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INTERIM REPORT ON THE GROUND-WATER RESOURCES OF PUTNAM COUNTY, FLORIDA

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ABSTRACT

Putnam County, in the northeastern part of the Florida Peninsula, has an area of 803 square miles. Sand, clay, and peat of Pleistocene and Recent age are exposed at the surface. They are underlain by deposits of Miocene or Pliocene age that consist principally of clay with a thin, fairly widespread limestone at the base. The Miocene or Pliocene deposits are underlain by limestones of Eocene age whose upper surface ranges from about 25 feet to about 170 feet below sea level.

Ground water in the county occurs under both nonartesian (water-table) and artesian conditions. Pleistocene and Recent sands contain water under nonartesian conditions. The limestones underlying the Miocene or Pliocene clay contain water under artesian conditions, and locally the water in beds of sand and shell within the Miocene or Pliocene deposits is artesian. The artesian aquifers are replenished by rain falling on recharge areas partly or completely within the county.

Records of water level show maximum seasonal fluctuations of 10 feet and a progressive decline of artesian head in recent years. The most pronounced seasonal fluctuation is in the winter vegetable farming area, east of Palatka, where discharge from irrigation wells lowers the artesian head and reduces the area of artesian flow during times of heaviest withdrawals.

The chloride content of water from wells in the principal artesian aquifer ranges from less than two ppm to 1,080 ppm. Water of the lowest chloride content is in and near recharge

areas in the upper part of the aquifer; water of the highest chloride content is in discharge areas, where the artesian head is lowest. In areas of seasonal discharge, the chloride content increases when the artesian head declines and decreases when it recovers.

INTRODUCTION

The economy of Putnam County is largely dependent upon the income from winter vegetables. From December 1, 1954, to November 30, 1955, the gross income from the marketing of Irish potatoes and cabbage was approximately four million dollars.[1] The most important farming area is in the lowlands east of Palatka, where adequate supplies of water for irrigation are available from flowing artesian wells.

In recent years there has been a decline in the artesian head in the farming area near Palatka. This decline has resulted in a decrease in the area of artesian flow, and necessitated the use of pumps in wells that had previously produced an adequate supply of water by natural flow. In addition to the loss of artesian head, there has been a noticeable increase in the salt content of the water.

Recognizing the threat to the fresh-water supplies of the county, the U. S. Geological Survey and the Florida Geological Survey decided to make an investigation of the ground-water resources of the county in conjunction with similar investigations in adjoining St. Johns and Flagler counties. The investigation was begun in February 1956.

The purpose of the investigation is to make a detailed study of the geology and ground-water resources of the county. Special emphasis has been placed on the problems of declining water levels and salt-water contamination.

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[1] H. E. Maltby, County Agent, Putnam County, Florida, personal communication, October 1956.

This report reviews briefly the progress of the investigation through November 1956. The investigation consists of the following phases:

1. An inventory of wells, to obtain information on the location, diameter, depth, yield, water level, use, etc.

2. Periodic collection and study of water-level data, to determine the seasonal fluctuations and progressive trends.

3. Analysis of the chloride content of ground water, to determine the location and extent of areas in which the water is salty.

4. Periodic analyses of water from selected wells to determine the chloride content and the relation between chloride content and artesian pressure.

5. Studies to locate the water-bearing zones and to determine their water-transmitting and water-storing capacities.

6. Studies of the subsurface geology, to determine the thickness, character, and extent of the different geologic formations.

The investigation was made under the general supervision of A. N. Sayre, Chief, Ground Water Branch, U. S. Geological Survey, and under the immediate supervision of M. I. Rorabaugh, District Engineer for Florida.

Previous Investigations

No detailed investigations of the geology and ground-water resources of Putnam County had been made prior to the present study. However, reports on several general investigations have included information on the county. These have been published by the U. S. Geological Survey and the Florida Geological Survey. Some of them are mentioned below.

Cooke (1945, p. 225, 236, 285, 291, 296, 310) briefly describes formations exposed at the surface in the county. A report by Vernon (1951, fig. 13, 33; pl. 2) includes Putnam County in generalized subsurface structural maps and in a generalized geologic cross section.

The geology and ground water of Putnam County are discussed by Stringfield (1936, p. 147, 149-151, 162, 173, 187, 195; pl. 10, 12, 16) in a report on the artesian water in the Florida Peninsula. This report includes a map showing the area of artesian flow, a map showing the areas in which the artesian water contains more than 100 ppm of chloride, and the first published map of the piezometric surface of the principal artesian aquifer. It also contains water-level measurements and other data on 26 wells in the county. A report by Stringfield and Cooper (1951, p. 61-72; fig. 4, 5, 6) contains a geologic cross section and a brief discussion of the artesian water of Putnam County.

Chemical analyses of water from wells in Putnam County are included in reports by Collins and Howard (1928, p. 226-227), and Black and Brown (1951, p. 96).

Matson and Sanford (1913, p. 391-393; pl. V) discussed the topography and stratigraphy of Putnam County and the occurrence and quality of ground water in the county. Their report included also a table of well descriptions and logs of three wells.

A report by Sellards and Gunter (1913, p. 206-213; fig. 8) contains a map showing the area of artesian flow in Putnam County, the log of an irrigation well near Orange City, and chemical analyses of water from a well at Palatka and a well at Welaka. It also contains descriptions of the construction and yields of several wells in the county.

Well-Numbering System

Each well inventoried during this investigation was assigned an identifying well number. The well number was assigned by first locating each well on a map which is divided

into 1-minute quadrangles of latitude and longitude, then numbering, consecutively, each inventoried well in a quadrangle. The well number is composed of the last three digits of the line of latitude south of the well, followed by the last three digits of the line of longitude east of the well, followed by the number of the well in the quadrangle. For example, well 939-134-1 is the well numbered 1 in the quadrangle bounded by latitude 29°39' on the south and the longitude 81°34' on the east. With this system, wells referred to by number in the text can be located on figure 9.

GEOGRAPHY

Putnam County, in the northeastern part of the Florida Peninsula, has an area of 803 square miles, nominally 513,920 acres (fig. 1). The mean temperature in the area is about 72°F, according to the records of the U. S. Weather Bureau. The average annual rainfall at Palatka is 54.59 inches, of which an average of 29.16 inches falls between June 1 and September 30.

Topographically Putnam County may be divided into two units: (1) relatively flat lowlands and (2) hilly uplands. The lowlands are in the eastern and central parts of the county, in the vicinity of Palatka and San Mateo, and in a large strip between Crescent Lake and the St. Johns River. The land surface of the lowlands ranges in altitude from about sea level to about 42 feet above sea level, where the lowlands merge into the hilly uplands. The hilly uplands occupy the remainder of the county. The surface features of this area consist of a few relatively level areas, numerous sandhills, and sinkholes. The sinkholes were formed by the removal of soluble limestone by ground water. In most cases these sinkholes have been partly filled with water to form lakes. The land surface of the uplands ranges in altitude from 42 feet above sea level, where it merges with the lowlands, to more than 220 feet above sea level, but most of the area is between 100 and 150 feet above sea level.

The surface drainage of the county is principally through the St. Johns River and its tributaries. The hilly uplands, especially in northwestern Putnam County and between

