

GROUND WATER IN LAKE COUNTY, FLORIDA

by
Darwin D. Knochenmus

Prepared by
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
BUREAU OF GEOLOGY
FLORIDA DEPARTMENT OF NATURAL RESOURCES,
BOARD OF COUNTY COMMISSIONERS OF LAKE COUNTY
and the
OKLAWAHA BASIN RECREATION AND WATER CONSERVATION
AND CONTROL AUTHORITY

TALLAHASSEE, FLORIDA
1971

INTRODUCTION

An investigation of the water resources of Lake County was begun by the U. S. Geological Survey in 1967 in cooperation with the Board of County Commissioners of Lake County to determine the mode of occurrence, quantity, and quality of water in the county. As aquifers are the source of most water used in Lake County for municipal, domestic, irrigation, and industrial supplies, this map report was prepared to give a general description of the ground-water features. The maps, sections, and graphs show some of the important hydrogeologic features, the quality of water, and fluctuations of the potentiometric surface of the Floridan aquifer.

Lake County, an area of 1,150 square miles, is in central peninsular Florida (location map). This part of Florida is characterized by numerous lakes and north-trending sand ridges (fig. 1), which locally have relief as great as 225 feet in Lake County. Two such ridges, the Lake Wales and Mount Dora ridges, are prominent features. Interridge areas slope gently northward and are drained by the Palatka River and other headwater streams of the Oklawaha River system on the west and by the St. Johns River on the east (fig. 1).

The climate is subtropical. Average annual rainfall is 51 inches at the National Weather Service (U. S. Weather Bureau) station at Clermont. Rainfall in any given year, however, can vary greatly from the average. For example, 68 inches was recorded in 1959, whereas only 32 inches was recorded in 1961. Seasonally the amount of rainfall also varies greatly; about twice as much rain falls in the summer as in the spring.

The principal industry is agriculture. Of the various crops, citrus fruit is the most important. Most citrus fruit is grown on the ridges, where higher altitudes provide frost protection and the well-drained soils are suited to citrus culture. Very little rain runs off the ridges, and water that is not lost to evapotranspiration percolates through the sand to the water table, where it recharges the ground-water reservoir.

The major use of water in Lake County is for irrigation. Of the 143,000 acres of citrus groves (1970), 36,000 acres, or about 25 percent, is irrigated. Seventy-five percent is irrigated from the Floridan aquifer and 25 percent from lakes and streams (Jackson Haddad, Lake County Agricultural Agent—oral communication, 1970). Most irrigation water is withdrawn from March to June, when rainfall is low and evapotranspiration is high and the fruit is just beginning to develop.

HYDROGEOLOGY¹

Lake County is underlain by unconsolidated to semiconsolidated clastic sediments of Pleistocene through Miocene age, which have a combined thickness ranging from 25 to 300 feet. Underlying the clastic sediments is a 2,000-foot section of permeable limestone and dolomitic limestone of early Miocene to middle Eocene age. These clastic materials may be classified into two hydrogeologic units: 1) a clastic upper unit of unconsolidated sand and semiconsolidated clayey sand, herein called the clastic aquifer, and a sandy clay (Hawthorn Formation) composing a confining bed; and 2) a lower carbonate unit of limestone and dolomitic limestone named the Floridan aquifer (Parker, 1955). Figure 2 and the hydrogeologic sections show the depth to the Floridan aquifer or the approximate combined thickness of the clastic unit.

The sediments of the clastic aquifer generally become finer with depth. The top 5 to 10 feet, which mantles most of the county, is a fine well-sorted sand having a high infiltration capacity. Below this sand is from 30 to 80 feet of clayey sand, which slightly retards the downward movement of water, but not sufficiently to cause the occurrence of perched water. Water percolates downward from the land surface to a water table in the clayey sand. Underlying the clayey sand is the sandy and silty clay of the Hawthorn Formation, except where it is absent under part of the Lake Wales ridge (fig. 1). This material of low permeability, which has a maximum thickness of 75 feet, directly overlies the Floridan aquifer and partly confines water in the Floridan aquifer.

