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THE ARTESIAN WATER OF THE RUSKIN AREA OF HILLSBOROUGH COUNTY, FLORIDA
INTERIM REPORT

By

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1953

C O N T E N T S

ILLUSTRATIONS

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INTRODUCTION

In several coastal areas of Florida where large quantities of ground water are used, water levels have been lowered sufficiently to permit the encroachment of sea water into the water-bearing formations. Encroachment in some areas has been so extensive that an adequate supply of fresh water has become difficult to obtain.

During recent years, rapid expansion and development of the farming industry in the vicinity of Ruskin, in the southern part of Hillsborough County, has greatly increased the use of artesian water for irrigation. This increased draft has lowered artesian pressures considerably, thereby creating a possibility of encroachment of salt water from Tampa Bay.

Recognizing this possibility, the Board of County Commissioners of Hillsborough County requested the United States Geological Survey and the Florida Geological Survey to make an investigation of the problem. Accordingly, an investigation was begun in October 1950.

This report gives the results of the progress of that investigation during the first year. The investigation was financed partly through a cooperative agreement between the United States Geological Survey and the Florida Geological Survey, and partly through an agreement between the United States Geological Survey and the Board of County Commissioners of Hillsborough County. The investigation was made by the author under the supervision of H. H. Cooper, Jr., District Engineer of the United States Geological Survey, Tallahassee, Florida.

The purpose of the investigation is to make a detailed study of the geology and ground water in the Ruskin area, especially as related to the problem of salt-water encroachment. The major objectives of the program includes:

(1) An inventory of wells to determine their number and distribution, their depths and diameters, and other pertinent information.

(2) A study of artesian pressures.

(3) Analyses of water from selected wells to determine the location and extent of any areas in which the artesian water is salty.

(4) A study of the surface and subsurface geology as related to the occurrence and movement of ground water.

(5) An estimate of the quantity of ground water withdrawn.

PREVIOUS INVESTIGATIONS

Several reports that include discussions of the geology and ground-water resources of Hillsborough County have been published by the Florida Geological Survey and the United States Geological Survey.

A report by Matson and Sanford (1913, pp. 320, 323, plate 5) (see references at end of report) contains a generalized map of the Pleistocene terraces, logs of wells, descriptions of the formations exposed at the surface and a brief discussion of the ground water in Hillsborough County. A report by Sellards and Gunter (1913, pp. 258-262) published in the same year includes a discussion of the geology and ground water of Hillsborough County and contains a map showing the area of artesian flow.

A report by Leverett (1931, pp. 18-20) contains a description and map of the shore line of the Pensacola sea in Hillsborough County. The geology and ground water of Hillsborough County were discussed in a report on the ground water of Florida by Stringfield in 1936 (pp. 127, 128, and 152). This report includes maps showing the area of artesian flow, of artesian water at moderate depths, chloride in excess of 100 ppm, and the first published piezometric map of the water in the principal artesian aquifer.

A report by Parker and Cooke (1944, plate 3) contains a map showing the general pattern of Pleistocene terraces in southern Florida, including Hillsborough County.

The formations penetrated by wells and exposed at the surface in the County are described in some detail in a report on the geology of Florida by Cooke (1945, pp. 34, 42, 47, 125, 208, 222, 290, and 305). A report by MacNeil (1949, p. 105, plate 19) on the Pleistocene shore lines in Florida and Georgia includes a map showing the general configuration of these shore lines. A recent report by Vernon (1951, figs. 11, 33 and plate 2) contains maps showing the subsurface features of some of the formations underlying Hillsborough County.

GEOGRAPHY

For the purpose of this report, the Ruskin area comprises about 140 square miles in the southwest corner of Hillsborough County adjacent to Tampa Bay (fig. 1).

The mean temperature in the area is about 72° F. according to the Annual Summary of Climatological Data published by the United States Weather Bureau in 1951. The average annual rainfall is about 55 inches, and, as in most of Florida, the season of heaviest rainfall is in the summer and early fall. The rainfall from June to September is usually more than half of the total during the year.

The topography of the area may be generally divided into two units: a relatively flat coastal area and an area of rolling sand ridges. The coastal area is about three to five miles wide and extends inland from Tampa Bay to an escarpment that marks the Pamlico shore line, a former

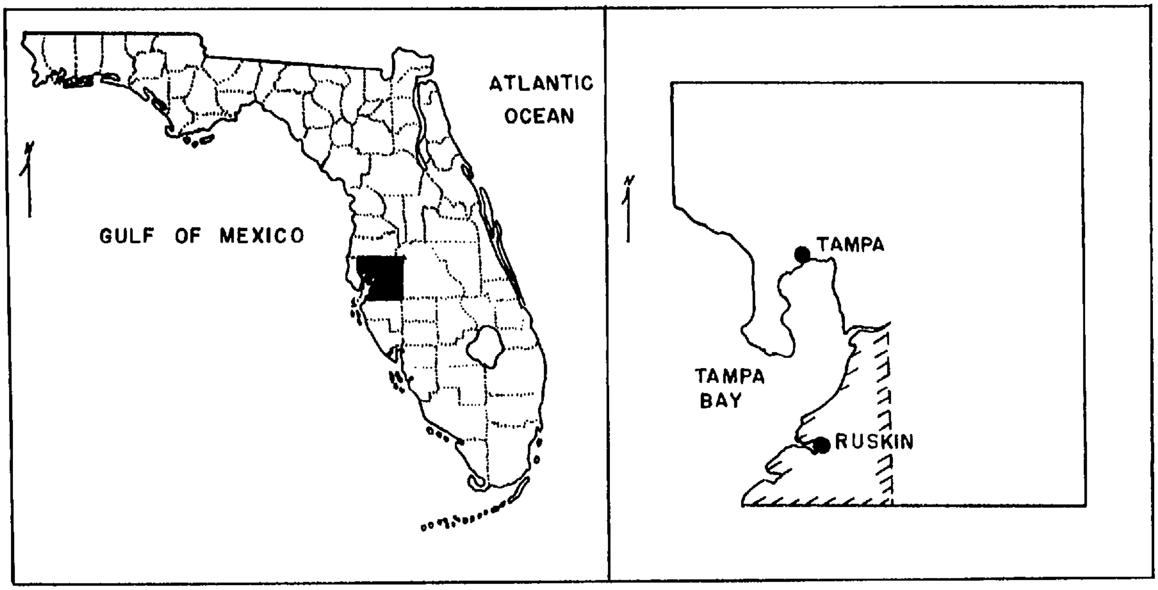

FIGURE I. A–MAP OF FLORIDA SHOWING LOCATION OF HILLSBOROUGH COUNTY.

