HYDROLOGIC RECONNAISSANCE OF TSALA APOPKA LAKE, CITRUS COUNTY, FLORIDA

By
A. T. Rutledge

Prepared by the
U.S. GEOLOGICAL SURVEY
in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

INTRODUCTION

Rapid growth in Citrus County, Florida, has increased the need for better understanding of an important natural resource—Tsala Apopka Lake. The main types of land use in this area are cattle farming, citrus farming, and residential. In recent years, citrus and cattle farming in lands adjacent to open water have been giving way to residential growth. The present and potential major water resource uses are recreation (surface water) and domestic and agricultural purposes (ground water).

The purpose of this report is to add to the understanding of the water resources of the Tsala Apopka Lake area by (1) mapping open water and wetlands that make up the lake system, and (2) describing the hydrology of the area with emphasis on the interrelations between the lake system and the Floridan aquifer. This report was prepared from a reconnaissance investigation made by the U.S. Geological Survey in cooperation with the Southwest Florida Water Management District during October 1975 to September 1976. The major sources of information were the data files of the U.S. Geological Survey and the various publications listed as references. New data collected during the investigation were from shallow test-well drilling, measurements of ground-water levels and of the specific conductance of lake and ground waters, and aerial photographs and ground verification of land-cover categories.

DESCRIPTION OF AREA

Tsala Apopka Lake is in west central Florida, 20 miles southwest of Ocala, 20 miles west of Leesburg, and 50 miles north of Tampa. The towns of Floral City, Inverness, and Hernando are adjacent to the lake on the west side and State Highway 44 and U.S. Highway 41 run through the area (fig. 1). Rainfall at Inverness averages 56 inches per year and the average temperature is 72° F. The study area, as referred to in this report, is bounded by the Withlacoochee River, State Highways 48 and 200, and by U.S. Highway 41, and extends about 16 miles in the north-northwest direction, averaging 6 miles in width. The lake is not a continuous expanse of open water, but a series of shallow, interconnected lakes, ponds, and marshes.

Tsala Apopka Lake is between two approximately parallel physiographic features—the Brooksville Ridge to the west and the Withlacoochee River to the east. Northwest of the study area, the river flows westward through a gap in the ridge near Dunnellon and into the Gulf of Mexico (fig. 1, inset).

Land-surface altitude in and around Tsala Apopka Lake ranges from 40 to 80 feet. The topographic relief in this area is in considerable contrast to the relief of the Brooksville Ridge where land-surface altitude ranges from 10 to 235 feet. Within the area of investigation, the terrain becomes increasingly flatter toward the Withlacoochee River. The decreasing land-surface relief from the west side of the lake to the east is accompanied by an increasingly shallower lake bottom from west to east. This, in turn, results in reaches of deeper open water on the west side whereas the lake consists mainly of marshes on the east side (fig. 1).

Figure 1, which is based on ground verification of aerial photographs taken during December 1972, shows two categories of topography—uplands and wetlands. The uplands, which cover 60 percent of the study area, consist of forests, citrus groves, grasslands, and urban areas. Upland forests are common throughout the area; citrus groves are mainly on the peninsulas in the southern part of the study area; grasslands are the predominant land cover between the lake and the river; and the urban areas are along the west side of the lake. The wetlands, which cover 40 percent of the study area, consist of swamps, dense marshes, sparse marshes, and open water. The swamps, which are abundant in the vicinity of the river, are a transition zone between dry land and water and are dominated by cypress trees. These wetland cypress forests cover 4 percent of the study area. The marshes cover 30 percent of the study area and are subdivided into dense marshes and sparse marshes. Dense marshes are characterized by stands of emergent plants, mostly sawgrass (fig. 2). These plants stand as much as 6 feet above the water surface. Dense marshes can generally be navigated only by airboat. Sparse marshes are characterized by relatively few emergent plants (fig. 3). Common sparse marsh plants are pickerelweed, waterlily, waterhyacinth, and grasses. Woody vegetation such as cypress trees do not inhabit the marshes because these areas do not have (1) periods of dryness or (2) sufficient water currents for seed dispersion. Sparse marshes may be traversed with canoe or airboat most of the time and some parts are accessible by outboard motor-driven boats. The "open water" category (fig. 4) includes canals, ditches, navigable connections between the lake and river, and waterways unobstructed by vegetation. Only 6 percent of the 103 square miles of study area is covered by open water.

