PRELIMINARY INVESTIGATION OF WATER-LEVEL DECLINES IN WELLS NEAR ESTILL, HAMPTON COUNTY, SOUTH CAROLINA, SPRING 1990

by

Nancy M. Whiting

and

A. Drennan Park

Open-File Report No. 37

South Carolina Water Resources Commission

1990

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OF
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ERRATA

Page 5, Table 1:

Town of Estill reported only one well operational. Yield reduced to 330 gpm and 475,000 gallons per day. Source: Mr. Kenneth Wechsler, Hampton County Engineer.

CONTENTS

ILLUSTRATIONS

TABLES

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ABSTRACT

An investigation of pumping-interference problems in upper Floridan aquifer wells was conducted in the vicinity of Estill, Hampton County, S.C. during the spring of 1990. The investigation consisted of a well inventory to obtain water-level observation wells and to identify major points of ground-water use, a 120-hour aquifer test, review of historical water-level data, and a series of computer-generated drawdown simulations. Six high-capacity wells discharging 130,000 to 2,000,000 gallons per day were identified. Aquifer test data indicated transmissivities of about 92,000 gallons per day per foot and storage coefficients of about 0.0004. The computer simulations predicted drawdowns of more than 8 feet within 1/2 mile of a 2,000,000 gallons per day discharge, and drawdowns on the order of 1 to 2 feet at a distance of 3 miles.

INTRODUCTION

Residents near Estill, Hampton County, S.C., (Fig. 1) depend on ground water for agriculture, industry, aquaculture, public supply and domestic use. Most wells are completed in the upper Floridan aquifer, the principal aquifer for this area. Wells range in depth from about 120 to 250 feet. Owing to confined aquifer conditions, the water levels in upper Floridan aquifer wells may rise several tens of feet above the top of the aquifer. Upper Floridan water levels have been measured in the Estill area as shallow as 6 feet below land surface.

Residents east of Estill began to report water-level declines in their wells in April 1990. Most of the problems occurred with domestic wells that were fitted with either shallow jet pumps having an effective intake depth of 17 to 22 feet or submersible turbine pumps set at 20 feet or less. Well problems occurred where water-level declines resulted in excessive lift and reductions in or loss of water pressure and yield.

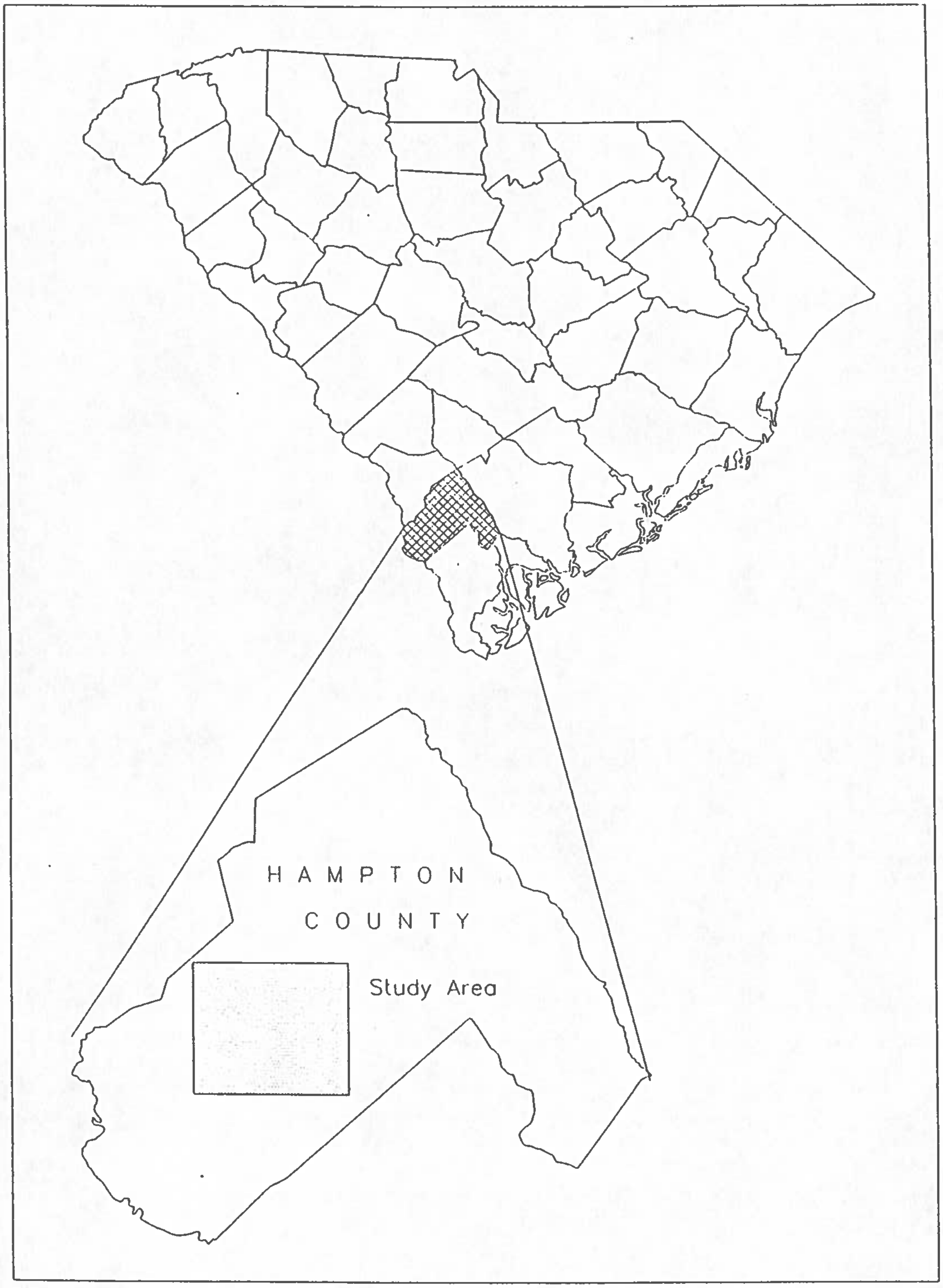

Figure 1. Location map of the Estill area.

