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THE DELTA'S GROUND-WATER SUPPLY AND THE EFFECTS OF PUMPING

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By

Joe W. Lang, District Geologist
Ground Water Branch, Water Resources Division
United States Geological Survey
Jackson, Mississippi

As important as sunshine and soil, the Delta's water resources are a necessary item in a progressive economy. Aside from furnishing domestic and industrial needs, our water resources today are being rapidly developed for irrigation. P. H. Grissom, Agronomist at the Stoneville Experiment Station, has pointed out some very significant findings in his research on crop response to irrigation. Although we are experiencing a prolonged drought, which has accelerated the development of irrigation, his records show that even during years of normal rainfall the distribution of the rain is such that supplementary irrigation in the Delta can be practiced very profitably on many crops every year. Full-scale irrigation too is profitable. The acreage in rice has been growing by leaps and bounds, and this crop must be irrigated with large volumes of water.

In view of the large development of water for rice irrigation, close attention must be given to the water budget in each locality. At first, most of the rice development was along the streams where surface water was most readily available. Soon it became apparent that

1/ Revised April 26, 1955 for release to Delta Council, Stoneville, Mississippi.

there was a definite limit to this water, and attention was turned more and more to the ground-water supplies to supplement the stream waters. As the rice growers began to realize that there was a very large ground-water reservoir available directly beneath their lands, wells were installed at sites chosen by the grower whether they were near a stream or many miles from one. Thus today we have a widespread development of wells for rice irrigation, as well as for other crops.

The phenomenal increase in the use of ground water for agriculture, industry, and public supplies in the past few years has been an important factor in accelerating the field inventory and appraisal of the ground-water supplies of Mississippi. Such an appraisal, under way at the present time as part of a Statewide study of the ground-water resources, was begun in September 1953. It is being made by the U. S. Geological Survey in cooperation with the Mississippi State Geological Survey. The purpose of the study is to determine the quantity and quality of ground water available for use in the various geologic formations. The work involves a long and tedious task of field contacts and inspections in order to obtain the pertinent basic data. In the Delta, for example, several months had to be spent in assembling data that will be used in preparing ~~in order that~~ reports ~~can be made to be~~ for use~~d~~ as intelligent guides for development of the ground-water resources and to aid in a State water-conservation program.

As an immediate result of the field work in the Delta, information has been collected for about 810 wells, 450 of which are irrigation wells drawing water from the shallow alluvium. Automatic water-level recorders are in operation on 8 carefully selected observation wells, and about 275 additional wells are being measured manually from time to time to determine the water-level changes. These records form a part of the information being used to map and interpret the character of the large underground reservoir in the alluvium. The alluvium ranges in thickness from only a few feet near the hills to about 160 feet and averages 140 feet. A properly constructed well in this aquifer will readily yield about 2,000 gallons a minute; some wells yield 3,500 gallons a minute or more.

Of the total number of irrigation wells about 300 were used to irrigate rice in 1954 and the remainder to irrigate pasture and various row crops. In Bolivar County alone records have been collected for 233 irrigation wells as of April 1955 of which 142 were in operation in 1954. About 100 were drilled during the 3-year period prior to 1954.

The total pumpage of ground water from the alluvium for irrigation in the entire Delta in 1954 has been estimated as 334,000 acre feet. The rate of use during the period of pumping, lasting between 90 and 105 days, amounted to an average of about 840,000 gallons a minute. This compares with an average discharge of about 135,000,000 gallons a minute in the Mississippi River at Vicksburg during the same period. In Bolivar County, which is perhaps the center of the large rice-irrigation district, the total rate of pumping by wells amounted to approximately 300,000 gallons a minute during the irrigation season. In addition to irrigation, a large volume of water in the aggregate was pumped for domestic, stock, and industrial uses in the Delta.

Now, with this great development of ground water, the question may well be asked, what is happening to the water table? The decline of ground-water levels during dry seasons, and particularly the decline in places where relatively large quantities of water are pumped from wells, are probably the chief reasons for the widespread but erroneous belief that the water table throughout the entire Delta is persistently falling and that the ground-water supplies will eventually be exhausted. Questions in the minds of many owners of irrigation wells are these: What are the limits of safe pumping in my neighborhood? How closely can the wells be spaced? These are largely questions of economics, it seems, in the light of present knowledge.

In discussing the long-range trends of ground-water levels it is of utmost importance to know the major causes of fluctuations of the water table. Such causes include the following: precipitation which causes recharge, usually resulting in a rise in water levels; and pumping a well or allowing an artesian well to flow, and evaporation and transpiration, all of which constitute discharge and result in a lowering of the water levels. Illustrations of the rise and/or fall of the water table in parts of the Delta due to some of these causes are shown in figures 1 and 2.

