THE EFFECT OF THE 1986 DROUGHT ON THE MISSISSIPPI RIVER ALLUVIAL AQUIFER

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INTRODUCTION

Groundwater is a priceless resource lying beneath most of the earth's land surface. In Mississippi, water is perhaps the State's most vital and important natural resource. The vulnerability of groundwater to overuse and water-quality degradation was not widely understood until recently as evidenced by the passage of the water laws of Mississippi (House Bill No. 762, 1985).

Underlying the 7,000 square mile alluvial plain in northwestern Mississippi commonly known as "the Delta" (Figure 1), is a shallow, highly productive groundwater-bearing unit, the Mississippi River alluvial aquifer. In 1980, about three-fourths of the total groundwater withdrawn in the State, chiefly for agriculture and aquaculture, was from this 80 to 180 feet of sand and gravel. Use of water from the alluvial aquifer increased from about 200 million gallons per day (Mgal/d) in the early 1970's to about 1,100 Mgal/d in the early 1980's (1,2). Increasing water use and decreasing water levels in the early 1980's prompted the U. S. Geological Survey in cooperation with the Mississippi Department of Natural Resources, Bureau of Land and Water Resources, to conduct a study on the effects of large groundwater withdrawals on the alluvial aquifer. This study defined the hydrology of the aquifer and quantified the effects of future withdrawals of water through field investigations and digital modeling of the aquifer (3).

The water-level declines experienced in the Delta over the past 10 years were greatly intensified by the record-setting drought during 1985-86. The drought conditions experienced in the winter and spring months combined with the tremendous demand placed on the aquifer for irrigation and aquaculture water resulted in the greatest yearly decline observed to date. The purpose of this study was to determine the effects of low precipitation, decreased runoff, and increased pumpage on the Mississippi River alluvial aquifer.

PRECIPITATION, LOW-FLOW CONDITIONS AND DIRECTION OF GROUNDWATER FLOW

Precipitation in the study area during the period of December, 1985 through April, 1986 was nearly 61% below normal (Table 1). The 0.49 inches of precipitation reported for the month of January, 1986 set an all time record low. These dry conditions resulted in record-setting low flows in numerous Delta streams.

Vertical recharge to the aquifer from precipitation is in the range of 0.5 to 1.0 inch per year. The major sources for aquifer recharge are the Mississippi River and runoff from the Bluff Hills. The lack of precipitation during the drought resulted in little recharge from the Mississippi River due to low stages or from the Bluff Hills due to lack of runoff.

The alluvial aquifer throughout most of the Delta is overlain by a relatively impermeable clay cap, although several streams have

Figure 1. Location of Study Area (Delta) In Northern Mississippi

completely or partially penetrated the cap. Streams in hydraulic contact with the aquifer include the Mississippi, Yazoo, and Tallahatchie Rivers and, to a lesser extent, the Coldwater and Sunflower Rivers and the Bogue Phalia (1). The direction of groundwater flow generally is away from these streams during high-flow stages in

TABLE 1. AVERAGE MONTHLY PRECIPITATION IN DELTA
Data from: National Weather Service (preliminary reports)

MONTH	REPORTED	NORMAL
Dec., 1985	3.45	5.25
Jan., 1986	0.49	5.14
Feb., 1986	1.79	4.78
Mar., 1986	2.52	5.85
Apr., 1986	2.23	5.70
TOTAL	10.48	26.72

16.24 inches (60.8) below normal

winter and spring and toward the streams during low- flow stages in summer and fall.

NORTHERN DELTA

The Mississippi River and Bluff Hills are within a few miles of each other along the northern boundary of the Delta. The resulting narrow width of the alluvium in the northern Delta creates an effective isolation of the bulk of the alluvium in Mississippi from the alluvium north of the area (2). Groundwater levels in this area generally are less than 25 feet below land surface. In some areas, the Coldwater River is in hydraulic contact with the Mississippi River alluvial aquifer. The average water-level decline in the area from April, 1985 to April, 1986 was 1.75 feet with the greatest decline (3.60 feet) near the Coldwater River in northern Quitman County (Figure 2). This measurable difference in decline not only infers the lack of recharge but also suggests that groundwater flow was from the aquifer to the river.