B–MAP OF HILLSBOROUGH COUNTY SHOWING AREA OF INVESTIGATION.

level of the sea during late Pleistocene time. The coastal area slopes gently toward the bay from the base of the escarpment, which is about 25 feet above sea level. Most of the coastal area is between five and fifteen feet above sea level, but it contains a few low ridges with elevations up to 20 feet or more. The area of gently rolling sand ridges extends eastward from the Pamlico escarpment, gradually increasing in elevation to more than 100 feet in the vicinity of Wimauma. Most of the ridge area is between 40 and 70 feet above sea level.

The principal drainage in the area consists of the Little Manatee River, the Alafia River, Bullfrog Creek, and their tributaries, all of which empty into Tampa Bay, as do several other smaller streams. Numerous ponds, depressions and swamps occur throughout the area.

GEOLOGY

Previous investigations of geology in southern Hillsborough County have been devoted primarily to the surface formations. The lack of well cuttings prior to the beginning of the current investigation has prevented a detailed study of the subsurface characteristics of the formations. Well cuttings and electric logs that have recently become available have not yet been studied; therefore a detailed description of the subsurface geology will not be attempted in this report.

A generalized cross section showing the formations penetrated by wells in the Ruskin area is shown in figure 2. The formations are separated by erosional unconformities and generally dip toward the south. The Hawthorn and younger formations thicken in that direction.

The Ocala limestone of Eocene age yields large quantities of water throughout most of the State. In the Ruskin area, however, only a few wells have been drilled into the Ocala limestone because the overlying formations

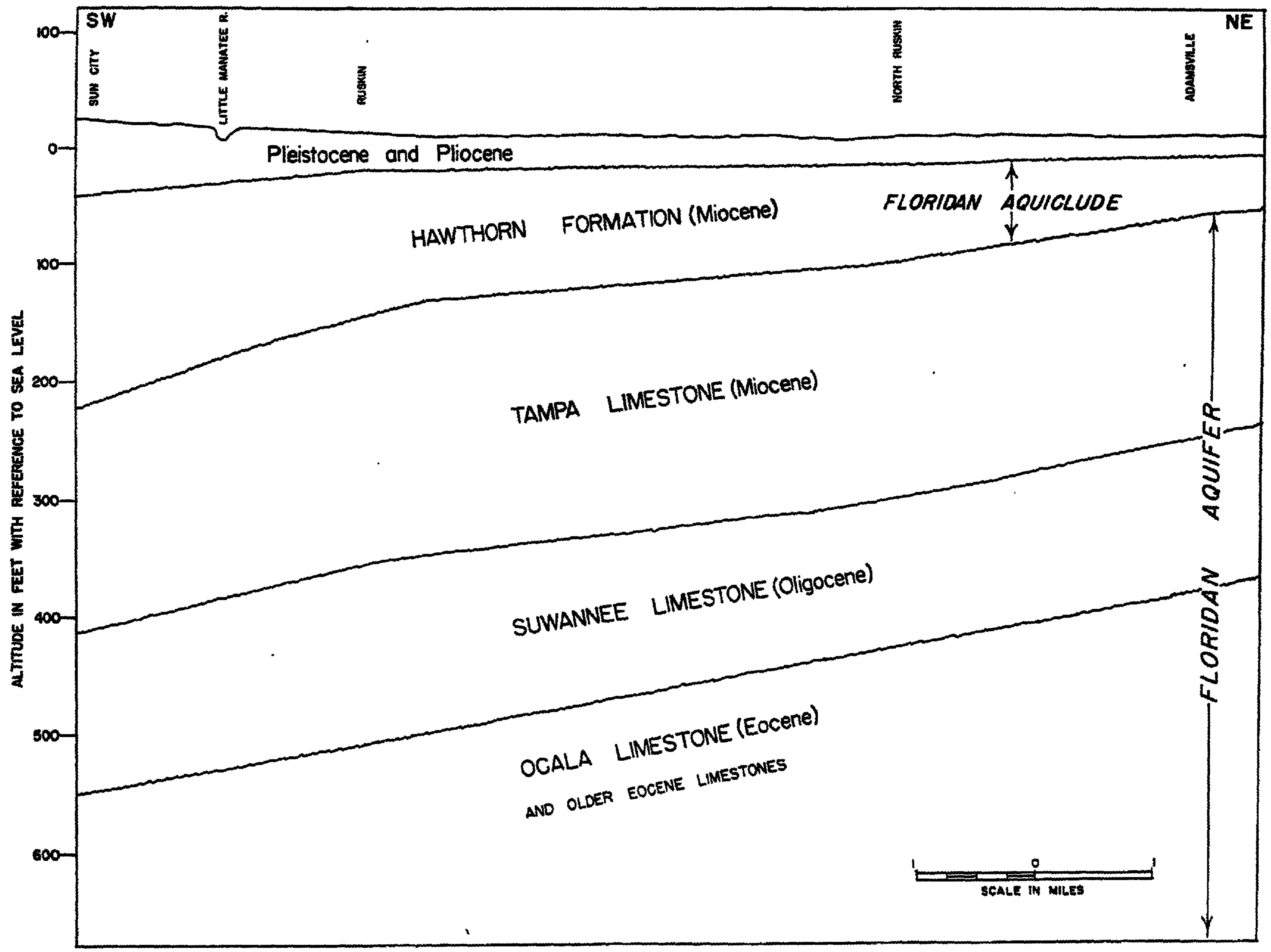

FIGURE 2. GENERALIZED CROSS SECTION SHOWING FORMATIONS PENETRATED BY WELLS IN THE RUSKIN AREA

generally yield sufficient water. The Ocala is a creamy-white to buff, soft, granular limestone containing abundant Foraminifera, and is probably more than 100 feet thick in the vicinity of Ruskin.