SURFACE WATER SETTING

Until about 1884, Tsala Apopka Lake was connected with the Withlacoochee River only through dense swamps and marshes with no open water connections between lake and river (Oden, 1967). Water movement in the lake and river was in the same northward direction, with only a small fraction of the total flow through the lake. A survey of Tsala Apopka Lake in 1893 indicated a northward water-surface slope of 0.5 foot per mile and water-surface altitudes of 43 feet near Floral City, and 38 feet near Hernando (Cooke, 1939). The same general flow regime exists today, but most of the flow in and out of the lake is through canals instead of the marshes and swamps, and the gradient of lake level from south to north is maintained by flow control structures. River water enters the lake system in the Orange State Canal and the Leslie-Hefner Canal in the south and returns to the river by way of Shinn Ditch and Bryant Slough along the eastern boundaries and through S-351 canal in the north (fig. 1). Some lake water also drains into Two-Mile Prairie in the north and there it evaporates or drains vertically through sinks into the Floridan aquifer. Records of surface-water flow into or out of the lake system are not available except for that part which occurs through S-351 canal. There, discharge records for 1968–75 indicate average outflow of 23.6 ft³/s and maximum daily discharge of 410 ft³/s on September 4, 1968. There was no flow from November 1, 1972, to March 27, 1973.

The open water of Tsala Apopka Lake occurs as three separate pools, or pool areas—the Floral City Pool in the south, the Inverness Pool, and the Hernando Pool in the north. The Floral City Pool and the Inverness Pool are separated by the Golf Course Structure, and the Inverness and Hernando Pools are separated by the Brogden Bridge Structure. Intralake flow—that is, flow from one pool to another—occurs through various natural and manmade channels, many of which have flow control structures (fig. 1). Records of intralake flow are not available.

The Withlacoochee River, whose headwaters are to the south in the Green Swamp, forms the eastern boundary of the Tsala Apopka Lake area. Discharge records are available from gaging stations near Floral City, at Wysong Dam, and near Holder. Between the gaging stations near Floral City and near Holder, the southernmost and northernmost of the three stations, the river receives surface-water inflow from Shinn Ditch, Bryant Slough, and S-351 canal which intermittently drain Tsala Apopka Lake, and from Jumper Creek, Outlet River, Dead River, Blue Spring, and Wilson Head Spring. Average discharge of the Withlacoochee River is 714 ft³/s at Wysong Dam and 1,132 ft³/s near Holder. Comparison of 7-day low-flow data for these two stations, for 1965–75, indicates discharges of 258 ft³/s at Wysong Dam and 404 ft³/s near Holder, a gain a 146 ft³/s along the 17-mile reach of river between the gaging stations.

GEOHYDROLOGIC SETTING

According to White (1958), the Withlacoochee Valley was formed as a lagoon behind an offshore bar that is now the Brooksville Ridge, and the present lake and adjacent segment of the Withlacoochee River are remnants of a much larger lake which at one time discharged southward into the Hillsborough River. At that time the Brooksville Ridge was continuous through the Dunnellon area, 12 miles northwest of Hernando, so that the present outlet of the Withlacoochee River to the Gulf of Mexico did not exist. According to Vernon (1951) a fault perpendicular to the Brooksville Ridge at Dunnellon facilitated subterranean flow of water from the lake area to the Gulf. White (1958) theorized that the ground water, as it flowed along the fault zone, dissolved the limestone and, by subsidence of the overburden, eventually formed a break or gap in the ridge. After this outlet to the Gulf of Mexico was formed, surface water in the Tsala Apopka area flowed northward and the lake receded to its present size and became separated from the river.

The Eocene Ocala Limestone, which in the Tsala Apopka Lake area is the most productive or transmissive part of the Floridan aquifer, is structurally higher here than it is in most parts of the state, is near land surface, and is covered by only a thin veneer of clayey sands of the Alachua Formation of Pliocene age (Vernon, 1951) and post-Pliocene sands (fig. 5). Drillers' logs inspected during this investigation indicate an abundance of permeable sands and a scarcity of clays within these overlying sediments, which are herein referred to as the water-table aquifer.