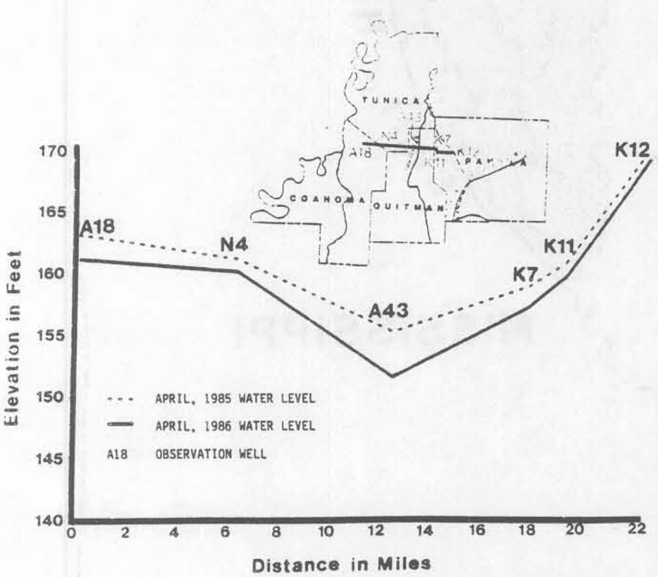

Figure 2. Groundwater Level Profile From Coahoma To Panola County

CENTRAL DELTA

The groundwater level in the alluvial aquifer in the central region of the Delta generally is from 25 to 40 feet below land surface. Water-level declines of about 2 feet per year have been observed since 1980. The water level profile from west of the Bogue Phalia in western Bolivar County to near the Tallahatchie River in Tallahatchie County is illustrated in Figure 3. The average water-level decline in this area was 3.1 feet during the period April, 1985 to April, 1986. As observed in the northern Delta, the greatest water- level declines were

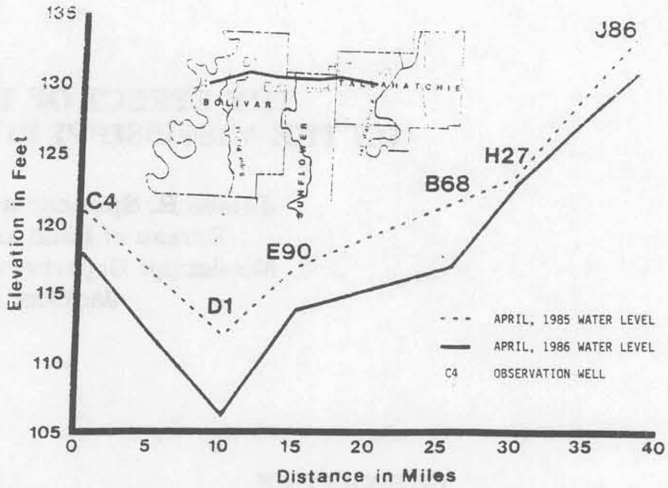

Figure 3. Groundwater Level Profile From Bolivar to Tallahatchie County

recorded near major water courses. A decline of 5.8 feet was recorded at well D1 near the Bogue Phalia.

The average water-level decline in the profile from western Washington County to the Tallahatchie River in eastern LeFlore County was 5.1 feet (Figure 4). The greatest water-level declines were recorded near the Tallahatchie River (10.3 feet) and in western Washington County (9.6 feet). According to Sumner and Wasson (3), the Sunflower River and that part of the Yazoo River below the mouth of the Sunflower historically have acted as long-term drains from the alluvial aquifer in the central part of the Delta. The difference in hydraulic head between the Sunflower River and the Mississippi River to the west has influenced the configuration of the potentiometric surface of the aquifer. This influence has resulted in the potentiometric surface of the aquifer sloping toward the Sunflower River from the north, west, and east.

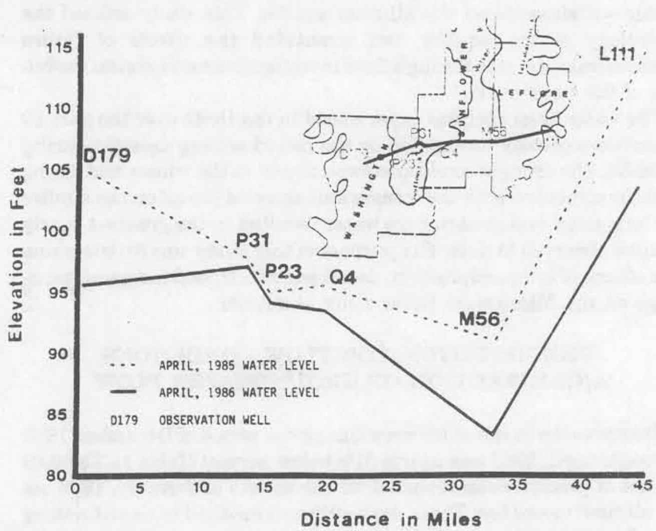

Figure 4. Groundwater Level Profile From Washington To Leflore County

SOUTHERN DELTA

In the southern part of the Delta, the alluvial plain narrows to a few miles in width where the Yazoo River forms an effective hydraulic barrier. Water levels generally are less than 25 feet below land surface.