The Suwannee limestone of Oligocene age is probably the most productive of the water-bearing formations in the Ruskin area. It overlies the Ocala limestone and is generally a creamy-white to brown, soft, granular limestone containing abundant Foraminifera and other fossils. The Suwannee limestone is about 150 to 200 feet thick in southern Hillsborough County.

The Tampa limestone of Miocene age, which overlies the Suwannee, is also a very productive source of artesian water. The Tampa generally consists of white to gray, hard, dense, sandy limestone containing many mollusk molds and some Foraminifera. It is generally silicified and interbedded with thin layers of clay. The average thickness of the Tampa limestone is about 200 feet in the Ruskin area.

Overlying the Tampa limestone is the Hawthorn formation, also of Miocene age, consisting predominantly of phosphatic clay, but containing beds of sand and sandy limestone. The sand and limestone beds yield small quantities of water to a few shallow wells. However, as the thick beds of clay cause the formation to have a very low vertical permeability, it constitutes an effective confining bed for the artesian water in the Ruskin area, as elsewhere in the State. Parker (1951, pp. 819-820) has named this confining layer, which in some places contains other than Hawthorn materials, the Floridan aquiclude.

The Hawthorn formation is overlain by Pliocene and Pleistocene deposits of marl and sand which yield water to a few small domestic wells. These deposits are generally 20 to 60 feet thick, but in a few places along the larger streams they have been removed by erosion and the Hawthorn is exposed.

GROUND WATER

Almost all the water withdrawn from wells in the Ruskin area is derived from the permeable limestones that compose the artesian aquifer throughout most of Florida. These limestones are of several formations and different ages, ranging from Eocene through Miocene (see figure 2), however, they comprise a hydrologic unit to which the name Floridan aquifer has been given (Parker 1951, p. 819). The water in the Floridan aquifer is replenished by rainfall in areas where the aquiclude is absent or sufficiently permeable to permit the passage of water from the surface into the water-bearing strata. The artesian pressure gradient indicates that the artesian water in the Ruskin area probably originates in the lake region of Polk County, which, as Stringfield (1936, plate 12 and, p. 148) revealed, is a large area of recharge and the source of much of the artesian water in the State.

In the Polk County recharge area, water enters the Floridan aquifer through numerous sinkholes, filled with permeable material, that penetrate the Hawthorn and younger formations. The water collects in the sinks by runoff from the land surface and also by seepage from the permeable beds in the Hawthorn and younger formations; it then percolates downward to recharge the Floridan aquifer.

From the recharge area, the water moves laterally through the pores and cavities in the limestone toward areas of lower pressure (fig. 4) at places either of natural or artificial discharge. From the intake area in Polk County, the water moves underground for a distance of about 30 miles to the Ruskin area.

A few small domestic wells yield water from the shallow Pleistocene sands or other permeable beds that lie in or above the Hawthorn formation. The water in these beds is replenished by local rainfall, as there is no

