the hydrographs show a net decline in annual lows and an increase in the magnitude of seasonal fluctuations. During the period 1976-79, levels trended upward and the magnitude of seasonal fluctuations decreased. However, the seasonal low- and high-water levels in all four southern area wells in the spring of 1980 remained below 1964 levels. The net decline in annual high-water levels ranges from about 5 feet in Tampa well 15 to about 19 feet in the Mulberry deep well. This indicates that discharge from the Floridan aquifer exceeded recharge since 1961. Overall, the long-term trend in the southern area wells is downward.

The wide range of seasonal low levels is probably due to year-to-year differences in the times and amounts of spring rainfall and irrigation withdrawals. Increases in the magnitude of annual fluctuations and the downward trend in annual lows from 1961 to about 1975 reflect the regional increase in seasonal and annual ground-water withdrawals. A decrease in industrial and agricultural pumpage during 1976-80 probably caused the upward trend in annual lows.

Changes in water levels between May and September 1980, shown in figure 3, reflect general recovery due to recharge during the rainy season and cessation of irrigation pumpage. The largest change is in the agricultural area of southern Hillsborough County where water levels rose more than 20 feet. Water levels in this area are sensitive to regional pumpage and levels respond rapidly to changes in withdrawal rates.

AREAL PATTERNS OF WATER-LEVEL FLUCTUATION

Changes in ground-water levels can be portrayed by maps that compare differences in water levels over a period of time. The change is generally mapped by determining differences in the altitude of water levels in a network of wells or by determining differences in potentiometric surface maps during the period and shown on maps by lines that connect points of equal change. Figures 4, 5, 6, 7, and 8 are maps that illustrate the change in water levels of the potentiometric surface of the Floridan aquifer from January 1964 to May 1969, from May 1969 to May 1975, from May 1975 to May 1980, from September 1975 to September 1980, and from January 1964 to May 1980, respectively. The maps present the areal pattern and magnitude of water-level changes during the selected periods. In areas where recharge exceeded discharge, water levels rose. Likewise, in areas where discharge exceeded recharge, water levels declined.

Change in Water Levels, 1964 to 1975

The change in water levels of the Floridan aquifer from January 1964 to May 1969, and May 1969 to May 1975, are shown in figures 4 and 5, respectively. The most significant feature of the maps is the water-level decline in the south-central part of the study area. Water levels in southwest Polk, southeast Hillsborough, northeast Manatee, and northwest Hardee Counties declined more than 40 feet between January 1964 and May 1975. Because levels in January are generally higher than those in May, the declines shown from January 1964 to May 1969 would probably have been less if water levels had been available for comparison for the same month.

The regional depression in the potentiometric surface in the south between 1964 and 1975 (figs. 4 and 5) is caused primarily by ground-water withdrawals. The largest declines are the result of a combination of pumpage for phosphate mining, mostly in southwest Polk County, and widespread agricultural pumpage in Hillsborough, Hardee, Manatee, De Soto, Polk, and Sarasota Counties.

A comparison of figure 4 to figure 5 shows that the magnitude of change and major center of decline changed slightly. The most significant change is the southwesterly movement of the major center of decline from southwest Polk County (fig. 4) to northeast Manatee County (fig. 5). By May 1975, expanding agricultural development and water use had extended the major area of decline south into Manatee, Hillsborough, and Sarasota Counties. The largest decline was within and adjacent to a large seasonal depression in the potentiometric surface centered in southwest Hillsborough County, extending from Pinellas County southeast into Manatee County. Although the depression in the potentiometric surface was not apparent until May 1975, seasonal low-water levels probably first occurred in parts of this area in the late 1960's (Wilson and Gerhart, 1979).

Change in Water Levels, 1975 to 1980

A comparison of water-level changes from May 1975 to May 1980 (fig. 6) and from September 1975 to September 1980 (fig. 7) shows that levels in most of the area have not changed appreciably except in the phosphate and agricultural parts of Polk, Hillsborough, Manatee, Hardee, and Sarasota Counties. As shown, water levels rose more than 20 feet from May 1975 to May 1980 in southwest Polk, Hardee, northeast Manatee, and southeast Hillsborough Counties (fig. 6). In northern Hillsborough County where ground-water withdrawals have been large, water levels rose 5 to 10 feet from May 1975 to May 1980. From September 1975 to September 1980, water levels rose more than 10 feet in southeast Polk County (fig. 7). Water levels in northern and coastal areas of west-central Florida in 1980 were generally within 5 feet of 1975 levels. The maps show that there have been larger rises over a much greater area during low water-level periods, which coincide with the irrigation season, than during high water-level periods.

