GROUND-WATER RESOURCES AND GEOLOGY OF COOK COUNTY, GEORGIA

By

Charles W. Sever, 1931

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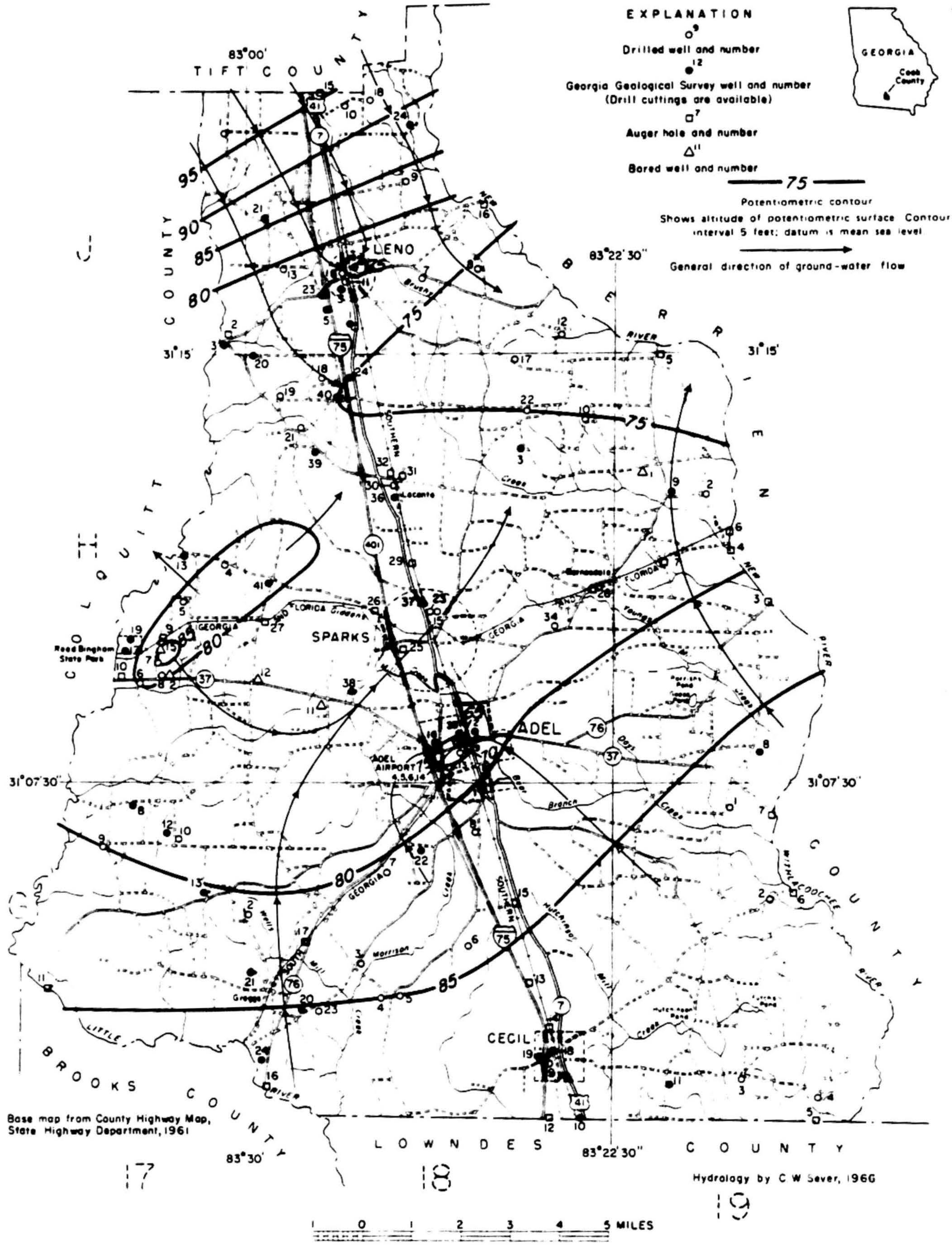

Figure 1. – Map showing locations of wells and potentiometric surface in the principal artesian aquifer, April 1966.

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ABSTRACT

Aquifer-performance tests and aquifer studies indicate that the limestone beneath the city of Adel and probably most of Cook County contains potable water to a depth of only about 400 to 500 feet and that "deep" wells that tap these limestones obtain most of their water from a few thin, highly permeable zones rather than from the entire thickness of the rocks. Below about 500 feet the water is mineralized and not potable without treatment. The yield of "shallow wells" is variable and the water generally is corrosive and at places contains appreciable dissolved iron.

The volume of ground water flowing through the Suwannee and Marianna Limestones in Cook County and available for development to properly spaced wells and well fields is estimated to be about 18,000,000 gallons per day. That in the Tampa Formation is estimated to be about 1,500,000 gallons per day

Water levels near the center of the Adel well field have declined 38 feet since 1890 and presently are declining at a rate of 1.6 feet per year.

INTRODUCTION

Purpose and Scope of the Investigation

A ground-water investigation at Adel and in Cook County was made for the purpose of evaluating the quantity and quality of ground water available for industrial and municipal use and to provide information about the water-bearing zones in the limestones which will allow the orderly development of this resource.

Ground water is the principal source of water supply for Cook County and the city of Adel. Adel, the county seat of Cook County, is located in the central part of southern Georgia. (See index map, fig. 1) The county is in the Atlantic Coastal Plain physiographic province. Previous limited knowledge indicated that the limestones tapped by water wells in Cook County might have several water-bearing zones that contain water of different quality. For example, large quantities of dissolved sulfate are present in some but not all municipal and irrigation wells. Also, a few wells yield small quantities of silt and fine sand suspended in the water, while most wells never produce silt or sand.

Previous Investigations

General geological and ground-water information about the area is included in McCallie (1898), Cooke (1943), Stephenson and Veatch (1915), and Herrick and Vorhis (1963). Herrick (1961, p. 134 to 137) has published detailed lithologic and paleontological logs of four wells in Cook County, two of which are in Adel. Wait (1960, p. 43) gave a chemical analysis of water collected from a well in Adel, and McCallie (1908, p. 52) published a record made by Mr. J. B. Spencer of the material penetrated by a well. Published geologic maps by both Cooke (1943) and MacNeil (1947) include Cook County.

Methods of Investigation

Hydrologic data were obtained by inventorying water wells over the county and conducting aquifer-performance tests at municipal well fields and at Reed Bingham State Park. Twenty-two samples of water were collected and analyzed for chemical constituents by the U. S. Geological Survey laboratory in Ocala, Florida.

Twenty-nine holes were augered for a total footage of 1,656 feet; gamma-radiation logs were made of 62 dug and bored wells totaling 1,911 feet of hole; and surface outcrops were examined.

The limestone aquifers were studied by examining samples of rock cuttings collected by well drillers as they constructed water wells in the county. Samples from 12,308 feet of hole were examined. In addition, seven test wells totaling 1,855 feet of hole were drilled in Cook County in areas where additional data were needed. Gamma-radiation, electrical resistivity, and self-potential logs were made in all test wells and in as many water wells as were available. Twenty-one wells totaling 3,228 feet of hole were logged.

Well Numbers

The field well-numbering system used in this report is based upon geographic coordinates. Each well is assigned two numbers separated by a letter. The first number and the letter refer to the coordinate system shown in figure 1 and identifies the individual 7½ minute quadrangle in which the well is located. The final number represents the well numbered serially within a quadrangle. Accordingly, well 18G18 was the 18th well to be inventoried within the 7½ minute quadrangle represented by coordinates 18 and G. Locations of wells inventoried during this study are shown in figure 1.

Wells for which drill cuttings are available have also been given a Georgia Geological Survey (GGS) number. These numbers are given in table 4 under "well numbers" and in table 6 under "remarks". Drill cuttings from these wells and other data collected during this study are on file in the sample library of the Georgia Department of Mines, Mining and Geology in Atlanta.

Acknowledgments

This investigation was made by the U. S. Geological Survey in cooperation with the city of Adel, Cook County, and the Georgia Department of Natural Resources, Earth and Water Division.

Acknowledgment is due Mr. S. H. Sutton, superintendent of the city of Adel Water and Gas Department, for his assistance with test drilling and pump testing; Mr. John Flatt, manager of Layne-Atlantic Drilling Company in Albany, Ga.; Mr. John Carr, owner of Carr Drilling Company in Valdosta, Ga.; Mr. Dayton Everetts, owner of Everetts Drilling Company in Lake Park, Ga.; for supplying well data and formation logs.

WATER-QUALITY STANDARDS

The mineral content of ground water generally is controlled by the lithology of the aquifer, or rock, in which the water is contained. Water obtained from a limestone contains appreciable calcium and bicarbonate because limestone is composed of the mineral, calcium carbonate. If the limestone contains dolomite, a magnesium calcium carbonate, its water will contain appreciable magnesium and calcium and bicarbonate. If the limestone contains gypsum, its water will contain appreciable calcium and sulfate. If the aquifer is a quartz sand, then its water will contain appreciable silica. The following additional minerals are known to affect the chemical quality of water in aquifers in southwest Georgia: common salt (sodium chloride), pyrite and marcasite (iron sulfides), glauconite (potassium iron silicate), and apatite (calcium phosphate containing fluoride).

The U. S. Public Health Service (1962) has established water-quality standards to be used in interstate commerce and suggests that these be applied to public water systems. Their recommended limits are given in table 1 and a brief discussion of the various constituents follows: Water containing concentrations in excess of those listed in table 1 ordinarily should not be used unless no other suitable supply can be obtained.

Table 1. – Drinking water standards. (From U.S. Public Health Service, 1962).

Chemical Constituent	Recommended Maximum Concentration (milligrams per liter)
Iron (fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Nitrate (NO_3)	45
Fluoride (F)	1.2
Dissolved solids	500

Iron

Iron is present in small amounts in most ground water but the recommended limit for domestic use is 0.3 mg/1 (milligram per liter). Water containing more than 0.3 mg/l will stain fabrics, utensils, and fixtures, and 0.5 mg/l is detectable by taste. Also, water having a high iron content favors growth of the organism **Crenothrix** which forms rust-colored deposits in water pipes and fixtures, partly or completely clogging them. Excessive iron may be removed from most water by aeration and filtration.

Sulfate

Most sulfate in ground water is derived from sulfur-bearing minerals such as gypsum, pyrite or marcasite, in the rocks, but sulfate also can be derived from sulfur-bearing organic compounds and from fertilizers containing sulfate.

Sulfate is purgative and causes a bitter taste in water if present in excess of 250 mg/l. Sulfate in excess of 100 mg/l causes hard scale in boilers if calcium and magnesium cations are also present.

Chloride

Sodium chloride is a characteristic constituent of sewage, and any appreciable pollution of water by sewage is accompanied by a measurable increase in chloride. Chloride also is dissolved from sodium chloride minerals contained in some rocks. Chloride gives a salty taste to water if present in quantities greater than about 400 mg/l. The recommended limit for drinking water is 250 mg/l.

Nitrate

Fertilizers contribute to the nitrate content of water in shallow aquifers and some nitrogen is dissolved from rocks; but most of the nitrate in water is considered to be the oxidation product of nitrogenous organic material (usually sewage or fertilizer). The presence of abnormal quantities of nitrate may indicate poor sanitary conditions.

The so-called "blue baby" disease (metheglobinemia or cyanosis) in infants is a possible hazard when the baby's feeding formulas are mixed with water containing more than 45 mg/l of nitrate which is the recommended maximum limit.

Fluoride

Fluoride is a natural constituent in much of the ground water in southwestern Georgia. It is dissolved from numerous complex fluoride-bearing minerals found in the rocks, the most important of which is apatite. The recommended maximum limit for fluoride content in water is based upon the average maximum air temperature. Thus, in the report area the recommended maximum concentration is 1.2 mg/l; recommended minimum is 0.7 mg/l and optimum is 0.9 mg/l. Fluoride in excessive concentrations is undesirable in water used for drinking because it may cause spotting of the tooth enamel and may affect skeletal bone structure.

AQUIFERS AND THEIR HYDRAULIC PROPERTIES

Within the Georgia Coastal Plain, aquifers (water-bearing zones) function both as storage reservoirs and as pipelines that transmit ground water from areas where it enters the ground to areas where it is discharged. In Cook County, wells that tap these aquifers obtain most of their water from a few thin, highly permeable zones capable of transmitting large volumes of water, and not from the entire thickness of the rocks. Knowing the depth, thickness, distribution, and yield of these zones as well as their hydraulic properties, allows for the proper construction and spacing of wells. Water wells drilled in Cook County, although they may tap one or more of these aquifers, locally are called either "deep", "semi-deep", or "shallow" depending upon the major aquifer they tap.

The "deep" drilled wells tap a system of limestones of Eocene to Miocene age referred to in this and most previous reports as the principal artesian aquifer, the most extensively used aquifer system in Georgia. Three geologic formations make up this aquifer system in the study area. They are the Ocala Limestone of late Eocene age, and the Marianna and

Suwannee Limestones of Oligocene age. This aquifer system is tapped by all municipal and irrigation wells and many domestic wells in Cook County.

The "semi-deep" drilled wells tap the Tampa Formation of early Miocene age. In the southern part of Cook County, this aquifer is tapped by a few irrigation and municipal wells. Because the Tampa yields sand when pumped from unscreened wells, it is usually cased off in municipal and irrigation wells. In the northern part of Cook County, it is separated from the principal artesian aquifer by silt, clay, and sandy limestone of lower permeability; here, the Tampa is tapped by domestic and stock wells and it usually yields sand-free water of good quality.

The "shallow" bored and dug wells tap whichever formation occurs at shallow depths below land surface where the well is constructed. Yield of these wells varies greatly. Those that tap an upper permeable zone are capable of yielding several hundred gpm (gallons per minute) while some of those tapping the tight lower zone reportedly yield less than 1 gpm.

The stratigraphic position and thickness of the water-bearing zones in an aquifer can be determined by monitoring a well that taps the aquifer with a current meter while water either is being pumped out of or into the well at a constant rate. A current meter consists of a helical vane mounted on a pivot and placed in an open-end tube through which the water moves. The revolutions per minute of the vane indicate the velocity of the water. If the well diameter and the rate of pumpage are known, the volume of flow at various depths can be estimated and the depth, thickness, stratigraphic position, and volume of water supplied by each water-yielding zone can be determined. The volume of flow generally can be controlled by valves or pump speed and measured with a meter. The diameter of a well can be determined by use of a caliper designed for use inside of wells. A graph recorded with such an instrument is called a hole-gage, well-diameter, or caliper log.

The position of each water-bearing zone with reference to the various stratigraphic formations is determined by examining samples of the rocks penetrated by the well or comparing the electrical and gamma-radiation properties of the rocks with rocks in other wells to locate the tops and bottoms of the formations.

The principal hydraulic properties of an aquifer are its transmissivity (T) and storage coefficient (S). A measure of a formation's ability to transmit ground water is its transmissivity, which is defined as the rate of flow of water in gallons per day, through a vertical strip of the aquifer 1 foot wide and extending the full saturated thickness under a hydraulic gradient of 100 percent (1 foot per foot). The storage properties of an aquifer are expressed by the storage coefficient, which is defined as the volume of water released from storage per unit surface area of the aquifer per unit decline in head or water level. The transmissivity and storage coefficient of an aquifer may be determined by means of aquifer-performance tests wherein the effect of pumping a well at a known constant rate is measured at the pumped well and at nearby observation wells penetrating the aquifer.

Graphs of drawdown versus time after pumping started or recovery versus time after pumping stopped, are used to solve equations which express the relation between the transmissivity and storage coefficient of an aquifer and the lowering of water levels in the vicinity of a pumped well (Theis, 1935; Cooper and Jacob, 1946; and Jacob, 1950).

