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WELL DESIGN AS A FACTOR CONTRIBUTING TO LOSS OF WATER FROM THE FLORIDAN AQUIFER, EASTERN CLAY COUNTY, FLORIDA

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Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
FLORIDA GEOLOGICAL SURVEY

TALLAHASSEE
1962

Completed manuscript received
September 5, 1961
Printed by the Florida Geological Survey
Tallahassee

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ABSTRACT

A number of wells penetrating the Floridan aquifer in eastern Clay County were found to be losing water to permeable zones above this aquifer. A differential in artesian pressure was observed in closely spaced wells of similar depth. Further investigation revealed that the pressure differential in the wells was due to the design of the wells, of which there were four principal types.

A comparison of the four types of wells in relation to the subsurface geology showed that three types of wells were open to the permeable zones above the Floridan aquifer. In such wells water of relatively high head from the Floridan aquifer moves up through the well bore and out into zones of relatively low head.

The estimated water loss from poorly designed wells ranged from 32 to 180 gpm (gallons per minute). The artesian head loss in leaky wells ranged from 3 to 15 feet. A total loss of water of 39 mgd (million gallons per day) was estimated from all the leaky wells in the area.

A significant decline of the piezometric surface of the Floridan aquifer was observed in eastern Clay County. Some of this decline can be attributed to the loss of water from the Floridan aquifer through these poorly designed wells.

INTRODUCTION

Clay County is in the northeastern part of the Florida Peninsula (fig. 1). This report is concerned with the area in the eastern section of the county that lies in the St. Johns River valley.

This area, which is shown by the crosshatched pattern on figure 2, is the part of Clay County in which wells tapping the Floridan aquifer will flow. Most of the wells producing water from the Floridan aquifer in Clay County have been drilled in this area. Although a few wells have been drilled to obtain water for municipal and industrial use, most wells have been drilled to obtain water for irrigation of truck farms and pastures, and for domestic purposes. The population has grown considerably in recent years in the area bounded by Orange Park, Green Cove Springs, and Middleburg, and this growth has resulted in an increase in the number of domestic wells.

An investigation of the water resources of Alachua, Bradford, Clay, and Union counties is currently being conducted by the U. S. Geological Survey in cooperation with the Florida Geological Survey. During this investigation the artesian heads in a number of flowing wells in eastern Clay County were measured and differential in artesian pressure was observed between nearby wells of comparable depth, which indicated that water was being discharged from the Floridan aquifer to other aquifers rather than to surface flow. This stimulated an interest in the design of wells in the area, particularly in the casing procedures used in the construction of flowing artesian wells. It appeared that certain types of wells permitted water to be lost from the Floridan aquifer to the zones above the aquifer.

A generalized geologic column for eastern Clay County is shown in figure 3. Beds of sand and clayey sand are found at the surface in a zone that is 5 to 20 feet thick. Below these surficial materials usually are found beds of clay, shelly clay, clay containing shells and phosphorite, and thin limestone. These beds form a zone that ranges in thickness from 75 to 125 feet and overlies a thick sequence of alternate hard and soft beds. The hard beds range in thickness from 5 to 25 feet and are composed of one of the following: limestone, dolomite, dolomitic limestone, crystalline dolomitic limestone, or chert. Commonly the hard beds grade downward from chert to crystalline dolomitic limestone, to dolomitic limestone, to limestone. The soft beds range in thickness