Although the upper surface of the Ocala Limestone is relatively featureless under the lake, certain irregularities exist elsewhere. Vernon (1951) shows one fault to the west of Tsala Apopka Lake and two faults to the east in his cross section as reproduced in modified form in figure 5. Possibly associated with the fault to the west is a system of widespread depressions in the top of the Floridan aquifer (fig. 6), which was delineated on the basis of drillers' logs examined during the present investigation. These depressions are under some of the highest parts of the Brooksville Ridge. This essentially north-south oriented zone of sand-filled limestone caverns probably accounts for relatively low transmissivity in the Floridan aquifer in this area. The faults east of the lake seem to have a different effect on the ground-water system. These faults may account for the several springs adjacent to and east of the Withlacoochee River.

Of the several thousand water wells in the general Tsala Apopka Lake Area that tap the Floridan aquifer, most withdraw water from the Ocala Limestone, but some penetrate the underlying Avon Park Limestone, also a productive part of the Floridan aquifer in this area. In the study area and in the area east of the Withlacoochee River, most wells are for domestic use, are rarely more than 100 feet deep, and are finished as open (unscreened) holes in limestone. In the Brooksville Ridge area, well depths range from 50 feet to 250 feet and most wells are more than 100 feet deep. Depth to rock may vary by as much as 200 feet over a 0.2-mile distance. For this reason, well drilling is an unpredictable enterprise in the ridge area. Irrigation and municipal supply wells in the Tsala Apopka Lake area are similar to domestic wells in depth and finish, but are of larger diameter and most penetrate 100 feet or more into the limestone.

The Floridan aquifer is a good source of potable water in the Tsala Apopka Lake area. The aquifer contains hard, calcium-bicarbonate water with a specific conductivity range of 250–350 umho/cm (micromhos per centimeter), equivalent to a range in dissolved solids concentration of 160–230 mg/L (milligrams per liter). Floridan aquifer water in this area is generally free of bacteriological contamination and its concentrations of sodium and chloride ions are low. Iron and hydrogen sulfide are sometimes troublesome in water from wells that tap the upper part of the Floridan aquifer (Lamonds, 1976).

As figure 6 shows, water in the Floridan aquifer in the Tsala Apopka Lake area moves generally from east to west, in the direction of declining potentiometric head. The water moves toward discharge areas that include Crystal River and Homosassa Springs which flow to the Gulf of Mexico. The relatively steep gradient of the potentiometric surface west of the lake may be attributed to low transmissivity in the region of the fault west of the lake (fig. 5). Two other characteristics of the potentiometric surface shown by figure 6 are: (1) the potentiometric surface is slightly mounded in the lake area and (2) the potentiometric surface is depressed near the Withlacoochee River. Mounding of the potentiometric surface under the lake probably indicates recharge to the Floridan aquifer from the lake. The depressed potentiometric surface near the Withlacoochee River indicates that water discharges from the Floridan aquifer into the river.

At low flow the major source of water in the Withlacoochee River is ground water from the Floridan aquifer. Outlet River, which drains Lake Panasoffkee, and Dead River, which originates at Gum Spring, contain water which ultimately comes from the Floridan aquifer. Blue Spring, Gum Spring, and Wilson Head Spring (fig. 1) are obvious points of ground-water discharge—obvious in the sense that the flow of these springs can be seen to enter the Withlacoochee at discrete points along the river reach. The average pickup between Wysong Dam and Holder for 3 days in May–June 1972 was 144 ft³/s. The total flow to the river from the springs, cited in the table below, was 103 ft³/s—41 ft³/s less than the increase in flow between the two gaging stations. The unaccounted for increase could hardly have come from rainfall as the largest daily rainfall during this period was 0.35 inch. Also, surface flow from Tsala Apopka Lake during this May–June period was negligible. It would appear, then, that unmapped points of spring discharge occur along the Withlacoochee, within the reach between the two stations.