When a well is pumped, water levels decline in a funnel shape called a cone of depression, with the greatest drawdown at the pumped well. With other factors remaining constant, the higher the transmissivity the less the water-level drawdown and the shallower the cone of depression. Similarly, the greater the storage coefficient the less the water-level decline required to obtain the amount of water being pumped from storage. With continuous pumping, water is taken from storage at greater distances from the pumped well and the cone of depression grows in size and depth until, or unless, a source of recharge equal to the pumpage is intercepted. In this event, a state of equilibrium is reached. Water-level decline, or drawdown, is directly proportional to the pumping rate and diminishes in a logarithmic manner outward from the pumped well.

In a multiple-well system, such as supplies the city of Adel, a cone of depression is formed around each pumped well. When the cones, or pumping effects, overlap, the wells are said to interfere and water levels decline in a manner directly proportional to the pumping rates and inversely proportional to the logarithm of the distance between wells.

Hydraulic properties determined for an aquifer can be used to evaluate, for different pumping rates, the magnitude of interference between theoretical wells located nearby that tap this same aquifer.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Rocks in Cook County probably contain potable (drinking) water to a depth of only about 400 to 500 feet. However, the water contained in the rocks to a depth of about 1,400 feet probably could be treated and used in an emergency. The rocks below 1,400 feet probably contain highly mineralized water.

The Lake City Limestone of middle Eocene age is believed to be the lowermost aquifer in Cook County that contains water which can be treated and used. It is a coarsely glauconitic, fossiliferous cream to brown colored limestone. It is about 200 feet thick and should occur in Cook County at about 1,200 to 1,400 feet below land surface. At Thomasville, Ga., located 25 miles southwest of Cook County, it contains mineralized water with 24,218 mg/l dissolved solids (Sever, 1966), and in Cook County it probably contains water of similar quality. Thus, demineralization of water from the Lake City would be required before it could be used for most purposes.

The Avon Park Limestone, also of middle Eocene age, overlies the Lake City. It is about 300 feet thick and occurs at about 900 to 1,100 feet below land surface. It is a limestone that is cream to brown, sandy, glauconitic, and at places, dolomitic. It reportedly yields moderate amounts of water to wells in the southeast Georgia area, but no information is available about its yield in Cook County. It could yield small to moderate amounts of slightly mineralized water in Cook County, but it is not considered to be a reliable aquifer.

The Ocala Limestone of late Eocene age overlies the Avon Park Limestone. It is about 500 feet thick and its top occurs at about 400 to 600 feet below land surface. It is a cream-colored nodular fossiliferous limestone interbedded with gypsum and orange saccharoidal dolomite. It is capable of yielding large volumes of very hard water containing amounts of dissolved sulfate, iron, and magnesium that exceed the recommended maximum limits for municipal use. (See table 1.) The few irrigation or municipal wells in Cook County that yield sulfur water tap this formation.

The Marianna Limestone of middle Oligocene age overlies the Ocala Limestone in Cook County. At Adel, the Marianna occurs at a depth of about 370 feet below land surface. The Marianna is about 50 feet thick and consists of white, nodular, pyritic limestone. It contains abundant water of good quality. It is the lowermost formation in Cook County known to contain good water, but this water is restricted to the upper few feet near the contact with the Byram Formation.

The Byram Formation of middle Oligocene age overlies the Marianna Limestone in Cook County. It is about 10 to 40 feet thick and underlies the county at depths from about 360 feet near Adel to about 500 feet near Lenox. It consists of dense, brownish gray dolomite.

The Suwannee Limestone of Oligocene age overlies the Byram Formation. It is about 160 feet thick and occurs at depths of about 200 to 400 feet below land surface. It is a white, rather pure, fossiliferous limestone and supplies most of the water pumped from wells in Cook County. It is capable of supplying large quantities of hard to very hard water of a quality suitable for municipal, irrigation, and most industrial uses.

The Tampa Formation of early Miocene age overlies the Suwannee Limestone and occurs at depths of 150 to 300 feet below land surface. It varies in thickness from about 40 feet in the southern part of Cook County to more than 100 feet in the northern part. It consists of light gray, extremely dense, cherty, sandy limestone. It contains appreciable moderately hard water of good quality; however, in some places wells developed by the open hole method in this formation yield a mixture of water and very fine-grained sand. The Tampa Formation is tapped by the "semi-deep" wells, most of which are in the northern part of Cook County.

As mapped by MacNeil (1947), the Hawthorn Formation overlies the Chipola Formation. The author believes that the Hawthorn Formation as mapped in Cook County may not be equivalent to the type section in Florida. For this reason the term, Miocene undifferentiated, has been used in the well logs.

The lower unit overlies the Tampa Formation. It crops out along the major streams in Cook County. (See fig. 2) It is about 75 to 100 feet thick and consists of yellowish-gray fine-grained quartz sand and yellowish-green sandy clay. It yields little or no water to wells and acts as the principal confining layer for water in the underlying limestones. This upper unit crops out over most of Cook County but has been eroded near many of the stream channels. At places it is as much as 85 feet thick and it consists of orange to red, clayey, hematitic, phosphatic medium- to very coarse-grained quartz sand. It is capable of supplying

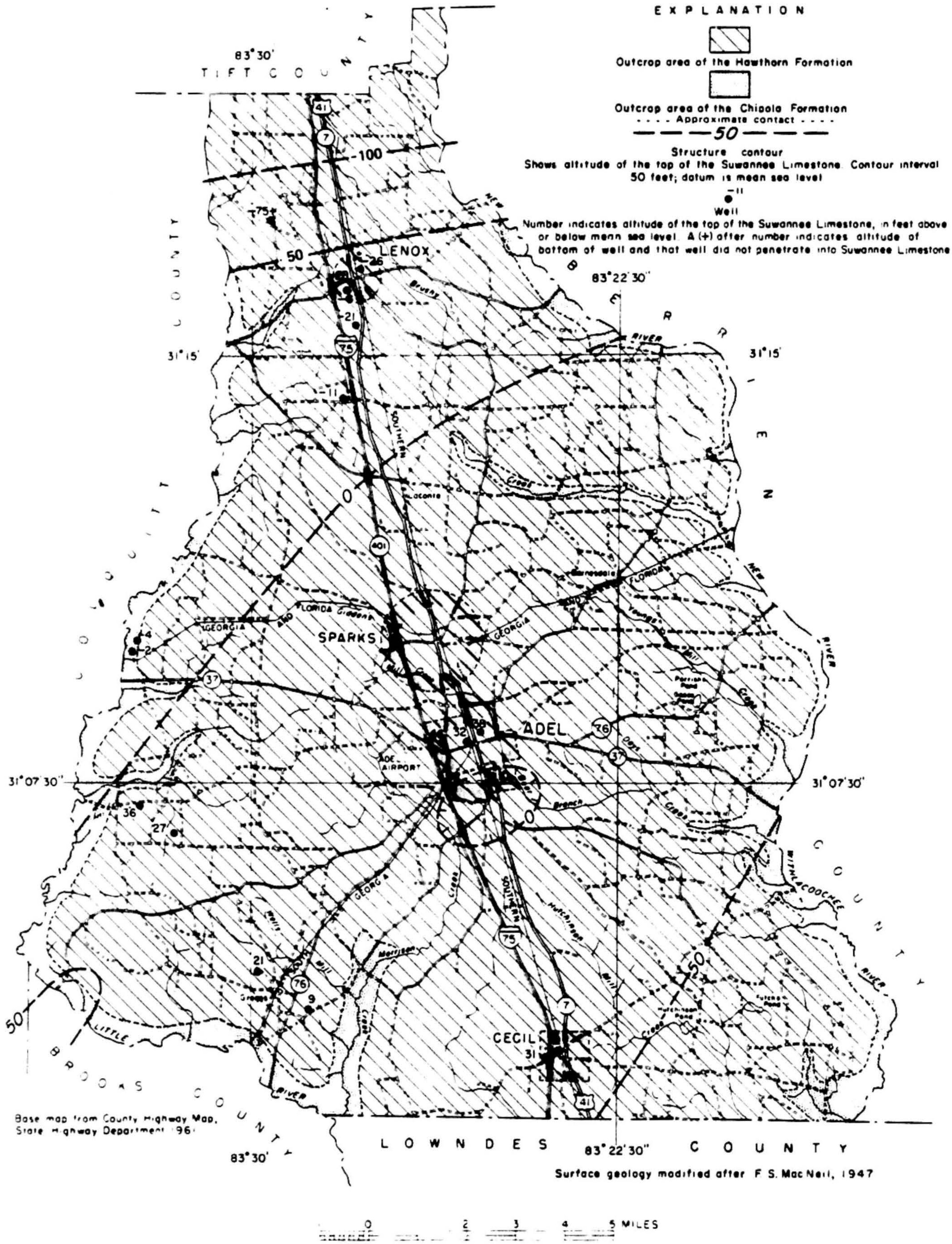

Figure 2. – Geologic map and configuration of the top of Suwannee Limestone.

moderate amounts of water suitable for domestic, irrigation, and most industrial uses. Many dug and bored wells in Cook County tap this formation. The water at most places is corrosive and high in dissolved iron. At a few places it probably is polluted.

Alluvial deposits of Pleistocene to Holocene age overlay the Hawthorn and Chipola Formations along the major streams. They consist of white to cream quartz sand and gravel. Maximum thickness is about 25 feet. They contain moderate amounts of corrosive water and are tapped by a few dug and bored wells.

U. S. GEOLOGICAL SURVEY TEST WELL AT ADEL

Geologic Formations Penetrated

A test well (18H16), located near the corner of West Second Street and North Elm Street in Adel, (fig. 3) was drilled to a depth of 865 feet and cased to a depth of 207 feet with 8-inch casing. Samples of the rocks penetrated by this well were collected and studied to determine the thickness, lithology, and depth below land surface of each geologic formation. The author's descriptions of these samples are given below, along with Foraminifera identified by S. M. Herrick:

Description	Thickness (feet)	Depth (feet)
MIOCENE SERIES (undifferentiated)		
Sand: yellowish gray (5Y8/1), medium- to very coarse-grained, angular, poorly sorted, clear quartz; argillaceous material sparse	10	10
Sand: pale reddish brown (10R5/4) to pale red (10R6/2), fine to very coarse grained, subangular to rounded, poorly sorted, clear quartz; hematite common; argillaceous	30	40
Sand: dark yellowish orange (10YR6/6), medium- to very coarse-grained, subangular to subrounded, fairly well sorted, clear quartz, stained quartz common, dark opaque grains common, phosphate pellets sparse; argillaceous material common	29	69
Sand: yellowish gray (5Y8/1), fine-grained, subangular, well sorted, clear quartz, feldspar common; argillaceous material common	95	164
UNCONFORMITY		
TAMPA FORMATION		
Sandstone: white (N9), fine- to coarse-grained, subrounded, failry well sorted, clear quartz, dark opaque minerals sparse to common, strong to weak calcareous cement; lignite common at 155 to 165; chert common at 160 to 175; fossil fragments rare	11	175
Dolomite: moderate yellowish brown (10YR5/4), saccharoidal	23	198
OLIGOCENE SERIES		
SUWANNEE LIMESTONE		
Limestone: white (N9), porous, fossiliferous, firm calcareous cement	60	258
Asterigerina subacuta at 205-210		
Pararotalia mexicana var., **Asterigerina subacuta** at 215-220		
Limestone: white (N9), very fossiliferous (almost a micro-coquina), weak calcareous cement	65	323
Lepidocyclina sp. and **Dictyoconus** sp. at 285-323		

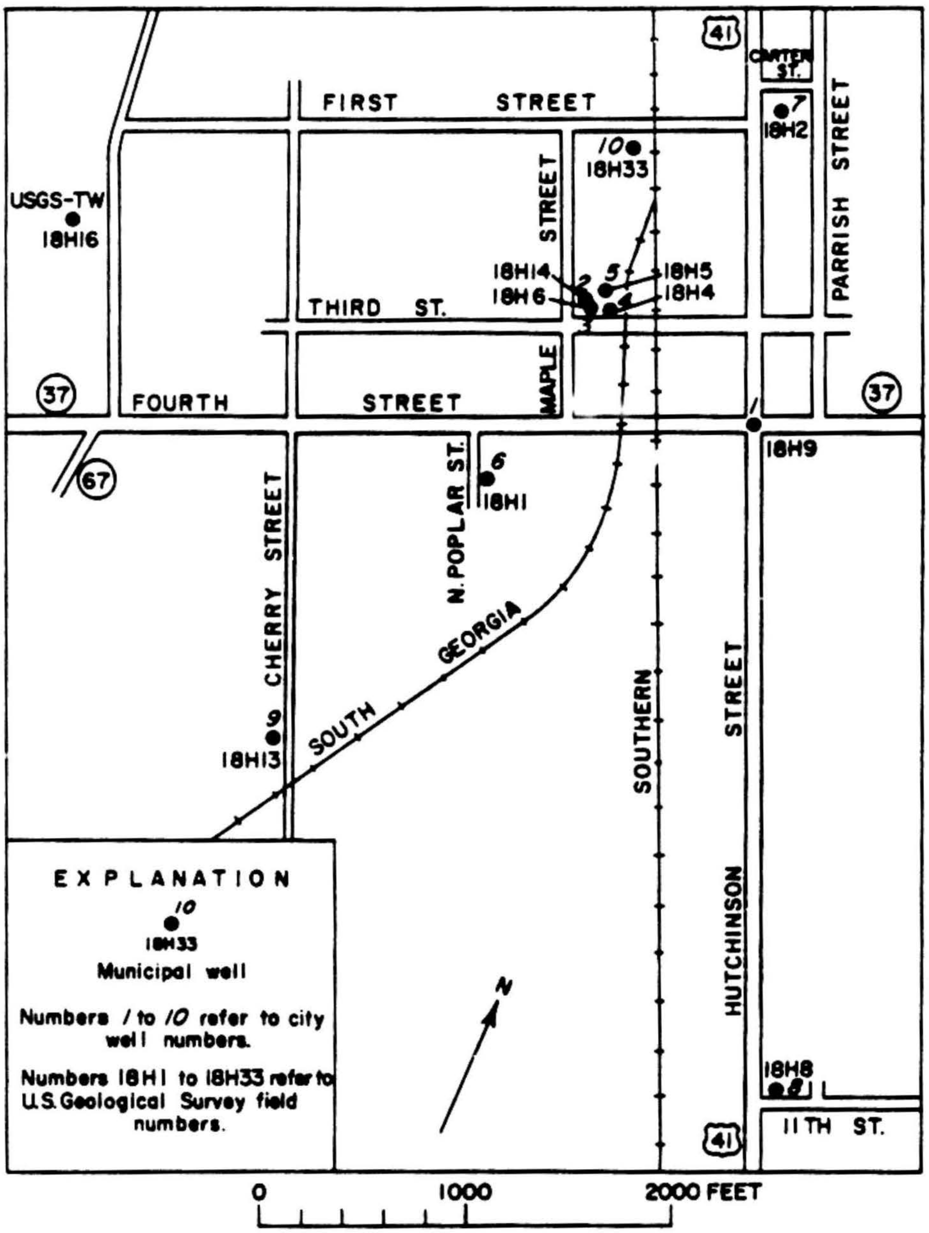

Figure 3. – Well locations at Adel.

