Interaction Between Yazoo River and Mississippi River Valley Alluvial Aquifer System

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Introduction

The area of study, the Yazoo River, is located in the Mississippi River Delta, northwest Mississippi (figure 1). The Yazoo River is formed in Greenwood at the confluence of Yalobusha and Tallahatchie Rivers. The Yazoo River meanders southwestward near the eastern edge of the Mississippi Bluff Hills to join the Mississippi River at Vicksburg, Mississippi.

The Yazoo River meanders over part of the Mississippi River Alluvial Plain, a convex lens-shaped part of the Gulf Coastal Plain (Fenneman 1938). Average channel incisement of 50 feet by the Yazoo River insures good hydraulic connection between aquifer and Yazoo waters. At the head of the Yazoo River, the alluvial surface is at an altitude of 137 feet above sea level and slopes to approximately 80 feet above sea level near Vicksburg. The alluvial plain slopes approximately one-half foot per mile to the south. The slight gradients insure moderate stream velocities for the Yazoo River.

Precipitation in the Delta averages 52 inches annually. Seasonal distribution of precipitation is approximately 18 inches in the winter, 15 inches in the spring, 10 inches in the summer, and 9 inches in the fall (Wasson 1984). Historically, base flow for the Yazoo River in the summer and fall months at Greenwood, Mississippi, averaged about 1600 cfs (cubic feet per second). Average flood stages of 30,000 cfs occur during the winter and spring months due to increased rates of precipitation.

Flooding in the Yazoo River basin has been a problem throughout history. Stream discharge in the Yazoo, however, is now controlled by four United States Army Corps of Engineers (USCE) flood control structures on its major tributaries. The Tallahatchie River stage is regulated by the USCE structure built in 1939 near Sardis, Mississippi. In 1941, the USCE control structure near Arkabutla was built to regulate the Coldwater River stages. At Enid, the USCE control structure was constructed in 1951 to regulate stream stages of the Yocona River. By 1953, the final USCE control structure on a tributary of the Yazoo River, the Yalobusha River, was built near Grenada. By the early 1950's the regulated stream flow of the Yazoo River was measured at the gaging station at Greenwood, Mississippi.

The purpose of this study is two fold. Understanding of the changes in historical and present hydrologic interactions between the waters of the Yazoo River and Mississippi River Alluvial Aquifer System is made possible through analysis of all directly related data. Secondly, this initial study is intended to propose the best method for measurement and quantification of actual stream-aquifer boundary conditions.

Geology of the Mississippi River Alluvial Aquifer System

Of Quaternary and Recent age, the Mississippi River Alluvium was deposited by the Mississippi River and tributaries (Brown 1947). The alluvium overlies an erosional surface of Tertiary-aged material characterized by a system of north-south valleys (Fisk 1944). Generally, the coarsest sediments (gravel and coarse sand) occur at or near the base of the formation and tend to thicken in the direction of increased alluvial deposition. A general upward-grading sequence of gravel to coarse sand to very fine sand, silt, and clay occur throughout most of the Mississippi River alluvium. Clay thickness generally averages about 20 feet at the alluvial surface with variations ranging from no clay present to clay plugs, 60 to 70 feet thick (Sumner and Wasson 1984). Average thickness of the alluvium at the Yazoo River is 125 feet. Alluvium thicknesses generally range from 110 to 150 feet across the Delta (figure 2) (Sumner and Wasson 1984).

Yazoo River Discharge Data

Continuous daily river stage measurements were begun on the Yazoo River at Greenwood, Mississippi, in 1907 by the United States Geological Survey. These data measurements were discontinued in 1912 and 1928 before being resumed by the USGS in 1928 and continued until 1980. In 1980, the USCE took over the measurement of daily stages of the Yazoo River at the Greenwood gaging station. Consequently, 65 years of discharge records of the Yazoo River under natural and controlled conditions were available for use by this study.