Spring	Discharge (ft³/s)	Date (1972)
Dead River (Gum Spring)	85.8	June 13
Blue Spring	15.1	May 25
Wilson Head Spring	2.4	June 5

The specific conductance of water, an indication of the degree of mineralization, is determined by measuring the resistance of the water to an electric current. Dissolved solids concentration in milligrams per liter can be estimated by multiplying the specific conductance in umho/cm (micromhos per centimeter) at 25° C by a factor which for most ground water is less than 1. Although this conversion factor may vary from one water source to another, for ground water and surface water in the Tsala Apopka Lake area it is about 0.65. The specific conductance of water discharging at Gum Spring, Blue Spring, and Wilson Head Spring averages approximately 300 umho/cm at 25° C. All are points of discharge for the Floridan aquifer. Because the Withlacoochee River is fed largely by Floridan aquifer water, the 10-year average specific conductance in the river is also high: 230 umho/cm at 25° C near Floral City, 263 umho/cm at 25° C at Wysong Dam and 268 umho/cm at 25° C near Holder. The specific conductance of water in Tsala Apopka Lake decreases northwards, away from the area of river inflow. The 10-year average specific conductance within the lake is 191 umho/cm at 25° C at Floral City, 150 umho/cm at 25° C at Inverness, and 139 umho/cm at 25° C at Hernando. During February and March 1976, specific conductance of water in the Withlacoochee River ranged from 300 to 315 umho/cm at 25° C; and in the open waters and canals of the lake, from 100 to 140 umho/cm at 25° C.

The geohydrologic section B-B′ of figure 7 is constructed from data from nine deep wells cased into the Floridan aquifer and eight shallow water-table wells drilled at the same sites as eight of the deep wells. The potential for recharge (or downward leakage) to the Floridan aquifer exists where the water table or the lake surface is higher than the potentiometric surface of the Floridan aquifer. The potential for discharge (or upward leakage) from the Floridan aquifer exists where the opposite situation occurs. Except for the area around well 8 near the springs at Crystal River, the water table and the lake surface along section B-B′ are above the potentiometric surface of the Floridan aquifer. The potentiometric mound which was shown in figure 6 can be seen in section in figure 7 (between wells 18 and 22, March 1976). The depressions in the water table and the potentiometric surface near well 15 (fig. 7) indicate that both the water table and the Floridan aquifer are discharging into the river. During periods of relatively high rainfall, such as June 1976, another potentiometric mound occurs between the lake and the river (fig. 7, well 16, June 1976). This intermittent mound nearest the Withlacoochee River acts as an occasional ground-water divide between the river and lake and causes Floridan aquifer water between the lake and river to move either westward into the lake area or eastward into the river. The slight depression in the potentiometric surface between the two potentiometric mounds could represent an area of northward flow in the Floridan aquifer. If the ground-water levels in geohydrologic sectin B-B′ (fig. 7) are typical throughout the lake area, then discharge of Floridan aquifer water into the lake is unlikely. Some lateral seepages from the water-table aquifer occur at the east edge of the lake where the water table slopes into the lake system (fig. 7).

Fluctuations of the potentiometric surface of the Floridan aquifer at well sites 18, 20, and 22 are similar to fluctuations in the stage of Tsala Apopka Lake (fig. 8). For this reason, and also because of the predominance of sandy materials in the intervening sediments, it is inferred that there is a hydraulic connection between the lake and the Floridan aquifer. Well sites 18, 20, and 22 are along State Road 44 on an isthmus which crosses the Inverness Pool in an east-west direction (fig. 6). The record of figure 8 shows that the mound in the potentiometric surface of the Floridan aquifer in this area is almost always present. Finally, the fact that the lake level is usually higher than the water levels in these wells is further support for the inference that the Florida aquifer is being recharged by water from the lake.