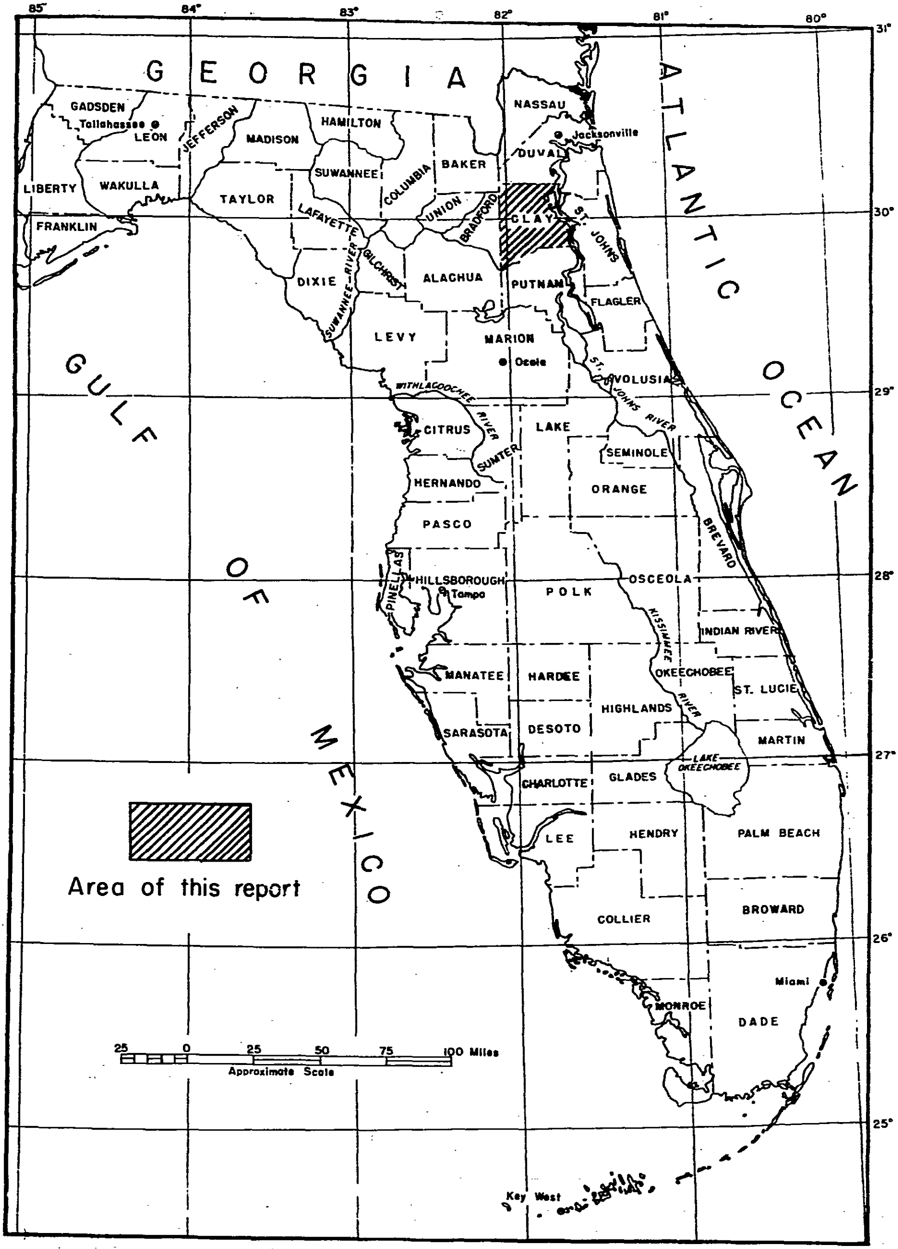

Figure 1. Florida Peninsula showing the location of Clay County.