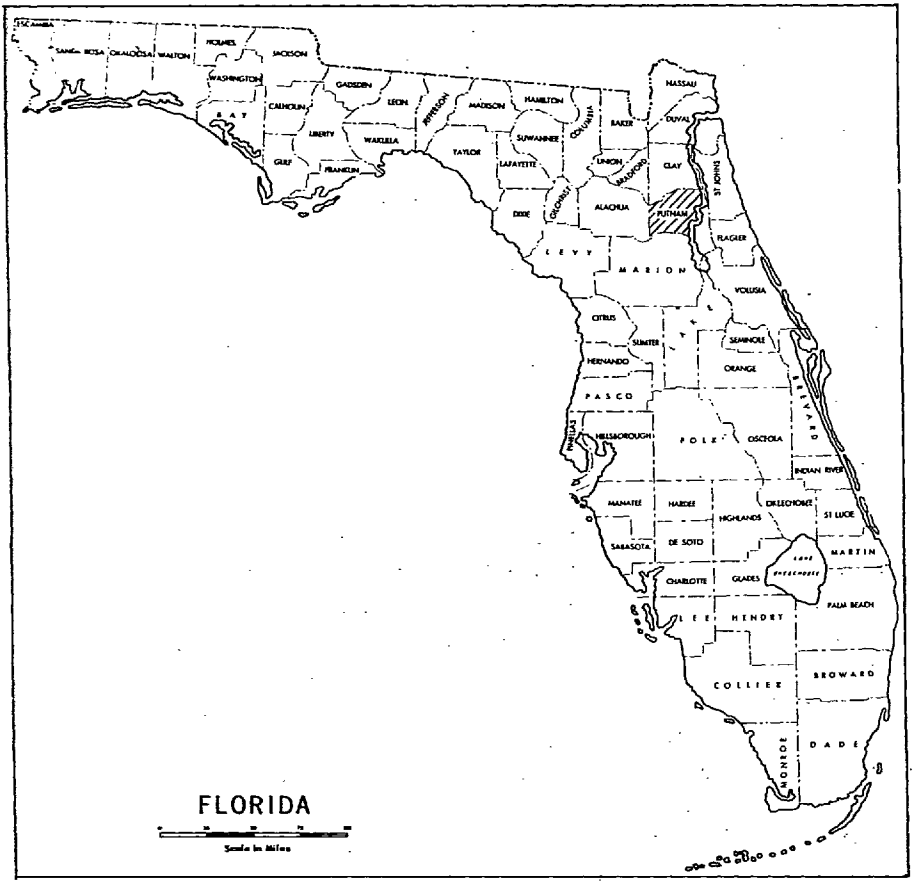

Figure 1. Map of Florida, showing the location of Putnam County.

Crescent Lake and the St. Johns River, are partly drained - through lakes and sinkholes - into the limestone aquifer.

GEOLOGY

A few sets of well cuttings collected during the current investigation and unpublished well logs in the files of the Florida Geological Survey were used to construct figure 2, a generalized geologic cross section showing the formations penetrated by wells in Putnam County. The two lowermost formations shown in figure 2 have been penetrated by only a few water wells in the county, because the overlying formations generally yield sufficient water for domestic and irrigation supply. Information on these two formations were obtained from logs of two relatively deep wells described by Vernon (1955).

The oldest formation shown in figure 2 is the Lake City limestone of early middle Eocene age. It is predominantly a tan to gray soft granular, porous limestone containing zones of hard, dense finely crystalline limestone and dolomite. The Avon Park limestone, of late middle Eocene age, overlies the Lake City limestone and is predominantly a tan dense, hard finely crystalline dolomite. It is 235 feet thick in well 943-144-1, in the central part of the county.

The beds of late Eocene age are referred to in this report as the Ocala group.[2] They include, in ascending order, the Inglis, the Williston, and the Crystal River formations (Puri, 1953, p. 130). During the present investigation no attempt was made to differentiate these formations.

The Ocala group in Putnam County consists of cream to

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[2]The stratigraphic nomenclature used in this report conforms to the usage of the Florida Geological Survey. It conforms also to the usage of the U. S. Geological Survey with the exception of the Ocala group and its subdivisions. The Florida Survey has adopted the Ocala group as described by Puri (1953). The Federal Survey regards the Ocala as a formation, the Ocala limestone.

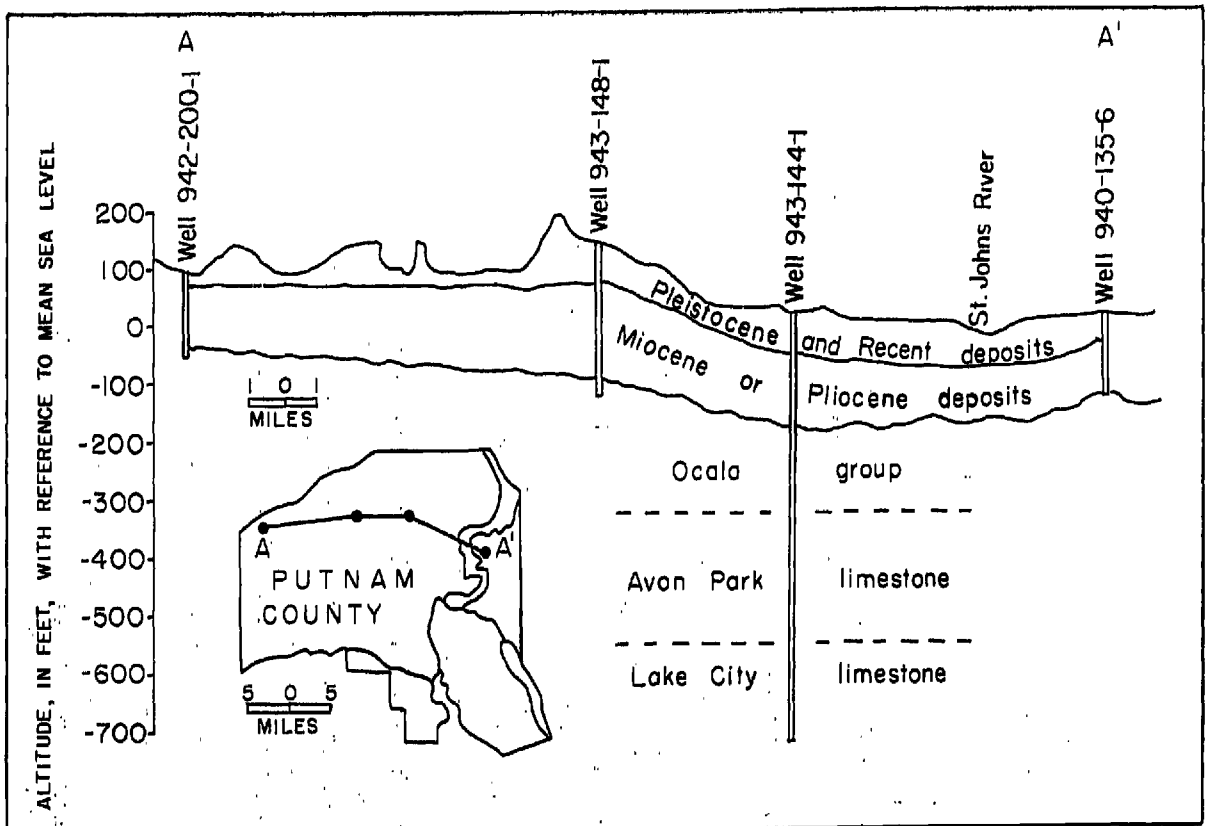

Figure 2. Generalized geologic section showing the formations penetrated by water wells in Putnam County.

white granular soft porous limestone. The limestone is very fossiliferous, and some zones are composed completely of loosely cemented shell fragments. As shown in figure 2, the depth of the top of the Ocala group is approximately 25 feet below sea level in the western part of the county and 125 to 170 feet below sea level in the central and eastern parts. Because of the irregular surface of the Ocala group, these depths may differ by as much as 50 feet within a few hundred yards. The Ocala group is approximately 110 to 135 feet thick in the central part of the county, and it is the principal artesian aquifer in the county.

The deposits unconformably overlying the Ocala group in Putnam County are referred to in this report as deposits of Miocene or Pliocene age. They are shown by Vernon (1951, fig. 13, 33) as the Hawthorne formation, of middle Miocene age, and overlying upper Miocene deposits. Previously, the upper Miocene deposits were described by Cooke (1945, p. 214-215, 225) as Pliocene in age. No attempt was made during the present investigation to determine the correct age of these deposits.

In a typical section of the Miocene or Pliocene deposits in Putnam County a thin, discontinuous gray dense, hard limestone is overlain by phosphatic blue to green clay and sandy clay. The beds of clay contain thin, lenticular beds of coarse to fine phosphatic sand and thin beds of gray dense limestone. In most parts of the county the phosphatic clay is overlain by nonphosphatic green calcareous clay and coarse to fine tan to white sand. The green clay locally contains a bed of shells and thin beds of white marl. The clays serve as confining beds for the artesian water in the Eocene limestone and the adjacent discontinuous Miocene limestone and for the small quantities of artesian water in the beds of sand and shell within the clays.

As shown on figure 2, the surficial deposits of Pleistocene and Recent age range in thickness from less than 10 feet to more than 125 feet. The Pleistocene deposits consist of fine to medium quartz sand deposited in the form of a series of marine terraces. The terraces rise progressively from the flat lowlands in the eastern part of the county to the hilly uplands in the southeastern and western parts.

The Recent deposits consist principally of isolated peat deposits and alluvial sand and clay.