An aquaculture project began filling 26 acres of newly constructed catfish ponds on April 17, 1990, pumping more than 2,000,000 gallons per day from the upper Floridan aquifer. On April 24, after several complaints from neighbors, pumping was voluntarily reduced by more than 60 percent and confined to late-night and early-morning hours. The pond operator and concerned residents requested an investigation by the South Carolina Water Resources Commission to determine the cause for and extent of the water-level declines and to suggest possible solutions. The results of that investigation are summarized in this report.

This report is based on interpretations of geophysical logs, drilling reports, historical and current water-level data, previous publications, information on file with the Water Resources Commission, and the analysis of a 5-day aquifer test. Propst Aqua Farm and many residents in the Estill area cooperated in the investigation.

HYDROGEOLOGY

All wells in the study area are, for the purpose of this report, considered to be completed in the Tertiary System. The sediments that compose the Tertiary System were deposited in shallow transgressing seas throughout the Paleocene, Eocene, Oligocene, and early Miocene Epochs, forming a seaward-dipping sedimentary wedge (Smith, 1988, p. 8). In the study area the Tertiary System is represented by, in ascending order, the Black Mingo Formation, the Santee Limestone, the Ocala Limestone, and the Hawthorn Formation.

Much of the following paragraphs is based on a report by Hayes, 1979 (See Referenced Cited).

Black Mingo Aquifer

The Black Mingo aquifer is considered part of the Paleocene to early Eocene Black Mingo Formation.

The deepest wells in the study area penetrate the Black Mingo Formation. Generally, the Black Mingo Formation consists of greenish-gray clay; phosphatic, glauconitic, fossiliferous limestone; fine- to medium-grained, light-gray sand; and shell fragments. Wells that tap this aquifer in the Estill area average about 900 feet in depth, or 800 feet below sea level.

Floridan Aquifer

The Floridan aquifer is considered here to include the middle Eocene Santee Limestone and upper Eocene Ocala Limestone.

Miller (1986, p.45) defined the Floridan aquifer as a series of carbonate rocks hydrologically connected in varying degrees in and offshore of Florida, southern Georgia, and parts of Alabama and South Carolina. In the Lowcountry the Floridan aquifer thickens southward from about 400 feet to 1,000 feet or more. The white to yellow sand and red to brown sandy clay of the uppermost section of the Black Mingo Formation constitute the lower confining unit for the Floridan aquifer. The upper confining bed for this artesian aquifer is a combination of upper Oligocene (?) sandy, calcareous, phosphatic clay and lower Miocene fine, sandy, greenish clay.

The Floridan aquifer is divided into three hydrologic units: lower, middle, and upper. The lower Floridan consists of a permeable, indurated, siliceous, slightly glauconitic, light-gray to cream-yellow limestone and is estimated to be 90 feet thick in parts of Hampton County. The lower Floridan, less permeable than the upper Floridan, is the primary source of ground water in northeastern Hampton County and Colleton County where the upper unit is thin or missing. No wells in the study area are known to be completed exclusively in this lower unit.

The middle unit of the Floridan is a soft, sandy, clayey, low-permeable limestone about 200 feet thick in the study area. Consequently, the middle unit acts as the upper confining unit for the lower Floridan and as the lower confining unit for the upper Floridan (Smith, 1988, p. 18).

The upper unit of the Floridan is a permeable white to light-gray calcitized, indurated, very fossiliferous limestone. The unit thins from more than 200 feet in southern Jasper and western Beaufort Counties to a feather edge near the Salkehatchie and Combahee Rivers along the northeast boundaries of Hampton and Beaufort Counties (Smith, 1988, p. 9). From previous reports and from drilling logs and geophysical logs of local wells, the upper Floridan in the Estill area is estimated to be 50 to 75 feet thick. The top of the upper Floridan in the study area is 0 to 20 feet above mean sea level (msl) and dips about 5 to 6 ft/mi toward the southeast.

The Hawthorn Aquifer

The Hawthorn aquifer is a persistent sandy, dolomitic limestone confined by the upper and lower units of the Hawthorn Formation. The Hawthorn Formation was described by Cooke and MacNeil (1952) as a series of Miocene age sandy clays and gravelly sand beds. Gamma-ray logs of wells in the study area indicate the existence of the Hawthorn Formation, but the lateral extent and thickness of this formation and its usefulness as an aquifer is not fully known.

Shallow Aquifers

Shallow aquifers in the Lowcountry consist of various post-Miocene sediments. Scattered remains of the Pliocene Duplin Marl consists of buff, sandy, friable, shelly, slightly phosphatic marl. The Pleistocene is represented by brown, gray and green clay interbedded with white to buff, subangular to angular quartz sand. Wells tap the shallow post-Miocene deposits in some parts of the Lowcountry, especially in Jasper County where deposits appear to be thicker and have yielded water of acceptable quantity and quality for domestic use. Use of the shallow aquifers in the study area is unknown.

GROUND-WATER WITHDRAWALS

Table 1 shows some of the major ground-water withdrawals from the upper Floridan aquifer in the study area. On any given day, pumpage at the Propst Aqua Farm might have accounted for 20 to 65 percent of known withdrawals. Any withdrawal will lower the water level. Effects of domestic wells and other small withdrawals are individually negligible, but collectively these smaller withdrawals should be considered. Pumping for other industrial and agricultural uses not shown in Table 1 is suspected and must be determined to fully understand the water demands of this area.

Table 1. Known major pumping in the Estill area

OWNER	WELL NO.	DISCHARGE GPM	GENERAL PUMPING SCHEDULE
Estill Saw Mill	15	90	Continuously (3.9 Mgal/mo)
Clemson Catfish Pond	1	460	Up to several days at a time
Rouse Brothers Farm	16	1500	As needed to irrigate 4 mos/yr
Propst Aqua Farm	18	1500	As needed to fill ponds
Town of Estill		420, 500	Combined total of 11-15 Mgal/mo.