Figure 1 shows the water-level fluctuation in unused well S4, drilled 105 feet deep for an irrigation supply 2.4 miles east of Lake Washington, and precipitation at Lake Washington and Greenville, Miss. Collection of precipitation records at Lake Washington was begun by the U. S. Geological Survey in December 1954; Greenville is a long-established station of the Weather Bureau. The observation well is equipped with an automatic water-level recorder. Note the close relationship between substantial rains that fell in the first half of May and the rise of water level in the well amounting to more than ~~two~~ feet. The small upward steps in the water level ~~following~~ September also correlate closely with the rains after the end of the irrigation season indicating recharge.

During the irrigation season the water level declined and recovered sharply in response to the ~~pumping pattern of 3~~ wells. (See fig. 1) An irrigation well about 1500 feet from S4 was pumped from May 6 to 11 and caused a water-level decline of more than 3 feet in S4. From May 16 to early June this well was on and off several times causing declines during pumping followed by rises when the pump was idle, as shown by the graph. ~~Pumpage~~ from this well ~~together with that~~ from another about 8,000 feet away caused the general decline in water level shown by the graph from June 3 to mid-July. The sharp peaks were caused by cessation of pumping ~~by~~ one or both wells for several hours or days and represent a ~~slow~~ recovery of the water table during these periods. Beginning in mid-July ~~all three~~ irrigation wells went into operation simultaneously (the third located about 9,000 feet from S4) and caused a total decline of about ~~one and one-half~~ feet in addition to the decline caused earlier by the other two wells. Close analysis of the hydrograph, however, indicates that the total decline would have been somewhat greater in the observation well except for irrigation returns ("insoak") to the water table of water applied to the fields and seepage losses from canals.

In late August and early September there were periods of reduced pumping or no pumping and the water table rose substantially as shown by the graph. The net decline of the water table from April 30 to September 30, 1954 was about two feet. However, there was a net rise between mid-April measurements in 1954 and 1955, indicating ready local recharge from favorable rains that fell during the first four months of 1955.

A general downward trend of the water table will be observed on Fig. 1 between the step rises caused by rains. This represents movement of ground water away from the well locality and is probably associated with areal drought conditions causing regional decline of the water table, which has been observed elsewhere.

It was decided in the spring of 1954 to construct a water-table map of Bolivar County (Fig. 2) for the following reasons:

1. It would likely be typical of other counties bordering the Mississippi River.
2. Irrigation development is greatest in Bolivar County.
3. A virtually complete inventory of irrigation wells had been made for the county and the map would show the effect of the concentrated pumping.

About 250 wells including drive points used for domestic and stock purposes and abandoned irrigation wells were used as observation wells in making the map. A set of measurements was obtained in the first half of April 1954 for all the wells. Another set of measurements was obtained in the last week of August on the same wells. The differences between April and August measurements were plotted to make this map. These differences showed that the water table fll 0.6 foot on the average on the flanks of the heavily pumped areas, and from 5 to 6 feet on the average throughout the heavily pumped areas. The maximum change of 13.7 feet occurred in an observation well near the center of pumping west of Bogue Phalia in the southern part of the county.

Three major cones of depression developed during the pumping season. (See map). The largest and most extensive lies southwest of Cleveland between Deer Creek and Bogue Phalia and indicates a local maximum decline of more than 10 feet in the water table. Two smaller cones lie 6 and 12 miles respectively northwest of Cleveland, and a third small one lies north of Cleveland. Two other comparatively small cones are in the northern part of the county. A set of measurements obtained on the same wells in April, 1955 for a comparison with the measurements of April 1954 showed that there was full recovery of the water table during the winter from the effects of pumping with the exception of the area 6 miles northwest of Cleveland where it lacked about two feet of recovery.

The cones do not indicate overpumping or excessive lowering of the water table. Such a condition, if it develops, can only be proved after a long period of observation when several more sets of seasonal measurements will be available.

Instrumental levels will be run as soon as possible to the wells to obtain elevations so that a water-level contour map can be drawn. This will be similar in appearance to a topographic map and will show the high and low places in the water table. This in turn will indicate the direction of flow of ground water into and in the area, the sources of recharge and the influence of the streams and rivers.

In the Grand Prairie district of Arkansas serious problems have developed in the past several years as a result of falling water levels caused by intensive pumping for irrigation. Today they are experimenting with artificial-recharge methods for building up the water table in the more critical localities. Although present data indicate that the hydrologic conditions in the rice-growing district of Mississippi are not exactly similar to those in the seriously affected Grand Prairie district the records for Mississippi at this time are too short and inadequate to make a direct correlation with any degree of accuracy. Possibilities of serious water-table declines may be averted by properly engineered well spacing. Should problems arise from over-development the ground-water reservoir in the alluvium may at considerable expense be artificially recharged in the several places that appear favorable for selective flooding or by pumping water from streams into key wells. Such methods have been successfully used in other states and the U. S. Geological Survey is investigating possibilities in this field for Mississippi should the need arise.