The Pleistocene and Recent sand is the source of water for a few shallow wells in the county. Locally, the water is confined beneath hardpan and will flow when tapped by wells.

GROUND WATER

Ground water is the subsurface water in that part of the zone of saturation in which all pore spaces in the rocks are filled with water under pressure greater than atmospheric. Rain that falls on the earth's surface is the most important source of ground water, but only part of it reaches the zone of saturation. Part of it is returned to the atmosphere by evapotranspiration, and part drains overland into lakes and streams.

Ground water moves laterally, under the influence of gravity, toward places of discharge such as wells, springs, surface streams, and lakes. It may occur under either nonartesian (water-table) or artesian conditions. Where the ground water is not confined and its surface is free to rise and fall, it is said to be under nonartesian conditions and its upper surface is called the water table. Where the water is confined in a permeable bed that is overlain by a relatively impermeable bed, its surface is not free to rise and fall and it is said to be under artesian conditions. The term "artesian" is applied to ground water that is confined under sufficient pressure to rise above the top of the permeable bed that contains it, though not necessarily above the land surface. The height to which water will rise in an artesian well is called the artesian pressure head, and the imaginary surface delineated by a number of wells is called the piezometric surface.

An aquifer is a formation, group of formations, or part of a formation, in the zone of saturation, that is permeable enough to transmit usable quantities of water. Areas in which aquifers are replenished are called recharge areas. Areas in which water is lost from aquifers are called discharge areas.

Nonartesian Aquifer

The Pleistocene and Recent sand that covers most of Putnam County contains ground water under nonartesian conditions, except in parts of central and southern Putnam County where the sand is overlain by thin beds of clay that confine the water under artesian conditions. Several shallow wells tap this water for domestic use, particularly in the western part of the county. These are usually either small-diameter driven sandpoints or large-diameter hand-dug wells.

The nonartesian aquifer is recharged principally by local rainfall, although some of the water may have percolated upward from the artesian aquifer in areas where the piezometric surface is higher than the water table. Water is discharged from the aquifer into lakes, streams, and canals, and in small quantities through domestic wells. In addition, water may be lost into the artesian aquifer in areas where the water table is higher than the piezometric surface.

Artesian Aquifer

The artesian aquifer is the principal source of water in Putnam County; therefore, most of the information collected and studied during this investigation concerns the artesian aquifer.

The artesian aquifer consists principally of beds of Eocene limestone but includes also a thin, discontinuous dense limestone of Miocene age. In parts of the county, thin, lenticular beds of sand and shell within the Miocene or Pliocene clay contain water under artesian pressure. As these thin beds yield a relatively small amount of water, and are not widespread, they are only briefly discussed in this report. The limestones are referred to collectively, in this report, as the principal artesian aquifer. Water is confined under pressure in the principal artesian aquifer by beds of clay in the deposits of Miocene or Pliocene age.

Differences in static head, chloride content, and temperature of the water at different depths in some parts of

the county suggest that impermeable beds within the principal artesian aquifer may separate it into several relatively thin aquifers. A deep-well current-meter traverse made in well 943-144-1, six miles northwest of Palatka, in September 1955 gave evidence of the presence of several aquifers within the principal artesian aquifer. A current meter is a device for measuring the velocity of flow of water through a well bore. The results of the current-meter test are shown graphically in figure 3. As shown on the figure, when the well was completely closed in there was upward movement of water within the limestone aquifer in the zone between 500 and 430 feet and between 400 and 300 feet. This movement shows leakage within the aquifer from zones of higher head to zones of lower head. The zones of different head are probably separated by relatively impermeable limestone beds within the aquifer.

In Putnam County the artesian aquifer is replenished by rain falling on recharge areas where many lakes and sinkholes penetrate the confining beds and allow water from the surface to reach the limestone formations that constitute the aquifer. The water in the artesian aquifer may also be replenished by water from the nonartesian aquifer in areas where the water table is higher than the piezometric surface.

From the recharge areas water moves laterally through pores and cavities in the limestone toward areas where discharge is occurring. Water is discharged from the artesian aquifer in Putnam County by springs and wells. It may also be discharged by upward percolation of water to the nonartesian aquifer in areas where the piezometric surface of the artesian aquifer is higher than the water table.

Periodic measurements of the artesian pressure heads in wells 939-138-1 and 925-138-1 were made from 1936 to 1950 by the U. S. Army Corps of Engineers. Since 1950 the measurements have been made by the U. S. Geological Survey. In addition, continuous water-level recorders have been installed on two wells and measurements are being made periodically in 30 other wells in order to determine the trends and seasonal fluctuations of water levels in different parts of the county.

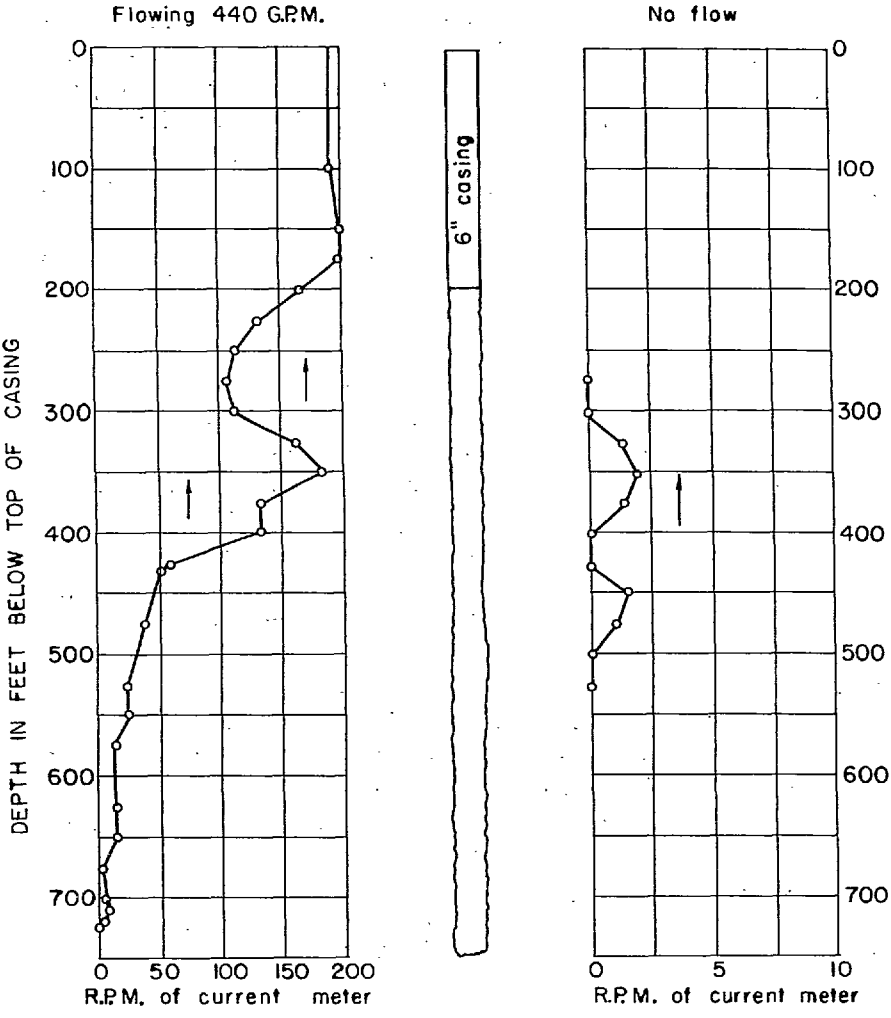

Figure 3. Diagram comparing the velocities of water in well 943-144-1, six miles northwest of Palatka, when water is flowing from the well and when no water is flowing from the well.

Hydrographs in figure 4 show seasonal fluctuations and progressive trends of the artesian pressure heads in well 939-138-1, in Palatka, and well 925-138-1, four miles southeast of Welaka. Both hydrographs show noticeable decline in the artesian pressure heads since 1953. Figure 4 shows that the maximum seasonal fluctuation of the artesian pressure head is less than four feet in well 939-138-1 and less than three feet in well 925-138-1. In the winter vegetable farming area east of Palatka, where large quantities of artesian water are used for irrigation, the artesian pressure head may be lowered by as much as 10 feet during times of heaviest withdrawals.