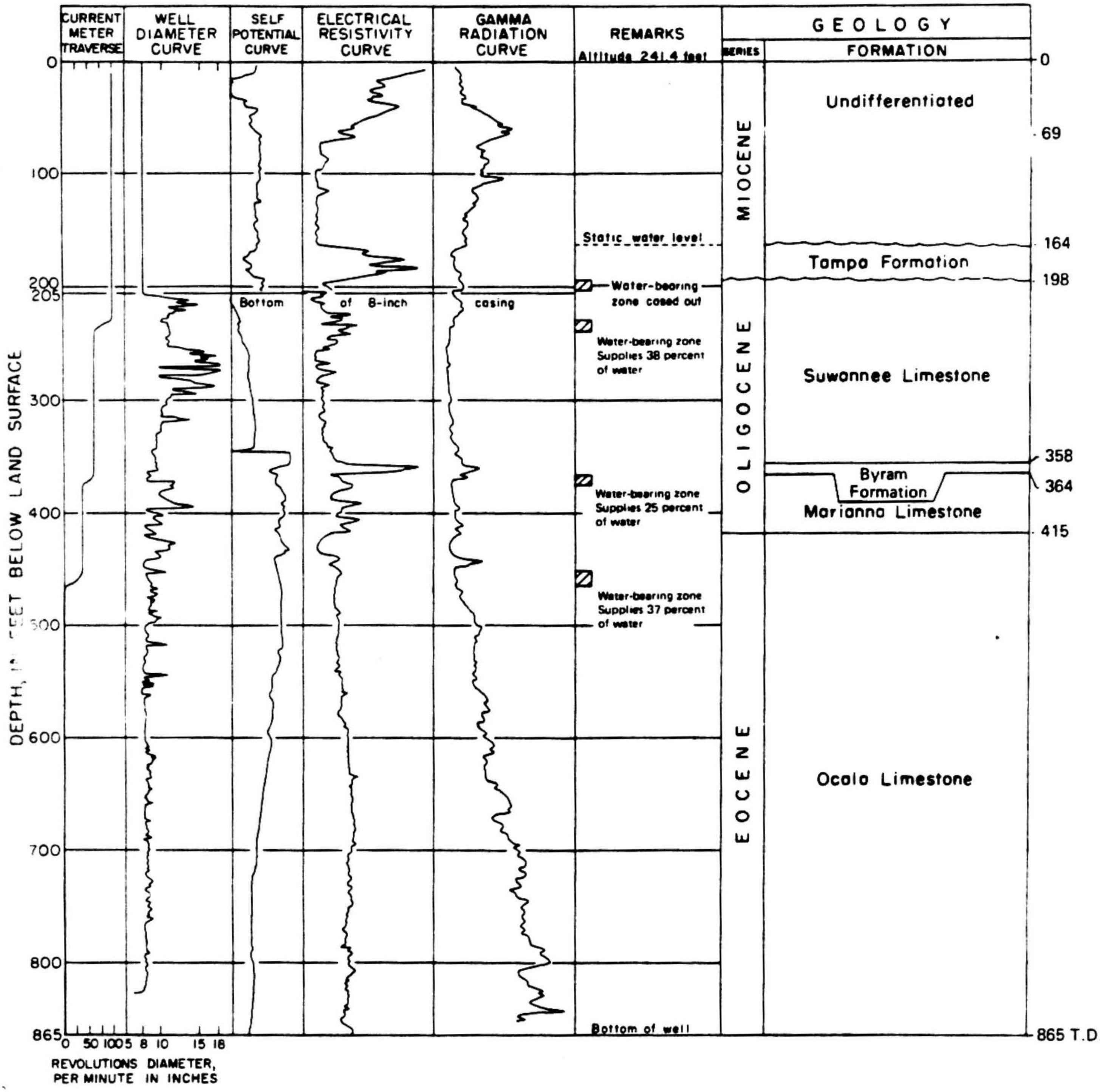

Figure 4. – Geophysical logs and distribution of water-bearing zones at Adel (well 18H16).

OLIGOCENE SERIES–Continued
SUWANNEE LIMESTONE–Continued

	Thickness (feet)	Depth (feet)
Limestone: pinkish gray (5YR8/1) to white (N9), weak calcareous cement, fossiliferous	38	361
Dictyoconus sp. common		
BYRAM FORMATION		
Dolomite: light brownish gray (5YR6/1), dense	8	369
MARIANNA LIMESTONE		
Limestone: white (N9) to yellowish gray (5Y8/1), fossiliferous, pyritic, iron nodules common	47	416
EOCENE SERIES		
OCALA LIMESTONE		
Limestone: white (N9), nodular, fossiliferous, Bryoza abundant	25	441
Heterostegina ocalana at 416-420		
H. ocalana, Asterocyclina nassauensis at 420-425		
Dolomite: very pale orange (10YR8/2) to pale yellowish brown (10YR6/2), saccharoidal, iron stained fragments abundant at 515	80	521
Dolomite and gypsum(?): very pale orange (10YR8/2) to white (N9), soft flaky white gypsum(?) very abundant	55	576
Limestone: very pale orange (10YR8/2) to white (N9), nodular, dense, fossiliferous	125	701
Nummulites striatoreticulatus, Amphistegina pinarensis var. at 576-580		
Limestone: white (N9), chalky, soft, fossiliferous	165+	865

Remarks: The interval from 820 to 860 caved badly and had to be cemented before the well could be drilled deeper. After about 6 months, the well had filled back to a depth of 850 feet.

To correlate geologic units and to help locate water-bearing zones, current-meter, well-diameter, self-potential, electric-resistivity, and gamma-radiation logs were made in the 865-foot deep test hole. The results of these logs are shown in figure 4.

Location of Water-Bearing Zones

While constructing the Adel test well, the driller noted mud loss as he penetrated the Tampa Formation and lost all circulation in the top of the Suwannee Limestone at a depth of 200 feet. This water-bearing zone was sealed out of the well when the casing was installed. After completing the well at a depth of 865 feet, the interval from 207 to 865 feet was traversed by a current meter while about 450 gpm was being injected into the well through a fire hose. The purpose was to locate any water-bearing zones tapped by the well.

Three zones were located as shown in figure 4 and listed in table 2. About 38 percent of the water entering the well moved out into the Suwannee Limestone between depths of 228 and 236 feet. Twenty-five percent of the water entered the water-bearing zone at the top of the Marianna Limestone between 365 and 268 feet. The remainder entered the Ocala Limestone between 456 and 462 feet.

No water-bearing zones were found between 462 and 865 feet. The caliper log shows that below about 470 feet the rocks are not cavernous and the electric resistivity and self-potential logs suggest that their permeability is low.

The yield from each zone when the pumping level is at 200 feet below land surface (near the bottom of the casing) is given in table 2. Also given are the estimated maximum yields for each zone.

Table 2. – Location and yield of water-bearing zones at Adel, Ga.

GEOLOGIC FORMATION	Description of water-bearing zones			Packer Settings (feet below land surface)		Chemical Data (milligrams per liter)				Specific capacity (gallons per minute per foot)	Estimated percent of total well yield supplied by each zone	Estimated yield at pumping level of 200 feet (gallons per minute)	Estimated maximum yield from zone (gallons per minute)
	Depth to top (feet)	Altitude of top (feet)	Thickness (feet)	Top	Bottom	Iron	Sulfate	Hardness	Dissolved solids				
Suwannee Limestone	228	13	8	227	243	0.31	256	376	515	31	38	1,100	1,900
Marianna Limestone	365	-124	3	362	378	0.23	262	380	524	21	25	700	2,100
Ocala Limestone	456	-215	6	452	468	1.0	612	720	1,020	31	37	1,100	9,000

Quality of Water

Each water-bearing zone tapped by the Adel test well, after being isolated with pneumatic packers, was pumped to determine the quality of its contained water. Chemical analyses of water from these zones are included further on in this report in table 4, but partial chemical analyses and the packer settings are given in table 2. These analyses show that the Ocala Limestone contains highly mineralized water that exceeds the recommended maximum concentrations of dissolved iron, sulfate, and total solids. Also, it is extremely hard (720 mg/l). Chemical analyses of water from nearby municipal wells show that water from the Suwannee and Marianna Limestones contains concentrations less than the recommended maximum for drinking water. The high dissolved solids from the upper two zones in the Adel test well are thought to be caused by leakage around the lower packer of water from the Ocala Limestone.

HYDROGEOLOGY OF THE PRINCIPAL ARTESIAN AQUIFER

Most wells drilled in Cook County tap either the Suwannee Limestone or both the Suwannee and Marianna Limestones. These two limestones constitute the upper part of what has been called the principal artesian aquifer in south Georgia and they yield abundant hard water of good quality throughout the county. A few wells are drilled deep enough to tap the Ocala Limestone in the lower part of the principal artesian aquifer, but these wells generally yield extremely hard, mineralized water of poor quality.

The upper surface of the Suwannee Limestone is somewhat irregular. Figure 2 shows the altitude of the top of the Suwannee Limestone in Cook County. The top ranges from about 500 feet above mean sea level in southeastern and southwestern Cook County to more than 100 feet below mean sea level in extreme northern Cook County.

The city of Adel, the largest user of water in Cook County, pumped an average of about 600,000 gallon per day from this aquifer in 1966.

City of Adel

History of Well Construction

Data on history and characteristics of municipal wells at Adel are summarized in table 3 and their locations shown on figure 3.

The city of Adel drilled its first municipal well (well 1 in table 3 and fig. 3) in 1893. It was drilled to a depth of 280 feet and cased to an unrecorded depth with 4½-inch casing. Its water reportedly came from a limestone bed 229 feet below land surface and rose under artesian pressure to within 154 feet of land surface. Mr. J. B. Spencer of Lumber City (McCallie, 1898, p. 153) kept the following record of the material penetrated by this well:

1. Sandy soil	2 feet
2. Red clay	10 feet
3. White sand	10 feet
4. Blue clay with sandstone boulders	125 feet
5. Fine white sand	25 feet
6. Limestone with thin layers of flint	100 feet

Well 1, located near the center of the intersection of Fourth Street and North Hutchinson Avenue, was abandoned about 1907 and later destroyed when the streets were paved.

Adel's second well (well 2, table 3) was drilled in 1907, at the city water works on West Third Street by White Company, to a depth of 675 feet (Stephenson and Veatch, 1915, p. 144). It was cased to a depth of 60 feet with 10-inch casing. Stephenson and Veatch reported that the static water level was only 50 feet below land surface in 1907, but this probably is a typographical error. Records of other wells in the area suggest that the static level should have been about 150 feet below land surface. Upon completion, this well yielded about 500 gpm of water which was very hard and contained 518 mg/l sulfate and 972 mg/l dissolved solids. This well was abandoned in 1925 because of its poor water quality.

Table 3. -- Construction data for municipal wells at Adel, Ga.

City Well Number	Location	Driller	Date Drilled	Altitude of land surface (feet)	Well Depth (feet)	Casing Size (inches)	Casing Amount (feet)	Depth to water (feet)	Specific Capacity (gpm/ft)	Field Number	Georgia Geological Survey Number	Remarks
1	Intersection of Fourth Street and North Hutchinson Avenue	Unknown	1893	246.0	280	4.5	?	154	----	18H9	---	Well destroyed, See Stephenson and Veatch (1915,p. 145) and McCallie (1898, p. 153)
2	Northwesternmost well at Adel Water Works on West Third Street	White and Co.	1907	240.3	675	10	60	150	----	18H14	----	Well destroyed, See Stephenson and Veatch (1915, p. 145)
3	Southwesternmost well at Adel Water Works on West Third Street	J.R. Connelly Co.	1925	240.4	400	12-8	?	153	----	18H6	----	Well abandoned and filled with dirt
4	Southeasternmost well at Adel Water Works on West Third Street	Gray Well and Pump Co.	1931	240.8	358	10	171	159	----	18H4	----	Do
5	Northeasternmost well at Adel Water Works on West Third Street	Layne-Atlantic Co.	1940	240.0	375	12	213	160	----	18H5	39	
6	On Poplar Street between Fourth and Fifth Streets	Do	1943	240.0	376	12	211	----	----	18H1	----	Well abandoned and filled with dirt
7	100 feet southeast of the corner of Carter Street and North Hutchinson Avenue	Do	1946	242.2	386	12	231	156	----	18H2	122	See Herrick (1961, p. 137)
8	Corner of Eleventh Street and South Hutchinson Avenue	Do	1957	240.0	359	16 12	0-46 46-253	154	200	18H8	682	
9	On South Cherry Street 200 feet north of the South Georgia Railroad	Do	1961	----	359	12	221	165	37	18H13	----	
10	On West First Street 100 feet west of the Southern Railroad	Do	1964	240.0	390	18	207	170	325	18H33	1218	Electric, Resistivity, Gamma-ray and current meter logs made

Well 3, located at the city water works about 70 feet south of well 2, was drilled in 1925 by J. R. Connelly Drilling Company to a depth of 400 feet and cased to an unknown depth with 12-inch steel casing. At a later date, 8-inch casing was seated inside the 12-inch casing in an attempt to seal out some sand being pumped from the well. Well 3 was abandoned in 1931 and later filled.

Well 4, located at the city water works about 60 feet east of well 3, was drilled in 1931 by Gray Well and Pump Company to a depth of 358 feet and cased to a depth of 171 feet with 10-inch steel casing. During construction, the driller described the materials penetrated by this well as follows:

Description	Thickness (feet)	Depth (feet)
Soil	1	1
Clay	13	14
Clay	31	45
Sandy clay	45	90
Gray marl	5	95
Sandy marl	5	100
Clay or fullers earth	45	145
Sand	10	155
White clay	15	170
Rock	15	185
Marl	5	190
Marl and rock	20	210
Water bearing limes	148	358

The driller's log shows that the well penetrated marl below the casing between 185 and 210 feet. Well 4 pumped a mixture of marl and water for about 10 years then, in 1941, the marl caved into the well and the well was abandoned. It was later filled to land surface with dirt.

Well 5, located at the water works about 100 feet north of well 4, was drilled in 1940 by Layne-Atlantic Drilling Company to a depth of 375 feet and cased to a depth of 213 feet with 12-inch steel casing. The annular space between the casing and rocks was filled with cement. During construction, the driller described the materials penetrated as follows:

Description	Thickness (feet)	Depth (feet)
Top soil	3	3
Fine sand and red clay	11	14
White sand	3	17
Red sandy clay, some sand	53	70
Soft clay	8	78
Hard gray clay	6	84
Soft gray clay	17	101
Hard clay	6	107
Gray clay and thin layers of rock	63	170
Hard rock, limestone	4	174
Hard, flinty limestone	26	200
Hard limestone	14	214
Medium hard limestone	6	220
Soft porous limestone	151	371
Very hard limestone	4	375
Drilling stopped in very hard, flinty limestone		

Samples of the rocks penetrated by well 5 were collected by the driller to a depth of about 270 feet. At this depth, circulation of mud was lost into a permeable zone in the limestones and samples of the rock could no longer be collected. The samples were examined and described by S. M. Herrick (1961, p. 135, well no. GGS 39) as shown below:

Description	Thickness (feet)	Depth (feet)
No Samples	15	15
IN MIOCENE (UNDIFFERENTIATED):		
Clay: mottled, very sandy, limonitic	55	70
No samples	10	80
Clay: yellowish-green, blocky, sandy, phosphatic, interbedded limestone, light-gray to white, dense, somewhat saccharoidal, sandy; sand, fine-grained, angular, phosphatic (finely disseminated)	85	165
Gray polished, phosphatic pebbles prominent at 80.		
No samples	20	185
Dolomitic limestone: light-brown, extremely dense, crystalline, somewhat sandy; some limestone as above	?	185
No samples	24	209
IN OLIGOCENE (UNDIFFERENTIATED):		
Limestone: light-gray to cream at depth, nodular, much calcitized, rather dense, cherty, fossiliferous (bryozoan remains and some Foraminifera)	61	270
Quinqueloculina sp., **Dictyoconus** sp. at 209-209½		
Quinqueloculina sp., **Rotalia mexicana** var. at 270		

In 1965 well 5 was still in use and yielded about 1,000 gpm with a turbine pump, driven by a 100 hp electric motor. On August 28, 1941 the static water level was 153.8 feet below land surface but on September 29, 1964, it was 173.2 feet below land surface – a decline of 19.4 feet in 23 years.