In the northeastern part of the county, a limestone bed at the base of the Hawthorn Formation rests on and is hydraulically connected to the underlying Eocene limestone and is therefore included as part of the Floridan aquifer (hydrogeologic section B-B'). Throughout most of the county, however, the uppermost limestone formations of the Floridan aquifer make up the Ocala Group of late Eocene age. The Ocala Group, which has a maximum thickness of just over 100 feet, is thin compared with the underlying limestone of middle Eocene age. The Ocala Group is thin or absent where erosion of the Ocala-capped fault blocks has been most active (hydrogeologic section C-C'). Where solution has removed the upper limestone formations (hydrogeologic section B-B'), underlying the Ocala Group is the Avon Park Limestone, having a thickness of 400 to 1,000 feet. Near Clermont and Lakes Eastis and Harris, the Ocala Group is missing, and the Avon Park forms the upper part of the aquifer. The Avon Park overlies the Lake City Limestone, which is the lowermost formation of the Floridan aquifer, according to Stringfield (1966, p. 97). The Lake City Limestone is 500 feet thick in southern Lake County, based on oil-test records.

The irregular surface of the Floridan aquifer was formed by solution of the limestone, a process which is still active today. As the limestone is dissolved by percolating ground water, cavities in the limestone grow and finally collapse from the weight of the overlying clastic material. The clastic materials flow into the cavity during collapse, thereby partly filling the solution channels and in the upper part of the aquifer with sand and clay. Consequently, the upper part of the Floridan aquifer has lower permeability than the unfilled cavernous zones below.

The contours on figure 2 indicate the approximate altitude of the top of the Floridan aquifer. The common method of water-well construction in central Florida is to seal off the clastic sediments by seating the casing in the upper part of the Floridan aquifer. Thus the length of casing needed will vary for different parts of the county; its length can be estimated from figure 2. The estimate of required casing length will have greater reliability if the proposed well site is on a hill rather than in a depression. Depressions are usually surface expressions of solution-collapse sites that require longer casing lengths to reach the sand-free part of the Floridan aquifer.

The depth to the Floridan aquifer is greatest in the vicinity of the large lakes in the northern part of the county (fig. 1 and hydrogeologic section B-B'). The area of greatest depth is delineated by the minus 50-foot contour on figure 2 and has the configuration of a buried stream valley. This configuration suggests that limestone was removed by stream erosion as fast by ground-water solution. The sandy alluvium that subsequently filled the valley is coarser, thicker, and more permeable than the fine sand and clayey sand of the clastic deposits described previously. Hydrogeologically, the sandy alluvium is considered here as part of the clastic aquifer. The alluvium is generally about 200 feet thick, although some wells have penetrated as much as 400 feet of it. Because of its relatively thick saturated section and good permeability, the sandy alluvium is capable of yielding more water to wells than the rest of the clastic aquifer.

GROUND WATER

Most of the ground water presently used in Lake County is drawn from the Floridan aquifer. Some water is available from the shallow clastic aquifer, which at present is used principally for domestic supplies. Except for the alluvial section, the saturated thickness of the clastic aquifer is generally less than 100 feet, as compared with about 2,000 feet for the Floridan aquifer. The permeability of the clastic aquifer is also lower than that of the more permeable zones of the Floridan aquifer, so the Floridan aquifer has the greater potential as a source of water.

Water in a well that penetrates the Floridan aquifer rises above the top of the aquifer to a level that coincides with the potentiometric surface at that point. The depth to water in a well drilled into the Floridan aquifer is less than 50 feet, in Lake County except under some of the highest ridges, where it is at or more than 200 feet below the land surface (fig. 3). The potentiometric surface is above the land surface in many places, as is shown on figure 3, and wells in those areas will flow. The depth-to-water map (fig. 3) can be used to predict the approximate depth to water in a well that taps the Floridan aquifer in any part of the county. If the altitude of a specific location is known, the depth to water can be predicted with greater accuracy than that shown on the map by subtracting the altitude of the potentiometric surface from the altitude of the land surface.

The gross direction of water movement in the Floridan aquifer is generally down the slope of the potentiometric surface, which is about 100 feet above mean sea level in the southeastern part of the county and 15 feet above the St. Johns River (fig. 3). Therefore, water in the Floridan aquifer moves generally in a north-northeastward direction. In an area of Clermont, reduced permeability along faults apparently retards the northward movement of water, as indicated by a closer spacing of contour lines on the potentiometric map in the area of faulting (fig. 3). To a lesser degree, the closer spacing of potentiometric contours along the St. Johns River valley also indicates a retardation of water movement caused by faults. Some ground water flows into the county from the Green Swamp in Polk County to the south, but most of the water in the Floridan aquifer infiltrates from the overlying clastic aquifer. Water leaves the Floridan aquifer within the county by withdrawals from numerous irrigation, municipal, and domestic wells and by spring discharge and seepage along Lake Harris, Lake Griffin, Black Water Creek, and St. Johns River.