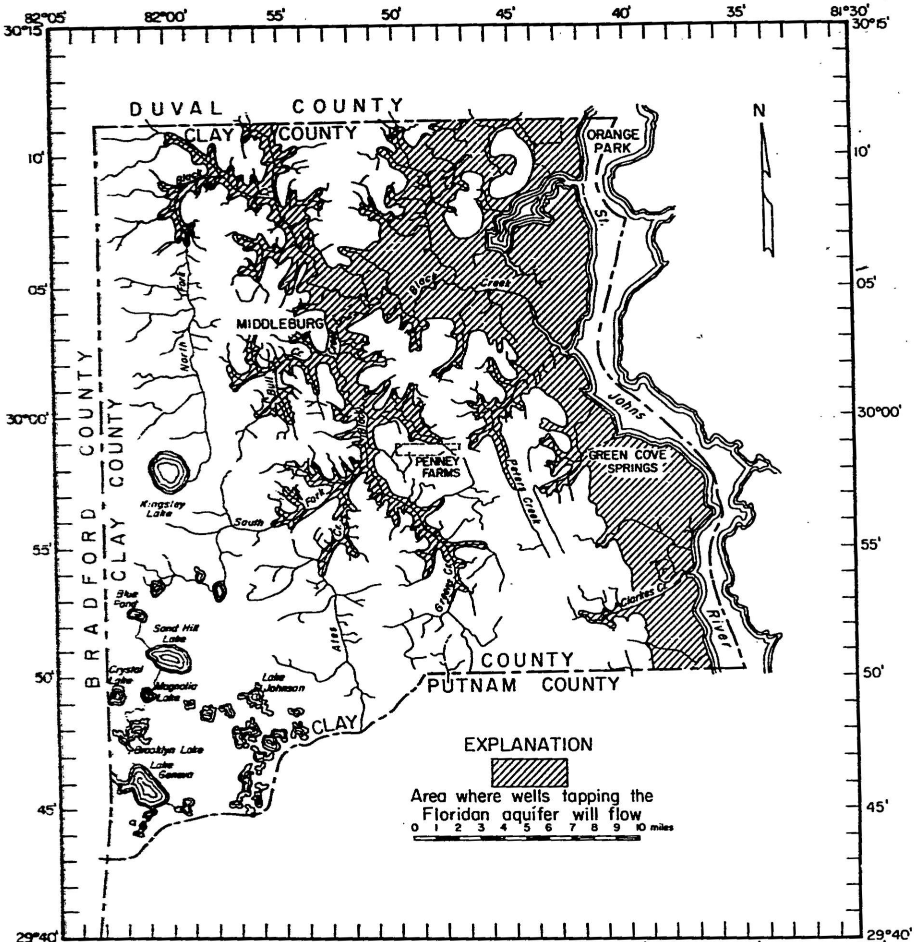

Figure 2. Clay County showing the area where wells tapping the Floridan aquifer will flow.

from 10 to 30 feet and are composed of unconsolidated sand, clayey sand, sandy clay, and clay; each bed contains phosphorite in varying amounts. The total thickness of the succession containing alternate hard and soft beds ranges from 175 to 250 feet. Beneath these beds are the water-producing limestones of the Floridan aquifer. The Floridan aquifer (or as it is known in Georgia, the principal artesian aquifer) underlies all of Florida and southern Georgia and includes several hundred feet of permeable limestone beds in eastern Clay County. Wells in the area generally penetrate the Floridan aquifer as much as 100 to 350 feet but usually they do not exceed a total depth of 600 feet below the land surface.

The piezometric surface of an artesian aquifer, such as the Floridan aquifer, is an imaginary surface representing the pressure head of the water confined in the aquifer. In eastern Clay County, in the area outlined in figure 2, the piezometric surface of water in the Floridan aquifer is above the land surface, and wells tapping the aquifer in this area will flow.

Water in the Floridan aquifer is under a higher head than the water in either the secondary artesian aquifers or the water-table aquifer both of which are above the Floridan aquifer. Thus any open connection between the Floridan aquifer and these other aquifers will permit water to move upward from the Floridan aquifer and into these overlying aquifers.

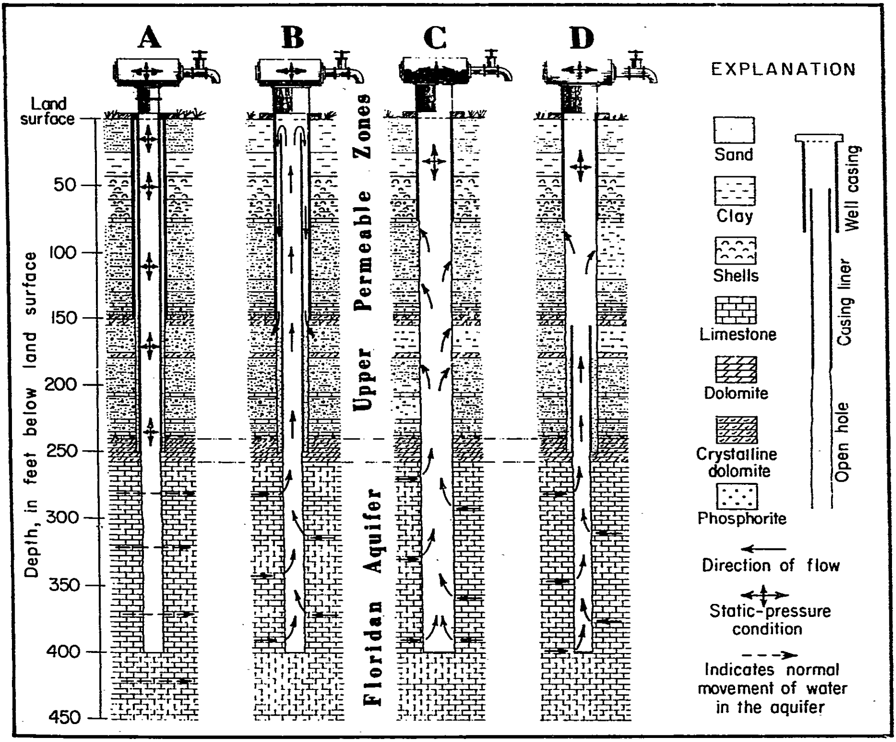

Figure 3. Diagrams showing four types of well-casing procedures used in the construction of wells.