In 1943 the city drilled its sixth well, selecting as a site the east side of Popular Street, about halfway between Fourth and Fifth Streets. Well 6 was drilled by Layne-Atlantic Drilling Company to a depth of 376 feet and cased to 211 feet with 12-inch steel casing. The annular space between the casing and rocks was filled with cement grout from 211 feet back to land surface. Between 211 feet and 376 feet, the well is open hole in limestone. During construction, the driller described the material penetrated by this well as shown below:

Description	Thickness (feet)	Depth (feet)
Red sandy clay	10	10
Hard red clay	35	45
Soft yellow clay	65	110
Hard sandy clay	10	120
Hard rock	1	121
Hard sandy yellow clay	15	136
Sandy yellow clay	22	158
White clay	11	169
Flint rock	6	175
Soft (lost circulation)	3	178
Rock, with cracks and holes filled with clay	12	190
Rock	6	196
Green clay	15	211
Hard rock	7	218
Cavity	1	219
Medium drilling rock	3	222
Cavity	4	226
Soft limerock	62	288
Hard rock	12	300
Soft limerock	18	318
Hard rock	11	329
Soft limerock	37	366
Real hard rock	10	376

Well 6 was abandoned and filled to land surface with dirt prior to 1963.

In 1946, the city drilled its seventh well selecting a site about 100 feet southeast of the corner of Carter Street and North Hutchinson Avenue. Well 7 was drilled by Layne Atlantic Drilling Company to a depth of 386 feet and cased to a depth of 231 feet with 12-inch steel casing. The annular space between the casing and rocks was filled with cement grout from 231 feet back to land surface. Between 231 feet and 386 feet the well is open hole in limestone. During construction, the driller described the material penetrated by this well as follows:

Description	Thickness (feet)	Depth (feet)
Pink chalk and some sand, hard	50	50
Yellow sand	12	62
White clay	20	82
Flint rock and clay	11	93
Yellow clay	5	98
Hard clay, gray with streaks	2	100
Soft gray pink clay	6	106
Soft clay	6	112
Hard gray clay	5	117
Hard clay with rock	6	123
Clay with rock	11	134
Blue clay	8	142
Soft blue and pink clay	3	145
Hard blue clay	8	153
Softer clay and fine silky sand	17	170
Hard substance resembling limestone	7	177
Very hard	1	178
Hard substance resembling limestone	1	179
Hard rock	4	183
Clean sandrock	15	198
Very soft rock with blue sandrock	10	208
Hard streak	1	209
Soft fine blue sand	3	212
Hard limestone	8	220
Soft, used considerable amount of water	5	225
Medium hard limestone	5	230
Very hard limestone, almost a standstill at 262 feet	32	262
Very hard limestone	1	263
Limestone, rock medium hard with soft cavities	23	386
Very hard, drilled 2 hours and didn't move any	—	386

The driller also collected samples of rocks penetrated by well 7 to a depth of 270 feet. Below 270 feet the rock samples were lost into a permeable zone in the limestones and could not be recovered. The samples later were examined and described by S. M. Herrick 961, p. 137, well no. GGS 122) as shown below:

Description	Thickness (feet)	Depth (feet)
MIOCENE (UNDIFFERENTIATED):		
Clay: mottled, very sandy, limonitic	93	93
Clay: yellowish-green, blocky, sandy; interbedded limestone at depth, white, dense, sandy; beds of sand, fine to coarse grained, angular	107	200
IN OLIGOCENE (UNDIFFERENTIATED):		
Limestone: light-gray, nodular, dense, much calcitized, fossiliferous (some bryozoan remains and Foraminifera)	70	270
Rotalia mexicana var. at 231		

Upon completion of the well, the city installed a turbine pump driven by a 60 hp electric motor which pumped about 700 gpm. Later, in 1962, this pump was replaced by another turbine pump driven by a 100 hp electric motor which produced, 1,016 gpm from the well with only 15 feet of water-level decline. In 1965 well 7 was still used by the city.

On June 19, 1946, the static water level was 156 feet below land surface but on September 29, 1964, it was 161. 4 feet below land surface – a decline of about 5.4 feet in 18 years.

In 1957 the city drilled its eighth well, selecting as a site the northeast corner of East Eleventh Street and South Hutchinson Avenue. Well 8 was drilled by Layne-Atlantic Drilling Company to a depth of 359 feet, cased to a depth of 46 feet with 16-inch steel casing, then cased from 46 feet to 253 feet with 12-inch steel casing. The annular space between the casing and rocks was filled with cement grout from 253 feet back to land surface. Between 253 and 359 feet, the well is open hole in limestone. During construction, the material penetrated by the well was described by the driller as shown below:

Description	Thickness (feet)	Depth (feet)
Top Soil	5	5
Yellow sand and yellow and red clay	8	13
White and yellow clay	2	15
Fine white sand	8	23
Coarse white sand	13	36
Coarse sand and gravel	6	42
Coarse chalky sandy clay	5	47
Fine sandy chalky clay	5	52
Fine sandy pink and yellow clay	5	57
Yellow sandy clay	5	62
Yellow sandy clay	5	67
Pink, white and yellow sandy clay	5	72
Lavender and white and yellow clay	5	77
Yellow and white clay	17	94
Soft sandy yellow clay	3	97
Hard sandy yellow clay	12	109
Soft white sandy clay	25	134
Chalky white clay	10	144
Soft white clay	20	164
Fine white and brown sandstone	2	166
Soft white chalky clay	27	193
White sandstone	1	194
Fullers earth	2	196
Hard sandstone	5	201
Soft sandy white clay	11	212
Fine sandy white clay	7	219
Green limerock and sandstone, hard	10	229
Fine white sandy clay	12	241
Soft white limerock with streaks of sandstone	9	250
Soft gray limerock	10	260
Limerock with hard streaks	46	306
Very hard and soft limerock	29	335

Samples of the rocks penetrated by well 8 (GGS 682; 18H8) were collected to a depth of 260 feet. Below 260 feet the rock samples were lost into a permeable zone in the limestones and could not be recovered. The samples collected were examined and described by the author as follows:

Description	Thickness (feet)	Depth (feet)
MIOCENE SERIES (Undifferentiated)		
Sand: very pale orange (10YR8/2) to grayish orange (10YR7/4), medium to very coarse grained, subangular, poorly sorted; hematite sparse	15	15
Sand: grayish orange (10YR7/4), fine to coarse grained, subangular, argillaceous fairly well sorted; interbedded sandy clay	67	82
Sand: grayish orange (10YR7/4), fine to coarse grained, subangular, phosphatic, poorly sorted, argillaceous; white polished phosphate pellets common	25	107
Clay: yellowish gray (5Y7/2), fullers earth type, sandy; interbedded sand, fine to medium grained, subangular, well sorted, clear quartz	10	117
PARAROTALIA		
Sand: white (N9), fine to medium grained, subangular, well sorted, clear quartz, weak argillaceous cement	20	137
Sandstone: white (N9) to very pale orange (10YR8/2), fine to medium grained, subangular, well sorted, firm siliceous cement	10	147
Sandstone: yellowish gray (5Y8/1), fine to medium grained, subangular, well sorted, weak to firm argillaceous cement	19	166
TAMPA FORMATION		
Sand: white (N9) to yellowish gray (5Y8/1), fine grained, subangular, well sorted; interbedded sandstone and clay	26	192
Chert: yellowish gray (5Y8/1), sandy	10	202
Sand: very pale orange (10YR8/2), very fine to fine grained, subangular, well sorted	11	213
UNCONFORMITY		
OLIGOCENE SERIES		
SUWANNEE LIMESTONE		
Limestone: white (N9), fossiliferous, cherty, firm calcareous cement to firm siliceous cement	20	233
No samples	99	332

On July 8, 1957 this well was test pumped at 1,199 gpm for 10 hours. During this test the water level declined only 6 feet. The test pump was removed and a turbine pump driven by a 100 hp electric motor was installed. This combination was producing about 920 gpm in 1965.

The static water level on July 8, 1957 was 154 feet below land surface. On September 29, 1964 it was 155 feet below land surface – a decline of 1 foot in 7 years.

In 1961, Adel drilled its ninth well on South Cherry Street between Sixth and Eighth Streets. It was drilled by Layne-Atlantic Drilling Company to a depth of 359 feet and cased to a depth of 221 feet with 12-inch steel casing. The casing was cemented into place. Between 221 feet and 359 feet the well is open hole in limestone. The driller's description of the materials penetrated during construction is given below:

Description	Thickness (feet)	Depth (feet)
Topsoil	1	1
Fine sand	2	3
Red sandy clay	3	6
Red sand	4	10
Fine white sand	2	12
Gray clay	12	24
Red clay	15	39
Yellow clay, soft with some sand	22	61
Gray clay	17	78
Gray clay with hard streak of sand rock	12	90
Gray clay	12	102
Gray clay with small streak of sand rock	20	122
Blue clay	21	143
Blue clay with fine white sand	21	164
White clay with small streak of limerock	4	168
Brown limerock, hard	3	171
No sample	2	173
Flint rock, hard	13	186
Brown limerock, medium drilling	9	195
Brown limerock with hard streak	12	207
Brown limerock and clay	2	209
Hard brown limerock	7	216
No sample	2	218
Brown limerock, hard	7	225
Gray limerock	11	236
No returns - limestone	123	359

Upon completion the well was test pumped at 1,120 gpm for 8 hours. The static water level was 165 feet below land surface. During pumping, the water level declined 35 feet to a depth of 195 feet. Then the test pump was removed and the 60 hp pump from well 6 was placed in this well. It supplies about 500 gpm to the system.

To meet increased water demands, Adel drilled its tenth well in 1964. This well was drilled by Layne-Atlantic Drilling Company to a depth of 390 feet and cased to 207 feet, with 18-inch steel casing. Cement grout fills the annular space between casing and rocks from land surface to 207 feet. The well is open hole in limestone from 207 to 390 feet. The driller's description of the material penetrated is given below:

Description	Thickness (feet)	Depth (feet)
Yellow sandy clay	3	3
Fine sandy and yellow clay	9	12
Red and white clay	10	22
Yellow clay	10	32
Coarse brown sand and yellow clay	9	41
Yellow clay with little sand	22	63
Sandy yellow clay	20	83
Sandy white clay with some sandstone	10	93
Sandstone with little limestone	30	123
Limestone, sandstone and white clay	30	153
Sand, limestone and clay	13	166
Limestone with hard and soft streaks	224	390

The driller collected samples of the rocks penetrated by well 10 (GGS 1218; 18H33) to a depth of 235 feet. The samples could not be recovered from below 235 feet. The samples from 0 to 235 feet are described below:

Description	Thickness (feet)	Depth (feet)
MIOCENE SERIES (Undifferentiated)		
Sand: white (N9) to very pale orange (10YR8/2), fine to coarse grained, subangular, fair sorted; hematite common; phosphate common at 63-83	83	83
Sandstone: white (N9) to yellowish gray (5Y8/1), fine grained, subangular, well sorted; weak calcareous cement	87	170
TAMPA FORMATION		
Dolomite: pale yellowish brown (10YR6/2), saccharoidal, sandy, firmly cemented; interbedded white, sandy, fossiliferous limestone	45	215
OLIGOCENE SERIES		
SUWANNEE LIMESTONE		
Limestone: white (N9), pure, fossiliferous	20	235
No samples	158	393

On November 18, 1964, well 10 was test pumped at 1,571 gpm for 8 hours, during which the water level declined only 5 feet. Thus the specific capacity of well 19 for this period of pumping was about 325 gpm per foot of drawdown.

Hydraulic Properties

On December 8, 1964, an aquifer test was made by recording the drawdown of water level in well 18H33 caused by pumping 900 gpm from well 18H5 located 700 feet to the south. Analysis of this data by the Theis (1935) nonequilibrium formula suggests that the transmissivity is about 1,600,000 gallons per day per foot (gpd per ft) and the storage coefficient is about 0.002 (fig. 5). However, the water-level decline in the city of Adel well field (fig. 7) suggests that the average values in the area are much lower.

Effects of Pumping

The amount of interference by a pumped well with nearby wells that tap the same limestones as the municipal wells at Adel can be estimated using the graph in figure 6. This graph shows the theoretical drawdown in water level caused by interference for wells spaced at distances of 10 feet to 1,000 feet apart for a continuous pumping period of 10 years at 1,000, 5,000, and 10,000 gpm. With intermittent pumping, the theoretical drawdown would be less than that shown in figure 6.

Declining Water Levels

Water levels in a multiple-well field, such as at Adel, decline in a manner directly proportional to the rate at which the wells are pumped. Figure 7 is a graph that shows the decline in water level at the Adel Water Works located on the corner of West Third Street and North Maple Street near the center of the well field. Each measurement was made while the pumps were off and represents the approximate static water level at the time of measurement.

The water level declined at a rate of 0.08 foot per year from 1890 to 1940; 1.4 feet per year during the World War II from 1940 to 1945; and 0.6 foot per year from 1945 to 1961, it has been declining at a rate of 1.6 feet per year. Since 1890 it has declined a total of 28 feet.

Away from the center of pumpage the water level is relatively constant as shown by a graph (fig. 8) of the water level in the U.S.G.S. test well (18H16) in Adel. This well is located about 2,600 feet west of the city's Third Street well field.

Quality of Water in Municipal Wells

Water from the municipal wells at Adel is hard but otherwise of chemical quality suitable for most present uses. Its dissolved chemical constituents are below the U.S. Public Health Service (1962) recommended maximum concentrations for drinking water. It is suitable for most industrial use as well as for domestic and municipal uses. Chemical analyses of water from three of the municipal wells are given on table 4.

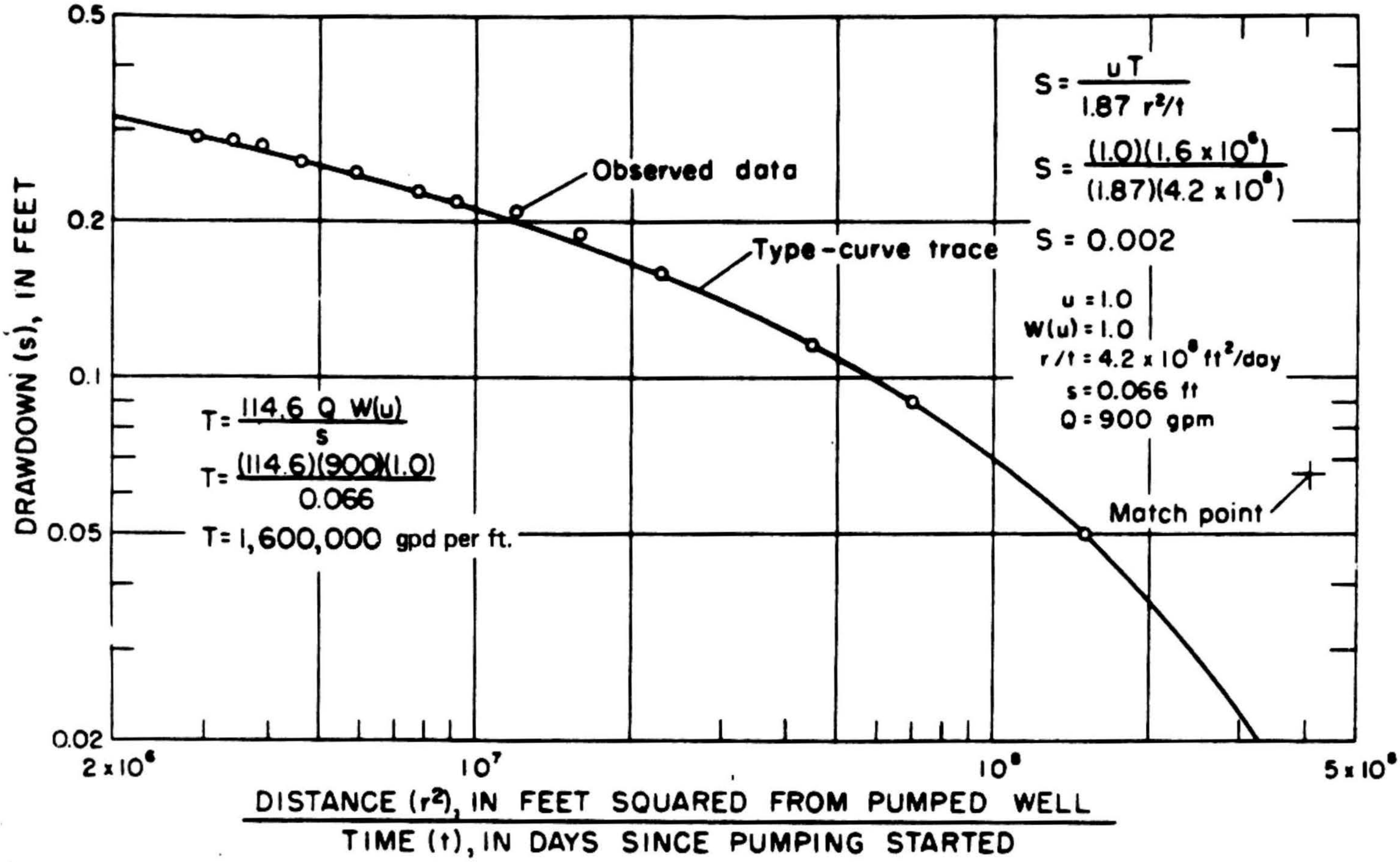

Figure 5. – Data plot for aquifer test of Suwannee Limestone at Adel.