WATER LEVELS

A network of wells throughout the State is monitored by the Water Resources Commission. Hydrographs of the water level from monitoring wells in the study area (Fig. 2) reflect seasonal variations. Water levels decline throughout spring and summer as water use increases and aquifer recharge decreases, and they recover throughout autumn and winter as water demands lessen and recharge increases. The unusually low measurement for No. 20 (HAM-147) in March 1985 is questionable. Such a drop would have taken the water level below the pump intake, resulting in a loss of water. Such a water loss was reported for 1988 but not prior to that time. This measurement aside, the hydrograph of well 20 depicts responses similar to those at the other monitoring wells.

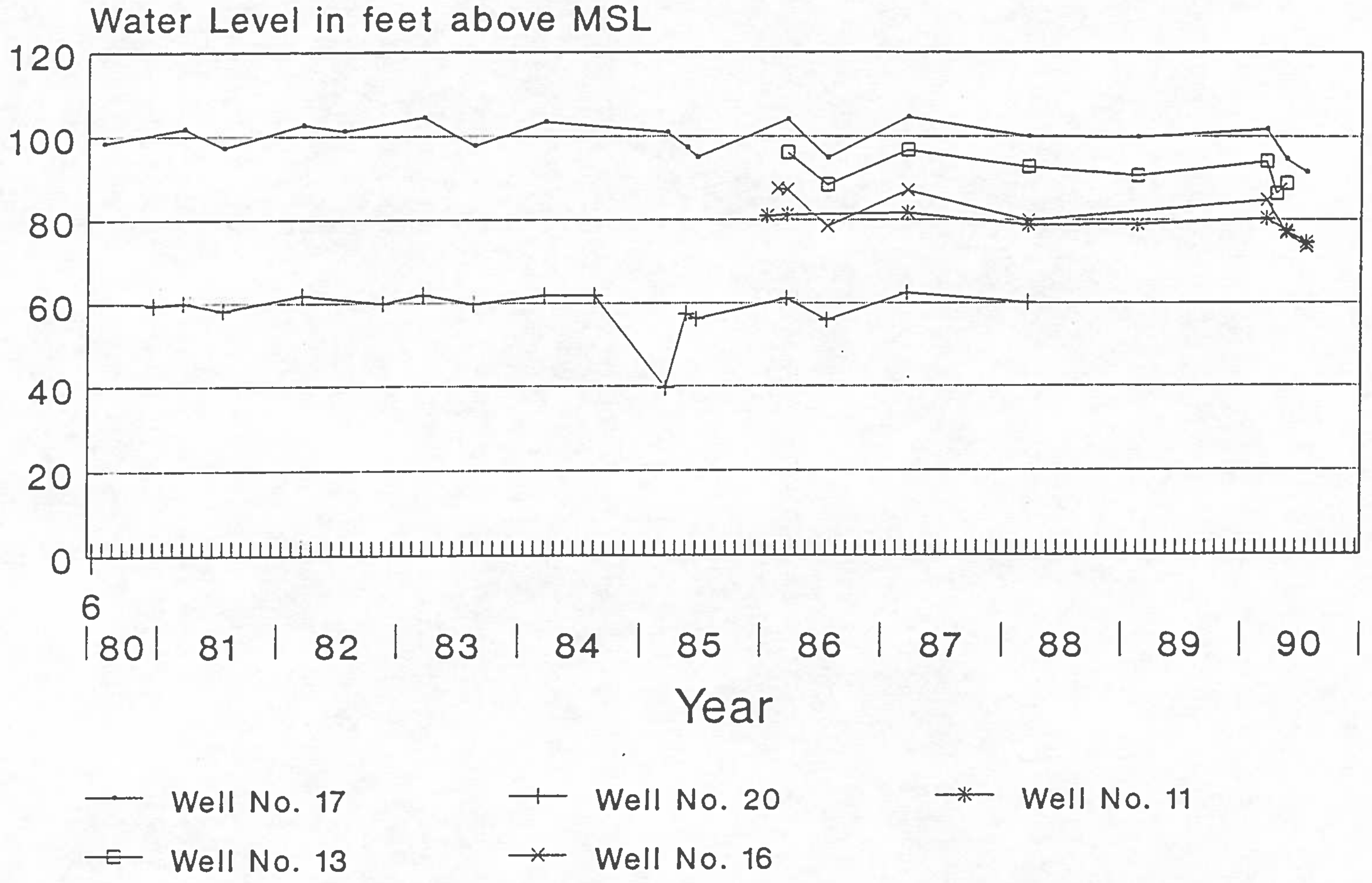

Figure 2. Hydrographs of five selected wells near Estill.

These historical data suggest that well No. 17 (HAM-108) is fairly representative of water-level fluctuations in the area. Before drawing conclusions from the hydrograph the following should be noted: 1) summer measurements for 1987 through 1989 are absent; 2) late winter measurements for 1988, 1989, and 1990 are some of the lowest on record for this time of year; 3) the water level in early May 1990 is already near the record seasonal low; and 4) according to the Climatology Division of the Water Resources Commission much of South Carolina, including the study area, was experiencing drought-like conditions at the time of the investigation. Seasonal fluctuations can account for nearly 10 feet of variation in water level. Although there were no measurements taken in the past two to three years that fall outside of the range of values established by previous seasonal fluctuations, the data may suggest the beginning of a decline in water level. Whether the data from the past two years represent an extreme seasonal variation or a continuing decline cannot be determined without further observations.

Hayes (1979, Fig. 19) obtained several water-level measurements throughout the Lowcountry in December 1976 and constructed a regional potentiometric map of the upper Floridan aquifer. Water levels in the study area are superimposed on the western edge of Hayes' 1976 map (Fig. 3). Allowing for typical seasonal variations, the possible 2.5 feet of error in estimating land surface elevation and therefore incorporated into the measurements with respect to mean sea level, and the generalized nature of Hayes map, many of the May 1990 values match the approximate water levels from 1976. The number of May 1990 water levels that deviate from the December 1976 measurements, and the size of that deviation, increases towards the Estill area. This suggests that water-level declines are fairly localized and a regional decline is immeasurable at this scale.

