UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FLORIDA DEPARTMENT OF NATURAL RESOURCES
published by BUREAU OF GEOLOGY

POTENTIOMETRIC SURFACE AND AREAS OF ARTESIAN FLOW OF THE FLORIDAN AQUIFER IN FLORIDA, MAY 1974

by
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Prepared by the
U. S. GEOLOGICAL SURVEY
in cooperation with the
BUREAU OF GEOLOGY
FLORIDA DEPARTMENT OF NATURAL RESOURCES
Tallahassee, Florida
1975

INTRODUCTION

The configuration of the potentiometric surface and the areas of artesian flow of the Floridan aquifer in Florida as of May 1974 are shown on the large map. The potentiometric surface is the level to which water will rise in tightly cased wells that tap the aquifer. The level of this surface is referenced to sea level. The position of the potentiometric surface for May 1974 is based on water levels measured in 670 wells in Florida. The water levels were measured and the map prepared as an integral part of the continuing cooperative program of monitoring the ground-water resources of the state.

THE FLORIDAN AQUIFER

The Floridan aquifer is part of an artesian aquifer system that extends over 82,000 mi^2 in Florida, southern Alabama, southeastern Georgia, and part of South Carolina, and is a principal source of ground-water supplies in these areas.

In Florida, the aquifer consists chiefly of limestone formations ranging from middle Eocene to Miocene in age. It was given the name "Floridan" by Parker (1955). The aquifer ranges in thickness from about 500 ft in north-central Florida in Citrus and Levy Counties to about 2,000 ft in northeast Duval County. The top of the aquifer is at land surface in north-central Florida and at least 1,200 ft below land surface in the extreme northwestern part of the State (fig. 1).

Water in the Floridan aquifer occurs under artesian conditions except where the aquifer is close to land surface. In those areas where the aquifer lies close to the surface, the aquifer is under water-table or unconfined conditions. Where the aquifer is overlain by confining beds it contains water under sufficient pressure so that water in wells will rise above the top of the Floridan aquifer and wells will flow if the potentiometric surface in the well is above land surface.

The Floridan aquifer is the major source of fresh ground-water supplies in the State of Florida. In 1970, the aquifer supplied about 280 mgd for municipal use, 710 mgd for agricutural use, and 360 mgd for industrial use. This total demand of 1,350 mgd represents 47 percent of the total daily fresh ground-water use in the State (Healy, 1972; Pride, 1973).

POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER

The potentiometric surface of the Floridan aquifer as of May 1974 is shown on the large map by a series of contours that connect points of equal altitude of water levels in wells that tap the aquifer. The earliest portrayal of the altitude of the potentiometric surface of a limestone aquifer in Florida was made by Gunter (1929) who prepared a potentiometric map for the northern part of the Florida peninsula. Stringfield (1936) prepared a potentiometric map that covered a segment of the State extending from the Suwannee River to the Florida Keys. The first potentiometric map to show artesian pressure conditions for the state as a whole was prepared by Healy (1962) from water-level information collected during July, 1961.

The potentiometric surface continually fluctuates in response to changes in rates of recharge to and discharge from the aquifer. If recharge exceeds discharge the pressure surface rises and if discharge exceeds recharge the surface declines. The surface also fluctuates in response to many natural phenomena other than rainfall, some of which include changes in atmospheric pressure, wind, ocean tides and earthquakes. Because the contours reflect the hydrologic regimen of the aquifer they, accordingly, denote such hydrologic features, in general, as areas of natural recharge and discharge, and areas of withdrawal by wells. Also, the contoured surface of the aquifer can be used in conjunction with other hydrologic data for quantitative determinations of hydrologic parameters such as the coefficient of leakance (Bermes, 1963), velocities of ground-water movement (Faulkner, 1973), and rates of recharge to the aquifer (Clark, 1964).

The principal source of recharge to the Floridan aquifer is rainfall. The aquifer is replenished by infiltration of rain over about 13,000 mi^2 (Cooper, 1953). In addition to rainfall in Florida, recharge also occurs by underground flow of water from Alabama and Georgia and in some areas from stream flow. Annual rainfall ranges from about 52 in. in central Peninsular Florida to more than 64 in. in northwestern Florida (Hughes, 1971). However, most of the rainfall is lost by evaporation and stream runoff; only a fraction is available to recharge the aquifer.

Recharge to the aquifer occurs (1) where the top of the aquifer intercepts land surface, (2) where sediments covering the aquifer are relatively thin and permeable, and (3) where the overlying impermeable formations have been breached by erosional processes and sinkholes.