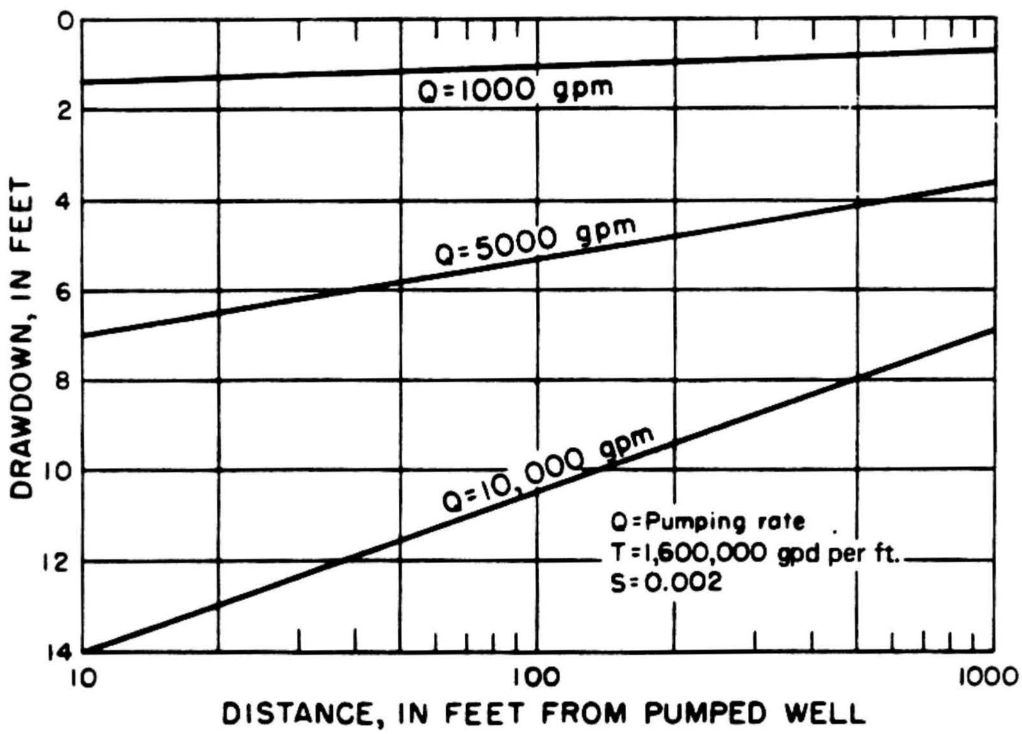

Figure 6. – Theoretical drawdown at Adel after 10 years continuous pumping.

Table 4. – Chemical analyses of water from wells in Cook County, Ga. 1/

Well Numbers						Milligrams per liter				
Field No.	GGS No.	Owner	Aquifer	Date of Collection	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)
			(Recommended maximum concentration)				0.3			
17G8	118	Dr. Dismuke	Tampa and Suwannee	5/03/65	22	31	0.1	45.0	17.0	4.2
17H15		Mrs. Elliza Flounders	Hawthorn	5/03/65	20	12	.02	10	5.4	13
17H17	1362	Reed Bingham State Park	Tampa and Suwannee	11/17/65	22	32	.00	45	18	4.9
18G18	1423	City of Cecil	Suwannee	3/17/65	21	44	.02	27	12	3.8
18H3	105	Bryant Gaskins	Tampa and Suwannee	5/04/65	25½	34	.02	38	16	5.6
18H5	39	City of Adel	Suwannee and Marianna	3/18/43	21	22	.04	46	19	5.1
18H8	682	[a]City of Adel	do	4/18/58	21	33	.26	53	16	4.6
18H15		City of Sparks	Suwannee	4/29/65	21	35	.02	49	14	3.4
18H16	966	[b]USGS Test Well	Suwannee, Marianna and Ocala	12/01/64	22	30	.17	96	39	14
18H16	966	[c] do	Suwannee	3/24/65	23	31	.31	91	36	14
18H16	966	[d] do	Marianna	3/25/65	23	30	.23	96	34	14
18H16	966	[e] do	Ocala	3/26/65		27	1.0	176	73	32
18H33	1218	City of Adel		11/17/65	22	26	.11	50	18	3.2
18H36	1264	[f]USGS Test Well	Tampa	6/11/65	23	43	.10	24	16	9.4
18H37		Adel Plating Production Co.	Chipola	11/17/65	22	13	.14	2.8	2.0	6.5
18J1	860	Levy Green	Tampa and Suwannee	5/05/65	24	34	.03	31	8.1	12
18J3	684	Town of Lenox	Suwannee and Marianna	4/29/65	23	37	.00	38	20	27
18J18		Howard Sumner	Chipola	5/05/65	22	80	.01	6.0	2.7	6.4
18J19		F.L. Fleming	Hawthorn	5/05/65	20	12	.02	7.6	2.7	5.0
19G8		Harry Futch	do	5/04/65	20	6.4	.02	.8	1.5	2.8
19H1	115	Alton Miers	Hawthorn and Chipola	5/04/65	19	4.7	03	3.2	.7	3.4

1/ Analyzed by U. S. Geological Survey.

2/ Recommended maximum concentration for area covered by this report (average maximum daily air

[a]From Wait, 1960, p. 43

[b]Int. from 207-869 ft.

[c]Int. from 227-243 ft. Collected after pumping 18 hours.

[d]Int. from 362-378 ft. after pumping 18 hours.

[e]Int. from 452-468 ft. after 10 hours pumping.

[f]Collected after pumping 20 hours.

Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (Residue at 180°C)	Hardness as ($CaCO_3$) Calcium Magnesium	Non-Carbonate	Specific conductance (micromhos at 25°C)	pH	Color	Hydrogen Sulfide (H_2S)(mg/l)
		250	250	1.2 2/	45	500	(From U.S. Public Health Service, 1962				Drinking Water Standards)	
0.7	152	55	3.5	0.5	0.0	232	184	60	340	7.9	0	
2.0	0	.8	25	.2	51	119	47	47	235	4.4	0	0.0
1.5	142	78	5.0	.4	.1	255	186	70	380	7.7	0	
.9	149	.0	3.0	.4	.0	164	117	0	228	7.9	0	.0
1.2	136	52	6.0	.5	.0	220	162	50	351	7.8	0	.3
1.9	144	75	4.8	.3	.0	260	193			7.6	0	
1.[illegible]	144	87	4.0	.3	.1	289	198	80	399	7.7	2	
.8	142	65	6.0	.4	.0	244	182	66	342	7.9	0	.0
1.2	144	276	14	.5	.0	542	400	282	746	7.6	3	
1.2	144	256	14	.4	.0	515	376	258	712	7.5	3	
1.2	146	262	14	.4	.0	524	380	260	720	7.6	3	
2.[illegible]	144	610	30	.6	.0	1020	720	602	1300	7.5	3	
1.2	147	87	3.0	.3	.1	261	199	78	390	7.8	0	
1.3	156	4.8	7.0	.5	.0	183	124	0	249	8.1	0	
1.2	2	10	8.5	.2	9.3	54	14	15	89	4.9	0	
1.9	151	7.2	5.0	.5	.0	174	111	0	240	8.1	0	
1.7	146	68	36	.6	.0	300	176	56	480	7.9	0	.0
1.0	49	.4	1.5	.4	.0	122	26	0	83	6.9	0	
4.6	6	20	10	.2	11	76	30	25	120	5.5	0	.1
.2	3	.0	5.5	.1	7.5	26	8	6	42	5.3	0	.0
.4	5	.4	6.8	.1	6.5	29	11	7	49	5.8	0	.1

temperature of 17.7-21.4°C) is 1.2 mg/l; recommended minimum is 0 7 mg/l and optimum is 0.9 mg/l.

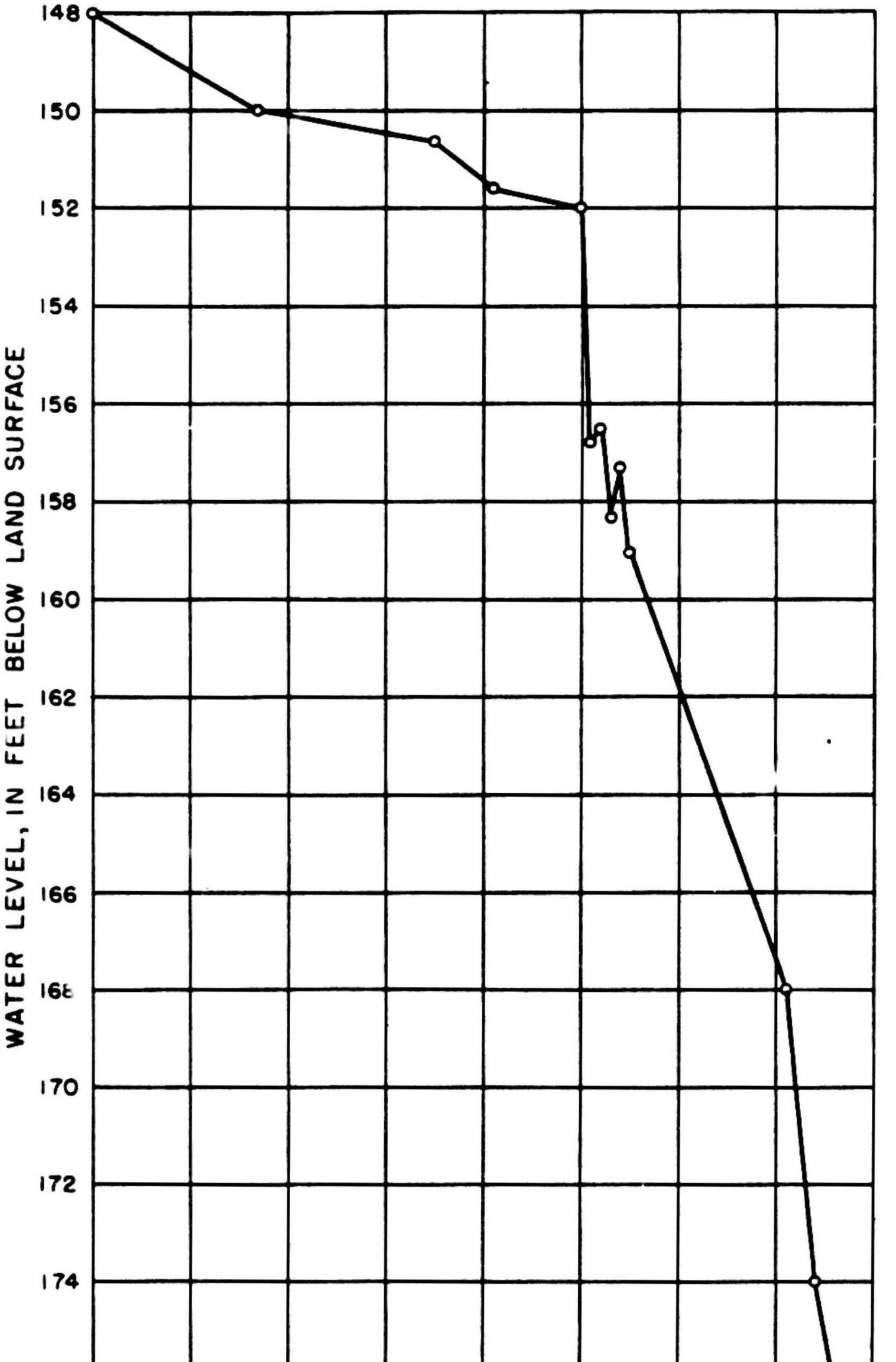

Figure 7. – Water-level decline in Adel at Third Street well field, 1890-1966.

City of Cecil

In March 1965, the city of Cecil drilled its first municipal well, 18G18, at the southeast corner of Union and Rountree Streets (fig. 9). The well was drilled by Everett Drilling Company to a depth of 308 feet and cased to a depth of 214 feet with 8-inch steel casing.

Samples of the rocks penetrated by the well were collected by the driller and examined by the author. Description of these samples are given below:

Description	Thickness (feet)	Depth (feet)
MIOCENE SERIES (Undifferentiated)		
Sand: mottled grayish-pink (5R8/2) to light red (5R6/6), fine to very coarse-grained, subangular to subrounded, poorly sorted, argillaceous	20	20
Sand: pale yellowish orange (10YR8/6), fine to coarse-grained, subangular, poorly sorted, argillaceous	40	60
Chert and sandy clay: mottled white (N9) to grayish orange (10YR7/4)	5	65
Sand: pale yellowish orange (10YR8/6), fine-grained, subangular, well sorted, argillaceous	75	140
Sand: very pale orange (10YR8/2), fine-grained, subangular, well sorted, argillaceous, calcareous	25	165
TAMPA FORMATION		
Limestone: yellowish-gray (5Y8/1), sandy, firmly cemented	5	170
No samples	5	175
Limestone: white (N9), fossiliferous, weakly cemented . .	5	180
Limestone: pale yellowish brown (10YR6/2), sandy, dolomitic, firmly cemented, dense	45	225
UNCONFORMITY		
OLIGOCENE SERIES		
SUWANNEE LIMESTONE		
Limestone: white (N9), fossiliferous, firmly cemented . .	70	295

During construction of this well, electric resistivity and self-potential logs were made of the upper part of the well before the casing was installed. After completion, these two types of logs were made of the lower part of the well, and gamma-radiation and well diameter logs were made of the entire well. These logs show that this well taps the Suwannee Limestone (fig. 10).

Hydraulic Properties

On March 15 and 16, 1965, an aquifer performance test was made by measuring the drawdown of water level in well 18G18 caused by pumping the well at 53 gpm. The data were analyzed using the method developed by Ferris and others (1962). The transmissivity of the Suwannee Limestone at Cecil is estimated to be about 50,000 gpd per foot (fig. 11). The storage coefficient could not be determined.