Water-level fluctuations in five wells open to the Floridan aquifer are shown by the hydrographs. These wells have the longest record of water-level changes in or near the county. The period shown, 1959-69, includes the highest water levels for the past 30 years. Lowest water levels of record occurred during 1956-57 and were about 1 foot lower than the water levels in 1962, 1963, and 1968. Levels during the 1960's were slightly below normal but appeared to be approaching normal levels in 1969. These short records indicate no overall decline of ground-water levels.

The Floridan aquifer in Lake County is semiconfined, and recharge may occur wherever the water level in the clastic aquifer is higher than the potentiometric surface. Where the potentiometric surface is only a few feet below the land surface (such as in wells 844-146, 832-154.1, and 822-149.1), it fluctuates much less than where it is tens of feet below the land surface (wells 910-138 and 857-138). Where the potentiometric surface is near the land surface, the clastic aquifer generally falls and therefore rejects recharge most of the time. Conversely, where the potentiometric surface is deep and water-level fluctuations are greater, such as in the ridge areas, more aquifer storage is available and recharge there is greatest. Thus the potential for recharge is greatest in the ridge areas.

The yield of a well is primarily related to the ability of the aquifer to transmit water and to the thickness of aquifer penetrated by the well. To a lesser degree, the yield is related to the well diameter, because a larger diameter well exposes more area of aquifer and therefore offers less frictional resistance to the flow of water into the well bore. Large-diameter wells (12-20 inch) that are open to 400-600 feet of the Floridan aquifer in Lake County generally yield 1,500-2,000 gallons per minute. No high-capacity wells have been constructed in the clastic aquifer, but completing high-capacity screened wells in the thick alluvial sediments (fig. 2) may be feasible.

In 1965, about 80 percent of the 45 mgd (million gallons per day) of water used in Lake County was ground water. About 16 mgd of this total was for irrigation, 90 percent of which was used on citrus groves. Another 19 mgd was used by industry in processing various citrus products. The number of irrigation wells has increased greatly since 1965, and it is estimated that ground water is the source of 85 percent, or 46 mgd, of the 55 mgd used in the county in 1970.

WATER QUALITY

Water in the Floridan aquifer is of good quality, except in the St. Johns River valley, where it contains dissolved solids that exceed the maximum of 500 mg/l (milligrams per liter) recommended for public supplies by the U. S. Public Health Service. The areal distribution of the dissolved solids and chloride content in water of the Floridan aquifer are shown on figures 4 and 5.

On figure 4 areas of low concentration of dissolved solids indicate in a general way where the aquifer receives the greatest recharge. Water that has just entered the aquifer has had less time to dissolve minerals than water that has traveled for some distance through the aquifer. Areas of greater or lesser recharge, however, can only be generalized from water-quality maps, because other factors, such as the mineralogy of aquifer materials and the type of water recharging the aquifer, affect water quality.

The hardness of water, a quality characterized by the amount of soap required to produce a lather, is caused predominantly by the presence of calcium and magnesium ions. Water having a hardness of 0-60 mg/l is considered soft; 60-120 mg/l, moderately hard; 120-180 mg/l, hard; and over 180 mg/l, very hard (Durfur, 1964). Water in the Floridan aquifer is of a calcium bicarbonate type and is hard. The areal distribution of hardness would be similar to the pattern shown on the dissolved-solids map (fig. 4) because calcium and magnesium ions (hardness) account for most of the dissolved-solids content. Water in Lake County having dissolved solids between 50-150 mg/l is moderately hard, that having between 150-250 mg/l is hard, and water having more than 250 mg/l is very hard. Thus, hardness of water in the Floridan aquifer may be closely approximated by use of figure 4.

Chloride indicates the presence of saline water. The U. S. Public Health Service recommends that chloride concentrations should not exceed 250 mg/l in water used for domestic purposes. The chloride content of the water in the Floridan aquifer, as shown on figure 5, exceeds 250 mg/l only in the St. Johns River valley. The two seamounts, shown on figure 5, of poorer quality of water along the St. Johns River valley occur at Alexander Springs and Black Water Creek. Other mineral constituents commonly dissolved in the Floridan aquifer water are silica, iron, sodium, potassium, bicarbonate, sulfate, fluoride, nitrate, and phosphate.