CONCLUSIONS

Geologic data, configuration of the potentiometric surface of the Floridan aquifer, and water-level records indicate that Tsala Apopka Lake is in hydraulic connection with the Floridan aquifer. The Floridan aquifer is close to land surface and is overlain by permeable sands. The configuration of the potentiometric surface of the Floridan, the similarity of fluctuations of lake and potentiometric level, and the fact that the lake level is above the potentiometric level indicate that the lake recharges the Floridan aquifer. Lake water contributed to the Floridan aquifer in the extreme west edge of the lake system flows westward within the aquifer; water contributed from the middle of the lake system (between wells 18 and 20 on fig. 6) flows generally northwest; and water contributed to the aquifer from the extreme east part of the lake system ultimately discharges into the Withlacoochee River. Since the level of Tsala Apopka Lake is almost always higher than the potentiometric level of the Floridan aquifer, the net flow from the lake system to the Floridan aquifer is positive. When the lake level rises, the hydraulic gradient between lake and aquifer temporarily increases and causes recharge from the lake to the Floridan to increase, and ultimately causes the potentiometric surface of the Floridan to rise. As the potentiometric surface rises, the hydraulic gradient between lake and aquifer temporarily decreases, slows the rate of downward leakage from the lake, and thereby reestablishes the original hydraulic gradient. Ground-water flow into the lake consists of seepage from the water-table aquifer into the east part of the lake when a water-table mound forms between the lake and the river during periods of high rainfall. There is no ground-water flow into the lake system from the topographically high areas to the west where the water table slopes away from the lake.

The level of Tsala Apopka Lake is affected by the potentiometric level of the Floridan aquifer; therefore, drawdown of the Floridan aquifer potentiometric level due to pumping could lower the lake level. A more extensive geohydrologic study would be required to describe more accurately the effect that a lowering of the Floridan aquifer potentiometric level would have on the level of Tsala Apopka Lake.

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Multiply English unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
feet per mile (ft/mi)	.1894	meters per kilometer (m/km)
inch (in)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)

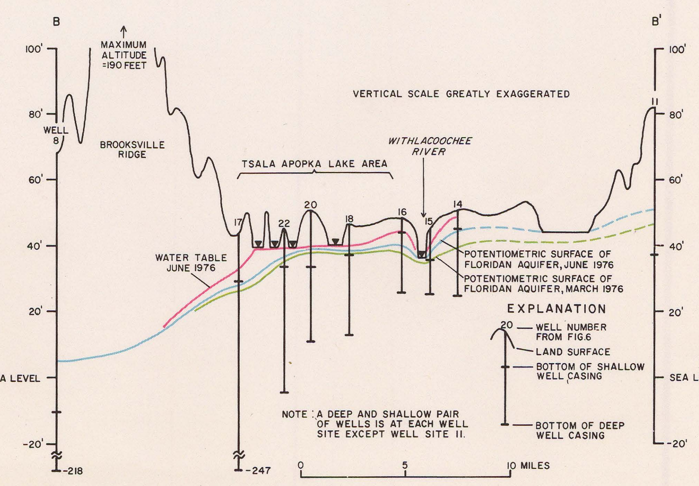

Figure 7—Geohydrologic section showing the relation of the potentiometric surface of the Floridan aquifer to the water table in the Tsala Apopka Lake area, March and June, 1976.

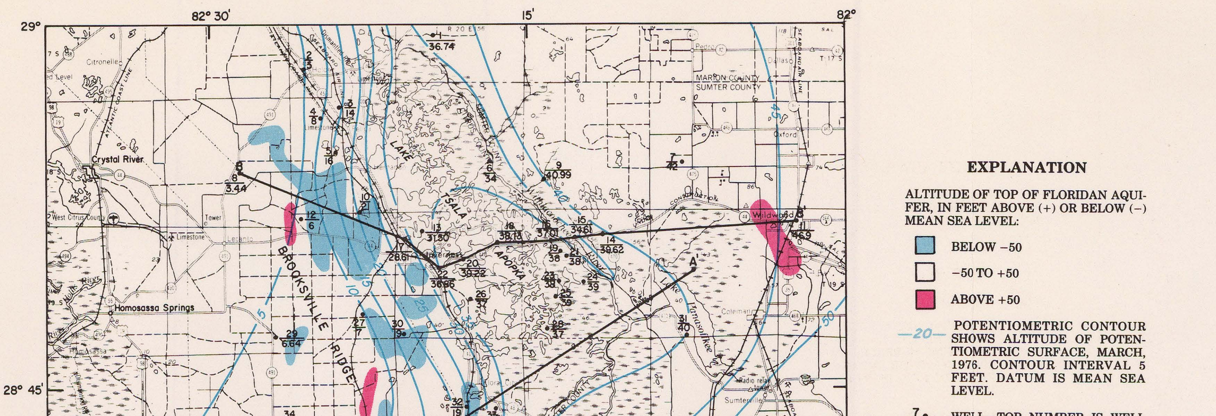

Figure 6—Tsala Apopka Lake Area, potentiometric surface of Floridan aquifer, altitude of top of Floridan aquifer, and locations of geohydrologic sections.