Recession Analysis and Interpretation of Hydrologic Data

Analysis of recession and low flow were accomplished through recession analysis methods (Rorabaugh 1964). Continuous stage data collected at the Greenwood gaging station by the USGS and the USCE was used. According to Rorabaugh (1964) bank- storage effects are related to stage fluctuations of a river. During recession, discharge of groundwater stored in the river bank controls the rate of recession. Daily stream-flow hydrographs were utilized for this analysis. Discharge in daily cubic feet per second was plotted on semilog graph paper vs time; in days was plotted on the arithmetic scale for each water year beginning in October and ending September. Recession lines were drawn tangential to the minimum or troughs formed during low flow periods on the Yazoo River (Daniel 1976). The recession lines remained fairly parallel throughout the early water years under natural flow conditions (Rorabaugh 1964). An average recession period for the Yazoo River under natural flow conditions for the period of record 1908 to 1939 was 97 days per log cycle.

By 1950, recession line slopes under controlled conditions had steepened. Average recession periods under controlled flow decreased to 44 days per log cycle. Unfortunately, as the stream flow of the Yazoo River is controlled the recession analysis method becomes unreliable.

Hydrographs of the daily discharge of the Yazoo River at the Greenwood gaging station under natural conditions vary greatly from hydrographs under controlled flow. During the recorded period from water year 1908 to 1940, the average minimum flow was 1600 cfs. Average high flow, or flood stage, which occurred during winter and spring was 30,000 cfs. After construction by USCE of containment structures on tributaries of the Yazoo River, nearly constant flow occurred on the Yazoo. Average low flow is now 10,000 cfs and average flood discharge is 30,000 cfs.

Conclusion

Down cutting and lateral movement by the Yazoo River under natural conditions before 1950 insured continual contact between the sands associated with the alluvial aquifer system and the stream. The Yazoo River accomplished this process under natural flow conditions that ranged from 1600 cfs at low flow to 30,000 cfs at flood stage during a water year. At normal and extended high stream flow, clay particles infiltrated the highly porous, unconsolidated sands of the alluvial aquifer (Matlock and others 1989). During low flow stages and drought conditions, the Yazoo River was normally supplied by groundwater discharge from bank storage and the alluvial aquifer. This discharge process of groundwater from the aquifer system removes clay particles from sand layers that are directly in contact with river waters (Matlock and others 1989; Azmon 1990). Distribution of infiltrated clays in pore spaces and along the sand grain surfaces can quickly change the permeability characteristics of the hydraulic contact zone between the river and the aquifer (Beard and Weyl 1973). Thus, the hydraulic boundary between the Yazoo River and Mississippi River Alluvial Aquifer system was continually changed under natural conditions.

Since 1950, the Yazoo River discharge rates have approached a more constant yearly flow rate of between 10,000 to 30,000 cfs at Greenwood due to the USCE flood control structures. Analysis of the recession of 97-days under natural conditions and the 44-day recession under regulated conditions indicate a possible change in the river-aquifer hydraulic boundary. As demonstrated by recession analysis, a decrease in the hydraulic conductivities of the alluvial aquifer near the Yazoo River bank, as well as a decrease in the permeability of the hydraulic boundary between river and aquifer, may have occurred.

Recommendations

Under natural flow conditions recession analysis is a fairly accurate method for measurement of groundwater recharge into a stream during recession. Once stream flow is controlled, however, the method actually becomes suspect (Bingham 1979). Other more direct measurement methods must be used to quantify the hydraulic boundary between the Yazoo River and Mississippi River Alluvial Aquifer System. Quantification of the existing hydraulic stream-aquifer boundary and surrounding aquifer hydraulic conductivity is necessary to establish the contribution of the Yazoo River waters to the Mississippi River Alluvial Aquifer System.

Under present regulation practices by the USCE, stream discharge in the Yazoo River and its tributaries is relatively constant year around. Because of this constancy, the hydraulic boundary between the Yazoo River and Mississippi River Alluvial Aquifer may also be relatively stable.

To quantify the permeability of the stream-aquifer boundary, the Mississippi Department of Environmental Quality's Bureau of Land and Water

Resources proposes to install two lines of 12 shallow water-table piezometers beginning on each side of the Yazoo River banks and extending outward approximately 1 mile from the river. A river stage recorder to continually measure the Yazoo River stages will be installed in conjunction with the piezometers.