Quality of Water

Water from the municipal well at Cecil contains dissolved mineral concentrations that are well below the U.S. Public Health Service recommended maximum limits for drinking water. A sample of the water was analyzed by the U.S. Geological Survey in 1965. This analysis, which is given in table 4, shows the water to be moderately hard and suitable for municipal, most industrial, and irrigation uses.

City of Lenox

The city wells of Lenox produce from the principal artesian aquifer. A well drilled in 1946 by Layne-Atlantic Company produces water from limestone of Oligocene age. Another

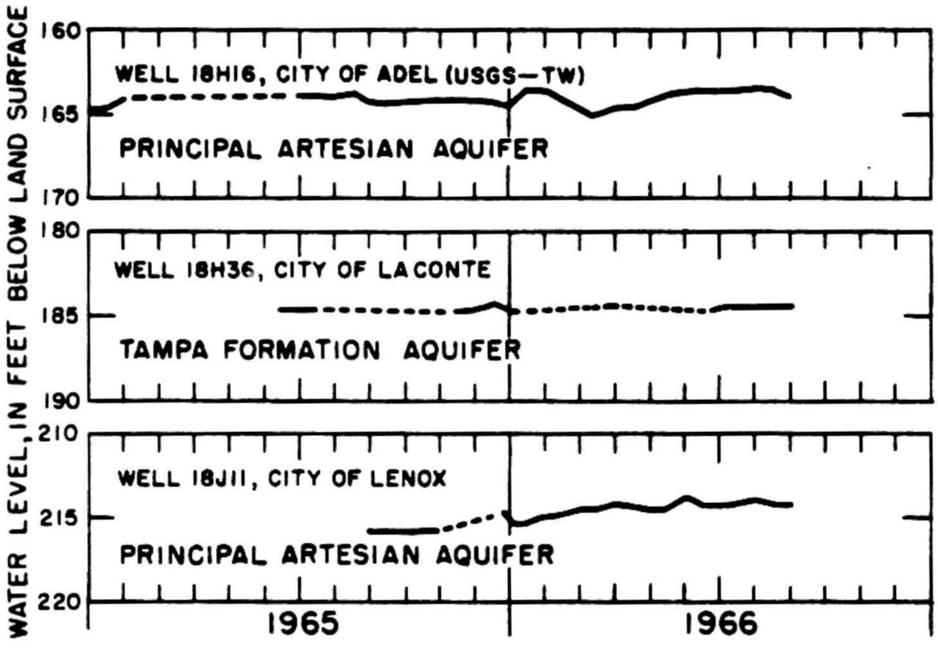

Figure 8. – Hydrographs of water levels in three Cook County wells during 1965-66.

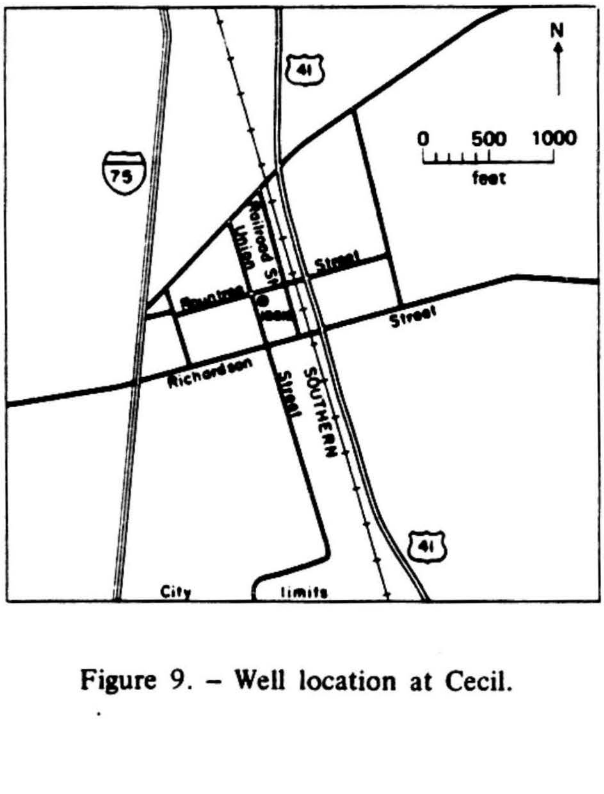

Figure 9. – Well location at Cecil.

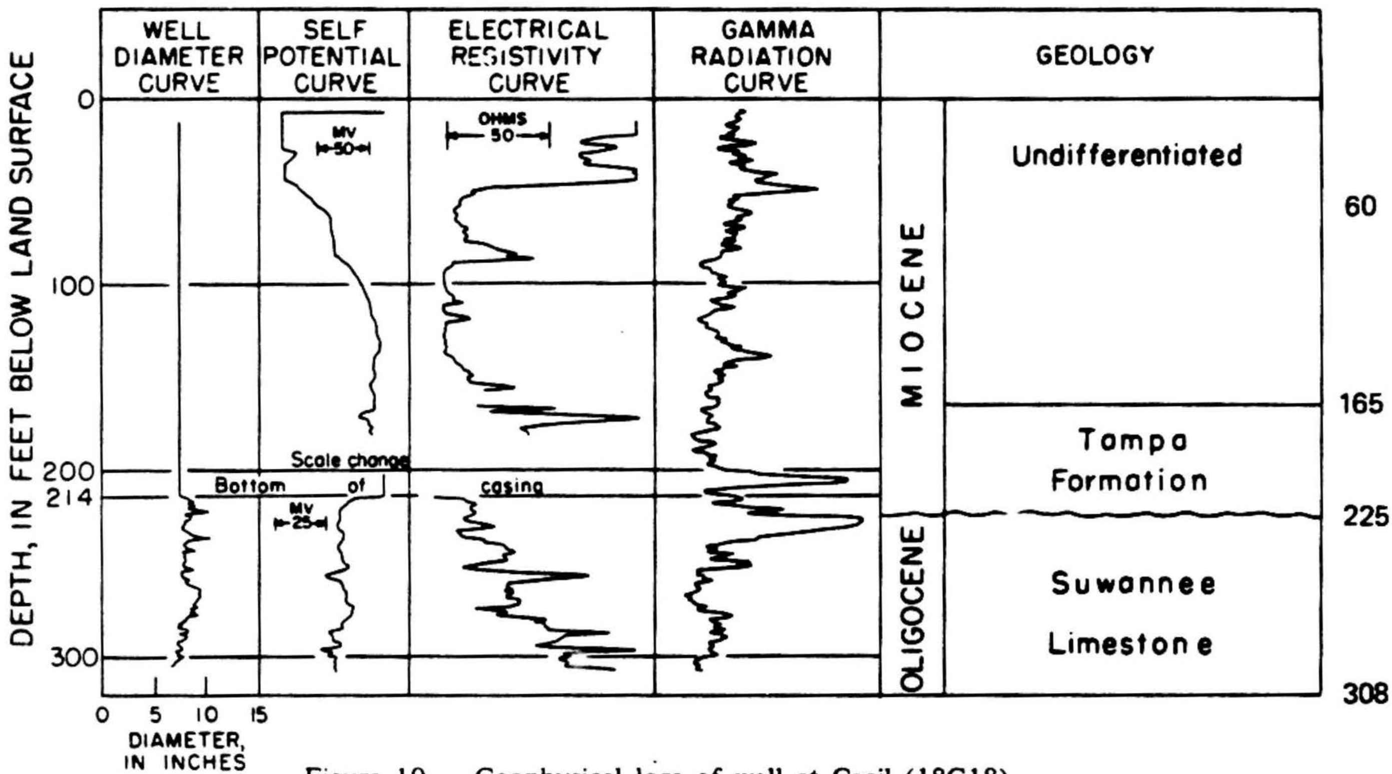

Figure 10. – Geophysical logs of well at Cecil (18G18).

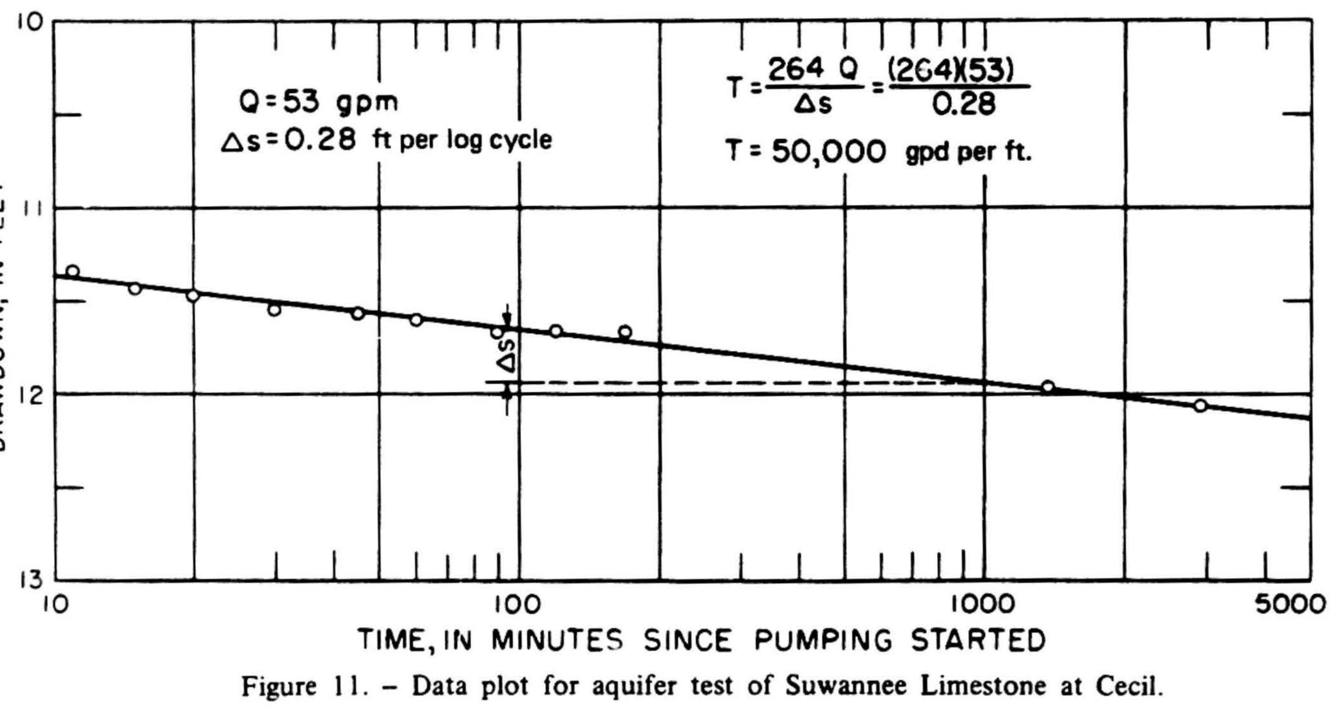

Figure 11. – Data plot for aquifer test of Suwannee Limestone at Cecil.

well drilled in 1957 by M. M. Gray Well Company produces from limestones of Oligocene and late Eocene age. Cuttings from this well were studied by S. M. Herrick, who prepared the following log:

Description	Thickness (feet)	Depth (feet)
MIOCENE SERIES (Undifferentiated)		
Clay: mottled, sandy, limonitic	20	20
Clay: as above, with some interbedded limestone; gray to white, much calcitized, dense, sandy	110	130
Clay: pale brownish-gray, somewhat laminated, sandy, with some interbedded limestone; white sandy	80	210
Lithology as above, with scattered tongues of dolomitic rock; light brown, saccharoidal	40	250
Dolomitic rock; light brown, saccharoidal, somewhat fossiliferous, with impressions and molds of molluscan shells	10	260
OLIGOCENE SERIES (Undifferentiated)		
Limestone: cream to light-brown, somewhat dolomitized, nodular, fossiliferous at certain levels, with some Foraminifera	200	460
Pararotalia mexicana var., **Quinqueloculina** sp. at 260-270 feet		
Dictyoconus sp. at 410-420 feet		
EOCENE SERIES		
OCALA LIMESTONE		
Limestone: as above, but becoming white and chalkier at depth	40	500 (T.D.)
Lepidocyclina ocalana, Lepidocyclina sp. at 490-500 feet		
Planulina kendrickensis, Asterocyclina nassauensis at 490-500 feet		

Potentiometric Surface

The potentiometric surface shown in figure 1 is an imaginary surface representing the static water level (in feet above mean sea level) in wells tapping the principal artesian aquifer as measured in April 1966. It is useful in showing the general direction of ground-water flow in the aquifer system and in showing areas of recharge and discharge. Ground water flows from areas of high potentiometric elevations toward areas of low potentiometric elevations in a direction generally normal to each contour. The general directions of ground-water flow in the upper part of the principal artesian aquifer in Cook County are shown by arrows in figure 1.

High potentiometric elevations in southern and western Cook County suggest that appreciable rainfall percolates through the Miocene sands and clays to recharge the aquifer in these areas. The high potentiometric contours and steep gradient in northern Cook County indicate that water is moving into northern Cook County from a recharge area located to the northwest of the county.

Data are inadequate to construct a potentiometric map of the limestone aquifer in the Tampa Formation. However, water levels in the Tampa in Cook County are about the same as those in the upper part of the principal artesian aquifer system shown in figure 1.

Quality of Water

Samples of water from at least one well in each town and from numerous other wells that tap the Suwannee and Marianna Limestones were analyzed. In each well the water was hard, but of quality suitable for municipal, domestic, and most industrial uses. Chemical analyses of these water samples are given in table 4.

Water in the Ocala Limestone is highly mineralized and of poor quality.

HYDROGEOLOGY OF THE TAMPA FORMATION AQUIFER

Many wells in southern Cook County tap both the Tampa Formation and the Suwannee Limestone, but generally the Tampa is cased out. However, in northern Cook County where the Suwannee is deepest, many wells tap only the Tampa.

The upper surface of the Tampa is very irregular in Cook County. As shown in figure 12, the top ranges from 100 feet above mean sea level in southern Cook County to below sea level in northern Cook County.

U. S. Geological Survey Test Well at Laconte

In June 1965 the U.S. Geological Survey, as part of this cooperative project, drilled a test well (GGS 1264 and 18H36) at Laconte to determine the amount and quality of water available from the Tampa Formation. Samples of the rocks penetrated by the well were collected by the driller and later examined and described by the author. Descriptions of these samples are given below:

Description	Thickness (feet)	Depth (feet)
MIOCENE SERIES (Undifferentiated)		
Clay: mottled to grayish orange (10YR7/4), sandy, hematitic	10	10
Sand and gravel: grayish orange (10YR7/4) to white (N9), medium-grained sand to fine pebble gravel, subangular, poorly sorted; stained quartz	25	35
Sand: mottled grayish orange pink (10R8/2) to very dark red (5R2/6), medium grained, subangular, fairly well sorted; argillaceous hematitic	50	85
Sand: yellowish gray (5Y8/1), fine grained, subangular, argillaceous, well sorted, clear quartz; calcareous fragments common; phosphatic	20	105
Sandstone: yellowish gray (5Y8/1), fine to medium grained, subangular, well sorted, clear quartz; firm to weak calcareous cement	10	115
Sandstone: yellowish gray (5Y8/1), fine to medium grained, subangular, well sorted, clear quartz; weak argillaceous cement	43	158
TAMPA FORMATION		
Limestone: yellowish gray (5Y8/1), firmly cemented, fossils sparse, sandy	24	182 (total depth)

The well was drilled to a depth of 210 feet and cased to a depth of 198 feet, with 4-inch steel casing. Upon completion of the test well, the author made electric-resistivity, self-potential and gamma-radiation logs of the well. The well casing is seated on the Tampa Formation and all of the water pumped came from a thin permeable bed at a depth of about 195 feet. The static water level was about 185 feet below land surface or about 10 feet above the water-bearing bed. This water level was measured periodically during the study, and it remained nearly constant as shown by the graph in figure 8.