AQUIFER TEST

Methodology

With cooperation of Mr. Thomas Propst, an aquifer test was undertaken by Water Resources Commission staff at Propst Aqua Farm May 9-14, 1990. All pumping at Propst Aqua Farm, except for a single domestic-supply well, was discontinued for 58 hours prior to the beginning of the aquifer test, to allow the water level to recover to the pre-pumping level.

The production well is 251 feet deep and penetrates the entire upper Floridan aquifer. The discharge of approximately 1,500 gpm (determined from pump-efficiency curves) from a 75-horsepower turbine pump was routed into nearby ponds. The water level was monitored in an observation well, located 940 feet north of the production well, by a pressure transducer and recorded by a data recorder. Pumping continued for 2,844 minutes (47.4 hours) followed by a recovery that was measured for 4,400 minutes (73.3 hours). Surrounding water levels were measured in 15 other wells in the study area just prior to pumping, after pumping for more than 42 hours, and after 70 hours or more of recovery (Fig. 4 and Table 2).

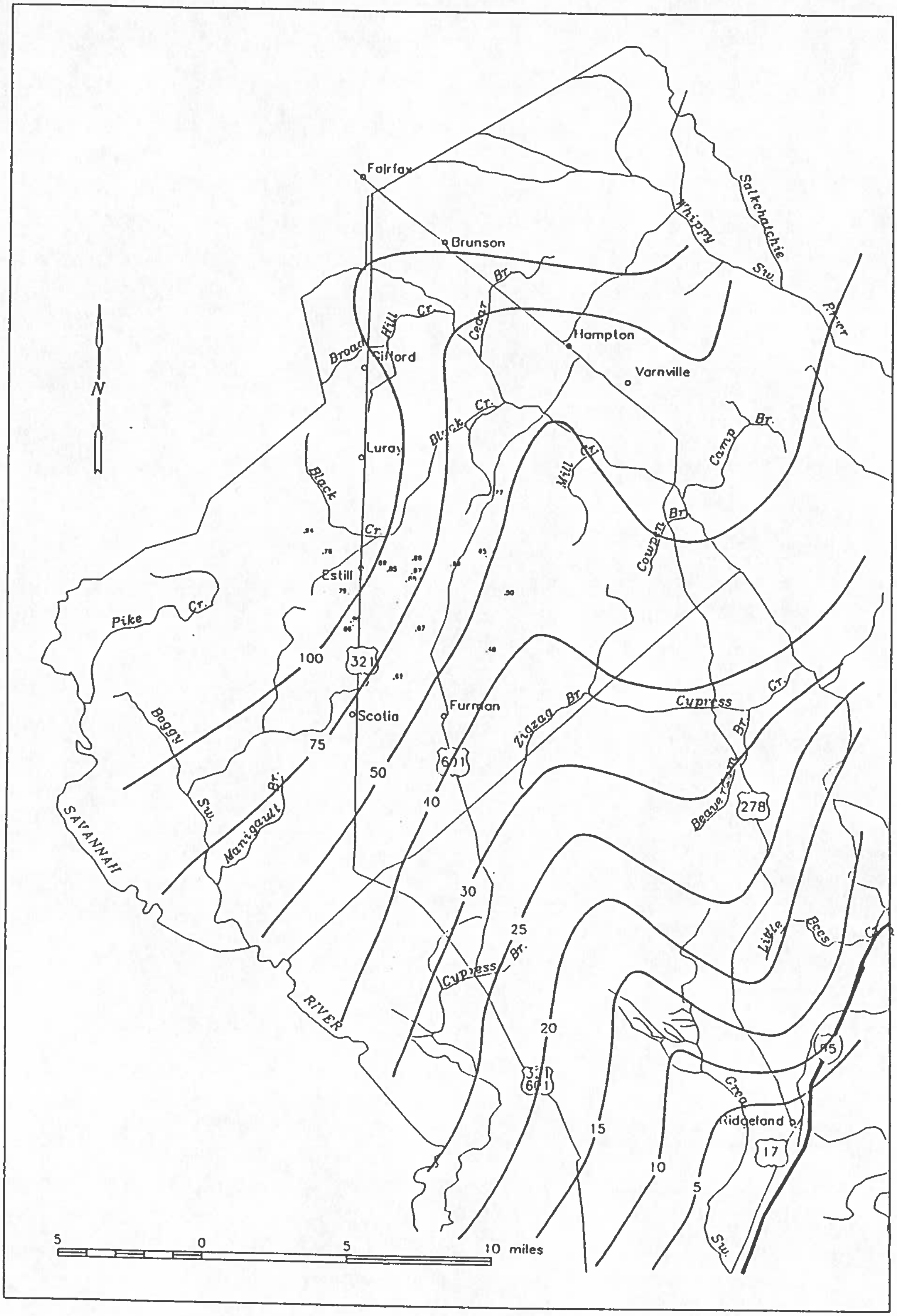

Figure 3. Potentiometric surface of the Floridan aquifer, December 1976 and water-level measurements of May 1990.