Comparing changes in water levels from 1975 to 1980 (fig. 6) and from 1964 to 1975 (figs. 4 and 5) indicates that ground-water levels have generally recovered in areas of previous declines. However, it is important to note that the rise in water levels during 1975-80 did not offset declines during 1964-75, particularly in the south-central part of the study area.

The recovery of water levels in the south-central part of the study area reflects the effects of decreased agricultural and industrial pumpage during 1975-80 (table 1). Agricultural withdrawals, which are seasonal and greatly influence yearly low-water levels, decreased from 365 Mgal/d in 1975 (Leach, 1978) to 302 Mgal/d in 1980 (Duerr and Trommer, 1981b). De Soto, Hardee, and Polk Counties had the largest reduction in agricultural pumpage—the remainder of the counties had slight to moderate increases. Industrial withdrawals, primarily phosphate mining and processing and citrus processing and packing, totaled 269 Mgal/d in 1980, a decrease of 62 Mgal/d from 1975. Polk County, which uses the most water for industrial purposes, showed the largest decrease in withdrawals. Industrial use of water is small in the other counties except in Hillsborough County where withdrawals increased from 53 Mgal/d in 1975 to 59 Mgal/d in 1980.

The effects of decreasing ground-water withdrawals on water levels can be seen on graphs showing the relation between water levels at Mulberry (Polk County), pumpage in Polk County, and rainfall at Lakeland (11 miles north of Mulberry) from 1975 through 1980 (fig. 9). The graphs show a good correlation between water levels and pumpage. A rise in water levels corresponds primarily with decreased pumpage, although rainfall affects the demands for water and consequently the magnitude of pumpage.

The change in water levels from May 1975 to May 1980 (fig. 6) reflects the regional influence of seasonal variations in withdrawals during low water-level periods. The largest rises were in areas of large decreases in agricultural and industrial withdrawals (table 1) and where seasonal water use is normally heavy. In coastal, northern, and extreme southern areas where withdrawals are light and changes in withdrawal rates were small, recoveries of May water levels from 1975 to 1980 were comparatively small. The exceptions are small, isolated areas of declines in eastern Hillsborough County and central Pasco County and parts of Hernando and Citrus Counties where water levels continued to decline between 1975 and 1980.

The change in water levels from September 1975 to September 1980 primarily reflects a decrease in total water withdrawals since 1975, mainly by the phosphate industry. Water levels recovered most in the phosphate mining area of southwest Polk County (fig. 7). The rise of water levels in the center of areas of previous decline, primarily in Polk County, reflects the effects of reduced pumpage. Water levels can be expected to continue to rise as long as ground-water withdrawals decrease. Should pumping rates increase, however, water levels will decline until recharge balances the rate of discharge.

Change in Water Levels, 1964 to 1980

The areal pattern and magnitude of change in water levels from January 1964 to May 1980 are shown in figure 8. An important feature of this map is the long-term decline of water levels in the lower three-fourths of the study area. The major area of decline, centered in the agricultural sections of southern Hillsborough and northern Manatee Counties, extends from southwest Polk County southwesterly into northeast Sarasota County. Water levels in this area declined from 5 to more than 30 feet from January 1964 to May 1980.

In the northern area, water levels showed a slight recovery in eastern Levy and western Citrus, Hernando, and Marion Counties. Water levels in these areas were zero to 5 feet higher in May 1980 than in January 1964. Water levels in the remainder of the northern area were zero to 5 feet lower in May 1980 than in January 1964. The exception is in the municipal well-field areas of northern Hillsborough, northeastern Pinellas, and central Pasco Counties where water levels declined from 5 to 20 feet.

SUMMARY

Water levels rose more than 20 feet from May 1975 to May 1980 in southwest Polk, Hardee, northeast Manatee, and southeast Hillsborough Counties; however, the rise did not offset declines during 1964-75. The depression in the potentiometric surface that was present prior to 1975 in the south-central part of the study area lessened and shifted slightly southwestward from Polk County into Manatee, Hillsborough, and Sarasota Counties. In isolated areas of eastern Hillsborough and central Pasco Counties and parts of Hernando and Citrus Counties, water levels continued to decline during 1975-80.

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———1980b, Potentiometric surface of the Floridan aquifer, Southwest Florida Water Management District, September 1980: U.S. Geological Survey Open-File Report 80-1280, 1 sheet.