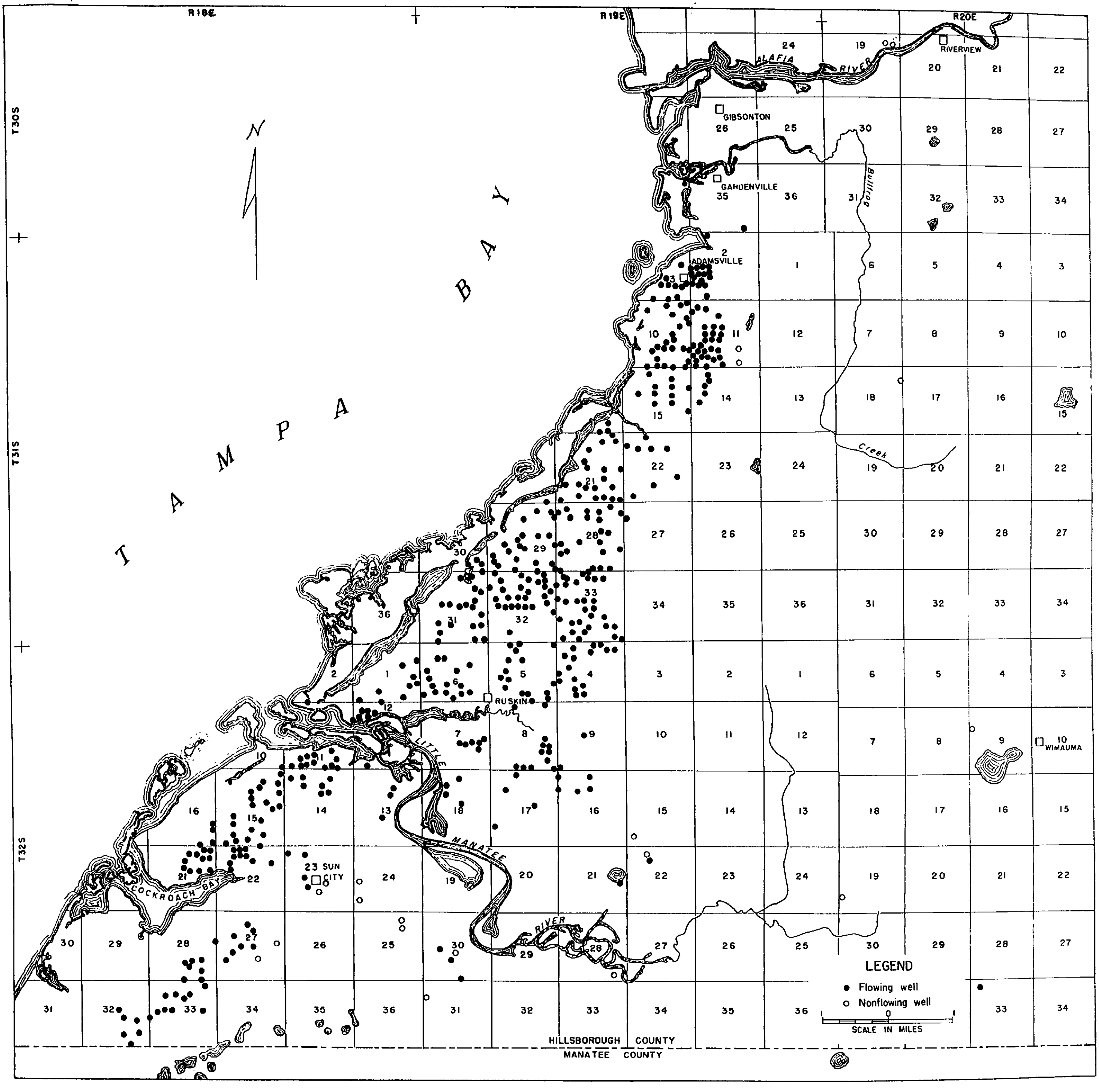

FIGURE 3. MAP OF THE RUSKIN AREA OF HILLSBOROUGH COUNTY

Showing the distribution of artesian wells that have been inventoried

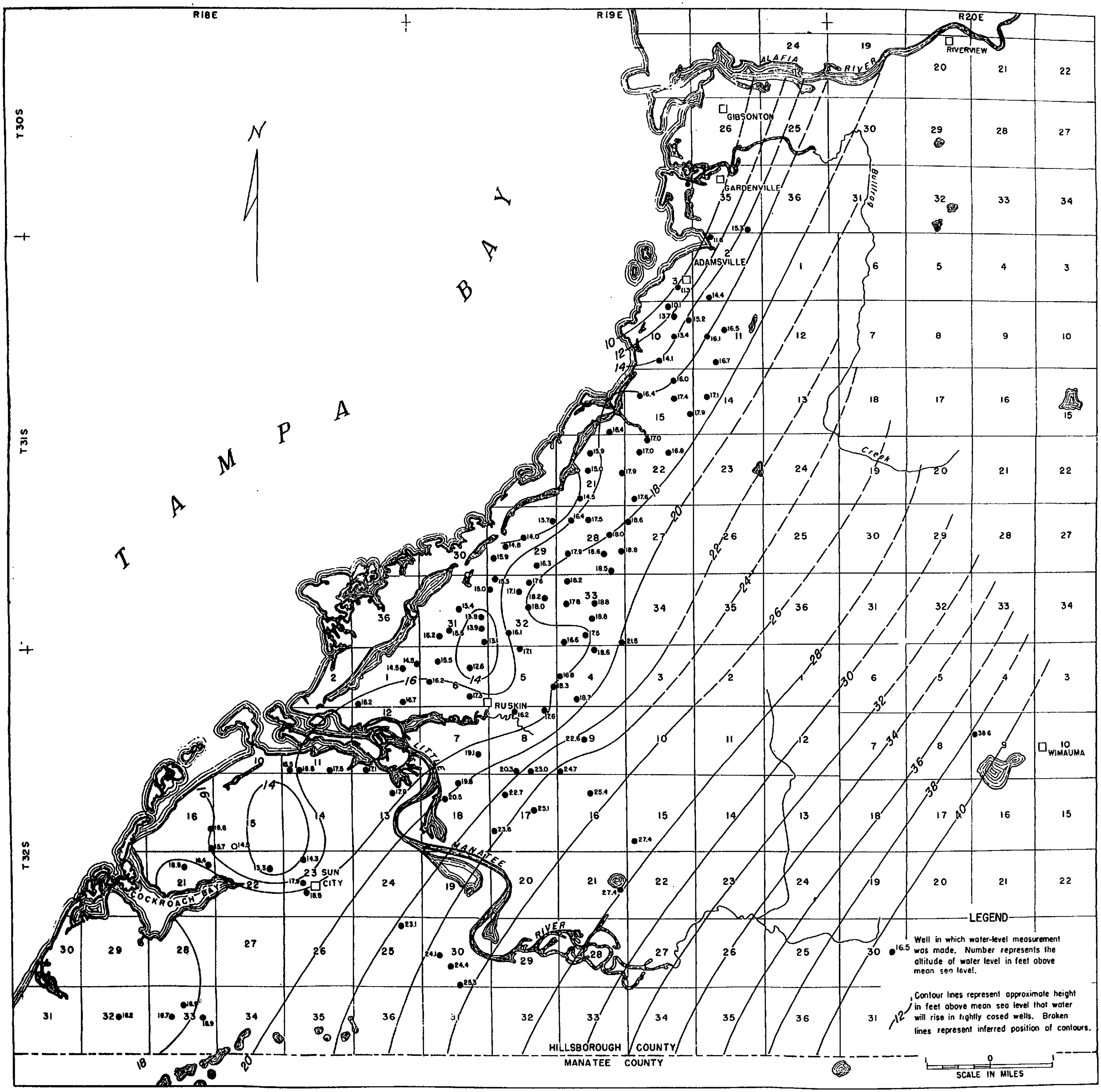

FIGURE 4. MAP OF THE RUSKIN AREA OF HILLSBOROUGH COUNTY
SHOWING THE PIEZOMETRIC SURFACE IN SEPTEMBER 1951

overlying impervious layer to hinder percolation of water from the surface. However, some of the water in the shallow aquifers may be derived from the Floridan aquifer through wells that are cased to shallow depths, or through the confining bed itself wherever it is sufficiently permeable to allow leakage.