Piezometric Surface

The piezometric surface of an aquifer is an imaginary surface that everywhere coincides with the static level of the water in the aquifer. It is the surface to which water from a given aquifer will rise under its full head. A map showing the piezometric surface of an artesian aquifer is constructed by first measuring the artesian pressure head in cased wells that penetrate the artesian aquifer, referring these measurements to a common datum, and then drawing contour lines connecting all points which have the same height above the common datum. The preparation of such a map is an important part of a ground-water investigation, as the shape of the contour lines indicates the direction of movement of the water and the general areas of recharge and discharge. Water enters the aquifer in those areas in which the piezometric surface is high and moves in a direction approximately perpendicular to the contour lines toward the areas in which the piezometric surface is low.

A map of the piezometric surface of the artesian aquifer in Putnam County is shown in figure 5. In constructing the map, all measurements of the artesian pressure head have been referred to mean sea level. The elevations of the measuring points were estimated from topographic maps drawn on a 10-foot contour interval. In the southeastern part of the county, where no topographic coverage was available, the elevations were determined with an altimeter.

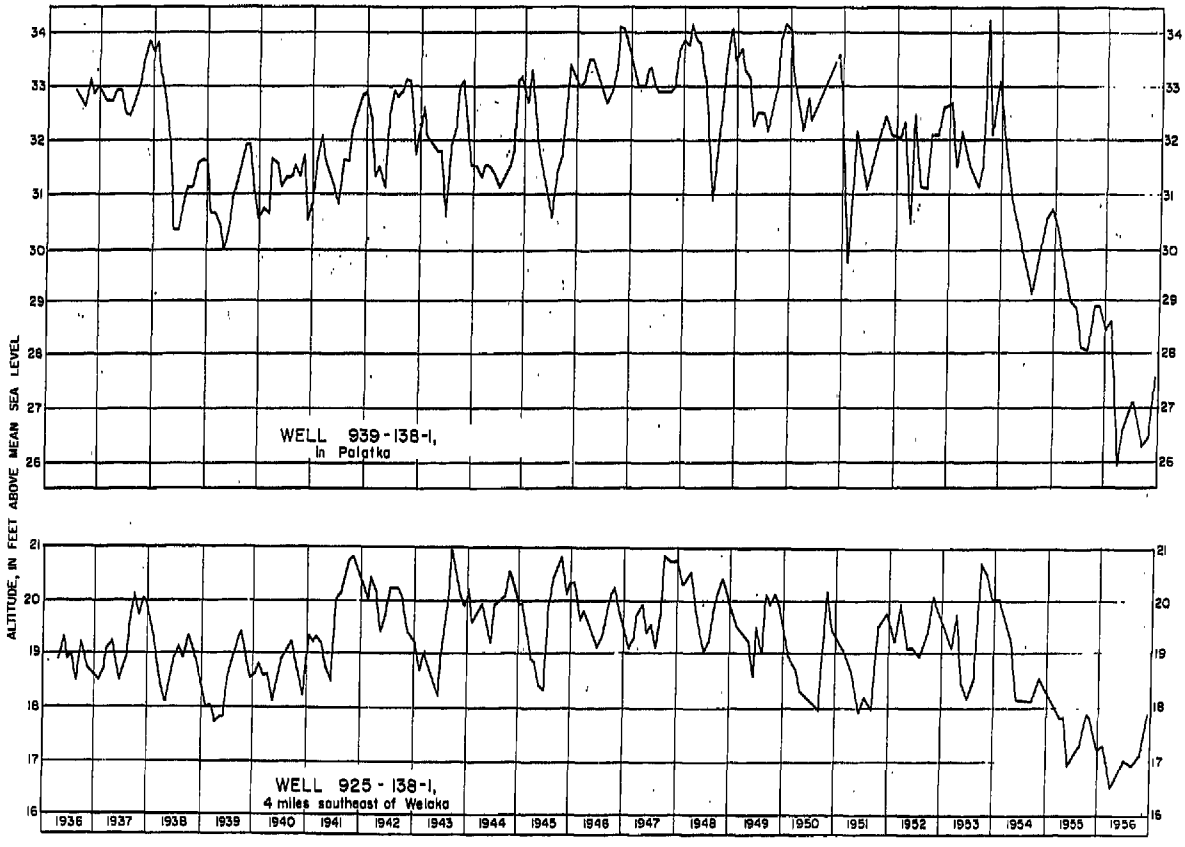

Figure 4. Hydrographs of wells 939-138-1 and 925-138-1.

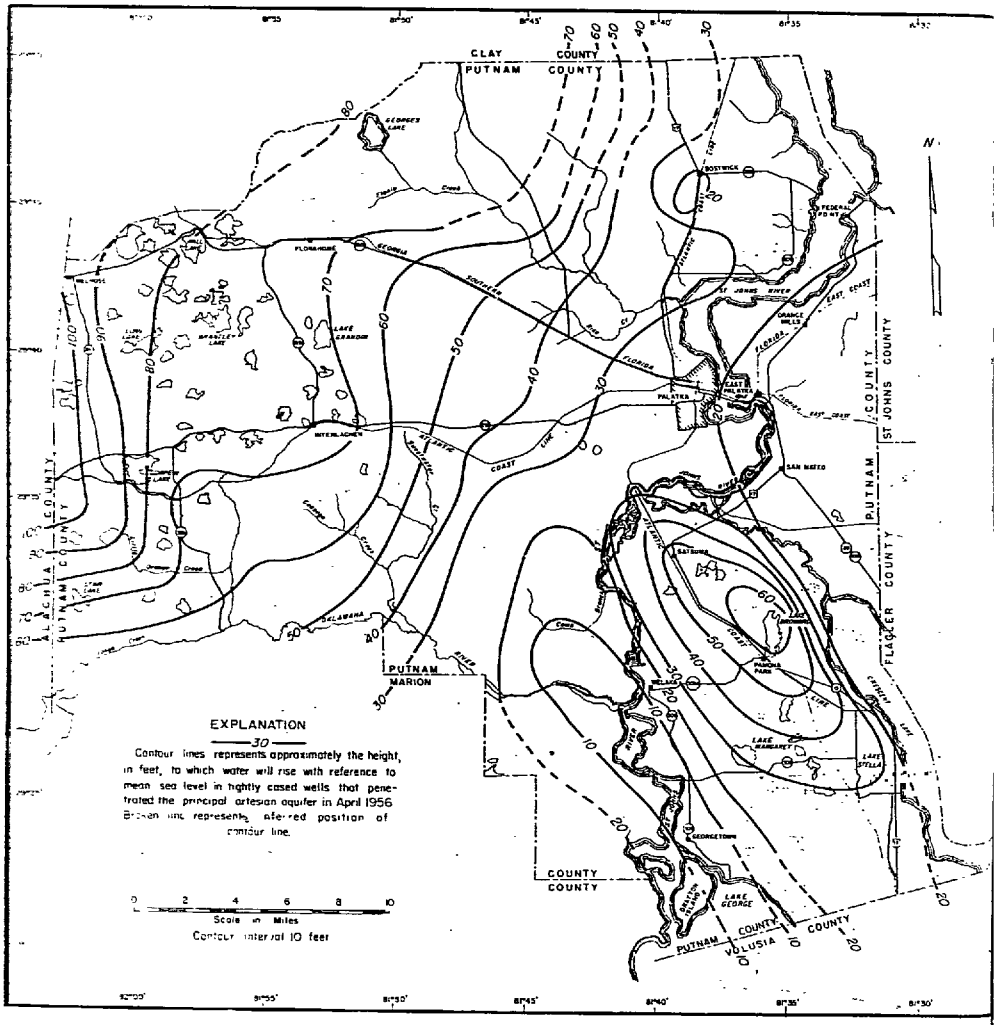

Figure 5. Map of Putnam County showing the piezometric surface.

The piezometric surface fluctuates continuously in response to changes in storage within the artesian aquifer. Therefore, figure 5, which was drawn from measurements made in April 1956, is only an approximate representation of the piezometric surface at other times. The positions of piezometric contour lines were inferred in many parts of the county where accessible wells were lacking.

Figure 5 shows two areas of relatively high piezometric surface in which recharge is presumed to occur. One begins approximately at Interlachen and extends west into Alachua County and north into Bradford and Clay counties. The other lies between the St. Johns River and Crescent Lake. Both these areas generally coincide with areas of topographic highs and are pocketed with numerous lakes and sinkholes through which water from the surface can reach the limestone aquifer.