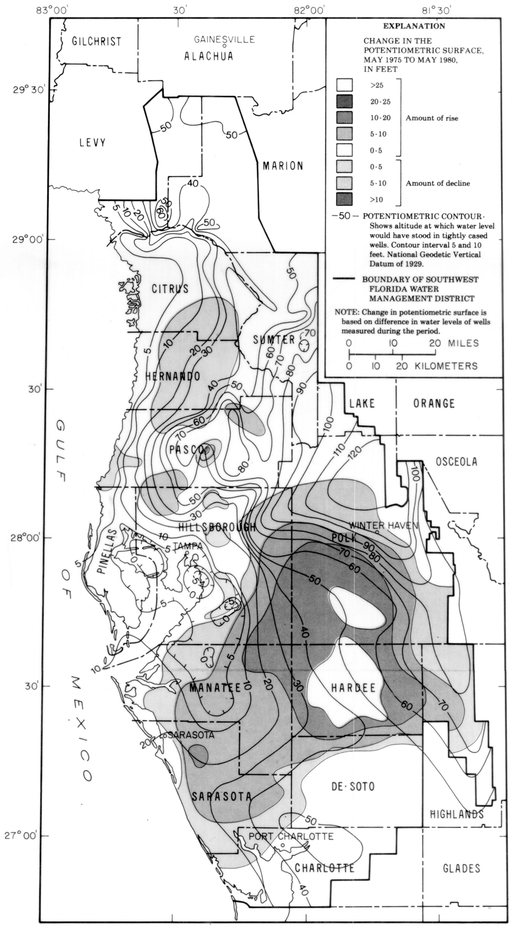


Figure 6.— Potentiometric surface of the Floridan aquifer, May 1980 (Yobbi and others, 1980a), and change of the potentiometric surface, May 1975 to May 1980.

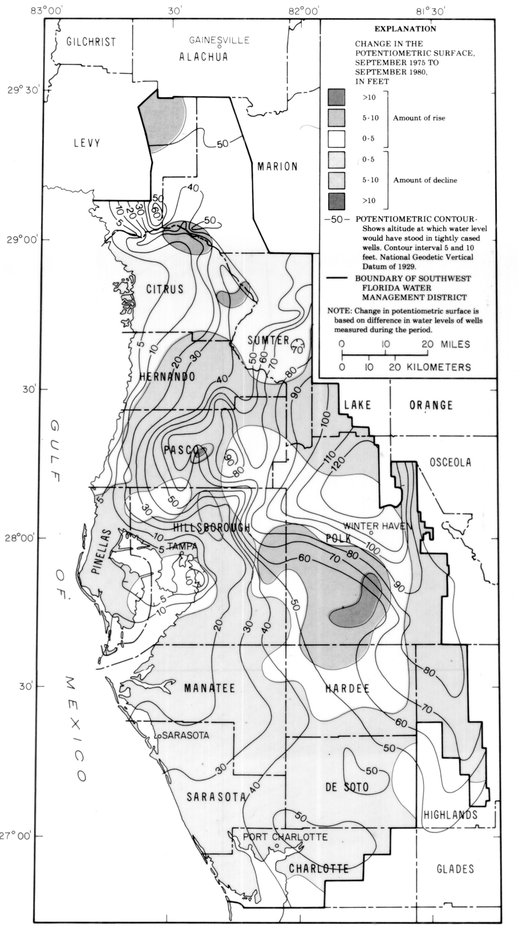


Figure 7.— Potentiometric surface of the Floridan aquifer, September 1980 (from Yobbi and others, 1980b) and change of the potentiometric surface, September 1975 to September 1980.