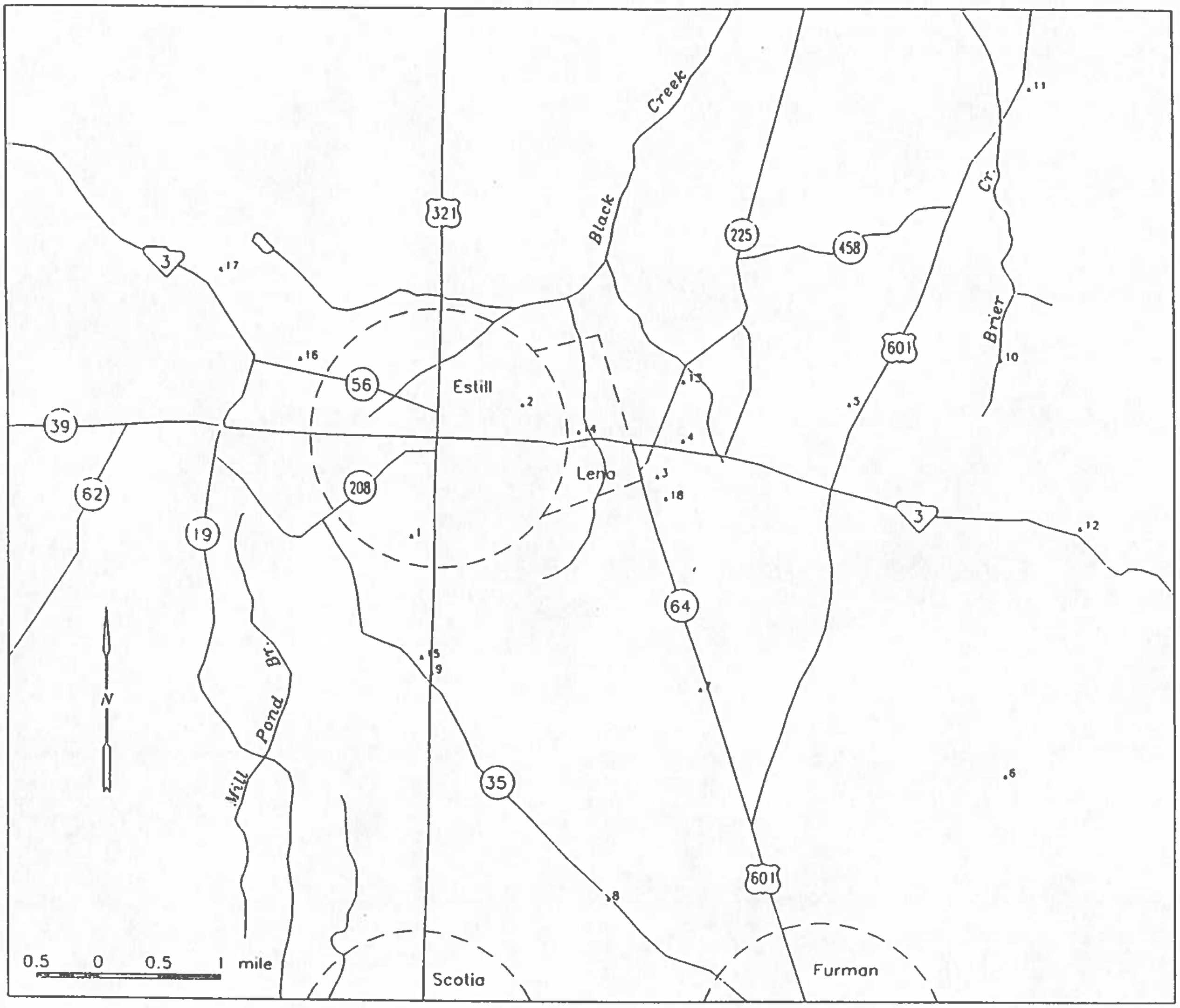

Figure 4. Locations of wells referred to in report.

Table 2. Measurements from surrounding wells during the aquifer test at Propst Aqua Farm

			WATER - LEVEL MEASUREMENT, IN FEET							
			BELOW MEASURING POINT			ABOVE MEAN SEA LEVEL			CHANGE IN WATER-LEVEL	
WELL NO.	WELL NAME	ELEVATION, IN FEET MSL	PRETEST 05/09/90	DURING TEST 05/11/90	RECOVERY 05/14/90	PRETEST 05/09/90	DURING TEST 05/11/90	RECOVERY 05/14/90	05/09 TO 05/11	05/11 TO 05/14
1	Clemson's Ponds	117 (T)	37.80	53.20*	53.33*	79	64	64	-15.40	- 0.13
2	Airfield	111 (T)	21.69	23.21	21.70	89	88	89	- 1.52	+ 1.51
3	Propst OB Well	106 (T)	17.62	29.00	17.88	93	82	93	-11.38	+11.12
4	Mrs. Duncan	105 (T)	17.95	24.53	18.25	87	80	87	- 6.58	+ 6.28
5	Patrick Henry Sch.	111 (T)	11.66	?	11.20	99		100		
6	Domestic Well	111 (T)	62.60	62.?	?	48	48?			
7	Church	111 (T)	44.16	45.15	44.67	67	66	66	- 0.99	+ 0.48
8	Steep Bottom Church	112 (T)	51.46	51.70	51.40	61	60	61	- 0.24	+ 0.30
9	Abandoned Dairy	123 (T)	?	37.02	36.64	?	86	86		+ 0.38
10	HAM-145	104 (T)	38.74	39.08	?	65	65		- 0.34	
11	HAM-164 Smokers Den	93 (T)	15.52	15.15	15.40	77	78	78	+ 0.37	- 0.25
12	Firestation	105 (T)	54.85	55.25	55.05	50	50	50	- 0.40	- 0.20
13	HAM-185 Woods	100 (T)	11.70	15.72	12.64	88	84	87	- 4.02	- 3.08
14	Mike Mikell	103 (T)	18.35	21.32	17.35	85	82	86	- 2.97	+ 3.97
15	Sawmill	127 (T)	*	37.2*	36.8*	90	90		- 0.37	
16	HAM-180 Rouse Bros.	120 (T)	44.22	42.80	*	76	77		+ 1.42	
17	HAM-108 Farm	140 (T)	46.20	44.85	47.50	94	95	93	+ 1.35	- 2.65

*Pumping

(T) From Topographic map

Analysis

The data were analyzed by the Theis curve-matching and the Jacob straight-line methods. From these analyses, local aquifer properties, such as transmissivity, storativity, and hydraulic conductivity, were estimated. For the scope of this report the following definitions apply:

> Transmissivity (T) is the rate at which water would be transmitted through a unit width of the aquifer under a unit hydraulic gradient.
>
> Hydraulic conductivity (K) is the rate at which water would move through each vertical foot of unit aquifer width under a unit hydraulic gradient. It is usually obtained by dividing transmissivity by aquifer thickness.
>
> Storativity, or storage coefficient, (S) is a measure of the water released from storage in the aquifer as head declines owing to pumping.