The piezometric surface contains noticeable depressions near the juncture of the St. Johns and Oklawaha rivers, where natural discharge from the artesian aquifer by springs forms some of the base flow of the St. Johns River, and in the winter vegetable farming area east of Palatka, where large quantities of artesian water are discharged by irrigation wells.

Piezometric maps were made by Tarver (1956) and Bermes (1956) as part of their investigations of ground-water resources in St. Johns and Flagler counties. These maps, together with a map of Putnam County, have been compiled into one map (fig. 6) which shows the piezometric surface of the artesian aquifer, in April 1956, in all three counties.

Figure 6 shows that the piezometric surface slopes eastward from recharge areas in Putnam County to discharge areas in southwestern St. Johns and western Flagler counties. The curvature of the 15-foot contour line in eastern Putnam County shows the effect of discharge in southwestern St. Johns County.

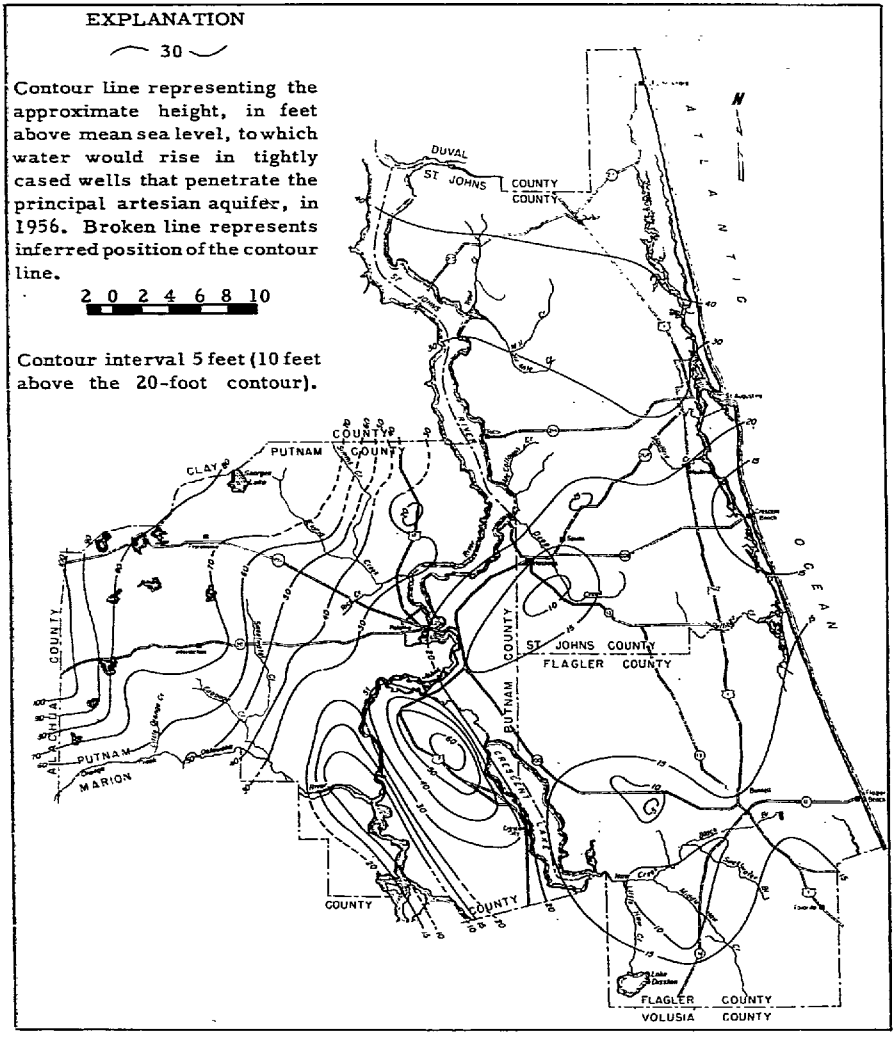

Figure 6. Map of Putnam, St. Johns, and Flagler counties showing the piezometric surface.

Area of Artesian Flow

Artesian wells will flow where the piezometric surface stands higher than the land surface. Figure 7 shows the approximate area of artesian flow in Putnam County in April 1956. Owing to continuous changes in the altitude of the piezometric surface, the area of artesian flow shown on this map is only an approximation of the area of flow at other times. Artesian flow occurs principally in the lowlands along the St. Johns River and its tributaries. Within this area, wells will not flow where the land surface locally is relatively high. In the hilly uplands, artesian flow occurs along some stream valleys and in isolated depressions of the land surface. Many of these areas of artesian flow could not be shown on figure 7 because of their small size.

A progressive decline in the artesian head in recent years (fig. 4) has doubtless reduced the area of artesian flow in Putnam County. However, the piezometric surface and the size of the areas of artesian flow change continuously in response to changes in storage within the artesian aquifer. In the winter vegetable farming area, east of Palatka, where the piezometric surface is about the same as the relatively flat land surface, a slight decline in the altitude of the piezometric surface can reduce the area of flow by as much as seven square miles.

Two detailed maps of the area of artesian flow in the farming area east of Palatka are shown in figure 8. The contours in each of the maps represent the height, in feet above land surface, to which artesian water would rise. Wells in the shaded area have no artesian flow. The water-level measurements used to draw these maps were made in April 1956, when the piezometric surface was lowered by discharge from numerous irrigation wells, and in August 1956, when the use of water was slight and the piezometric surface was relatively high. Comparing both maps in figure 8, it may be seen that the artesian pressure head is considerably lowered and the area of artesian flow is much reduced, during times of heavy withdrawals.

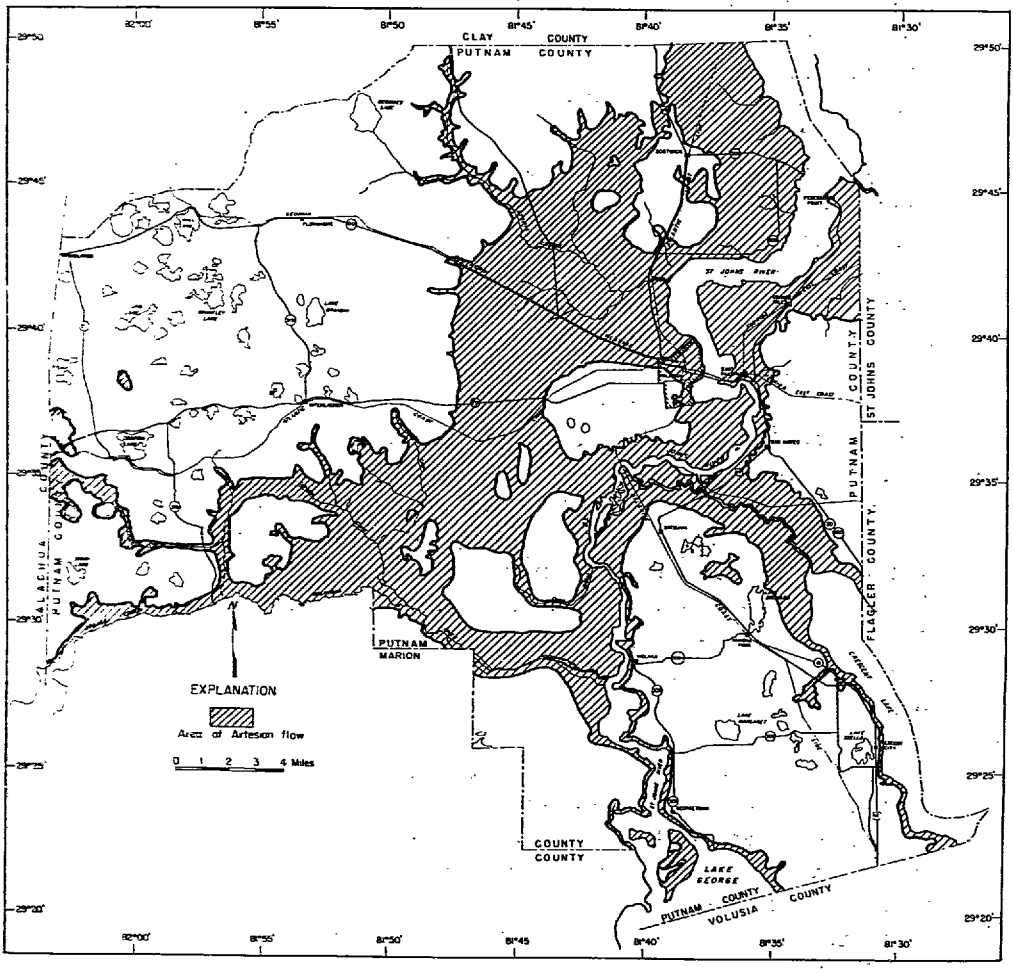

Figure 7. Map of Putnam County showing the area of artesian flow.