A very large quantity of water, which has accumulated over a long period of time, is stored in the natural underground reservoir formed by the beds of sand and gravel that lie below the Delta surface in Mississippi. Very little is known of the exact method of natural replenishment although it seems that ready replenishment may be at hand to supply present withdrawals. On the other hand, no one can predict how extensive the future irrigation development may be. Therefore, much additional field research is needed before sound predictions can be offered concerning the ultimate safe yield of the shallow ground-water aquifer in the Delta. Although it is a water-rich area, there is no such thing as an inexhaustable supply, and more rigid conservation methods should be applied.

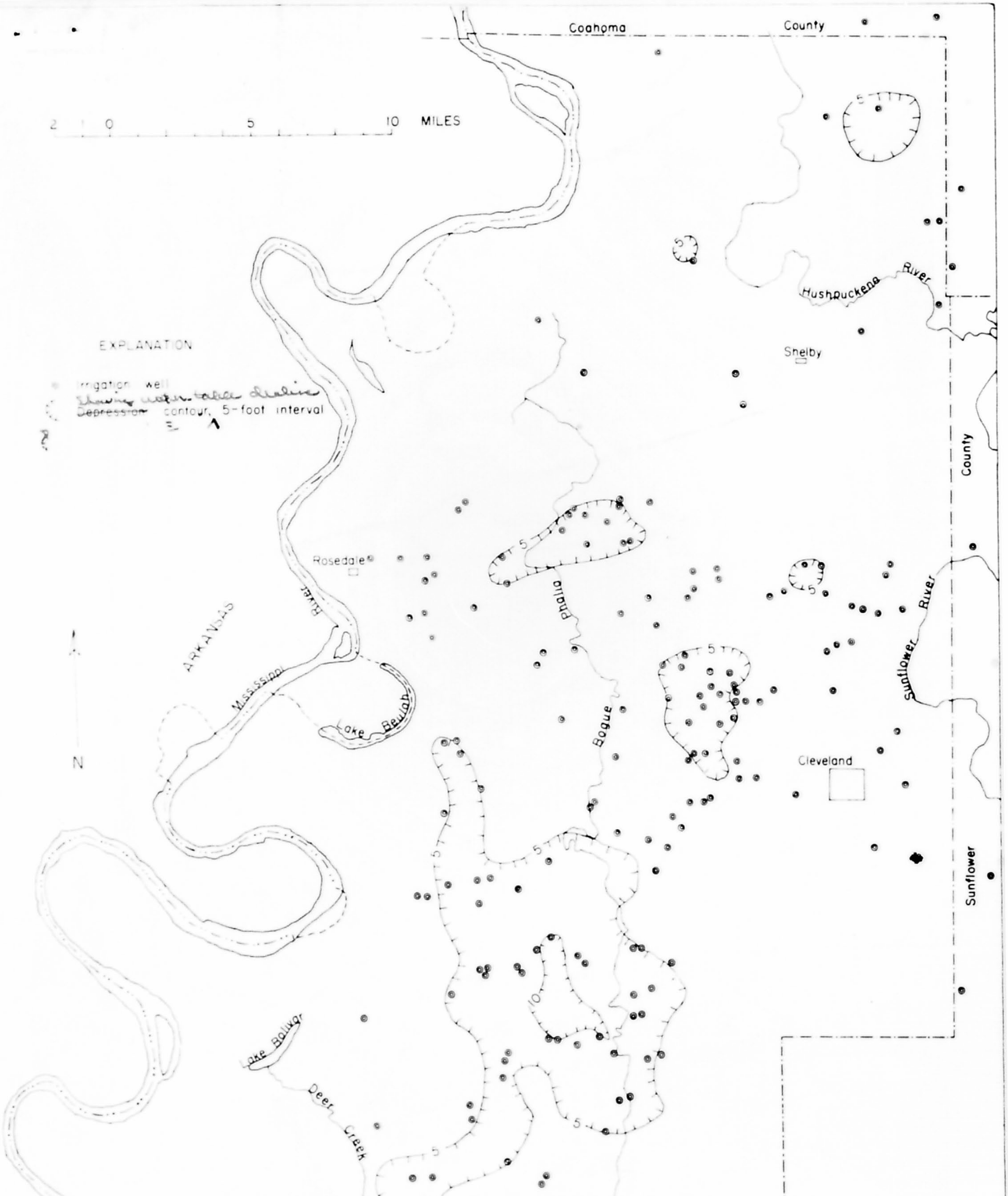

Figure 2.
Decline of Water Table due to Pumping from April to August 1954, Bolivar County, Mississippi