The site for the piezometers will be on the Yazoo River at Egypt, 8 miles south of Greenwood, Mississippi. This investigation will be conducted by the Bureau of Land and Water Resource in cooperation with the USCE, USGS, and the Yazoo-Mississippi Delta Water Management District. Installation and monitoring of the piezometers will begin in June 1990. Test dredging of the Yazoo River channel by the USCE is scheduled to begin at Egypt in 1991. The cooperative study will continue monitoring during and after dredging. The artificial scouring process of dredging may dramatically alter the stream hydraulic boundary at the study site. As conditions normalize at the stream bed and banks, the clay infiltration process hypothesized in this study should begin to decrease permeability of the aquifer sands directly in contact with the Yazoo River waters.

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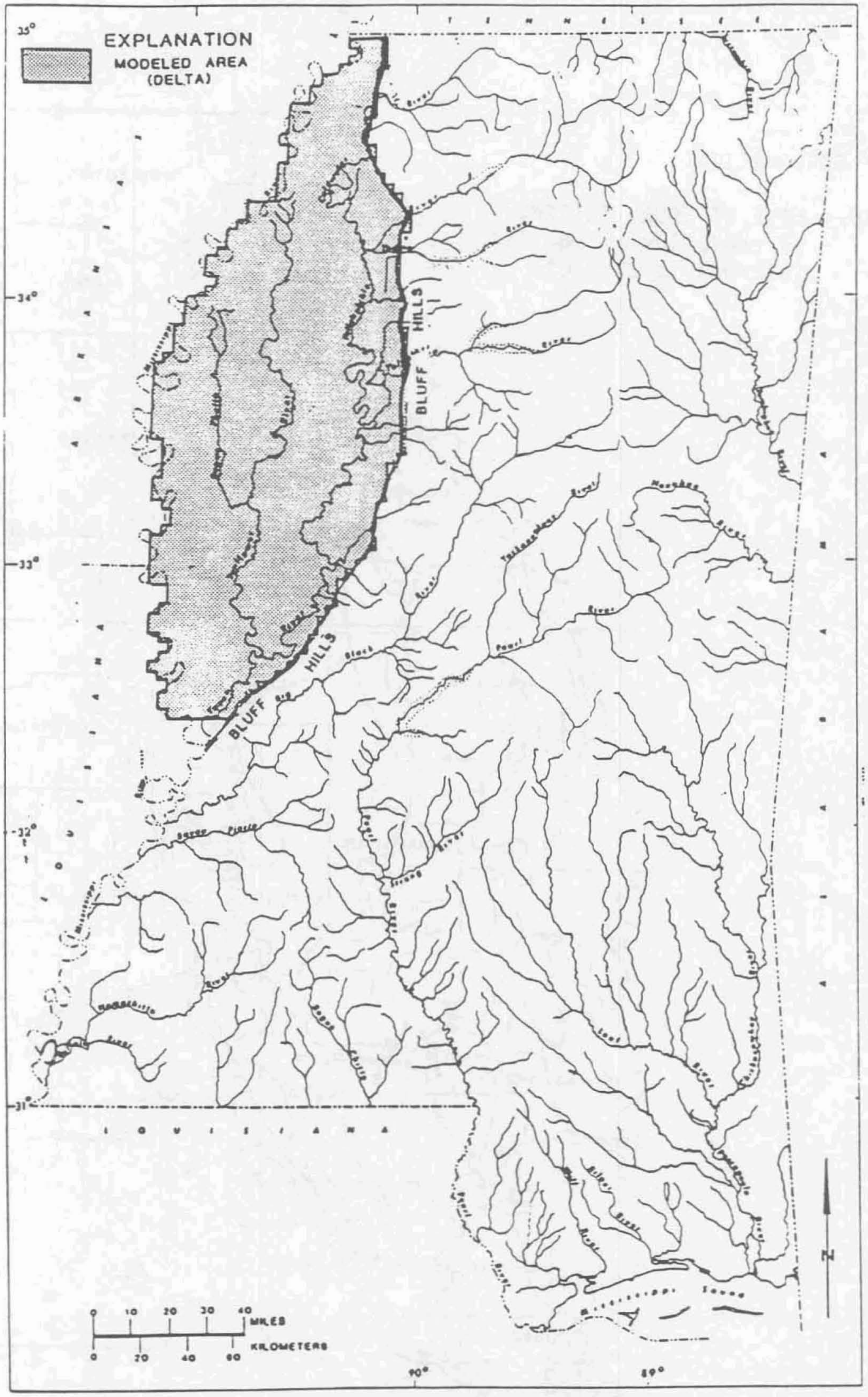

Figure 1.--Location of the study area (Delta) in north-western Mississippi.