Field data were plotted on logarithmic paper. Utilizing the Theis curve-matching method of solution the following values were determined:

T = 92,000 gpd/ft (gallons per day per foot) -or-
12,000 ft^2/day (feet squared per day)

K = 1,500 gpd/ft^2 (gallons per day per square foot) -or-
200 ft/day (feet per day)

S = 0.0002 (dimensionless)

The data plotted consistently along a reverse type curve that closely matched the Theis curve except for the first 10 minutes of the test. Because of some of the initial assumptions, less weight in general can be given to the data from the early part of the test (Kruseman and de Ridder, 1983, p. 56). The close match between the drawdown data and the Theis curve implies nonleaky conditions for the duration of the test.

The data from the recovery phase was plotted also as a function of time on semilogarithmic paper and analyzed by the Jacob straight-line method. The resulting values for T and S are basically the same as those derived from the Theis solution, giving confidence in those values.

Using a modification of the straight-line method, the drawdowns in several of the surrounding wells were plotted as a function of distance from the pumping well. Four of the six nearest wells fell close to a straight-line plot from which the following values were derived:

T = 75,000 gpd/ft -or- 10,000 ft^2/day

K = 1,200 gpd/ft^2 -or- 160 ft/day

S = 0.0004 (dimensionless)

On the basis of the straight-line plot the drawdown at the pumping well, after 2 days of pumping, is an estimated 45 feet. The pumps at two of the wells (No. 13 and No. 14) were cycling on and off at the time they were measured, which doubtlessly affected drawdown observations.

PUMPING EFFECTS

The aquifer test results were used in a computer model (Walton, 1985) to estimate water-level declines caused by pumping selected high-capacity wells in the vicinity of Estill. The model uses the transmissivity and storativity derived from the test and the reported discharges for four 90- to 1,500-gpm wells, and it solves the Theis equation in two spatial dimensions. The resulting drawdown predictions should be reasonable representations of actual field conditions because (1) the indicated leakage is small, (2) geological data indicate the aquifer to be confined, (3) the simulated pumping periods were of brief duration, and (4) drawdowns predicted for a 48-hour pumping period compared well with drawdowns observed during the last few hours of the aquifer test.

A preliminary simulation was run to observe the correlation between model results and aquifer-test field observations. The conditions of the experiment included a single 1,500-gpm discharge and a 2-day pumping period. The predicted drawdowns were compared to drawdowns measured in nearby domestic wells near the conclusion of the aquifer test. Observed drawdowns generally were greater than predicted, but differences were not significant. Local variation in transmissivity and leakage, well interference, differences in the time of observation, and error in estimating the distance between the pumping and observation wells could contribute to the lack of correlation.

The second simulation approximated the effects of the aquaculture-project well pumping continuously for 10 days (Fig. 5). The effects of the withdrawal would be observed several miles from the pumping well (No. 18); a drawdown between 1 and 2 feet would occur at a distance of 3 miles. The drawdown at 1 mile and at 1/2 mile would be 6 feet and 8 feet, respectively. Actual drawdowns probably would be less, because leakage, which could not be quantified with the test and therefore not incorporated into the model, may become significant during a prolonged period of withdrawal.

A third simulation was run to determine the effects of other high-capacity wells (Fig. 6). These are the 460-gpm Clemson catfish-pond well (No. 1), the 90-gpm sawmill well (No. 15), and a 1,500-gpm irrigation well (No. 16) at the Rouse Brothers Farm. The Clemson well was pumping continuously during part of the study; the sawmill well runs constantly; and the irrigation well runs intermittently. The pumping simulation assumes that these wells discharged simultaneously for a duration of 10 days, with the irrigation well cycling on and off but with an average discharge of 750 gpm. The Walton model is not formulated to accommodate intermittent pumping, so the simulated effect of the irrigation well is a rough average.