Hydraulic Properties of the Tampa Formation

On June 10, 1965 a 5 hp submersible test pump was installed. After pumping for only a few minutes at 50 gpm, the pump broke suction. The pumping rate was reduced by valves until the pump regained suction and pumped no air. The metered discharge showed that the pump supplied 21.6 gpm continuously for about 20 hours without again breaking suction. This means that the specific capacity of the well is about 2.2 gpm per feet for this period of pumping, an that the maximum yield of the aquifer at Laconte is about 22 gpm.

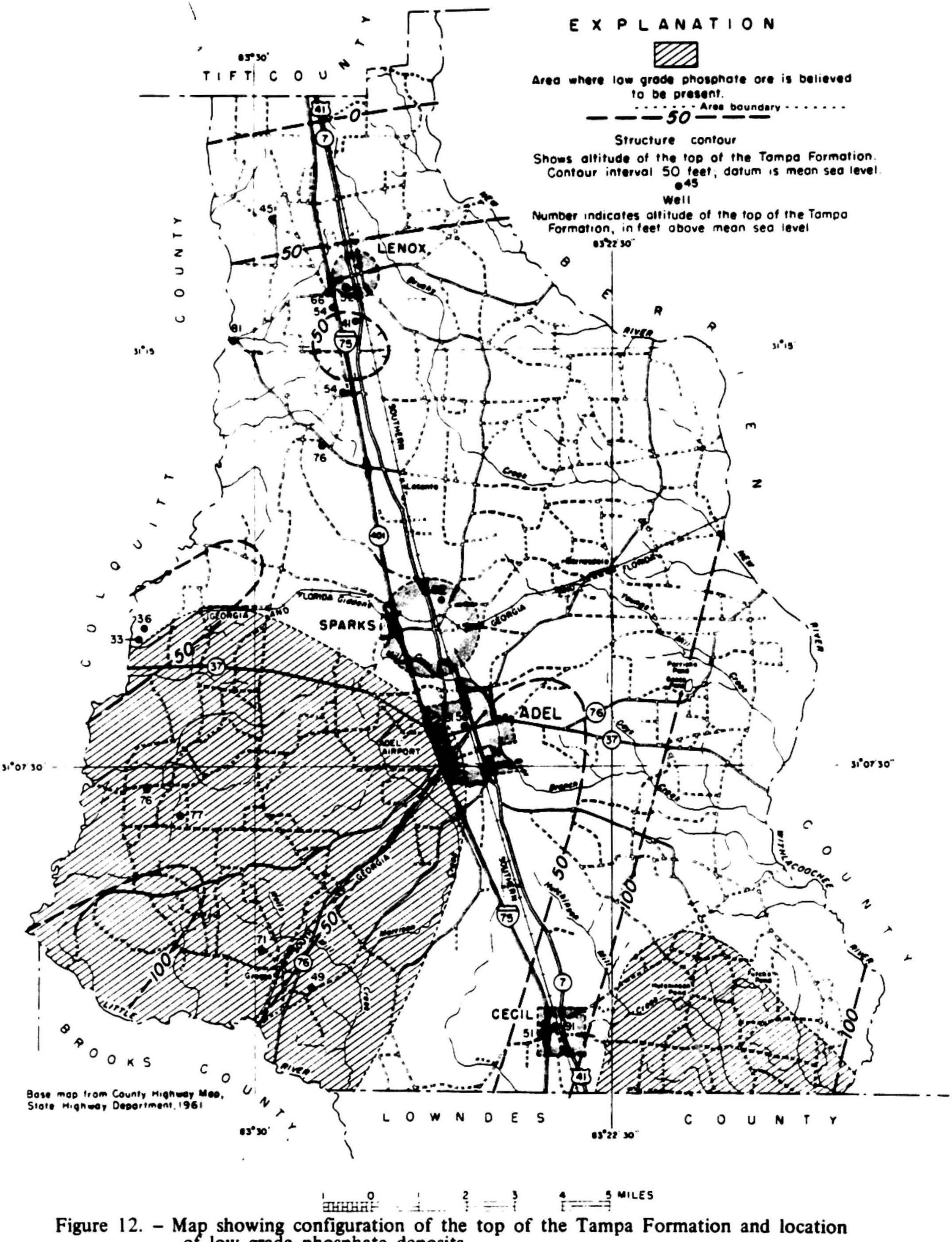

Figure 12. – Map showing configuration of the top of the Tampa Formation and location of low grade phosphate deposits.

Water-level recovery data from the pumping test were analyzed by the straight-line graphical method (Cooper and Jacobs, 1946), which is a modified form of the Theis (1935) non-equilibrium formula. The transmissivity was determined to be about 17,000 gpd per ft (fig. 13). The storage coefficient was not determined.

The maximum yield of wells that tap the Tampa Formation in Cook County south of Lenox generally is about 10 to 20 gallon per minute. Their maximum yield increases northward from Lenox until, near Tift County, the maximum yield in some wells is as much as 150 gpm.

Quality of Water

Ground water in the Tampa Formation at Laconte is moderatkly hard to hard and suitable for domestic, most industrial and irrigation uses. A chemical analysis of water from well 18H36 is given in table 4.

VOLUME OF GROUND-WATER FLOW

The potentiometric map of the Suwannee Limestone provides a means whereby the volume per day of ground-water flow through Cook County can be estimated. The formula used in this comparison is Q = T I L, where

Q = Volume of flow in gallons per day.
T = Transmissivity of the aquifer.
I = Hydraulic gradient in feet per mile (from fig. 1).
L = Distance along a given contour in miles (from fig. 1).

To determine the transmissivity of the Suwannee and Marianna Limestone, eight aquifer tests were conducted during this study on wells in Cook County which tap the Suwannee and Marianna. Results of these tests suggest that the average transmissivity in Cook County for these two limestones is about 200,000 gpd per ft. As computed, the approximate volume of ground-water flow in the Suwannee and Marianna Limestones in Cook County is as follows:

- Amount of water flowing south across 90-foot contour in northern Cook County (see fig. 1)	6,000,000 gpd
- Amount of water flowing north across 85-foot contour in southern Cook County	5,000,000 gpd
- Amount of water recharging aquifer and flowing across 80-foot contour in western Cook County	7,000,000 gpd
- Approximate total volume of water flow	18,000,000 gpd

Using a transmissivity of 17,000 gpd per ft (page 79), the potentiometric map shown in figure 1 (the water levels in the Tampa Formation are about the same as those in the Suwannee Limestone), and the formula Q = T I L, the volume of ground-water flow in the Tampa Formation was computed to be:

- Amount of water flowing south across the 90-foot contour in northern Cook County (fig. 1)	510,000 gpd
- Amount of water flowing north across 85-foot contour in southern Cook County	425,000 gpd
- Amount of water recharging aquifer and flowing across 80-foot contour in western Cook County	595,000 gpd
- Total volume of water flow	1,530,000 gpd

Data on wells in Cook County gathered during the investigation are tabulated in table 5.

Table 5. – Record of Wells in Cook County, Ga.

Well No.	Owner or Name	Driller	Date completed	Altitude above sea level (feet)	Type of Well	Depth of Well (feet)	Diameter of Well (inches)	Depth to which well is cased (feet)	Water Level: Below land surface (feet) 1/	Water Level: Date of measurement	Use of Water	Remarks and GGS No.
17G8	D.F. Burton	W.B. Graham	2/11/46	225.7	Drilled	330	4.5	176.0	147.14	4/18/66	Domestic	Cuttings collected GGS118
17G9	R.M. Alderman	Davis Drl. Co.	11/14/62	232.2	do	240	4	163.7	152.36	4/18/66	do	
17G10	Frank Gibbs	Bishop Drl.Co.	----	220.6	do	----	4	----	141.58	4/18/66	do	
17G11	USGS A.H. 4	U.S.G.S.	12/--/63	171	Bored	----	4	----	----	----		Cuttings collected-filled in GGS1200
17G12	Earnest Flowers	Bishop Drl.Co.	3/03/66	----	Drilled	234	4	197	147(R)	3/03/66	Domestic	Cuttings collected GGS1606
17G13	Co5 Ga. Tech	Ga. Tech	7/--/66	----	Cored Drilled	96	4	----	----	----		Drilled as test hole-filled in-Cuttings collected GGS1658
17H2	Bill Purvis	Bishop Drl.Co.	1960	233.7	Bored	65	12	----	----	----		Gamma-ray log
17H4	M.H. Berryhill		1954	252.7	Drilled	350	4	----	171.85	4/19/66	Domestic	
17H5	J.T. Roundtree	Rowe Brothers	1958	262.7	do	278	4	----	179.54	----	do	
17H6	Mrs. Nell Purvis	do	1960	223.0	do	287	4	----	----	----	do	Could not measure water level
17H7	John Flounders	Friedlander	1960	247.6	do	350	4	120	162.82	4/19/66	do	
17H8	Bill Purvis	Bishop Drl.Co.	1963	232.6	do	263	4	225	153.79	4/19/66	do	
17H9	USGS A.H. 9	U.S.G.S.	12/--/63	255.1	Bored	73	4	----	----	----		Cuttings collected-filled in GGS1201
17H10	do A.H. 10	do	12/--/63	----	do	36	4	----	----	----		do GGS1202
17H13	USGS T.W. 1	Tyson & Dean	2/--/65	----	Drilled	140	4	----	----	----		Cuttings collected-Electric and Gamma-ray logs GGS1422
17H15	Elliza Flounder		----	----	Bored	54	12	----	28.0	1/9/65		Gamma-ray log
17H17	Reed Bingham no.1 State Park	Creasy Drl.Co.	8/--/65	213.2	Drilled	230	4	192	135	9/--/65	Public Supply	Cuttings collected-Electric and Gamma-ray logs GGS1362
17H19	Reed Bingham no.3 State Park	do	11/--/65	216.2	do	----	4	----	137.57	4/19/66	do	Cuttings collected GGS1470

17J1	T.E. Rutland	Lynch Drl.Co.	10/--/55	-----	do	206	2	84	28(R)	10/--/55	Domestic	
17J2	USGS A.H.18	U.S.G.S.	12/--/63	206.6	Bored	-----	4	-----	-----	-----		Cuttings collected-filled in GGS1203
17J3	USGS T.W. 3	Tyson & Dean	3/--/65	-----	Drilled	140	4	-----	-----	-----		Cuttings collected-Electric and Gamma-ray logs-filled in GGS1424
18G1	Dave Jackson	W.B. Graham	1946	220(?)	do	232	6	215	-----	-----		Cuttings collected GGS114
18G2	Wendell Best	Bishop Drl.Co.	6/--/64	240.8	do	260	4	180	160.24	4/18/66	Domestic & Irrigation	
18G3	Joe Alterman		-----	188.9	do	225+	4	-----	107.12	4/18/66	Domestic & Stock	
18G4	Gary Handcock		-----	-----	do	-----	-----	-----	-----	-----	Irrigation	
18G5	J.T. Dougherty	Rowe Brothers	3/--/64	-----	do	-----	10	-----	-----	-----	do	
18G6	M.T. Taylor	Merdith Bros.	1951	-----	do	401	12	150+	160(R)	1951	do	
18G7	C.L. Sirmans	do	4/--/55	-----	do	287	6	190	150(R)	4/--/55	do	
18G8	James E. Massey		-----	-----	do	349	6	181	165(R)	-----	Domestic & Stock	
18G9	Stuckey Candy Co.	Davis Drl.Co.	3/--/64	245.2	do	285	4	-----	157.78	4/18/66	Public Supply	
18G10	Joe Attison	do	1/--/64	225.1	do	300	4	-----	136.96	4/21/66	Domestic & Public Supply	
18G12	USGS A.H. 1	U.S.G.S.	12/--/63	222.4	Bored	57	4	-----	-----	-----		Cuttings collected-filled in GGS1204
18G13	.... A.H. 2	do	12/--/63	229.0	do	57	4	-----	-----	-----		do GGS1205
18G14	.... A.H. 22	do	12/--/63	227.5	do	-----	4	-----	-----	-----		do GGS1206
18G15	.... A.H. 29	do	12/--/63	232.8	do	27	4	-----	-----	-----		do GGS1207
18G16	.... A.H. 3	do	12/--/63	158	do	41	4	-----	-----	-----		do GGS1208
18G17	.... A.H. 11	do	12/--/63	237	do	89	4	-----	-----	-----		do GGS1209
18G18	City of Cecil	Everett Drl.Co.	2/--/65	244.4	Drilled	308	6	214	158.30	3/16/65	Public Supply	Cuttings collected-Electric and Gamma-ray logs GGS1423
18G19	Otis Forsautte	do	12/20/65	231.0	do	230	4	213	157(R)	12/20/65	Public Supply	Cuttings collected GGS1497
18G20	Burris Whitehurst	Creasy Drl.Co.	2/23/66	229.2	do	230	4	192	131(R)	2/23/66	Domestic	do GGS1580

18G21	Grady Whitehurst	do	2/24/66	229.2	do	295	4	190	136.25	4/18/66		do GGS1581
18G22	Mont.Phos.Co. (Hole No.25)	do	1965	240.0	do	105	4	-----	-----	-----		Cuttings collected-filled in GGS1587
18G23	Burris Whitehurst	Rowe Brothers	1964	220.7	do	295	4	240+	134.34	4/21/66	Irrigation	
18G24	Fletcher's Feeder Lot	Everett Drl.Co.	5/--/66	-----	do	180	4	95	117(R)	5/--/66	Stock	Cuttings collected GGS1608
18G25	City of Cecil no.2	do	1966	-----	do	230	4	-----	-----	-----	Public Supply	do GGS1663
18H1	City of Adel	Layne-Atlantic	1943	239.4	do	376	12	211	-----	-----		Well abandoned
18H2	City of Adel no.5	do	1946	238.1	do	386	12	231	159.51	4/22/66	Public Supply	Cuttings collected GGS122
18H3	Bryant Gaskins	Graham & Risher	1/30/46	274.8	do	291	4	202	197.86	4/20/66	Domestic	do GGS105
18H4	City of Adel	Gray Drl.Co.	1931	240.8	do	385	10	171	-----	-----		Well abandoned
18H5	do	Layne-Atlantic	1940	240.8	do	376	12	211	172.57	4/22/66		Cuttings collected GGS39
18H6	do	-----	1925	-----	do	325	10	-----	-----	-----		Well abandoned
18H8	do	Layne-Atlantic	1957	230.1	do	359	16-12	253	150.16	4/22/66	Public Supply	Cuttings collected-tested for 10 hours. 7/8/57-yielded 1199 gpm-drawdown 6ft. GGS682
18H9	do	-----	1893	-----	do	220	4.5	-----	154(R)	-----		See Ga.Geol.Survey Bull.15,p.53
18H10	Ralph Lendsey	W.B. Graham	-----	277.0	do	100	6	60	55(R)	-----	Domestic	Cuttings collected GGS116
18H11	J.W. Carson	-----	1944	-----	Bored	46	12	-----	-----	-----		Gamma-ray log
18H12	Willie McCrane	-----	1950	-----	do	43	12	-----	-----	-----		Gamma-ray log
18H13	City of Adel	Layne-Atlantic	3/--/61	239.6	Drilled	369	16	253	163.2	4/22/66	Public Supply	Tested for 8 hrs.-yielded 1120 gpm-drawdown 31 ft.
18H14	do	White & Co.	1907	240.5	do	675	10	60(?)	150.9(R)	8/28/42		See Water-Supply Paper 341,p.145
18H15	City of Sparks	-----	1908	236.3	do	407	8	350+	157.50	4/20/66		do
18H16	USGS Test Well	Carr Drl.Co.	1964	241.4	do	865	8	207	164.16	4/20/66	Observation	Cuttings collected-Elec- and gamma-ray logs, caliper log.Flowmeter test,Recorder on well GGS966
18H17	Dan Gray	Merdity Bros.	1955	-----	do	510+	8	110	210(R)	1955	Irrigation,Dom. & Stock	