Figure 4—Open water bordered by marsh vegetation.

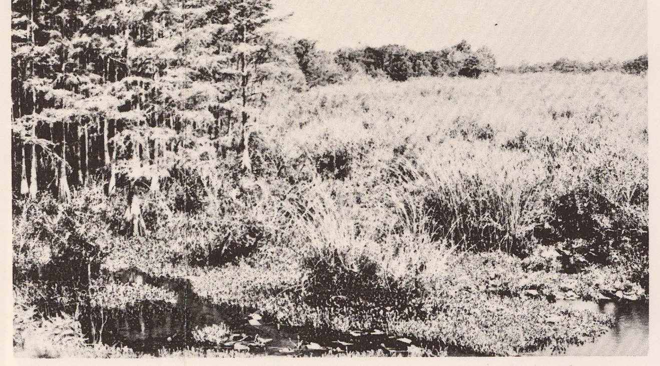

Figure 2—Cypress swamp and dense marsh. (Marsh vegetation reaches 6 feet in height.)

Figure 3—Sparse marsh covered by grasses (above) and by waterlilies (below).

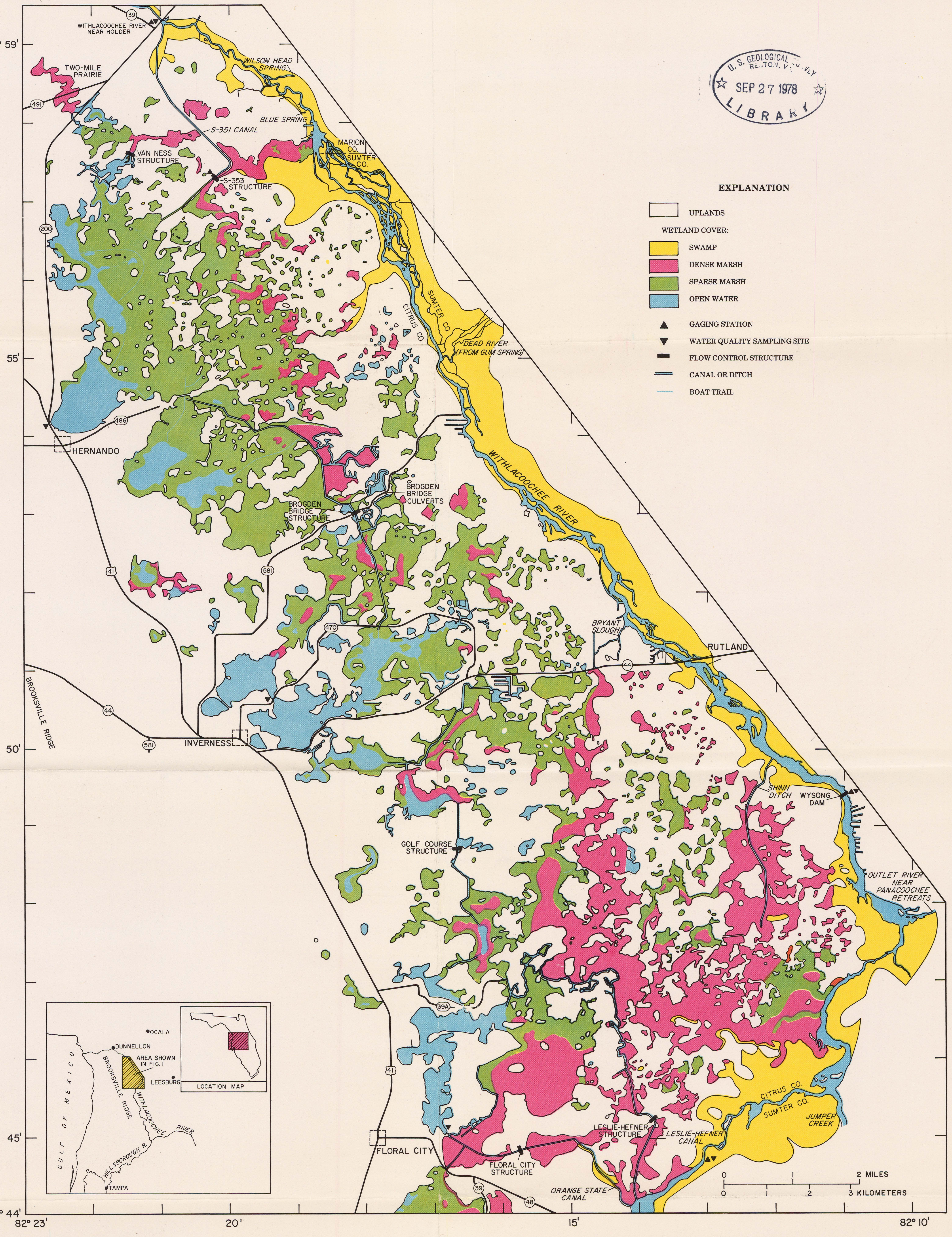

Figure 1—Tsala Apopka Lake Area

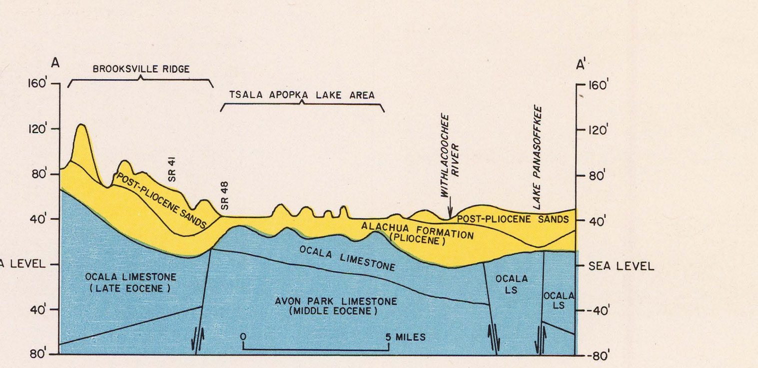