Wells

Figure 3 shows the distribution of more than 500 wells that have been inventoried in the Ruskin area, almost all of which are used for irrigation. Most of them have been drilled during the past 10 to 15 years, a period of intensive agricultural development. They are concentrated in a zone about three or four miles wide along the coast, which includes nearly all the cultivated land. Most of the wells will flow, hence only a few are equipped with pumps.

About 350 of the wells are six inches in diameter and about 125 are eight inches in diameter. Of the rest, some have diameters of four inches or less and some have diameters of ten inches. The depths of the artesian wells range from 100 and 700 feet, but most are between 350 and 500 feet.

Piezometric Surface

The contours on the map in figure 4 represent the piezometric surface in the Ruskin area in September 1951. The piezometric surface is an imaginary surface that represents the height above sea level that water will rise in tightly-cased wells. The configuration of the contours on such a map reveals the hydraulic gradients and provides a means of determining the directions of the movement of the artesian water. The water moves from the higher toward the lower pressures in the direction of the steepest gradient, which is at right angles to the contours. If there is any recharge in an area, it is generally represented by a high in the piezometric surface. Areas of discharge are indicated by depressions in the piezometric surface.

The map in figure 4 shows no evidence of recharge in the Ruskin area, and indicates that, in general, the water moves from the region of higher pressures in the south and southeast toward the northwest. In the area east of the 22-foot contour, where interference by discharging wells is negligible, the piezometric surface has a fairly uniform gradient of about two to four feet per mile, as indicated by the gentle curvature and relatively uniform spacing of the contours. In the farming area long the coast, the contours are irregular and unevenly spaced because of discharge from wells during the period in which pressure measurements were made. Areas of heavier withdrawals are indicated by the depressions in the piezometric surface, as shown by the more pronounced distortion or the closure of the contours.

The area of low pressure west of Sun City, indicated by the closed 14-foot contour, is a result of the combined drawdown of a large number of wells that were discharging at the time measurements were made. See figure 4 for location of wells within this and other low pressure areas. A second area of low pressure, centered about a mile north of Ruskin at another closure of the 14-foot contour, may also be the result of discharge from wells. However, as there are many wells in this area that are cased to only shallow depths, some reduction of pressure may result from leakage of the artesian water into the shallow formations.

Local changes in the piezometric surface occur almost constantly, as there are several factors that cause fluctuations of artesian pressures. These fluctuations, their causes, and related phenomena have been discussed in a recent paper by Parker and Stringfield (1950). The large daily and seasonal variations in withdrawal of water from wells produce the more significant fluctuations in the Ruskin area, although observable changes in pressure are caused by rainfall, changes in barometric pressure, and ocean tides. Pressures are measured at intervals of about six weeks in 12 selected observation wells distributed over the area, and from automatic water-stage recording instruments on two wells. Also, about twice a year, measurements are made in a large number of wells so as to construct maps of the piezometric surface.

SALT-WATER ENCROACHMENT

The occurrence of salt water in artesian wells in coastal areas of Florida may be a result of (1) encroachment of salt water into the aquifer directly from the sea, or (2) contamination by highly mineralized water that exists naturally in the aquifer or underlying formations. Contamination from either source may be directly related to the lowering of artesian pressures.

In coastal areas where the water-bearing formations crop out beneath the sea, the artesian head must remain well above sea level to prevent sea water from entering the water-bearing strata. The specific gravity of sea water is slightly higher than that of fresh water so that the fresh water "floats" almost completely submerged in salt water, in much the same way that ice floats in water with only a small part of its mass above the surface (Brown, 1925, p. 16). The specific gravity of sea water is generally about 1.025, whereas, that of fresh water is, for practical purposes, 1.000. It may be shown that with these specific gravities, a column of fresh water 41 feet high will exactly balance a column of sea water 40 feet high. Application of this principle to ground water in areas adjacent to the sea indicates that for each foot of fresh water above sea level there will be 40 feet of fresh water below sea level. This relationship is applicable, however, only in aquifers of fairly uniform geohydrologic characteristics, therefore, proper allowance must be made for relatively impervious strata that may occur within or beneath the water-bearing formations. See Brown and Parker (1945) and Parker (1945). Proper allowance must also be made for the time lag between changes in pressure and adjustment of the hydrostatic balance between the salt and fresh water. Wentworth (1942, pp. 683-693) concluded that the time lag is a period of at least several months in an aquifer of relatively high permeability, and probably many years in an aquifer of relatively low permeability. His conclusions were strengthened by the work of Brown and Parker (1945, pp. 256 and 257) at Miami.

As shown on the map in figure 4, artesian pressures along the coast range from less than 10 feet in the vicinity of Adamsville to more than 16 feet south of the Little Manatee River. Application of the 40 to 1 ratio indicates that, theoretically, the depth to salt water is about 400 feet at Adamsville, and increases southward to more than 600 feet south of Little Manatee River. During periods of heaviest withdrawal, artesian pressures in areas where the wells are concentrated are several feet lower than those shown in figure 4. Thus, wells in these areas that are drilled to only moderate depths might be susceptible to contamination unless vertical migration of the salt water is hindered by the presence of relatively impervious beds in the aquifer.

Available geologic information indicates that the artesian water in the upper part of the Floridan aquifer occurs in permeable zones which are often separated, at least locally, by relatively impervious layers that retard or prevent vertical movement of the water. If encroachment were occurring in the deeper formations, the impervious strata would form an effective barrier against contamination from below. Thus the process of encroachment would be slowed considerably, as each permeable zone could become contaminated only by lateral migration of sea water from the outcrop, or through wells that penetrated the underlying contaminated beds. Much of the coastal land of Florida is underlain at moderate depths by highly mineralized water which entered the formations prior to Recent time, when the sea stood at higher levels. Thus, wells in many coastal areas may yield salt water where geologic and artesian conditions would not permit direct encroachment of water from the sea. In such areas, the lowering of artesian pressures would cause vertical migration of the salt water, except where such migration might be hindered by overlying impervious beds.