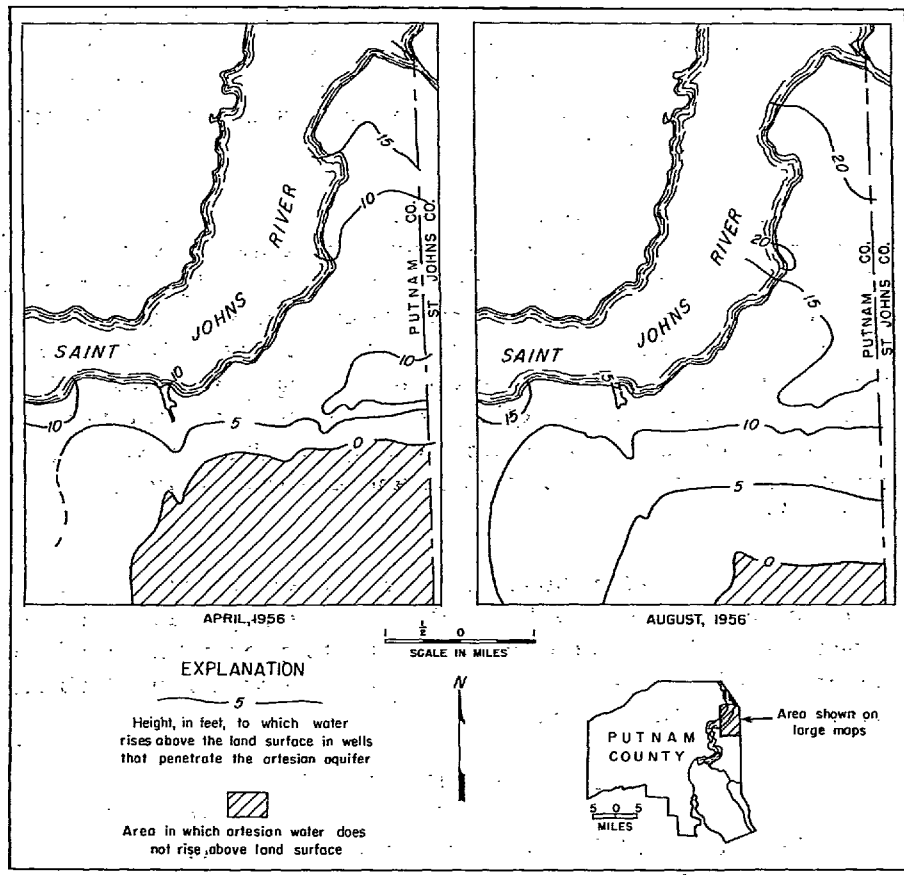

Figure 8. Maps of the farming area east of Palatka showing the height to which water will rise above the land surface in wells that penetrate the artesian aquifer and the area of artesian flow.

Wells

A well inventory consists of a collection of pertinent information such as location, diameter, depth, length of casing, and use of each well, and supplies much valuable information concerning the ground-water resources of an area. Figure 9 shows the locations of 161 wells that have been inventoried during this investigation. All these wells are believed to have been completed in the principal artesian aquifer, except 14 wells which draw water either from the nonartesian aquifer or from the beds of sand and shell within the Miocene or Pliocene clays.

Figure 9 shows that the greatest concentration of wells is east of Palatka, in the winter vegetable farming area. The wells in that area range from three to eight inches in diameter and are used for irrigation. They range in depth from 130 to 460 feet, although most are between 180 and 300 feet deep. Except for a few deep, large-diameter public supply and industrial wells, the wells in the remainder of the county are used for domestic supply. They range in diameter from one to three inches and are generally 75 to 200 feet deep.

Not all the wells shown on figure 9 are in Putnam County. Lack of accessible wells in the sparsely populated areas along the northern, southern, and western boundaries of the county made it necessary to inventory wells in adjoining areas outside the county.

QUALITY OF WATER

The chemical character of ground water is largely dependent upon the type of material with which the water comes in contact or by contamination with sea water. In recharge areas, where the water first enters the ground, it is only slightly mineralized. As the water moves through the ground it dissolves mineral matter from the rocks through which it flows and mixes with mineralized water already in the rocks.

Information on the mineral content of the ground water

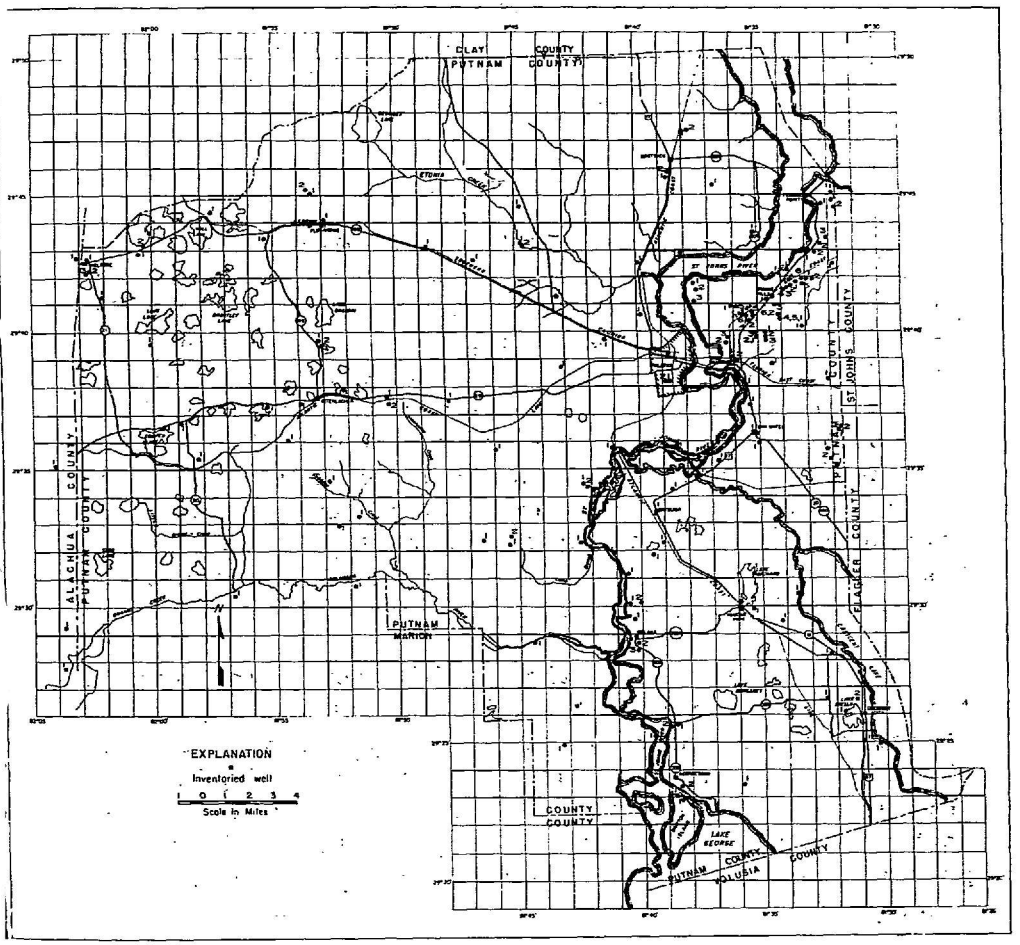

Figure 9. Map of Putnam County showing the locations of wells.

in Putnam County was obtained from chemical analyses of water from seven wells. Table 1 shows the results of the chemical analyses. The wells range in depth from 62 to 564 feet and are distributed throughout the county. The degree of mineralization, expressed by the dissolved-solid content, differs widely throughout the county. In general, however, the water from wells in and near recharge areas is less mineralized than that from other wells.

Salt-Water Contamination

Saline water is present in the principal artesian aquifer in the southern part of Florida and in some other areas, particularly near the coast and the St. Johns River. The presence of this saline water appears to be due principally to the infiltration of sea water into the aquifer during Pleistocene time when the sea stood above its present level and much of the present land surface was inundated (Cooke, 1939, fig. 12-16). Subsequently, the Pleistocene seas receded and fresh water circulating through the aquifer began gradually to dilute and flush out the salty water. The flushing has not been completed, and the remaining diluted sea water is a source of ground-water mineralization.