DRILLING METHODS

Most of the wells drilled in the area are constructed by either the jetting or the cable-tool method. The usual procedure is to drive a 20-foot length of casing, with a drive shoe attached to the bottom, into the unconsolidated surface materials. The material in the casing is then drilled out and an open hole is drilled below the casing. The next step is to add a second length of casing to the top of the first length and to drive it down to the bottom of the drilled hole. Because the bit is operated through the casing, the diameter of the open hole is somewhat smaller than the outside diameter of the drive shoe, and the drive shoe must shear off a thin rim of rock around the hole as the casing is driven. In this manner the drilling proceeds until one of the hard beds of chert, dolomitic limestone, or dolomite is reached. It is often impossible to drive the casing through these hard beds, thus an alternate method of completing the well must be followed. Such a situation has resulted in a variety of well-casing procedures.

VARIATIONS IN CASING PROCEDURES

There are four general types of well-casing procedures used to overcome the situation where the casing is stopped by a hard bed.

One type of well in the area is shown by figure 3A. This type is constructed by seating the casing on a hard rock and then drilling an open hole to the top of the Floridan aquifer. A liner of pipe of smaller diameter is lowered into the well and seated near the top of the Floridan aquifer. The liner is sealed to the casing at the land surface to prevent the flow of water through the opening between the casing and the liner. Then an open hole is drilled into the aquifer to complete the well. This type of well represents one of the most satisfactory methods of casing and lining wells under the existing geologic conditions in the area.

A second type of well is shown by figure 3B; it is constructed similarly, except that, instead of running the liner to the land surface and sealing it to the casing, the liner is left a little below the top of the casing and is not sealed. As a result, water moves up the well, down between the casing and the liner, and into the permeable zones below the casing and above the Floridan aquifer. (See the direction of movement shown by arrows.) Wells of this type could easily be changed to eliminate the loss of water, by sealing the liner to the casing with a packer.

A third type of well is shown by figure 3C and is the most common type in the area. Such a well is cased only to the first hard rock, which in this area ranges in depth from 40 to 180 feet below the land surface, and then an open hole is drilled from the casing into the Floridan aquifer. In the beds below the casing and above the Floridan aquifer there are permeable zones which absorb water from the well.

A fourth type of well is shown by figure 3D. This type of well is cased to the first hard rock, and then an open hole is drilled to the top of the Floridan aquifer. A short liner is set in the open hole to prevent sand in the section above the Floridan aquifer from caving into the well. After the liner is set in the well, an open hole is drilled below the liner into the Floridan aquifer. In this type of well there are permeable zones left uncased between the top of the liner and the bottom of the casing which absorb water from the well.

LOSS OF WATER

Wells B, C, and D in figure 3 illustrate the situation where water under the higher head in the Floridan aquifer is moving into the permeable zones of lower head which are above the Floridan aquifer. At the present time it is not feasible to measure the volume of water flowing from the Floridan aquifer into the permeable zones through these wells. However, it is possible to make some estimates of the losses from the Floridan aquifer. The specific capacity (gallons per minute per foot of drawdown) times the estimated loss of artesian head in the leaky wells is the estimated loss of water from the Floridan aquifer. Specific capacities of wells developed in the Floridan aquifer in this area range from 3 to 26 gpm per foot of drawdown. The estimated water loss in poorly designed wells ranges from 32 to 180 gpm. Of the 69 wells inventoried, 14 were found to be leaking, and the total estimated loss of water from the leaky wells amounts to about 1,000 gpm. It is assumed that 5 percent of the existing wells were inventoried and it seems probable that the same percentage of leaky wells would be found among all the wells in in the area. If these assumptions are reasonably correct, the total water loss would be about 20,000 gpm, or about 30 mgd.

When a poorly designed well is opened and allowed to flow freely, most of the water that would be lost to zones of lower head will be discharged at the surface. However, there are wells through permeable zones that are not under artesian pressure, and these zones will continue to absorb water from the well even when the well is opened and allowed to flow. This condition is present in some of the wells in eastern Clay County, where it was found that the well flow was considerably less than the estimated volume of water being lost to the permeable zones.

In a sense, the water that is lost through these leaky wells is not actually lost, because it recharges the permeable zones above the Floridan aquifer. However, from the standpoint of recovery, the water is lost because these low-pressure permeable zones are not used in this area. The construction of a well in the low-pressure zones is expensive, owing to the cost of screening that is required to keep the sand out of the well.

LOSS OF ARTESIAN HEAD

When water is lost from a well by the movement of water from a zone of higher head to a zone of lower head there is a resultant loss of artesian head at the well. In a properly designed well there should be no head loss due to leakage into the permeable zones above the Floridan aquifer. If it can be assumed that wells of similar depth near each other should have comparable artesian pressures, then the 14 wells losing water had an accompanying loss of pressure head that ranged from 3 to 15 feet.