EXPLANATION

—125— LINE OF EQUAL THICKNESS, of the alluvial aquifer. Interval is 25 feet.

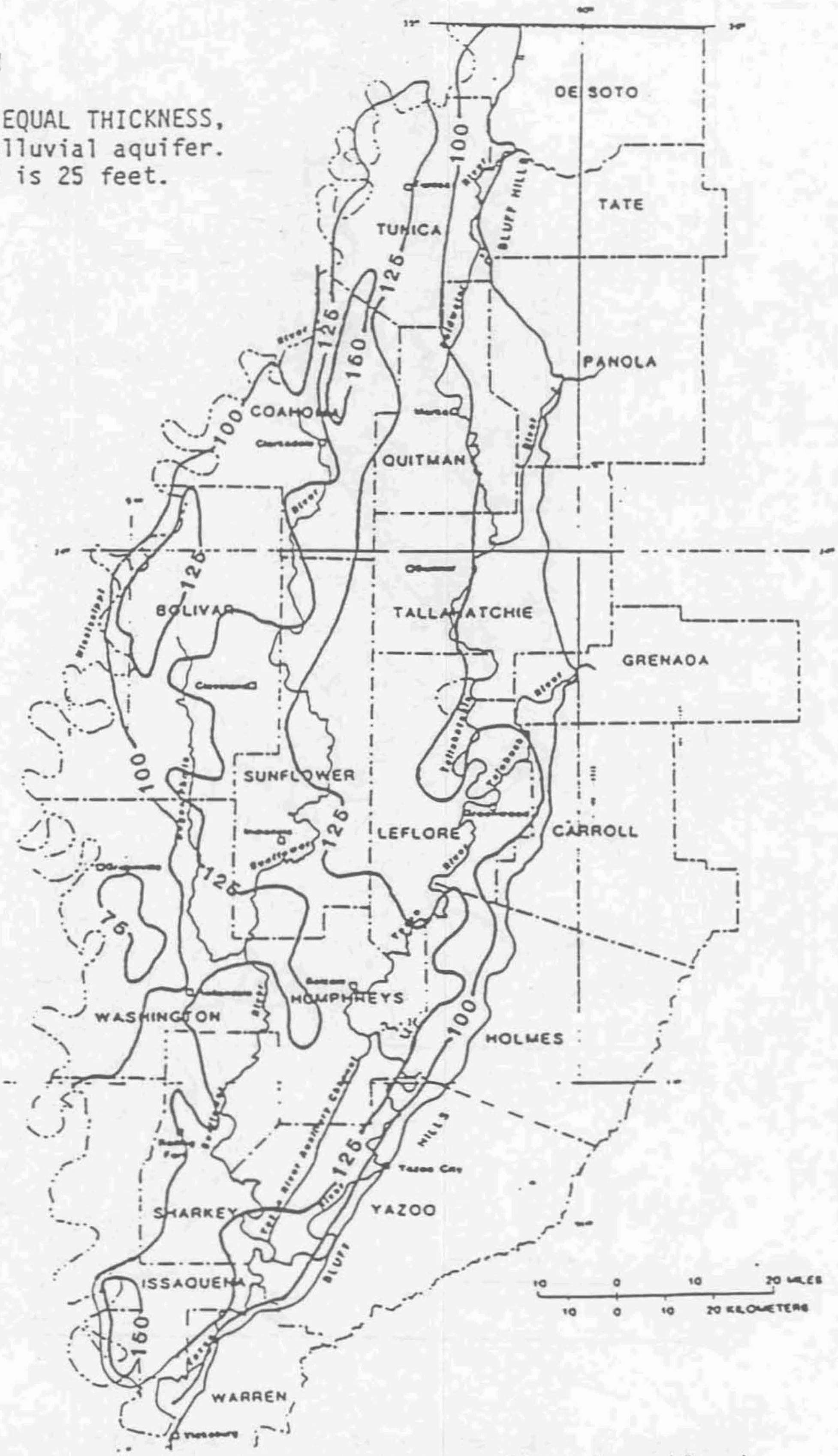

Figure 2.--Thickness of the Mississippi River alluvial aquifer in the Delta.
(From Sumner and Wasson, 1984)