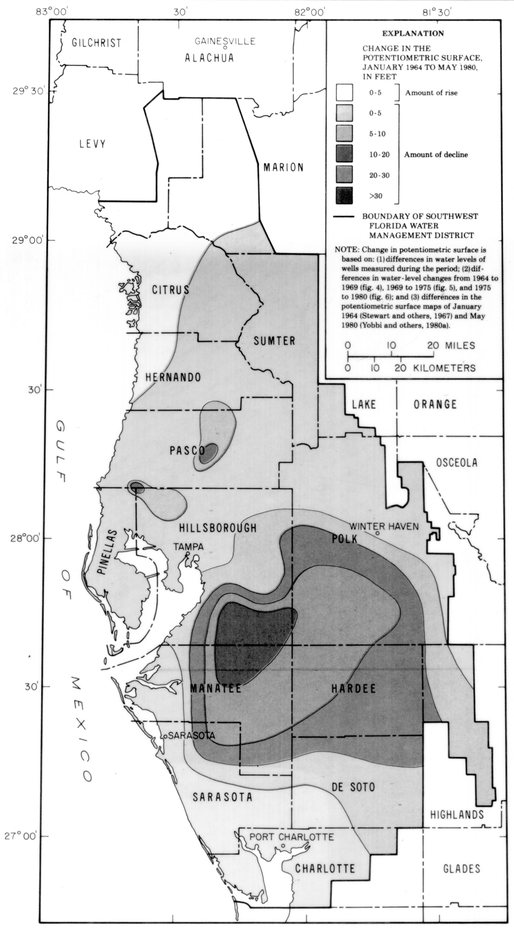
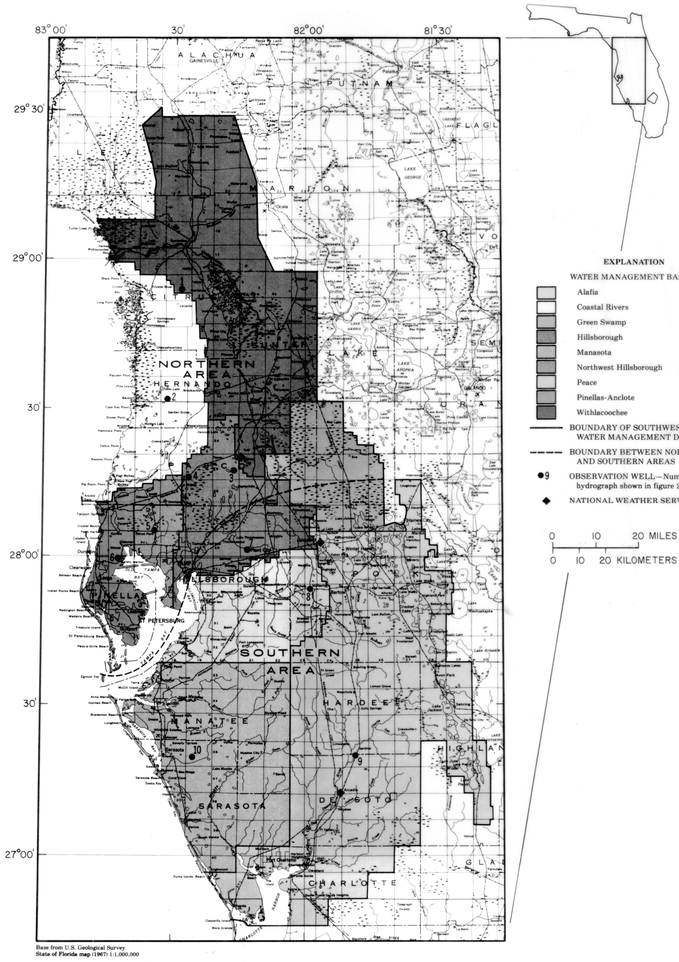
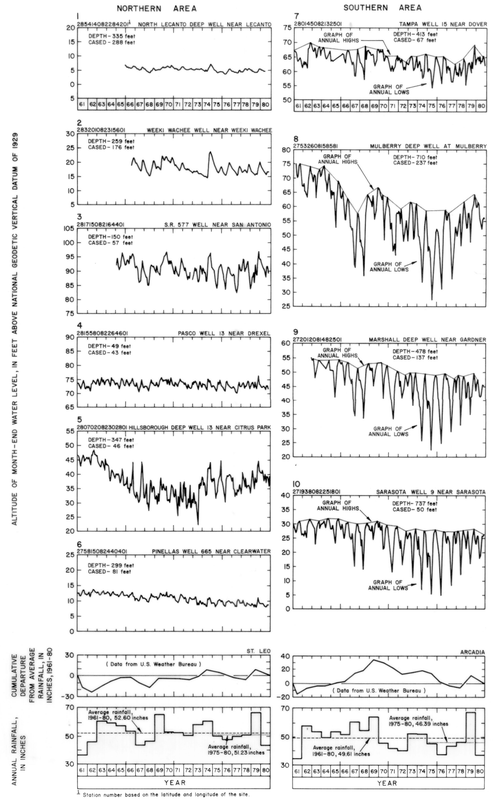


Figure 8.— Change in the potentiometric surface of the Floridan aquifer, January 1964 (Stewart and others, 1967) to May 1980 (Yobbi and others, 1980a).



Base from U.S. Geological Survey
State of Florida map (1967) 1:1,000,000

Figure 1.—Locations of study area, water management basins, and data sites used in figure 2 and figure 9.



[1] Station number based on the latitude and longitude of the site.

Figure 2.— Annual rainfall and departures from average rainfall at St. Leo and Arcadia and hydrographs of water levels in selected wells tapping the Floridan aquifer. (Site locations shown in figure 1.)