Mounds or highs in the potentiometric surface generally indicate recharge areas of the aquifer; however, the existence of a mound or high in the potentiometric surface does not necessarily indicate that recharge is significant. At least two significant hydrogeologic conditions can produce potentiometric highs in the Floridan aquifer: (1) the cover of impermeable formations is thin or discontinuous and (or) numerous sink holes are open to the aquifer. Such conditions are favorable for significant recharge. The mound (on the large map) in parts of Alachua, Bradford, Clay, and Putnam Counties is an example of this condition (Clark and others, 1964, p. 124). (2) the Floridan is of relatively low permeability and silt and clay in abundance form a continuous cover. Recharge, generally small, can maintain a potentiometric high because the rate of lateral migration of water in the Floridan is low. The mound on the surface in the north part of Liberty County is an example of this condition. Yields of wells that tap the Floridan there generally are less that 250 gpm (Pascale, 1975).

Of the two conditions cited above, the second, concerned with low permeability in the Floridan, may be relatively common. That recharge is being rejected in the areas of some potentiometric highs is obvious: land surface in these areas is wet or swampy much of the year.

Discharge from the Floridan aquifer occurs as seepage or by spring flow into streams, withdrawals by wells, ground-water outflow to the ocean or to the Gulf, and evapotranspiration where the aquifer is near land surface. Some of the discharge areas are defined by the configuration of the potentiometric contour lines on the large map. For example, the many depressions, nearly circular (of which some are emphasized by hachures), indicate the existence of wells or well fields where ground-water withdrawal is significant. The depression at the coast in Okaloosa County is a result of such withdrawal.

The trough in the potentiometric surface paralleling the Suwannee River is the result of draining the aquifer by springs discharging to and in the bed of the river. Approximately 34 springs discharge to the river (Rosenau, 1974). According to Ferguson (1947), spring discharge to the Suwannee River in the 32-mi reach from White Springs to Ellaville is 385 mgd. Discharge from the aquifer includes flow of 5,000 mgd from at least 200 springs (Rosenau, 1974) which is nearly four times the total estimated water use from the Floridan aquifer in 1970.

A comparison of the potentiometric surfaces of the Floridan aquifer for 1961 (Healy, 1962) and 1974 reveals most of the major features of the potentiometric surface have not changed appreciably during the intervening 14-yr period. Areas where the potentiometric surface is declining, the average annual rate of decline for the 14-yr period, and the net decline of ground-water levels are shown on figure 2. The average annual rate of decline of water levels in individual wells in the Floridan aquifer ranged from 2 ft/yr to less than 1 ft/yr during 1961-74. In five areas where withdrawal of ground water has been heavy the potentiometric surface has declined markedly: 10 ft or more in the north-central part of Orange County, in Putnam and St. Johns Counties, and in the northern part of Hillsborough County; and 20 ft or more in the coastal parts of Nassau and Okaloosa Counties and in the west-central part of Polk County (fig. 2).

The potentiometric surface also changed in Bay, Liberty, and Walton Counties. However, this change was probably the result of additional control data, obtained since 1961, that allowed better definition of the potentiometric surface in 1974.

The potentiometric surface declined markedly in several areas before 1961. A decline of at least 60 ft occurred during 1946-61 along the coast in Okaloosa County; about 65 ft during 1939-61 in Nassau County; and about 25 ft during 1947-61 in Polk County. In Okaloosa County the decline has not yet resulted in sea-water encroachment possibly because the transmissivity of the aquifer decreases seaward. In Nassau County, sea-water encroachment began in the early 1940's, possibly because of the observed decline in potentiometric surface there. In Polk County, the decline has not resulted in any noticeable upward movement of saline water from depth. There, the confining beds below or in the lowermost part of the Floridan seem to be effective in preventing such upward movement.

AREAS OF ARTESIAN FLOW

The areas in which water in the aquifer is under sufficient pressure to rise above land surface and, therefore, to flow from open wells and springs, is shown on the large map.

Water will flow from wells that tap the Floridan aquifer in 19,700 mi^2 or 36 percent of Florida. Areas of flow include the Atlantic coast extending from Nassau to Dade County, the southern third of the peninsula and the Gulf Coast from Monroe County and the Keys northward as far as coastal parts of Taylor, Jefferson and Wakulla Counties, and many areas in northwest Florida. Inland, flow areas parallel many of the major rivers and springs but are too small to be included on the map.

Just as the potentiometric surface fluctuates because of changing quantities of recharge (prolonged dry or wet periods) and discharge (increased pumping, spring flow) so must the areas of artesian flow increase and decrease—in response to these changes—where the altitiude of the potentiometric surface is equal to or nearly equal to the altitude of land surface. If the potentiometric surface rises, the area of flowing wells will increase and, if the surface declines, the area of flow will decrease. Thus, the area and amount of flow will decrease during a drought and increase during or after periods of heavy rainfall. Prolonged dry periods and (or) periods of heavy pumping can lower the potentiometric surface to the extent that wells and springs in the center of, rather than marginal to, the area of flowing wells will cease to flow. For example, Kissengen Spring flowed 28.2 mgd in 1933 and ceased to flow in February 1950 as a result of the decline of the potentiometric surface below the spring outlet (Peek, 1951). Comparison of the area of flow in 1961 (Healy, 1962) with that of 1974 as delineated by the large map in this report reveals that the area of artesian flow has decreased only slightly in many areas in spite of major declines in the potentiometric surface locally. In other words, the declines were not regional.