Chloride Content of the Artesian Water

The chloride content of ground water is generally a reliable index of contamination with salt water from the sea or from other sources. As a part of the investigation, analyses of chloride have been made in about 250 selected wells. The results of these analyses are shown by symbols on the map in figure 5. However, the symbols do not represent the exact amount of chloride in each well, but show the limits within which the chloride content of each well is included. It is planned that the exact chloride contents of the wells will be given in tabular form in a subsequent report.

As indicated by the open circles in figure 5, the chloride content of the artesian water over most of the area is no more than 30 parts per million. In fact, most of the wells represented by the open circles had chloride contents of about 25 p. p. m. or less. A chloride content of 20 to 30 p. p. m. is about what one might expect to find in water that is uncontaminated by salt water from the sea or other sources, and may be considered as being normal for the area. Thus, the circles that are partly or completely filled indicate wells in which the aquifer has in some way become contaminated with salt water. The wells in which contamination has occurred are restricted to the northern half of the coastal area.

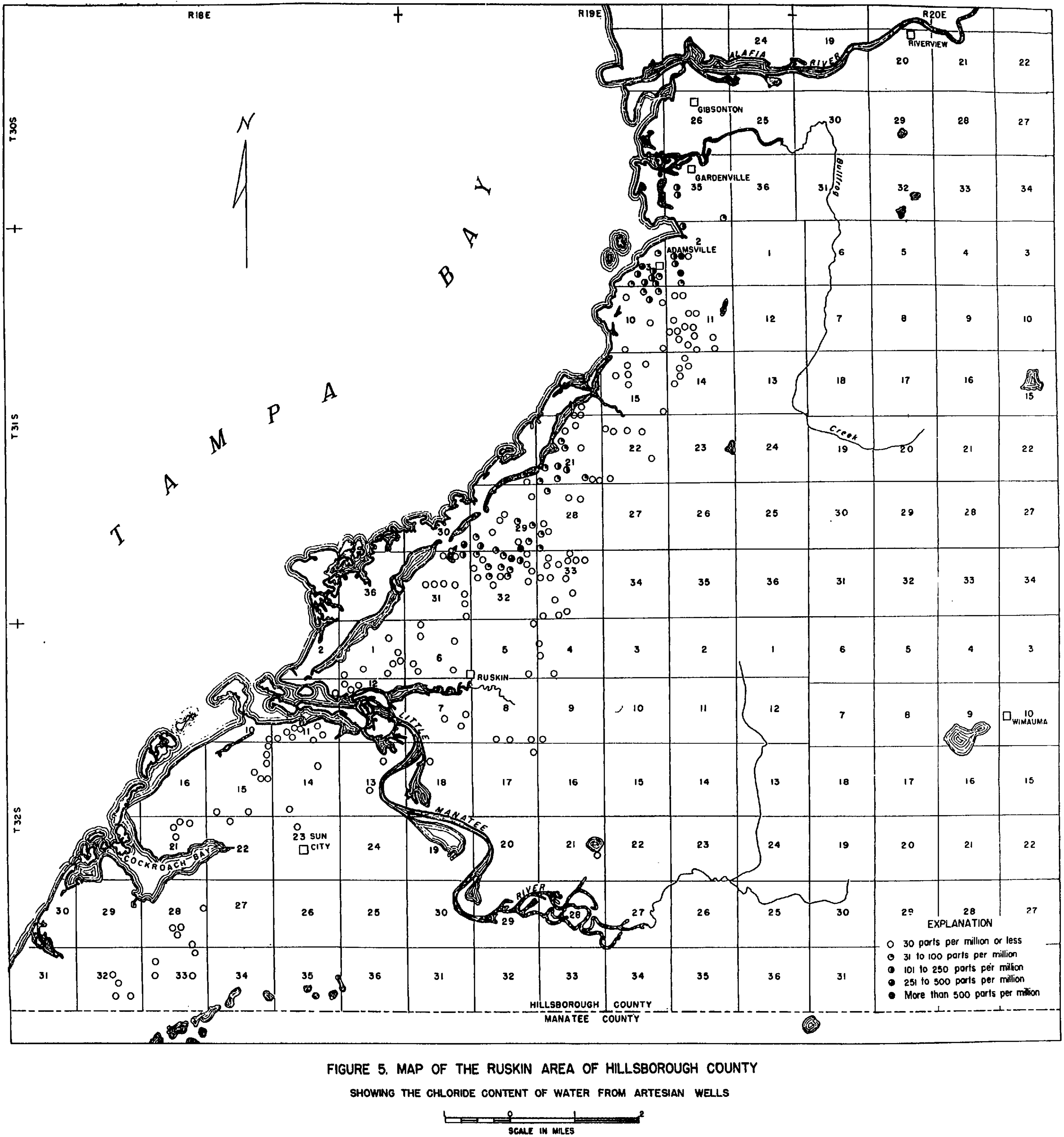

FIGURE 5. MAP OF THE RUSKIN AREA OF HILLSBOROUGH COUNTY

SHOWING THE CHLORIDE CONTENT OF WATER FROM ARTESIAN WELLS

SCALE IN MILES

As indicated in figure 5, the wells that yield water with a relatively high chloride content are restricted to three small areas. One area is about two miles north of Ruskin, chiefly in the northern part of Sec. 32, and the southern part of Sec. 29, T. 31 S., R. 19 E. The water from one well in this area contains more than 500 p.p.m. of chloride. A second area, somewhat smaller than the first, in Sec. 21 about four miles north of Ruskin, includes wells yielding water with a chloride content ranging up to 250 p.p.m. The third area extends an undetermined distance northward from the vicinity of Adamsville, along the shore of Tampa Bay. Water from two wells at Adamsville contained more than 1,000 p.p.m. of chloride, but each of these wells are more than 700 feet deep. Most of the wells near Adamsville, having depths of about 400 feet or less, yield water having contents of no more than 300 p.p.m.