Water samples were taken at different depths from a few wells that penetrate the principal artesian aquifer in Putnam County. Analyses of these samples showed that the chloride content of the water increased with depth. The chloride content of the water, which is an index of salt-water contamination, suggests that diluting and flushing have progressed less in the lower part of the aquifer than in the upper part.

Water samples from more than 160 wells in Putnam County were analyzed for chloride content. The chloride content of water from wells that penetrate the principal artesian aquifer ranged from less than two ppm in well 945-136-1 to 1,080 ppm in well 940-134-3. Figure 10 shows the generalized results of these analyses. It shows that the chloride content of the water is lowest in and near recharge areas, thus indicating that flushing has been most effective in the recharge areas.

Table 1. Analyses of Water from Wells in Putnam County
(Chemical constituents in parts per million)

Well number	947-137-1	930-139-1	940-134-2	944-131-2	932-152-1	932-145-2	943-144-2
Depth in feet	350	62	452	245	189	85	564
Diameter in inches	4	4	6	4	8	4	20
Date collected	8-28-56	8-27-56	8-27-56	8-27-56	8-28-56	8-28-56	12-6-55
Silica (SiO_2)	12	14	17	11	11	12	13
Iron (Fe) dissolved[1]	.00	.04	.12	.11	.00	.00	.00
Iron (Fe) total	.56	.13	1.3	2.7	.22	.15	---
Calcium (Ca)	25	327	166	142	26	58	32
Magnesium (Mg)	15	243	116	99	8.1	23	11
Sodium (Na)	5.9	1,960	190	80	3.1	80	4.1
Potassium (K)	1.3	50	9.0	5.0	.6	2.8	.6
Bicarbonate (HCO_3)	140	150	128	80	113	138	144
Carbonate (CO_3)	0	0	0	0	0	0	0
Sulfate (SO_4)	8.5	551	535	595	1.2	39	6.5
Chloride (Cl)	6.0	3,840	430	155	4.5	169	6.8
Fluoride (F)	.4	.1	.5	.4	.0	.2	.2
Nitrate (NO_3)	.2	.0	.6	.8	.1	.6	.0
Dissolved solids - sum	---	7,060	1,530	1,130	---	---	---
Dissolved solids - residue on evap. 180°C	142	---	---	---	109	482	146
Hardness as $CaCO_3$	124	1,820	891	762	98	239	125
Noncarbonate	9	1,690	786	696	6	126	7
Specific conductance (micromhos at 25°C)	251	12,100	2,390	1,600	195	836	249
pH	7.7	7.5	7.8	7.7	8.1	7.8	8.1
Color	2	9	9	4	2	3	9
Density in gms/ml at 20°C		1.002					

[1]In solution at time of analysis.

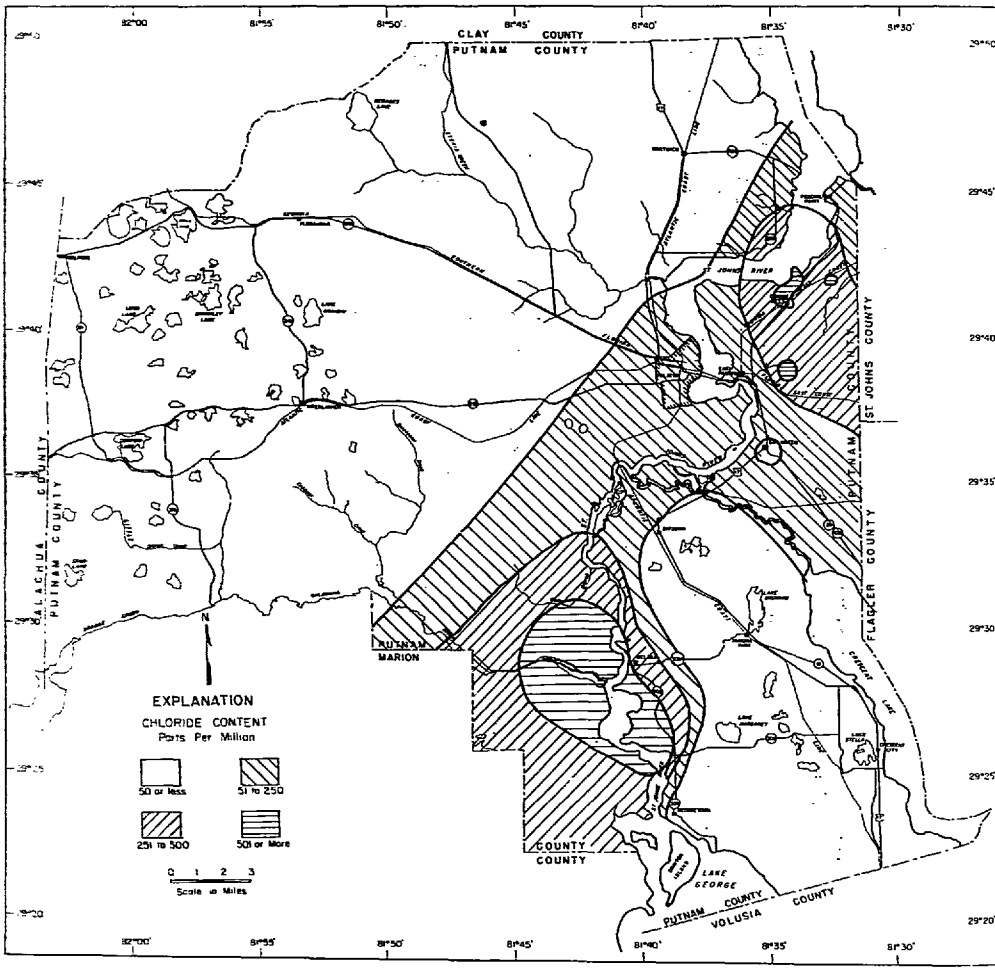

Figure 10. Map of Putnam County showing the approximate chloride content of water from the artesian aquifer.

A comparison of figure 10 with a map of the piezometric surface (fig. 5) shows that the areas where the piezometric surface is lowest generally correspond to the areas where the chloride content of the water is highest. These areas are in the vicinity of Welaka, where natural discharge from springs in the St. Johns River maintains a depression in the piezometric surface, and in the winter vegetable farming area, east of Palatka, where discharge from many irrigation wells seasonally depresses the piezometric surface. Analyses of water samples collected periodically in the farming area indicate that the chloride content of the artesian water varies with changes in the artesian pressure head. Figure 11 shows that decreases in the artesian pressure head in well 940-134-2, in the farming area, are accompanied by increases in the chloride content of water from the well, and vice versa.

Most water samples that were collected from irrigation wells in the winter vegetable farming area during this investigation did not contain enough salt to endanger the crops. However, as fresh water is withdrawn from the wells salty water may move toward the wells and make them unsuitable for irrigation.

Water from wells not drawing from the principal artesian aquifer generally has a chloride content of less than 30 ppm, but water from well 930-139-1 (table 1) contains 3,840 ppm, the highest concentration in any water sample collected during this investigation. As this well is relatively shallow, it is believed that it draws water from one of the beds of sand or shells within the Miocene or Pliocene deposits. These beds probably have not been flushed as much as has the more permeable limestone aquifer.

SUMMARY AND CONCLUSIONS

The progress made during the first year of this investigation is summarized below.

1. More than 160 wells have been inventoried to obtain pertinent information on the ground-water resources of the county.