The water-level declines observed from eastern Issaquena County near Steele Bayou to central Yazoo County are illustrated in Figure 5. The average water level decline in this area of the southern Delta was 5.2 feet, with the greatest decline of 8.1 feet occurring near the Sunflower River on the Sharkey-Yazoo County line. As was observed in the central Delta, wells located near major water courses (the Yazoo River, Sunflower River, and Steele Bayou) recorded above normal water-level declines from April, 1985 to April, 1986.

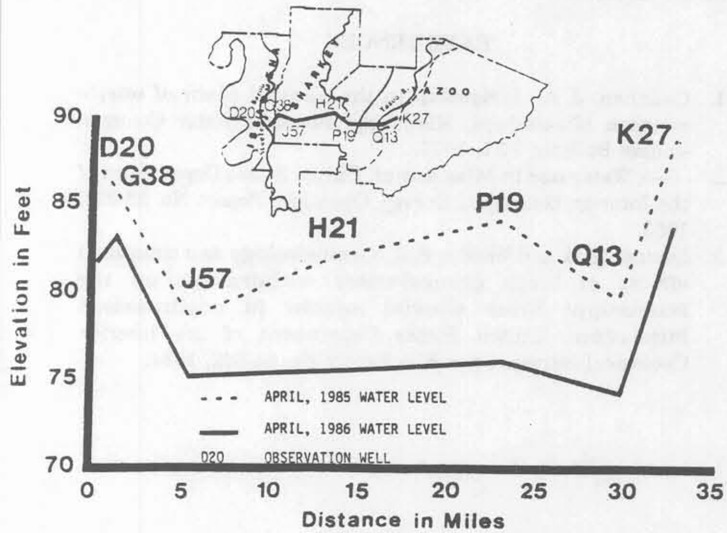

Figure 5. Groundwater Level Profile From Issaquena To Yazoo County.

The greatest groundwater-level declines in the Delta were recorded in northwestern Warren County (Figure 6). The low-river stages observed along the Mississippi River and the lack of runoff from the Bluff Hills had a pronounced effect on the potentiometric surface of

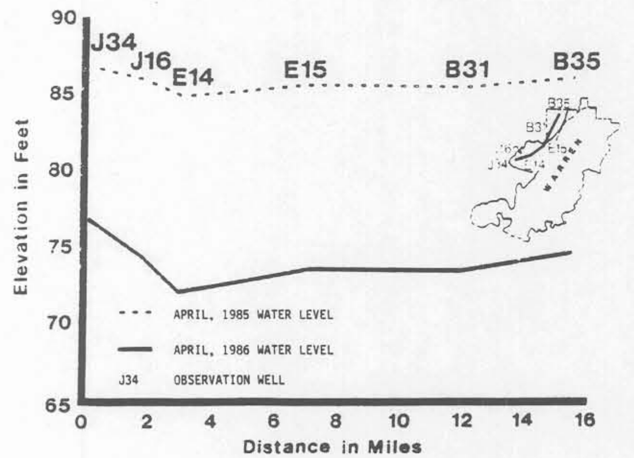

Figure 6. Groundwater Level Profile In Warren County

the alluvial aquifer due to the proximity of this area to these recharge sources. The average water-level decline was 11.6 feet with a maximum of 12.9 feet at well E14. The Mississippi River, deeply incised into the coarser part of the alluvium and in complete hydraulic contact with the alluvial aquifer, recharges and drains the alluvial aquifer on a seasonal basis. With the low-stages observed along the Mississippi River and the lack of runoff from the Bluff Hills during the drought, the net effect was one of draining the aquifer.