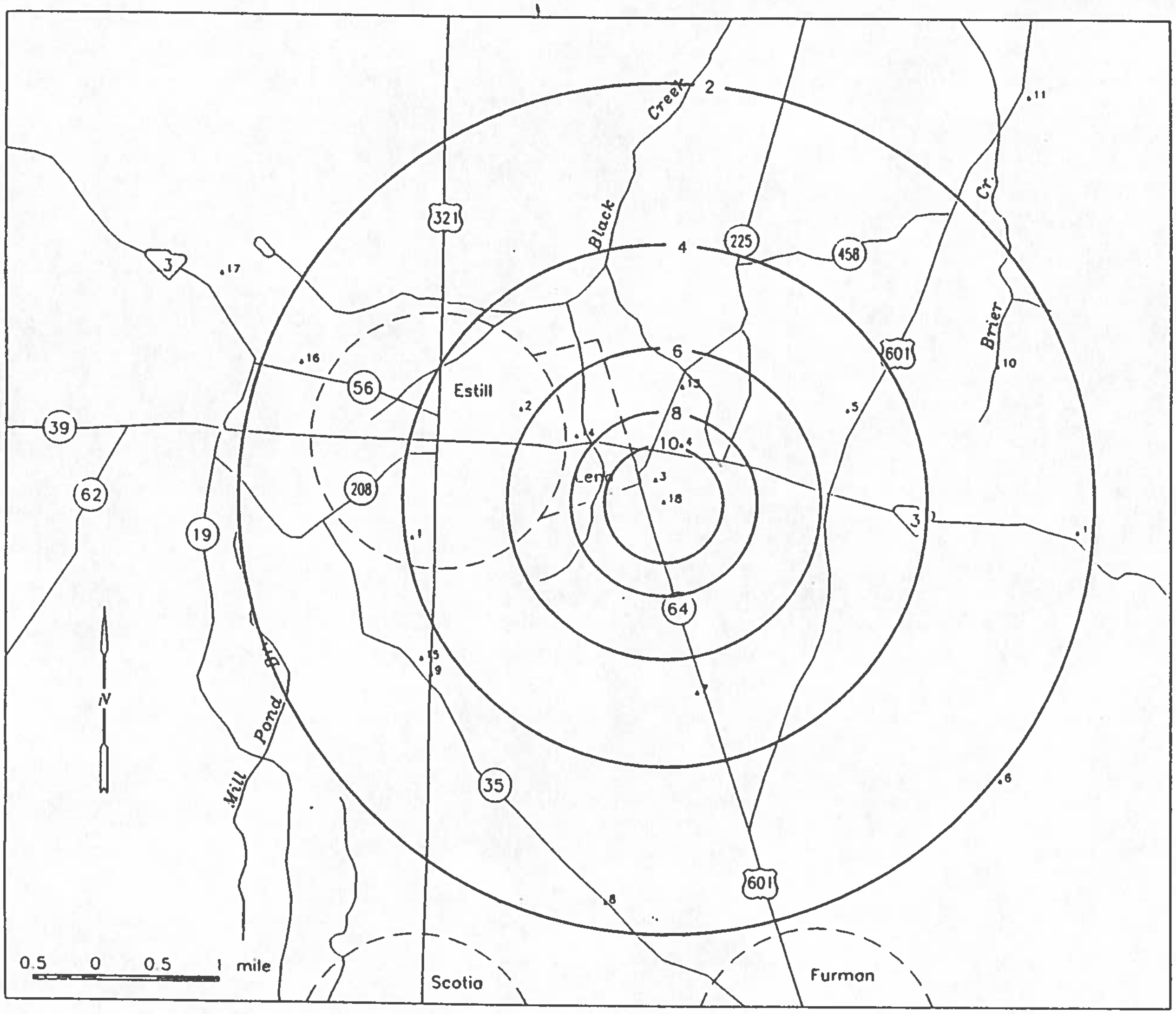

Figure 5. Simulated drawdown from a well pumping 1,500 gpm for 10 days, contours in feet.

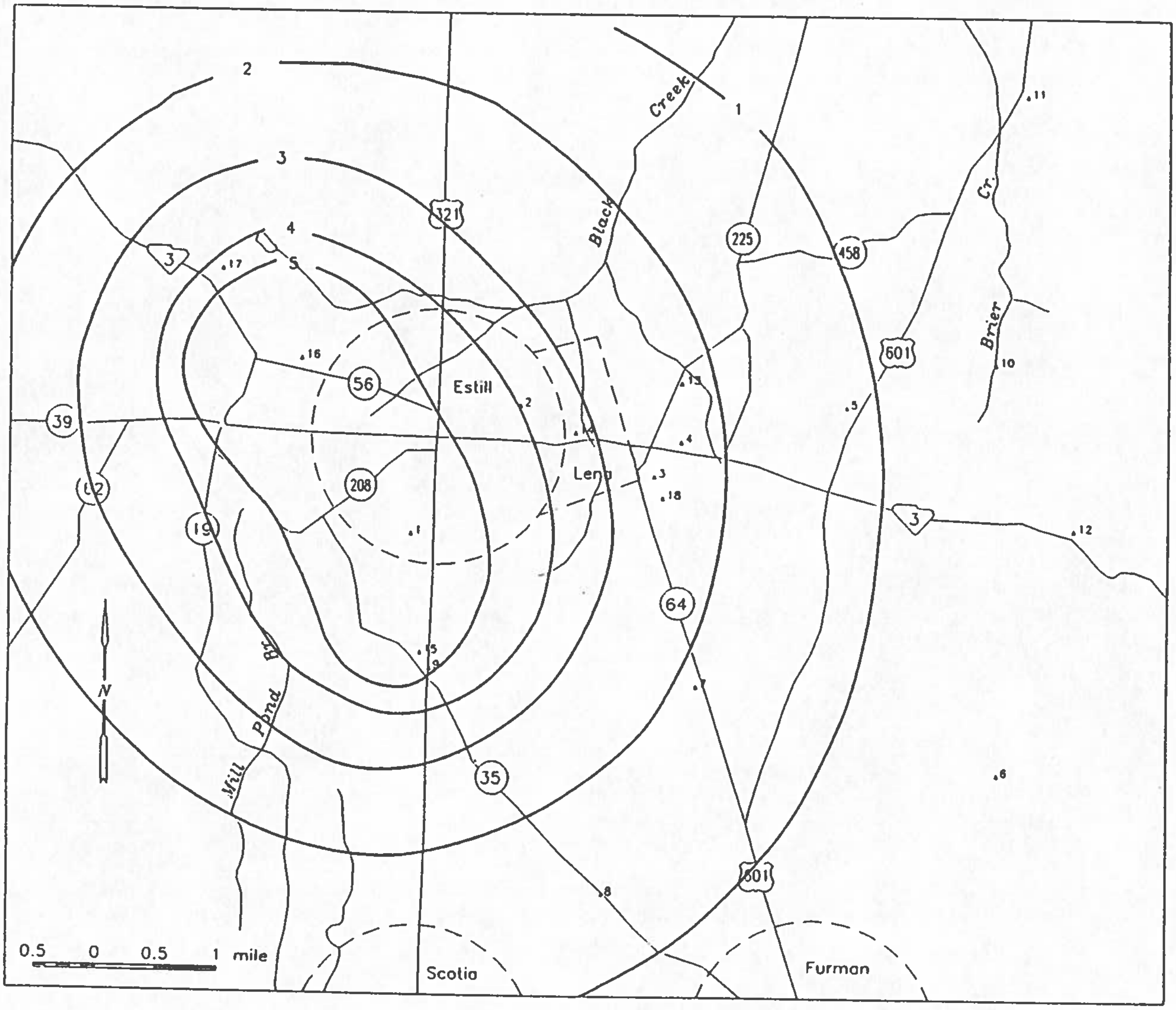

Figure 6. Simulated drawdown from three wells pumping a combined average of 1,300 gpm for 10 days, contours in feet.

The three wells have a measurable effect on water levels in the study area. Even though these wells are 2 to 3 miles from the Lena area, simulations indicated water level would be lowered 2 to 3 feet at Lena when pumping simultaneously. Periods of simultaneous withdrawal occurred during the course of the investigation. Other wells in the vicinity of Estill also contribute to water-level declines.

The Town of Estill operates two wells having capacities of 420 and 500 gpm. They produce a combined total of 11 to 15 million gallons per month. Wells used for irrigation and aquaculture are active near Furman, 5 to 6 miles south of Estill. The combined withdrawals near Furman could exceed withdrawals at Estill and may contribute to the decline observed near Estill.