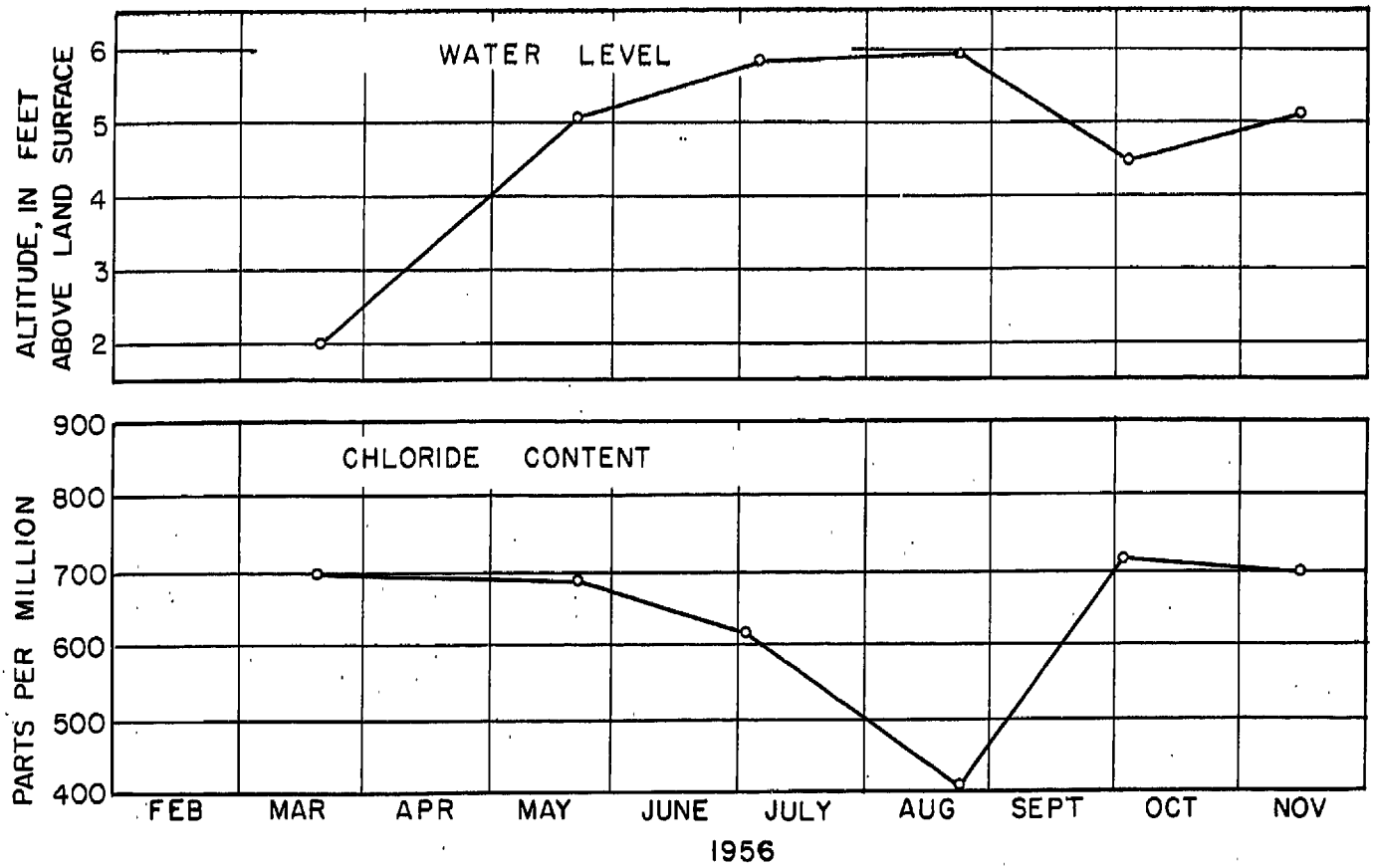

Figure 11. Graph showing the relation between the chloride content on the water and the water level in well 940-134-2, three miles northeast of Palatka.

2. Periodic measurements of water levels and artesian pressures are being made in 32 wells, and continuous water-level recorders have been installed on two wells, to determine seasonal fluctuations and long-term trends.

3. Water samples from more than 160 wells have been analyzed for chloride content, to delineate areas in which the water is salty. Analyses have been made of water from different depths in a few of these wells.

4. Periodic determination of the chloride content of the water from 13 wells have been made, to determine the relation between changes in artesian pressure and chloride content.

5. Comprehensive chemical analyses were made of water from seven wells in different parts of the county.

6. Geologic information has been obtained from sets of rock cuttings collected from several of the wells drilled in Putnam County.

Final conclusions concerning many of the ground-water problems in the county are beyond the scope of the present report. However, from data already collected, the following conclusions can be reached.

1. Thick Eocene limestones underlie the county at the depths ranging from 25 to 170 feet below sea level. These limestones are overlain by deposits of Miocene or Pliocene age which consist principally of clay and thin beds of sand, shell, and limestone. The Miocene or Pliocene deposits are overlain by sand, clay, and peat, of Pleistocene and Recent age, that range in combined thickness from 10 feet to more than 125 feet.

2. In Putnam County ground water occurs under

nonartesian conditions in the Pleistocene and Recent sands, and under artesian conditions in the limestone beds underlying the Miocene or Pliocene clays and in the thin beds of sand and shells within the clays.

The nonartesian aquifer is recharged over most of its surface by direct infiltration of rainfall. The principal artesian aquifer is recharged principally by rainfall in southeastern and western Putnam County.

3. Water-level records show that there has been a progressive decline of the artesian pressure head in recent years and that the artesian pressure head fluctuates, seasonally, as much as 10 feet in parts of the county. The most pronounced fluctuations are in the winter vegetable farming area, east of Palatka, where pumping of irrigation wells lowers the artesian pressure head. A decline in the artesian pressure head in this area considerably reduces the area of artesian flow.

4. The chloride content of water samples from wells in the principal artesian aquifer ranges from less than two ppm to 1,080 ppm. Generally, the chloride content is lowest in and near recharge areas and in the upper part of the aquifer. Most of the wells that yield water of high chloride content are in areas of discharge, where the artesian head is low. In areas of seasonal discharge, increases in artesian pressure are accompanied by decreases in the chloride content of the water, and vice versa.

Water from wells not drawing from the principal artesian aquifer generally has a chloride content of less than 30 ppm.

Future studies in Putnam County will include:

1. An inventory of additional wells.

2. A more exact determination of the altitudes of measuring points on observation wells, in order to define the piezometric surface more exactly.

3. Accumulation of additional geologic information through well cuttings and electric logs, to determine in more detail the thickness, character, and extent of the different geologic formations.

4. The exploration of selected wells with a current meter, to determine the position and thickness of the aquifers, and use of deep-well sampling equipment to determine the quality of water in each water-bearing zone.

5. Pumping tests to determine the water-transmitting and water-storing capacities of the artesian aquifer.

6. A detailed study of recharge areas, to determine the rate and distribution of recharge to the artesian aquifer.

7. Additional comprehensive analyses of water for more adequate coverage of the county.

REFERENCES

Applin, Esther R. (see Applin, Paul L.)

Applin, Paul L.
1944 (and Applin, Esther R.) Regional subsurface stratigraphy and structure of Florida and southern Georgia: Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 12, p. 1673-1753.

Bermes, B. J.
1956 Interim report on the ground-water resources of Flagler County, Florida: Florida Geol. Survey Inf. Circ. 13.

Black, A. P.
1951 (and Brown, Eugene) Chemical character of Florida's waters - 1951: Florida State Bd. Cons., Div. Water Survey and Research, Paper 6.

Brown, Eugene (see Black)

Collins, W. D.
1928 (and Howard C. S.) Chemical character of waters of Florida: U. S. Geol. Survey Water-Supply Paper 596-G.

Cooke, C. W.
1939 Scenery of Florida: Florida Geol. Survey Bull. 17.

1945 Geology of Florida: Florida Geol. Survey Bull. 29.

Cooper, H. H., Jr. (see Stringfield)

Gunter, Herman (see Sellards)

Howard, C. S. (see Collins)

Matson, G. C.
1913 (and Sanford, Samuel) Geology and ground waters of Florida: U. S. Geol. Survey Water-Supply Paper 319.

Puri, Harbans S.
1953 Zonation of the Ocala group in peninsular Florida (abstract): Jour. Sedimentary Petrology, vol. 23.

Sanford, Samuel (see Matson)

Sellards, E. H.
1913 (and Gunter, Herman) The artesian water supply of eastern and southern Florida: Florida Geol. Survey 5th Ann. Rept.

Stringfield, V. T.
1936 Artesian water in the Florida peninsula: U. S. Geol. Survey Water-Supply Paper 773-C.

1951 (and Cooper, H. H., Jr.) Geologic and hydrologic features of an artesian spring east of Florida: Florida Geol. Survey Rept. of Inv. 7.

Tarver, G. R.
1956 Interim report on the ground-water resources of St. Johns County, Florida: Florida Geol. Survey Inf. Circ. 14.

Vernon, R. O.
1951 Geology of Citrus and Levy counties, Florida: Florida Geol. Survey Bull. 33.

1955 Logs of wells 3635 and 3636 drilled in Putnam County, Florida: Florida Geol. Survey open-file releases.