Figure 5—Geologic section A-A′ or lake area alignment of section is shown on fig. 6. Vertical scale is greatly exaggerated. Section modified from Vernon, 1951.)

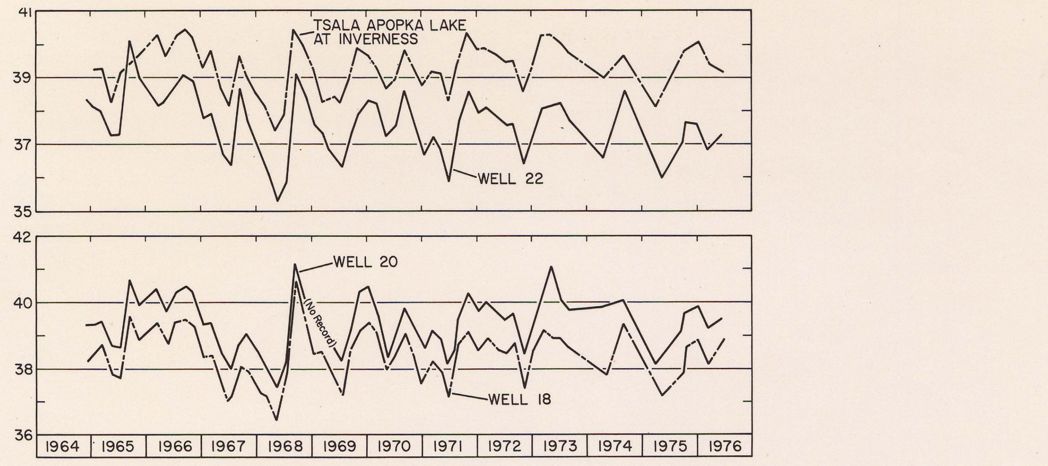

Figure 8—Hydrographs of wells 18, 20, and 22, and Tsala Apopka Lake at Inverness, Florida, 1965–76.

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