Data used in preparing the water-quality maps represent water from wells ranging from 70 to 750 feet in depth. In general, the variation of water quality was found not to be related to well depth, thus the variation represents the areal distribution of quality of water in the upper one-third of the Floridan aquifer. An exception to this relationship occurs along the St. Johns River, where water quality may change with well depth. In the proximity of the St. Johns River, the fresh salt-water interface approaches the land surface, where the potentiometric head is lowered by ground-water discharge along the valley, and where faults allow upward movement of deep saline water. Fresh water occurs in the aquifer to a maximum depth of about 2,000 feet, based on data from an oil-exploratory well drilled in the southwest corner of the county.

Data used in preparing the water-quality maps represent water from wells ranging from 70 to 750 feet in depth. In general, the variation of water quality was found not to be related to well depth, thus the variation represents the areal distribution of quality of water in the upper one-third of the Floridan aquifer. An exception to this relationship occurs along the St. Johns River, where water quality may change with well depth. In the proximity of the St. Johns River, the fresh salt-water interface approaches the land surface, where the potentiometric head is lowered by ground-water discharge along the valley, and where faults allow upward movement of deep saline water. Fresh water occurs in the aquifer to a maximum depth of about 2,000 feet, based on data from an oil-exploratory well drilled in the southwest corner of the county.

SELECTED REFERENCES

- Durfur, C. N.,
1964 (and Becker, Edith) *Public water supplies of the 100 largest cities in the United States, 1962*. U. S. Geol. Survey Water-Supply Paper 1812.
- Lichter, W. F.,
1968 (and Anderson, Warren, Joyner, B. F.) *Water Resources of Orange County, Florida*. Fla. State Bd. of Conservation, Div. of Geol., Rept. of Inv., no. 50.
- Parker, G. G.,
1955 (and Ferguson, G. E., Love, S. K. and others) *Water resources of southeastern Florida*. U.S. Geol. Survey Water-Supply Paper 1255.
- Pride, R. W.,
1966 (and Meyer, F. W., and Cherry, R. N.) *Hydrology of the Green Swamp area in central Florida*. Florida Geol. Survey Rept. of Inv., no. 42.

¹ The geologic nomenclature is that of the Bureau of Geology, Florida Department of Natural Resources.