DISCUSSION

The depth of a water table is the workings of a steady-state process: it is a balance between aquifer recharge and the rate of discharge at rivers and streams and pumping water wells. A water table remains fairly constant when precipitation occurs frequently enough to stay in balance with river, stream, and well outflow. Any imbalance in the system, typically caused by seasonal fluctuation of rainfall and pumpage, raises or lowers the water table. A long-term imbalance may result if there is either a decrease in recharge, such as from a prolonged drought, or from an increase in discharge.

The Mississippi River alluvial aquifer typically shows seasonal water-level fluctuations. Water level increases generally are recorded in April of each year due to winter and spring precipitation. Conversely, water-level declines generally are observed in September due to pumpage during the growing season. However, overall water levels have decreased an average of 1 to 2 feet a year since 1980 due to discharge being greater than recharge. For the 2-year period April, 1981 to April, 1983, estimated pumpage was 1,100 Mgal/d and the net inflow from recharge sources was about 820 Mgal/d (3). With the low stream stages observed during the drought, net recharge to the alluvial aquifer was greatly reduced resulting in the greatest yearly water- level decline observed to date.

During the drought months, not only was recharge to the aquifer drastically reduced but discharge by pumpage was greatly increased since the lack of precipitation resulted in increased irrigation to maintain proper subsoil moisture. The maintenance of a proper subsoil moisture content during droughts can mean the difference between a successful crop or a crop failure. In order to maintain a proper subsoil moisture, not only was irrigation begun earlier but also continued throughout the growing season.

Water levels in April, 1986 were lower than normal as a result of abnormally low rainfall and stream stages, and residual drawdown from pumpage for irrigation and catfish farming. Water-level measurements taken in April, 1986, ranged from 3 to 12 feet lower than water levels measured during April, 1985. The continued drought conditions during the summer months of 1986 created even greater withdrawal demands on the aquifer system resulting in further declines of the potentiometric surface. Water-level measurements taken during September of 1986 ranged from less than 1 to 2.5 feet lower than measurements taken in September of 1985. These data indicate that the lack of recharge to the aquifer during the low-flow conditions had a greater effect on the groundwater declines that the increased pumpage from April to September. The declines recorded in September of 1986 indicated no appreciable change in water level declines over previous years.

During the drought, groundwater levels near streams were the most affected. The degree of drawdown near streams is due not only to the lack of recharge to the aquifer from the streams, but also to baseflow recharge, which occurs when the stream hydraulic head is reduced such that groundwater flow is from the aquifer to the stream. The amount of flow between the surface water and groundwater systems is dependent upon the degree of hydraulic connection.

The decline of the water table in the Delta during the drought of late 1985 through mid-1986 may be attributed to a succession of events. These events are summarized below.

(1) Precipitation in the Delta from December, 1985 through April, 1986 was nearly 61% below normal.

(2) The lack of precipitation and subsequent runoff resulted in low river stages throughout the Delta area. Many of the primary and secondary streams in the Delta set new low-flow records during this period.

(3) The normal relationship between the alluvial aquifer and the overlying streams was drastically altered due to the extreme low river stages.

(4) Groundwater levels throughout the Delta declined due to the lack of recharge. The greatest declines were observed near the sources of recharge.

(5) Streams having direct hydraulic contact with the alluvial aquifer may have been subject to base-flow recharge. Therefore, the water table declines observed near these streams may be attributed not only to the lack of recharge, but also to the flow of water from the aquifer to the streams.

CONCLUSION

The above average groundwater declines observed in the Mississippi River alluvial aquifer during April, 1986 in the Delta were due to the lack of precipitation and subsequent runoff. Groundwater levels near streams were the most affected. This is attributed to the fact that these areas lie in an aquifer recharge zone and possibly to base-flow recharge. Further studies would be required to define precise areas of groundwater and surface water interaction.

Since the major source of recharge for the Mississippi River alluvial aquifer is the Mississippi River, no long term effects due to the drought are anticipated. Water-level measurements made in the Delta during September, 1986 indicated no appreciable change in water level declines over previous years. However, this study has shown that during drought years, water levels are rapidly affected. The lack of recharge to the aquifer from the Mississippi River and runoff from the Bluff Hills resulted in a dramatic lowering of the alluvial aquifer potentiometric surface. During these periods of temporary shortage, it may be necessary to further regulate groundwater use in affected areas. For this reason, a complete updated inventory of the alluvial aquifer is necessary for the formulation of sound water-managing policies within the Delta area to protect this vital and important natural resource.

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