18H18	E.J. Betts	Steven Southern	1955	-----	do	440	6	250	60(R)	1955	Irrigation & Stock	
18H19	G.C. Henry	Bishop Drl.Co.	1956	257.1	do	394	4	150	177.50	4/20/66	Domestic & Stock	
18H20	Mrs. E. Mathis	Stewart Brothers	5/--/64		do	210		84	135(R)	5/--/64	do	
18H21	L.D. Daugherty	Bishop Drl.Co.	-----	216.9	do	300	4	-----	182.75	4/20/66	do	
18H22	Steve Summer	----	1959	-----	do	-----	6	-----	-----	-----	Irrigation, Dom.&Stock	
18H23	City of Sparks	Layne-Atlantic	4/--/48	232.5	do	497	8	394	157.30	4/20/66	Public Supply	
18H24	State of Georgia I-75 Rest Sta.	Merrell Gray	6/29/60	271.5	do	302	6	224	186.09	4/19/66	do	Cuttings collected GGS629
18H25	USGS A.H. 8	U.S.G.S.	12/--/63	236.7	Bored	107	4	-----	-----	-----		Cuttings collected-filled in GGS1210
18H26	.... A.H. 26	do	12/--/63	246.2	do	22	4	-----	-----	-----		do GGS1211
18H27	.... A.H. 20	do	12/--/63	255.0	do	107	4	-----	-----	-----		do GGS1212
18H28	.... A.H. 12	do	12/--/63	238.0	do	84	4	-----	-----	-----		do GGS1213
18H29	.... A.H. 25	do	12/--/63	250.0	do	17	4	-----	-----	-----		do GGS1214
18H30	.... A.H. 13	do	12/--/63	262.8	do	88	4	-----	-----	-----		do GGS1215
18H31	.... A.H. 23	do	12/--/63	260.5	do	17	4	-----	-----	-----		do GGS1216
18H32	.... A.H. 24	do	12/--/63	261.2	do	17	4	-----	-----	-----		do GGS1217
18H33	City of Adel	Layne-Atlantic	10/--/64	240.1	Drilled	393	18	207	162.60	4/22/66	Public Supply	Cuttings collected-Electric and gamma-ray logs-QW analysis 11/17/65 GGS1218
18H34	W.C. Patterson	Bishop Drl.Co.	1956	242.0	do	-----	4	-----	164.36	4/20/66	Domestic	
18H36	USGS T.W. 2	Creasy Drl.Co.	6/--/65	263.8	do	210	4	189	184.64	4/20/66	Observation Recorder	Cuttings collected-Electric and gamma-ray logs GGS1264
18H37	Adel Plating Production Co.	Bishop Drl.Co.	-----	-----	Bored	98	10	-----	-----	-----		QW analysis 11/17/65
18H38	Mont.Phosp.Co. Hole no.26	Creasy Drl.Co.	-----	236.0	Drilled	185	4	-----	-----	-----		Cuttings collected-filled in GGS1589
18H39	W.S. Fletcher	do	3/--/66	260.8	do	300	4	202	181.85	4/20/66	Domestic & Stock	Cuttings collected GGS1591

18H40	R.E. Stripling	do	7/05/66	274.0	do	315	4	240	187.43	7/05/66	do	do GGS1638
18H41	Co4 Ga. Tech	Ga. Tech	7/--/66	----	do	98	4	----	----	----		Cuttings collected-filled in GGS1657
18H42	Paul Loveitt	Creasy Drl.Co.	8/25/66	----	do	320	4	210	170(R)	8/25/66	Domestic	Cuttings collected GGS1671
18H43	Charles Mathis	do	9/01/66	----	do	300	4	280	171(R)	9/01/66	do	do GGS1672
18J1	Levy Green	Rowe Brothers	3 63	263.6	do	288	4	226	186.50	4/19/66	do	do GGS880
18J2	City of Lenox	Layne-Atlantic	1946	292.4	do	491	8	----	217.72	4/19/20	Public Supply	Cuttings collected-(See Georgia Geol.Society Bull.70,p.134) GGS25
18J3	do	M.M. Grey	8/--/57	186.1	do	501	-	266	----	----	do	Cuttings collected(ALB22) GGS884
18J5	State Highway Dept. I-75 rest area	do	6/08/60	279.8	do	315	6	244	201.83	4/19/66	do	Cuttings collected GGS630
18J6	Lenox Consolidated School	----	1928	----	do	490	4	----	150.0(R)	----	do	Gamma-ray log. Well Well abandonded
18J7	J.F. Hinson	Stewart Bros.	3/24/64	266.0	do	253	4	220	188.14	4/19/66	Domestic	
18J8	E.B. James	Bishop Drl.Co.	----	266.0	do	----	4	----	192.58	4/19/66	do	
18J9	Mr. Brown	----	1955	278.0	do	450	4	350	194.43	4/19/66	do	
18J10	J.C. Holt	Edwards Bros.	11/--/63	319.0	do	550	4	348	228.08	4/19/66	do	
18J11	W.R. Lindsey	Winters Hdw.Co.	1942	291.3	do	396	4	254	215.46	4/20/66	Observation Recorder	Electric, gamma-ray logs. Flow meter test
18J12	Harvey Gray	----	1960	----	do	216	4	200	----	----	Domestic	
18J13	T.V. Hiers	Bishop Drl.Co.	6/--/62	264.4	do	290	4	212	179.25	4/19/66	do	
18J14	USGS A.H. 16	U.S.G.S.	12/--/63	261.7	Bored	92.5	4	----	----	----		Cuttings collected-filled in GGS1219
18J15	do 17	do	12/--/63	319.6	do	50.1	4	----	----	----		do GGS1220
18J16	do 19	do	12/--/63	158	do	----	4	----	----	----		do GGS1221
18J17	USGS T.W.4	Tyson & Dean	2/--/65	237	Drilled	188	4	----	----	----		do GGS1222
18J18	Howard Sumner	Stewart Bros.	10/--/63	----	Jetted	216	4	56	54.80(R)	5/05/65	Domestic	
18J19	F.L. Fleming	----	----	231	Bored	48	12	----	3.86	2/09/65	do	
18J21	Lake View Church	Biship Drl.Co.	1/09/66	295.0	Drilled	360	4	312	205.89	4/19/66	Public Supply	Cuttings collected GGS1576

18J23	Sinclair Ser.Sta.	Everett Drl.Co.	2/--/66	292.8	do	318	4	265	214.52	4/22/66	do	do GGS1582
18J24	Co3 Ga. Tech	Ga. Tech	7/21/66	-----	do	95	4	-----	-----	-----		Cuttings collected-Electric log-filled in GGS1582
19G1	W.E. Croy	Bishop Drl.Co.	3/--/62	241.0	do	270	4	155	153.85	4/21/66	Domestic	
19G2	R.T. Futch	Rowe Brothers	-----	207.0	do	370	4	150	127.79	4/18/66	do	
19G3	C.N. Wood	Truluck Drl.Co.	1958	-----	do	179	3	100+	-----	-----	do	
19G4	Elmer Cowart	Winters Hdw.Co.	-----	-----	do	172	4	-----	112(R)	-----	do	
19G5	USGS A.H.21	U.S.G.S.	12/--/63	174.1	Bored	87		-----	-----	-----		Cuttings collected-filled in GGS1223
19G6	do 5	do	do	175.	do	23		-----	-----	-----		do GGS1224
19G7	do 6	do	do	180.	do	54		-----	-----	-----		do GGS1225
19G8	Harry Futch	-----	-----	-----	Bored	27	12	-----	6.05	1/29/65		Electric log
19G9	James McNeese	-----	1915	-----	Dug	25	36	-----	12.20	11/17/65		QW Analysis
19G10	Mont.Phosp.Co. No. 24	-----	1965	-----	Drilled	50	4	-----	-----	-----		Cuttings collected-filled in GGS1590
19G11	Freddie King	Creasy Drl.Co.	8/23/66	247	do	265	4	194	160(R)	8/23/66	Domestic	Cuttings collected GGS1660
19H1	Alton Miers	W.B. Graham	2/05/46	254.8	Bored	73	8	12	14(R)	2/05/46	do	do GGS115
19H2	W.J. McMillan	Bishop Drl.Co.	4/--/62	336.9	Drilled	220	4	-----	160.29	4/20/66	do	
19H3	USGS A.H.7	U.S.G.S.	12/--/63	184.3	Bored	57	4	-----	-----	-----		Cuttings collected-filled in GGS1226
19H4	do 14	do	do	193.	do	48	4	-----	-----	-----		do GGS1227
19H5	do 15	do	do	216.5	do	93	4	-----	-----	-----		do GGS1228
19H6	do 27	do	do	196.	do	-----	4	-----	-----	-----		do GGS1229
19H7	do 28	do	do	229.2	do	27	4	-----	-----	-----		do GGS1230
19H8	USGS T.W.6	Creasy Drl.Co.	1965	223	Drilled	126	4	-----	-----	-----		Cuttings collected-Electric,gamma-ray logs-filled in GGS1361
19H9	Co2 Ga. Tech	Ga. Tech	7/--/66	-----	do	94	4	-----	-----	-----		do GGS1645

1/ Water level followed by (R) is "reported"

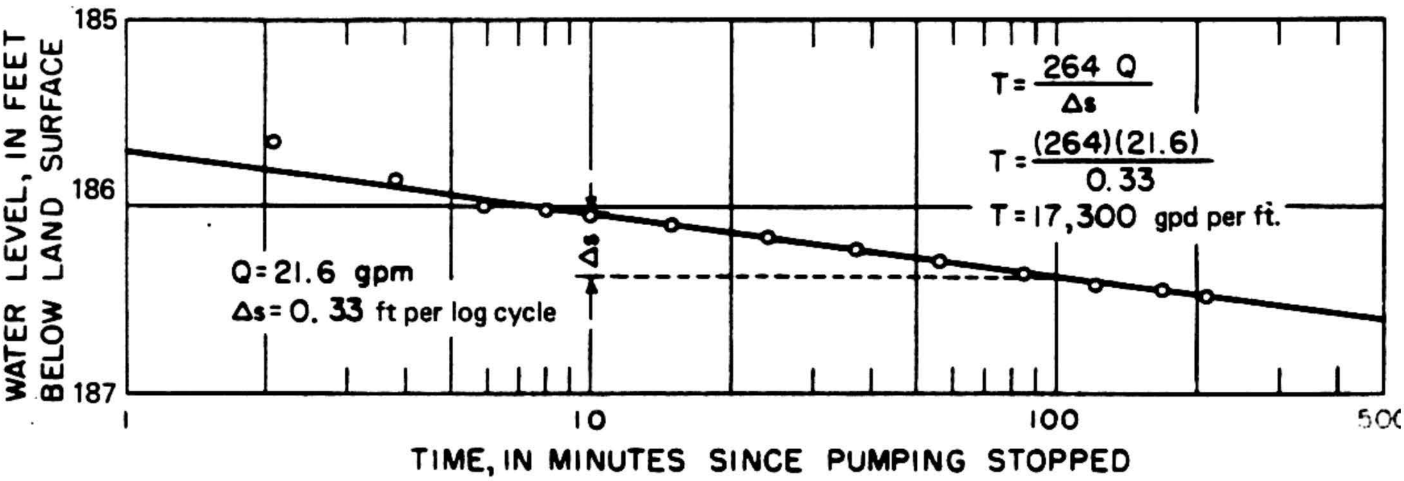

Figure 13. – Data plot for aquifer test in Tampa Formation at Laconte.

OTHER MINERAL RESOURCES

Deposits of fuller's earth clay, phosphate, and sand are present within the county.

Nearly pure clay similar to fuller's earth was found in the Miocene deposits above the Tampa Formation over most of northern and western Cook County. The clay occurs in an 8- to 10-foot thick layer at a depth of 70 to 80 feet below land surface (about altitude 200 feet). X-ray diffractograms made by Dr. Ray Germillion (written commun., December 31, 1963) show that sepiolite and attapulgite are the principal clay minerals. Montmorillonite also is present. Sever (1964, p. 17) shows the bulk density to be about 30.4 pounds per cubic foot and the oil retention to be 90.1 percent.

Five surface samples of clay were submitted to research laboratories to be tested for use in making ceramic products such as brick, tile, and similar items. These clays proved to be unsuitable for use as the primary body component in such products because of high vitrification temperatures, poor color, and very high shrinkage. The detailed laboratory reports are available for inspection at the Georgia Department of Natural Resources, Earth and Water Division, Room 400, 19 Hunter Street, S.W., Atlanta, Georgia.

Numerous white polished pellets of phosphate were observed near the base of the Hawthorn Formation in cuttings from auger holes drilled in southern Cook County. This zone is about 5 to 10 feet thick and generally contains less than 10 percent phosphate pellets. Gamma-radiation logs were made of 62 dug and bored wells in an effort to delineate the deposit. Figure 12 shows the area in Cook County thought to be underlain by this deposit. Chemical analyses of the phosphate are not available.

Sand deposits as much as 30 feet thick occur adjacent to Little River in western and southern Cook County. Those in western Cook County are being mined. A hole was augered through the terrace sands on the east bank of Little River on the north side of Georgia Highway 37 and samples of the sand were collected for sieve analysis. The results are shown in table 6.

Table 6. – Sieve analyses of sand from flood plain of Little River, western Cook County, Ga.

Sieve Opening Size	Accumulative percent retained — Sample interval, in feet below land surface					
	1 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30
4	0.0	0.0	0.0	0.1	0.0	0.0
8	.0	.0	.0	1.7	.0	.0
16	.1	.1	.1	3.4	1.4	3.1
30	1.7	8.9	13.9	17.5	18.3	20.6
50	6.2	52.6	65.0	73.5	65.3	71.4
70	19.4	76.1	84.2	92.8	81.7	87.4
100	46.3	87.4	91.2	96.9	89.1	93.1
140	76.6	94.5	95.4	99.0	95.1	98.9
200	92.5	98.0	98.4	99.7	98.3	99.6
Pan	100.0	100.0	100.0	100.0	100.0	100.0

The old terrace deposits adjacent to Little River in southern Cook County contain up to 0.5 percent heavy minerals, but the mineral concentrations appear to be too low grade and too scattered to be minable. However, these heavy minerals might be developed as a by-product from sand mining.

SUMMARY AND CONCLUSIONS

The limestones beneath Adel and most of Cook County contain drinkable water to a depth of only about 400 to 500 feet. Wells that tap these limestones obtain most of their water from a few thin, highly permeable zones rather than from the entire rock thickness.

The Ocala Limestone at Adel and probably throughout all of Cook County contains water of quality unsuitable for drinking. Wells should not be drilled deep enough to tap this aquifer.

Most "deep wells" tap the Suwannee and Marianna Limestones which are capable of yielding as much as 2,000 gpm to wells. They contain water that is hard but which is suitable for municipal, irrigation, and most industrial uses. In northern Cook County many "semi-deep" wells tap the Tampa Formation which is capable of yielding only about 20 to 150 gpm to wells. At places, wells which tap the Tampa yield a mixture of fine sand and water. The water, hough hard, is otherwise of quality suitable for domestic use. The yield of "shallow wells" is variable and the water generally is corrosive and at places contains appreciable dissolved iron.

The volume of ground water flowing through the Suwannee and Marianna Limestones in Cook County and available for development to properly spaced wells and well fields is estimated to be about 18,000 gpd. That in the Tampa is estimated to be about 1,500,000 gpd.

The water level in wells at the Adel Third Street well field has declined 38 feet since 1890. It is presently declining at a rate of about 1.6 feet per year.

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