The occurrence of debilitated wells would increase if a regional water-level decline coincided with increased local withdrawals. Hayes (1979, Fig. 14) estimated a water level decline of about 10 feet in the vicinity of Estill between 1880 and 1976. Much of the decline resulted from increased pumping at Hilton Head Island, S.C. and adjacent Chatham County, Ga. Because pumping in Hampton, Jasper, and Beaufort Counties, S.C., and adjacent Chatham County, Ga., has increased over the past 10 years, continued regional decline is probable.

CONCLUSIONS

The drawdown-interference problem in the Estill area stems from a multitude of withdrawals distributed over a wide area and the practice of setting pump intakes at relatively shallow depths. Increased regional and local withdrawals due to continued growth and seasonal fluctuation have combined to create water level declines below many pump intakes.

Water levels in the Floridan aquifer of central Hampton County probably have declined an additional 1 to 3 feet during the past few years. The decline can be attributed mainly to increased withdrawals for agricultural irrigation and aquaculture.

The degree of decline depends on the rate and duration of discharge. Transmissivities in the Estill area are on the order of 75,000 to 90,000 gpd/ft. Therefore, a 500-gpm well will lower water levels as much as 3 feet at a distance of 1/2 mile; a 1,500-gpm well will lower water levels as much as 9 feet. Water levels at the pumping wells will decline as much as 45 feet.

There is a high probability of well interference when the drawdown by a high-capacity well is superimposed on the regional water-level decline. Wells located within a 1-mile radius of a high-capacity well that is pumping will experience a measurable water-level decline. If such a decline coincided with other local pumping, seasonal lows and/or a regional decline, nearby wells with shallow intakes would probably experience problems. Since drawdown is a logarithmic function of distance from the pumping well, the likelihood of a "dry well" or reduced yield tends to increase exponentially with decrease in distance from the pumping well.

Similar problems would occur if the regional decline followed a stabilization of local withdrawals. Under such conditions, the interference caused by the local withdrawal would not necessarily be manifested by immediate debilitation of nearby wells. Well problems would occur over a period of years as ground-water use in the region increased instead of several near-simultaneous complaints. Identifying the ultimate cause of each problem would be difficult because it could be any combination of wells distributed over an area of several thousand square miles.

RECOMMENDATIONS

Little can be done to limit future water-level declines, short of prohibiting new uses of ground water. The demand for ground water will increase with population growth, influx of commerce and industry, and need for agricultural irrigation. Water levels inevitably will decline in response to the greater demand. There are, however, means of reducing the probability of debilitating well interference caused by high-capacity wells.

1. Use of aquifers other than the upper Floridan. Most domestic wells are completed in the upper Floridan. Underlying aquifers, between 700 and 1,000 feet, could yield substantial quantities of water. Wells completed in the deeper aquifers are more expensive to construct and operate. Water quality is generally good but might not be suitable for every purpose.

2. Construct wells to produce the minimum quantity of water necessary to serve the intended purpose. As noted previously, a 500-gpm well causes one-third of the drawdown of a 1,500-gpm well during a given period of discharge. The lower capacity well must be pumped longer to achieve the same purpose, and drawdown will continue while it pumps, but the maximum drawdown will be substantially less. As an example, an upper Floridan well near Estill will cause about 8 feet of drawdown at a distance of 5,000 feet if pumped at 1,500 gpm for 30 days (64.8 million gallons). The same well will cause about 3.2 ft of drawdown after pumping 500 gpm for 90 days (64.8 million gallons).

3. Distribute withdrawals among several widely spaced lower-capacity wells. Drawdown then is distributed over a broader area, and the drawdown near the well field is generally less. The drawdown caused by two 250-gpm wells spaced 2,500 feet apart and pumping 90 days would be about 4.7 to 5.2 feet at 1,000 feet from either well; a single 500-gpm well would cause 5.4 feet of drawdown at 1,000 feet. The benefit from distributing withdrawals among multiple wells is decreased as the distance between wells is decreased, but is increased where aquifer transmissivities are low. The cost of well construction is not necessarily greater, however, if circumstances allow smaller diameter wells to be used; that is, the cost of two 8-inch wells is about the same as a single 12-inch well.

4. Schedule withdrawals to minimize the additive effects of drawdown. The drawdown experienced at any given location is the sum of the drawdowns caused by some combination of pumping wells. Thus, well interference can

be minimized by staggering withdrawals from high-capacity wells and minimizing the amount of water pumped at any given time. For example, this might be accomplished in the Estill area by scheduling withdrawals at the Rouse Farm, the Clemson ponds, and the Propst pond so that they never occur at the same time; or by deactivating the Propst well while the Clemson and Rouse wells are pumping, and the reverse.

5. Schedule withdrawals to coincide with periods of low demand by domestic users. Withdrawals would have to be limited to late evening and early morning hours and would be curtailed substantially by this practice.

6. Pump intakes should be set well below static water level to minimize future well-interference problems. Considering the probability of continued regional decline, increased local withdrawals and seasonal fluctuations, pump intakes should be set at a minimum of 35 to 45 feet below static water level.

REFERENCES CITED

Cooke, C. W., and MacNeil, F. S., 1952, Tertiary stratigraphy of South Carolina: U. S. Geological Survey Professional Paper 243-B, p. 19-29.

Hayes, L. R., 1979, The ground-water resources of Beaufort, Colleton, Hampton, and Jasper Counties, South Carolina: South Carolina Water Resources Commission Report No. 9, 91 p.

Kruseman, G. P., and de Ridder, N. A., 1983, Analysis and evolution of pumping test data, International Institute for Land Reclamation and Improvement/LRI, 200 p.

Miller, J. A., 1986, Hydrological framework of the Floridan aquifer system in Florida, and in parts of Georgia, Alabama, and South Carolina: U. S. Geological Survey Professional Paper 1403-B, 91 p.

Smith, B. S., 1988, Ground-water flow and saltwater encroachment in the upper Floridan aquifer, Beaufort and Jasper Counties, South Carolina: U. S. Geological Survey Water-Resources Investigations Report 87-4285, 61 p.

Walton, W. C., 1985, Practical aspects of ground water modeling, National Water Well Association, 2nd Edition, 587 p.