Salt Water in Relation to Depth and Pressure

The areas in which wells yield water containing chloride contents above the normal are all adjacent to Tampa Bay and in the vicinity of areas of relatively low artesian pressure, where saline contamination from the sea or other sources would be most likely to occur. Some areas of low pressure, however, such as the one west of Sun City (fig. 4) contain no contaminated wells. The reason for the absence of contaminated wells in this area has not been determined, but there are several possible explanations, among which are:

1. The wells in this area may not penetrate the strata that yield salty water to wells in other low pressure areas.

2. Impervious beds may prevent contamination from the underlying strata or from the sea.

3. Artesian pressures between the area and the submarine outcrop may be sufficiently high to prevent sea water from entering the aquifer.

4. Contamination may not have reached this area because of the slow rate at which salt water moves through the aquifer.

The wells that yield water of highest chloride content generally penetrate the deeper formations, which indicates that an increase in chloride with depth is the normal situation. These wells are generally cased to only shallow depths and below the bottom of the casing are open to all the permeable strata they penetrate. However, most of the water yielded is probably from the deeper formations where artesian pressures are slightly higher than in the shallow strata. Because of this difference in pressure, there would be a tendency for the water in the lower part of the aquifer to move up through the wells and, in the uncased part, flow out into the shallow formations. Thus, contamination of the shallow formations in the vicinity of the deeper wells is possible. This possibility would account for the higher than normal chloride contents in nearby wells that penetrate only the shallow formations.

Periodic chemical analyses indicate that the chloride content of water from wells in this area varies with major changes in artesian pressure. Generally, a decrease in artesian pressure is accompanied by an increase in the chloride content, and vice versa, as shown in figures 6 and 7. The analyses have not covered a period of sufficient length to allow for determination of whether or not the chloride content is progressively increasing, but they indicate that no impervious formation separates the fresh and salt water in the deeper part of the aquifer, and that migration of the salt water is probably hindered only by the fresh water in the aquifer. Further lowering of the artesian pressure probably would bring the salt-water contact nearer to the land surface and thereby extend the contaminated area.

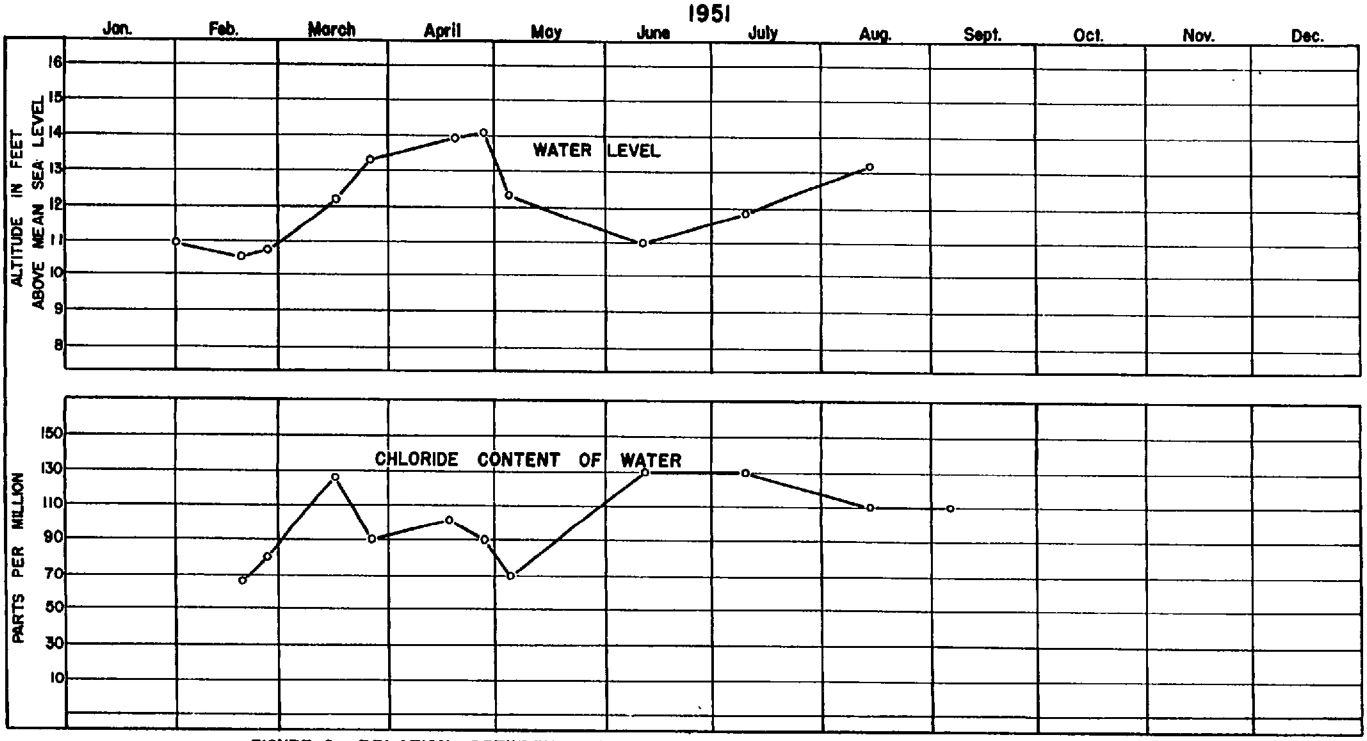

FIGURE 6 — RELATION BETWEEN CHLORIDE CONTENT AND WATER LEVEL IN WELL H-55
(WELL LOCATION: SW/4 of SE/4 of SEC. 3, T31S, R19E)