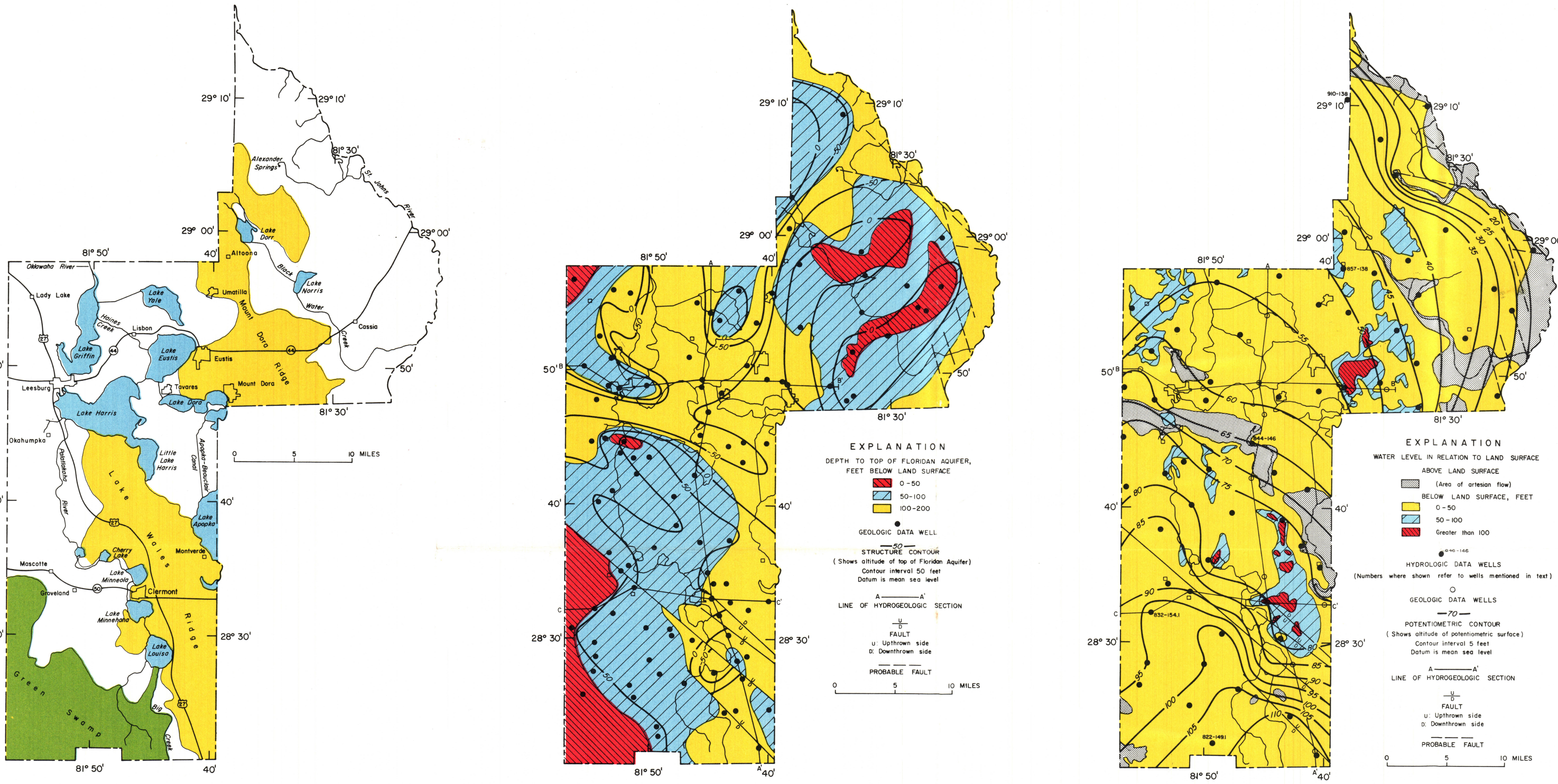


Figure 1. Culture, drainage and physiographic features.