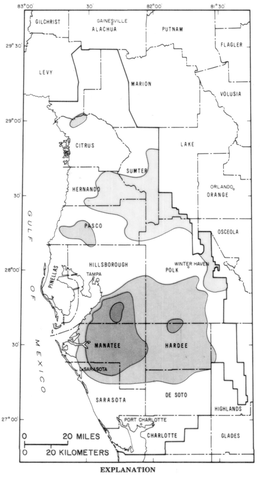


Figure 3.— Seasonal change of the potentiometric surface of the Floridan aquifer, May 1980 to September 1980.

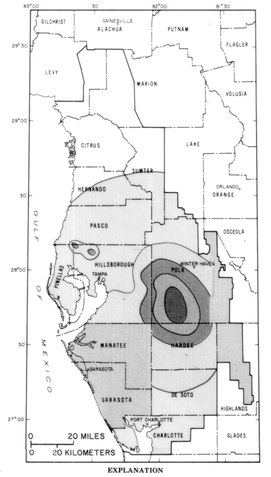


Figure 4.— Change in the potentiometric surface of the Floridan aquifer, January 1964 to May 1969.

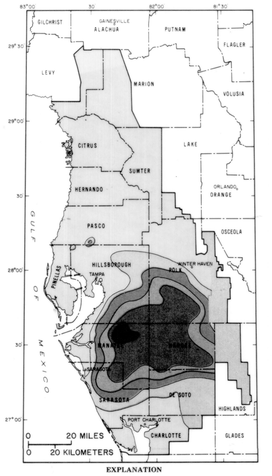


Figure 5.— Change in the potentiometric surface of the Floridan aquifer, May 1969 to May 1975.

Table 1.—*Ground water withdrawals of selected counties in 1975, 1977, 1978, 1979, and 1980*

County	Water withdrawn for indicated purposes, in million gallons per day																			
	Public supply					Industrial					Agricultural					Total ground water[1]				
	Year					Year					Year					Year				
	1975	1977	1978	1979	1980	1975	1977	1978	1979	1980	1975	1977	1978	1979	1980	1975	1977	1978	1979	1980
Charlotte	0.2	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	34.3	20.9	29.6	35.2	22.5	36.1	22.7	30.1	36.2	23.7
De Soto	0.8	0.7	0.7	0.7	0.7	0.6	1.1	0.5	0.7	0.5	61.8	62.1	35.8	41.2	33.3	67.2	66.1	39.2	44.9	36.7
Hardee	1.2	1.0	0.8	1.3	1.3	1.5	9.9	11.0	16.0	0.8	90.5	56.2	48.0	34.8	38.9	97.1	69.4	62.4	54.3	43.5
Hillsborough	31.4	41.4	21.0	29.1	34.8	53.2	83.4	75.3	73.7	58.9	43.6	47.9	56.5	57.4	70.7	154	186	169	199	175
Manatee	0.0	0.0	0.0	0.0	0.0	2.0	3.4	5.2	0.2	0.2	22.8	41.0	45.6	59.4	64.9	30.8	50.8	57.3	64.3	70.2
Polk	31.2	30.4	32.2	34.9	34.6	270	233	223	200	209	94.4	89.3	94.3	64.0	51.2	408	364	363	312	311
Sarasota	9.3	9.6	9.1	9.9	11.1	3.0	2.9	0.3	0.3	0.1	18.0	22.4	30.5	24.7	20.4	38.0	41.9	45.7	40.5	33.1
Totals[2]	74.1	83.2	63.8	75.8	82.5	330	334	315	291	269	365	340	340	316	302	831	801	766	750	693

[1]Includes rural water use.
[2]Totals rounded to a whole number for values greater than 100.

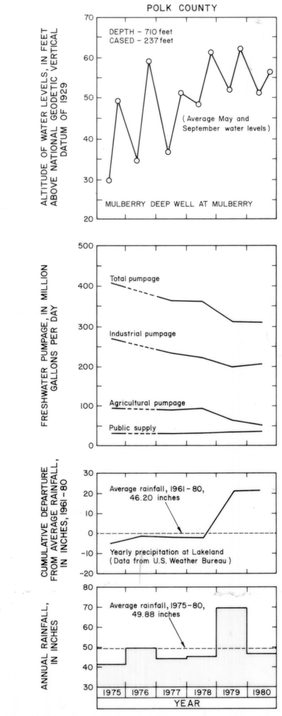


Figure 9.— Ground-water levels at Mulberry, pumpage in Polk County, cumulative departure from average rainfall at Lakeland, and annual rainfall at Lakeland, 1975-1980.

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TRENDS AND FLUCTUATIONS IN THE POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER, WEST-CENTRAL FLORIDA 1961-80

By
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1983