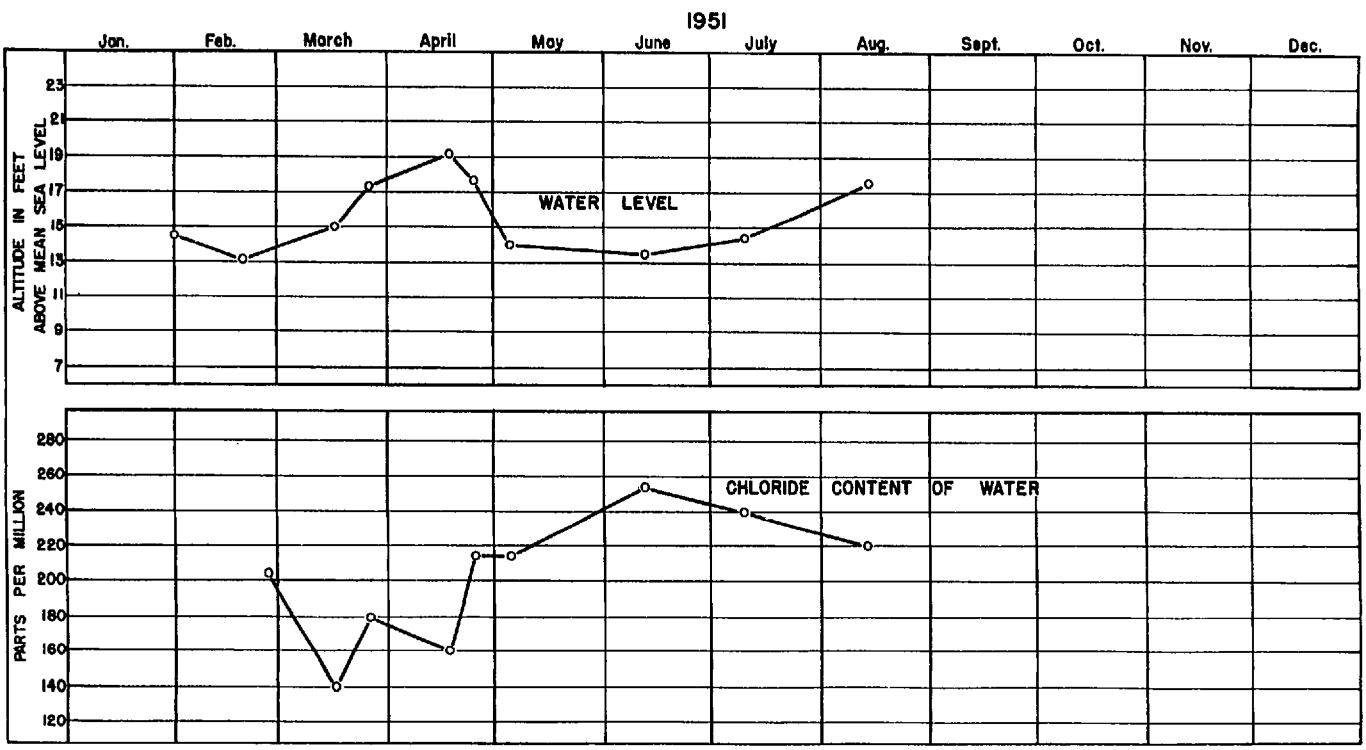

FIGURE 7 — RELATION BETWEEN CHLORIDE CONTENT AND WATER LEVEL IN WELL H-133
(WELL LOCATION: NE/4 of SW/4 of SEC.21, T31S, R19E)

SUMMARY AND CONCLUSIONS

The field work during the period covered in this report consisted of:

1. An inventory of wells.

2. Periodic water-level measurements in selected observation wells for use in studying fluctuations of artesian pressures.

3. Establishing altitudes of measuring points on wells for use in mapping the piezometric surface.

4. Mapping the piezometric surface.

5. Making chloride analyses of water from about 250 wells in order to determine areas in which the water is highly mineralized.

6. Periodic chloride analyses of water from selected wells in order to determine the relation between artesian pressures and salinity.

7. Collection of geologic data for use in preparing maps of the subsurface formations and for aid in determining their water-bearing properties.

8. An inventory of the estimated yield from wells for use in calculating the total quantity of ground water used in the area.

As the investigation was still incomplete at the end of the period covered in this report, available data are not sufficient to reach definite conclusions concerning the problem as a whole. However, the results obtained do allow tentative conclusions to be drawn concerning certain aspects of the problem, and they provide a basis for future study.

Records of fluctuation of artesian pressure show that local pressures are lowered as much as eight feet during periods of heaviest withdrawal. This lowering of pressure creates relatively large depressions in the piezometric surface, such as those shown in figure 4, where either encroachment of sea water, or migration of salty water from the deeper formations, is possible. Extension of the cultivated area and the drilling of new wells indicates an increase in withdrawal of ground water from the aquifer. This will result in further lowering of artesian pressures.

Wells in three small areas yield water with a chloride content above the normal (for the area of this report) of 20 to 30 p.p.m. Most of these wells penetrate the deeper water-bearing strata, and are in or near low pressure areas where contamination by salt water would be most likely to occur.

Although the chloride content of water from wells varies with major changes in artesian pressure, the information obtained during the relatively short period of observation is not sufficient to allow for determination of whether the chloride content is progressively increasing.

Plans for completing the investigation require the continuation of periodic water-level measurements and chloride analyses in order to allow for determination of long-range trends or any major changes in ground-water conditions.

Future studies will also include:

1. Pumping and recovery (aquifer performance) tests to determine the capacities of the formations to transmit and store water.

2. Analyses of water samples taken at various depths in wells to determine the chloride content of water in the different formations.

3. Exploration of wells with current meter and resistivity instruments to determine the depths of producing strata and the depths at which changes in the salinity of the water occur.

4. A detailed study of well cuttings and electric logs in order to construct maps of the subsurface formations and to aid in the determination of the water-bearing properties of these formations.

5. A study of the use of ground water and the making of an estimate of the annual withdrawal.

6. Complete chemical analyses of water samples from selected wells to determine the general chemical properties of the water and their relation to the chloride content.

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