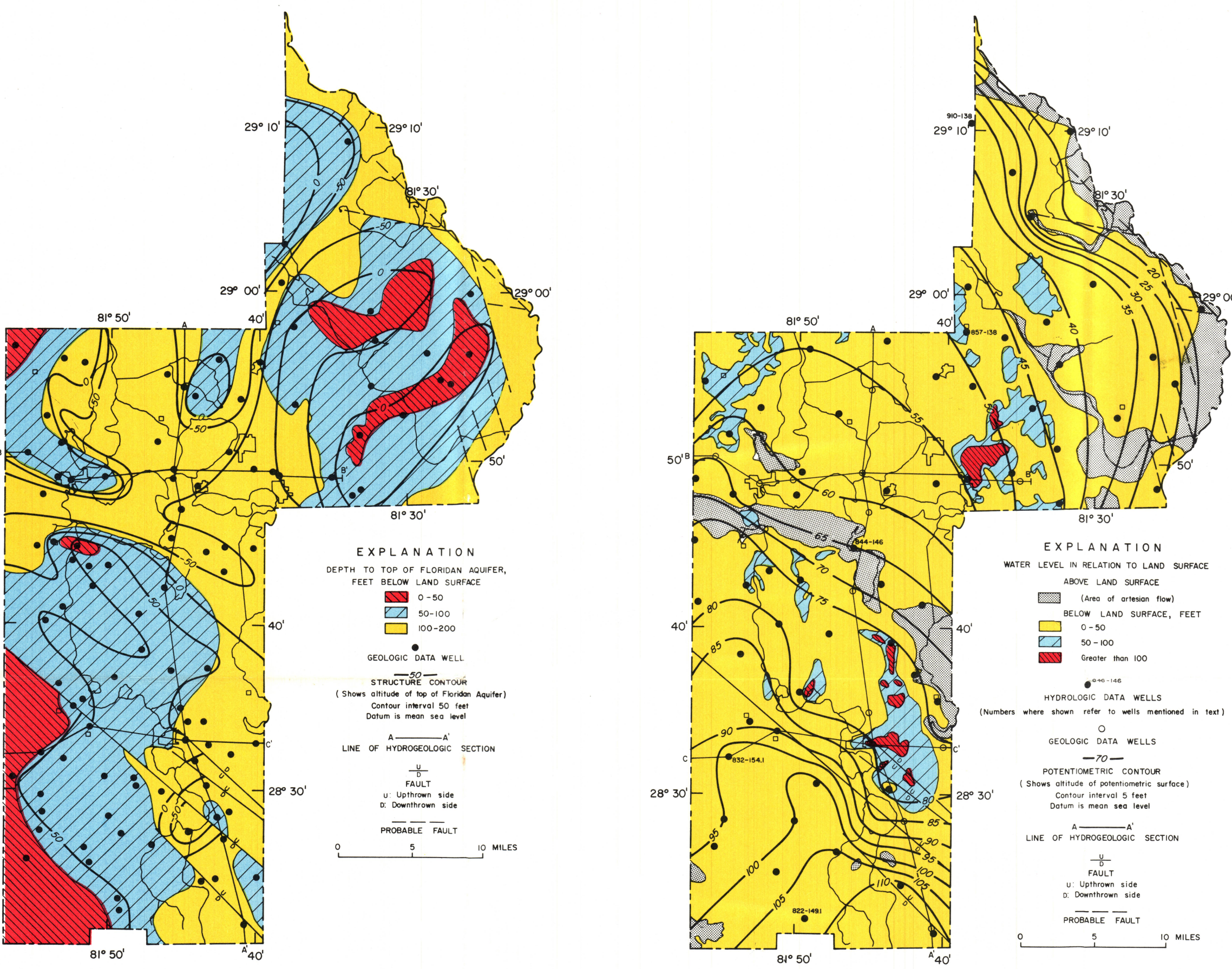


Figure 2. Depth to top and configuration of the top of the Floridan Aquifer.