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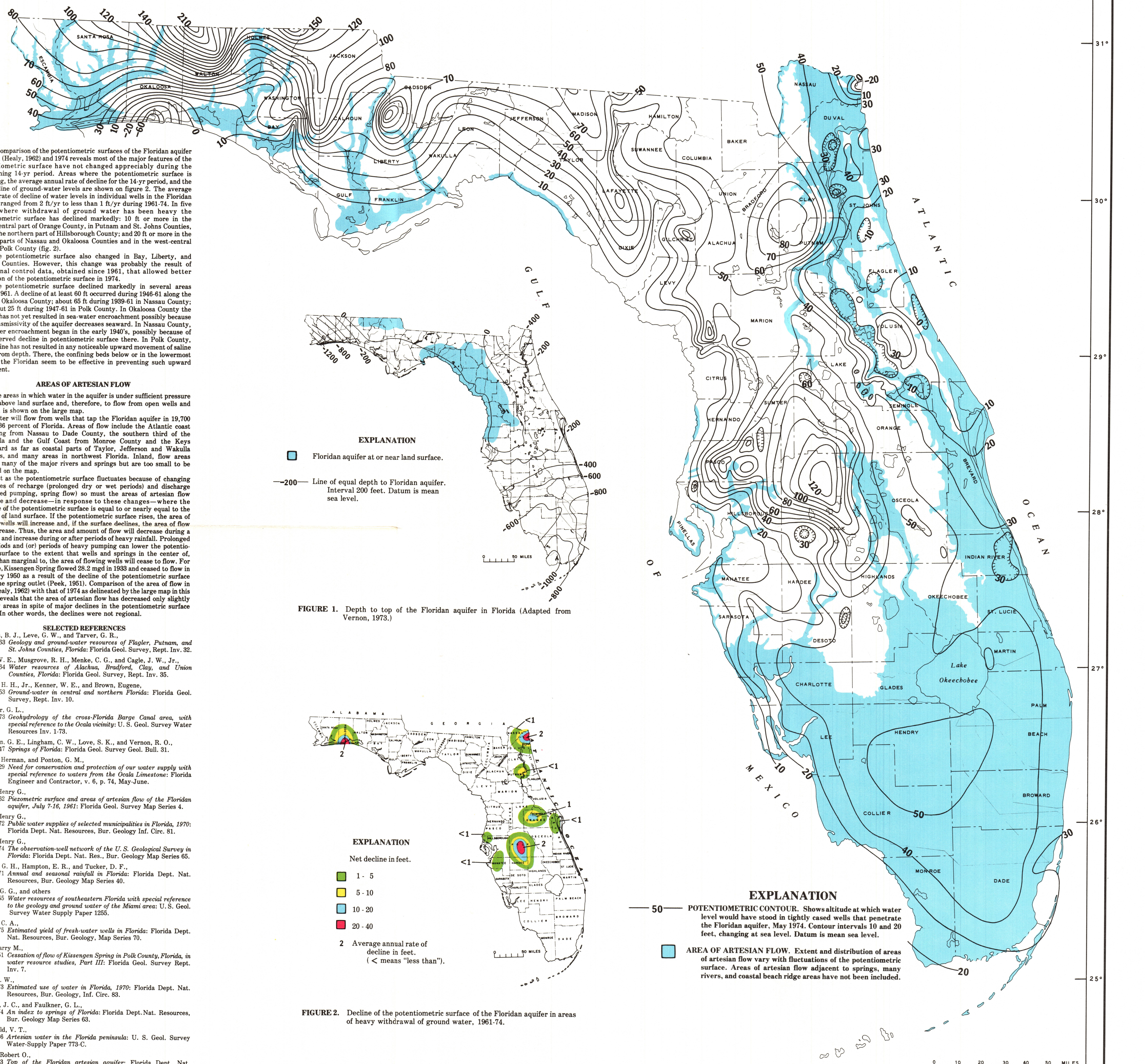

FIGURE 1. Depth to top of the Floridan aquifer in Florida (Adapted from Vernon, 1973.)

FIGURE 2. Decline of the potentiometric surface of the Floridan aquifer in areas of heavy withdrawal of ground water, 1961-74.

Graphics by D. F. Tucker