DISCUSSION AND CONCLUSIONS

From the available data it is not possible to determine the amount of decline of the piezometric surface due to loss of water from the Floridan aquifer. A map showing the decline of the piezometric surface in eastern Clay County during the period from June 1934 to June 1960 shows a significant drop in head (fig. 4). The large increase in pumping in the vicinity of Jacksonville, just northeast of this area, could account for the major part of the decline in the piezometric surface, but certainly a part of the decline must be the result of the estimated loss of 30 mgd of water from wells that were improperly designed. This would be enough water to supply a population of 150,000 to 200,000.

The water loss and the resulting head loss from a poorly designed well can seriously affect its usefulness to the owner. In some cases the head loss makes the difference between using the natural pressure of the well to supply water or having to install a booster pump with the additional costs of power and maintenance.

As more information is obtained it will be possible to determine more accurately the effect that water loss will have on water levels in areas of the State where poorly designed wells permit the loss of water from the Floridan aquifer. In the future, well design should be an important consideration in the conservation of the ground-water resources of Florida.

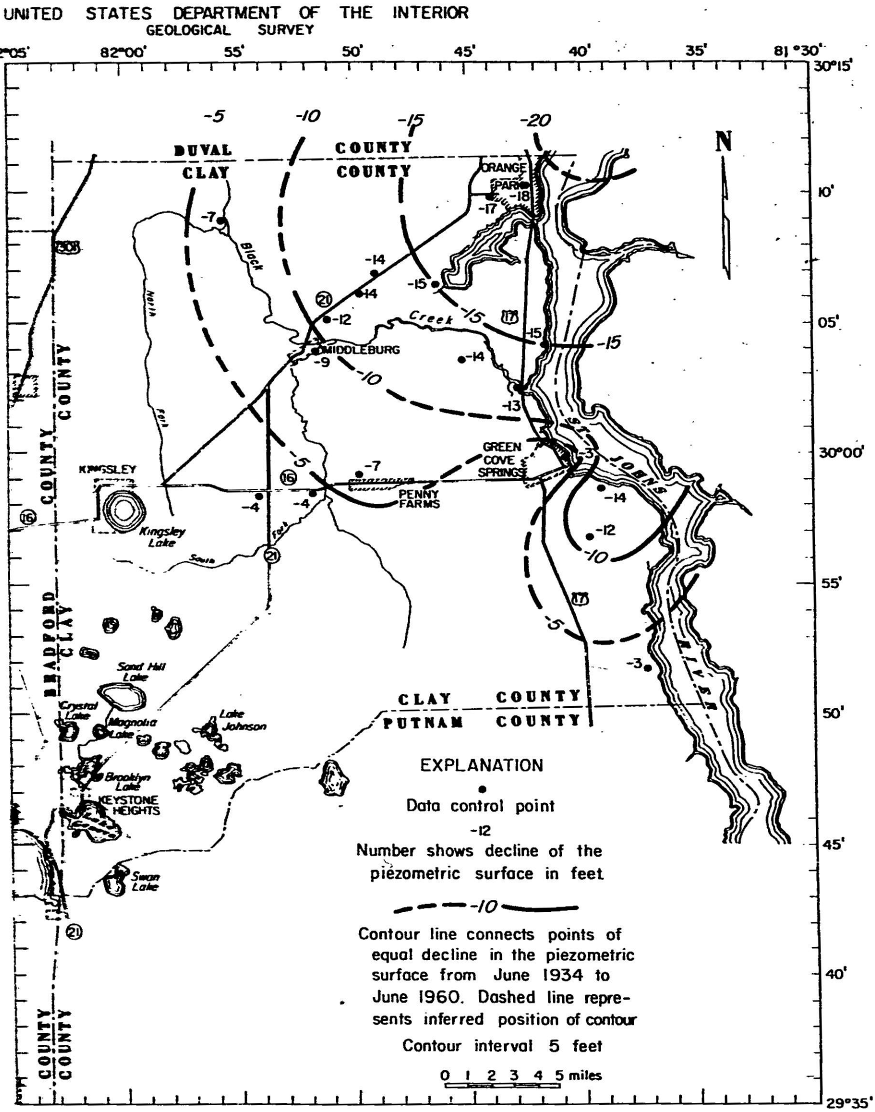

Figure 4. Clay County showing the decline of the piezometric surface in eastern Clay County from June 1934 to June 1960.