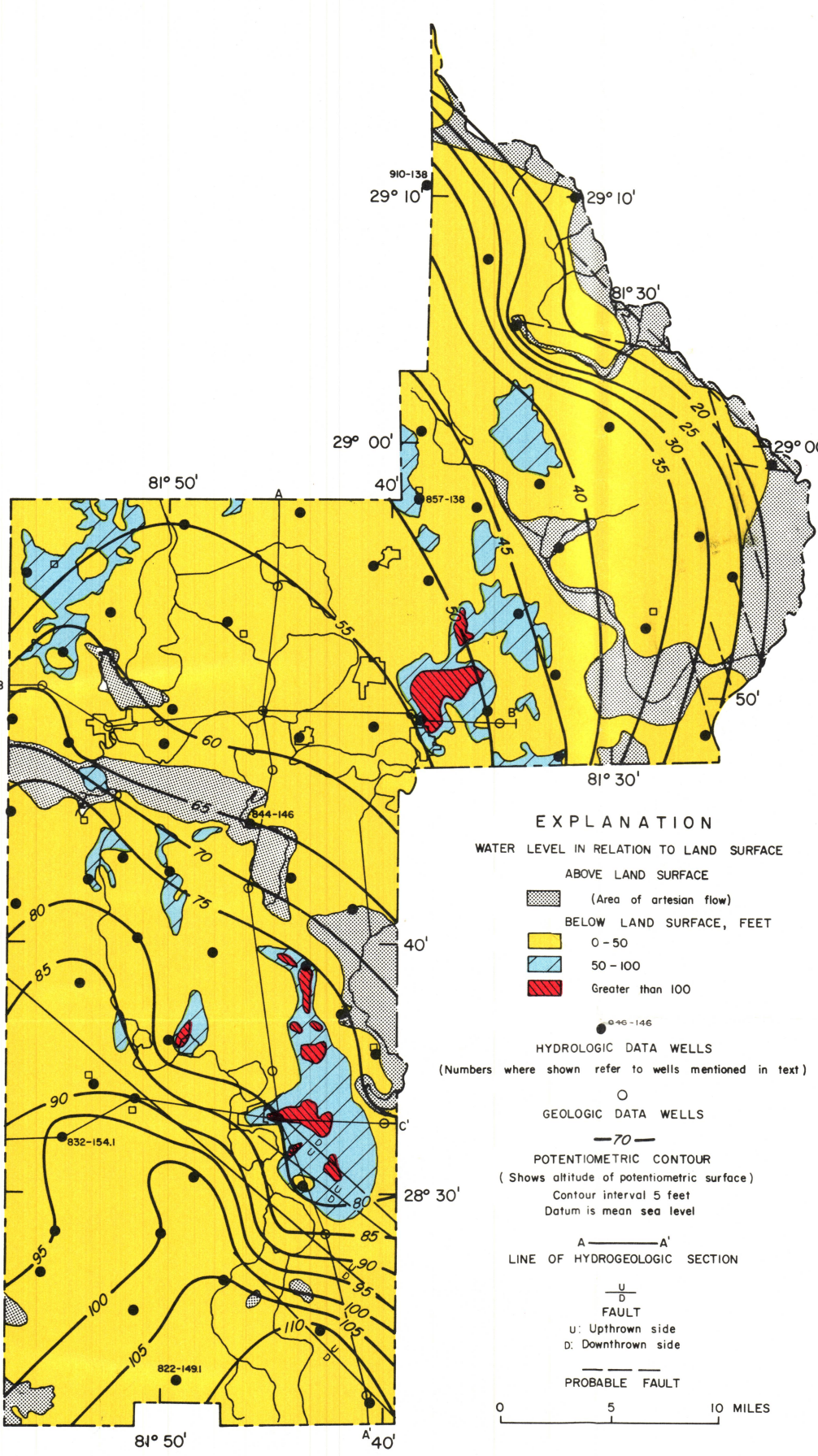


Figure 3. Depth to water and potentiometric surface of the Floridan Aquifer, May 1968.

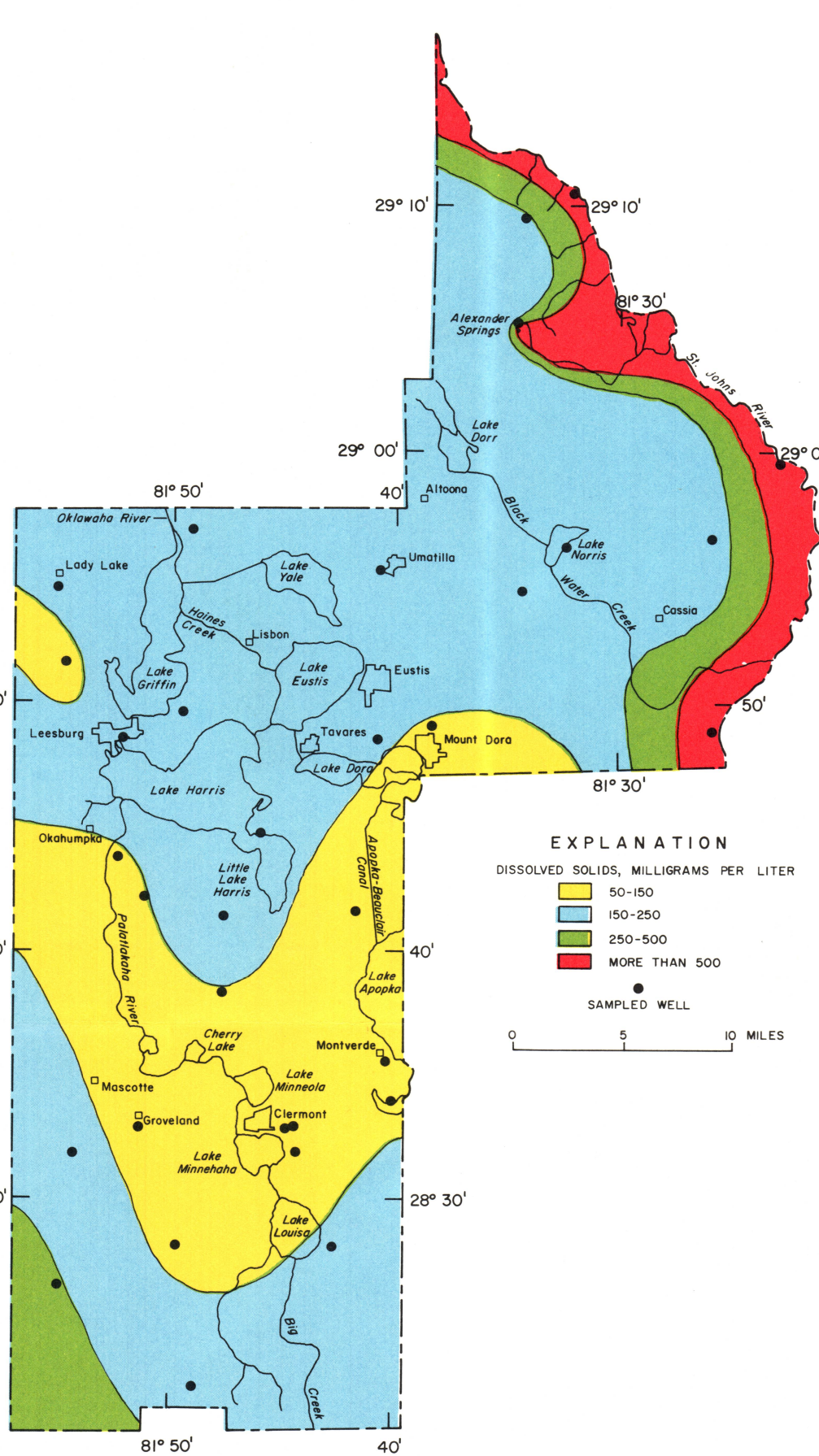
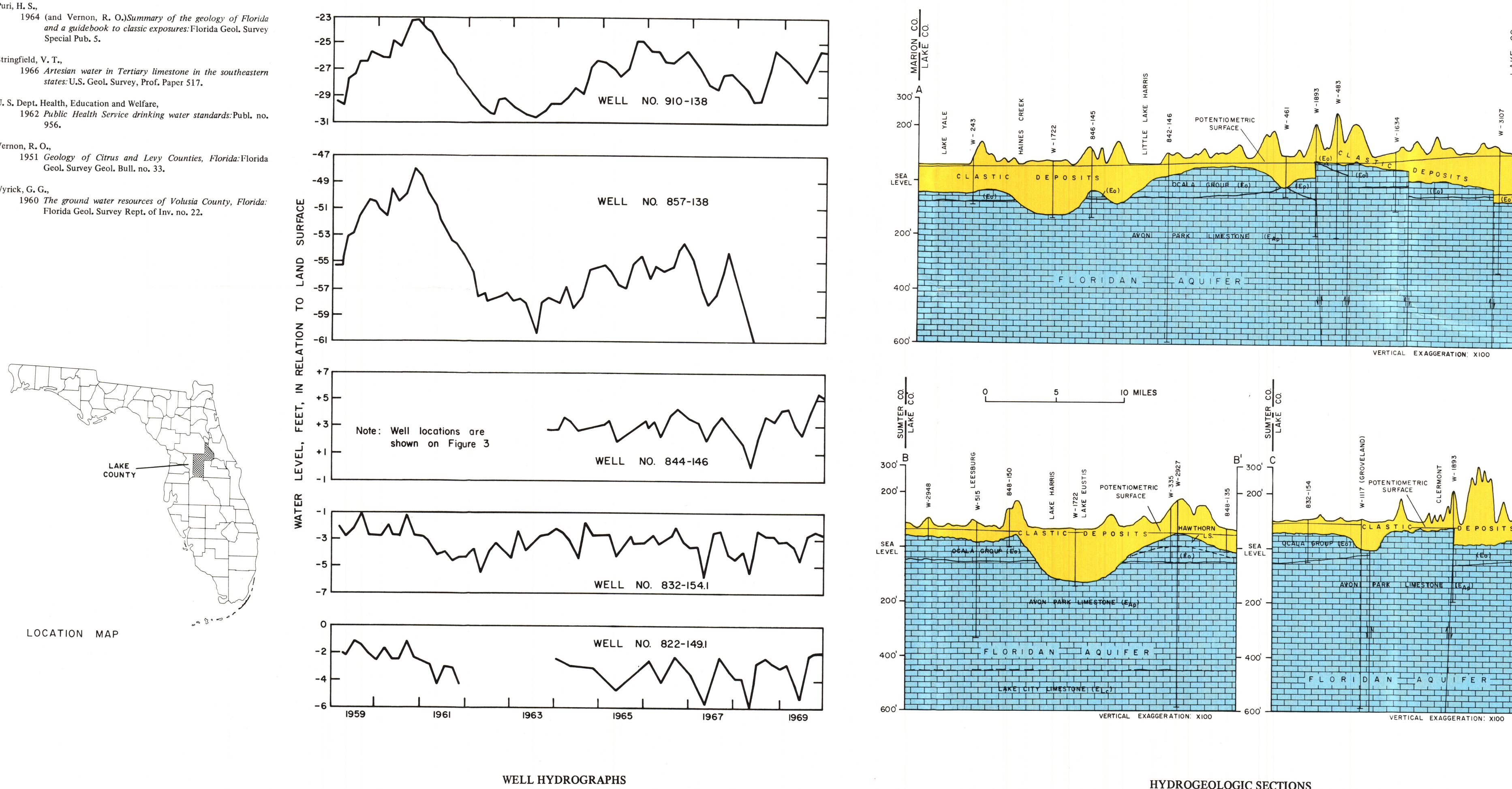


Figure 4. Dissolved solids of water from the Floridan Aquifer, 1968.



WELL HYDROGRAPHS

HYDROGEOLOGIC SECTIONS

Figure 5. Chloride content of water from the Floridan Aquifer, 1968.