INTERACTION STUDY OF THE SUNFLOWER RIVER AND THE MISSISSIPPI RIVER VALLEY ALLUVIAL AQUIFER

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Introduction

The Mississippi Delta is extremely blessed with abundant water resources. Over the past 15 to 20 years, ground water has surpassed surface water as the primary source of water in this area. Two reasons for this change are: 1) during periods of dry weather, surface water supplies have not been sufficient to meet the ever-increasing demands for this resource; and 2) the relative ease in finding large quantities of suitable ground water at shallow depths.

The main use of ground water in the Delta is for agricultural purposes, and the Mississippi River valley alluvial aquifer (MRVA) is the major source (Sumner and Wasson 1984). With the huge demands for ground water come several consequences. One, obviously, is the decline in water levels in this aquifer throughout the region. Another is the decreasing ability of the alluvial aquifer to supply baseflow to Delta streams. The trend is clear: continually falling ground water levels equal reduction in baseflow to streams.

Purpose and Scope

The continuing declines of water levels in the alluvial aquifer and the extremely low flows of the past few years in some of the Delta streams prompted this study to examine the relationship between the surface- and ground-water systems.

In cooperation with the United States Geological Survey, twenty-two 2-inch diameter observation wells (piezometers) were drilled, forming four lines (Figure 1). Two of these lines are located near Doddsville, with one line on each side of the river. Each line consists of seven piezometers and extends approximately 1800 feet perpendicular to the river. The other two lines are located near the town of Sunflower, again situated on each side of the river. Each line consists of four piezometers which extend 100 feet perpendicular to the river. The average depth of the piezometers is 60 feet, the lower 10 feet of which penetrates the upper sands of the alluvial aquifer.

Frequency of water level measurements on the piezometers depended on the time of year and occurrence of storm events. During the summer and early fall, measurements were made about every two weeks. During late fall, winter, and spring months, the piezometers were measured about once a week; however, with the occurrence of a storm event, they were measured once a day for several days immediately after the storm.

Several parameters were considered for the location of these lines. First of all, they needed to be fairly close to a stream gage where continuous daily stage and/or discharge information could be obtained. The gage at Sunflower provides this data. Second, access to the piezometers needed to be relatively easy as monitoring would be conducted year round. Third, each line needed to be perpendicular to a straight stretch of the river, rather than adjacent to or inside a meander. The lines also needed to be in an area where their presence would not hinder daily farming operations or any other ongoing activities.

The Sunflower River provides an excellent illustration of the effect of lower ground water levels upon streamflows. Figure 2 shows hydrographs for the Sunflower River and for two wells within a few miles of the river. The hydrograph for the river illustrates how the annual minimum stage for this stream at Sunflower, Mississippi, has steadily declined over the past 20 years. The data for the hydrographs for the two wells came from water level measurements made in the fall of each year for each well. These two hydrographs depict a general trend of continually falling water levels in the alluvial aquifer. Figure 1 shows the location of these wells, the gage at Sunflower, Mississippi, and the study area.

Doddsville Piezometers

For the purpose of this discussion, the line on the east side of the river at Doddsville is designated Doddsville East (DE), and the line on the west side of the river is designated Doddsville West (DW). In each line, the piezometers are numbered so that #1 is the nearest to the river and #7 is the farthest from the river.

Samples were collected during drilling at this location. The samples from the upper 20 to 25 feet consist of clays and silty clays. Samples from the next 30 to 35 feet are indicative of point bar deposits and typically consist of silty and sandy clays, clayey silts, and silty fine-grained sands (Smith 1979). Samples from the lower 10 feet consist of medium to coarse-grained sands and are indicative of the substratum sands of the alluvium.

Examination of Figures 3 and 5 will show that the Doddsville East line is the most responsive of the two lines in this area. The rise in the water level at DE is not only faster but is also more pronounced than at DW; therefore, the main focus of this part of the discussion will be on Doddsville East.

The potentiometric surface of the alluvial aquifer at Doddsville changed very little from the first of October 1990 through mid December 1990 (Figures 4 and 5). The small rise in water levels during this time probably represents the gradual recovery this aquifer usually undergoes after the irrigation season. Rain events that result in small rises on the Sunflower River, such as occurred around October 11 and November 13, appear to have had little effect on the water level in the aquifer at these locations. The October and November 1990 hydrographs in Figures 3 and 5 illustrate this condition.

Event #1 - December 1990 and January 1991

During the first rain event the river stayed above flood stage for 15 days. At DE roughly 10 days elapsed between the first day the river was at its highest (elevation of about 118 feet on 12/24/90) and when the water level in the alluvial aquifer peaked (elevation of about 94 feet around 1/3/91).

The first water-level profile along the Doddsville East line, as shown in Figure 4, corresponds with the December 1990 and January 1991 hydrograph. This profile shows the 1/3/91 water level peak in the alluvial aquifer and the lowest recovery level (2/7/91) before the next big rain event in February. The potentiometric surface that corresponds to the date of 10/9/90 represents the lowest potentiometric surface for the fall of 1990.

Event #2 - February and March 1991

The second large rain event occurred in late February and early March 1991 (Figure 3). With this event, the Sunflower River stayed above flood stage for 20 days. The time between river peak (elevation of about 121 feet on 2/24/91) and peak of the water level in the alluvial aquifer (elevation of about 116 feet around 3/4/91) was about 10 days.

The second water-level profile corresponds with this event. This was the first time since the irrigation season ended that the water level in the aquifer rose above the river bottom. After the 3/4/91 peak, the water levels began to fall and the potentiometric surface gradually flattened out. The lowest recovery level before the third rain event occurred roughly on 4/15/91.

Event #3 - April through June 1991

The third large rain event (Figure 3) resulted in the Sunflower River staying above flood stage for about 38 days. The time between river peak (elevation of about 121 feet on 5/2/91) and peak of the water level in the aquifer (elevation of about 111 feet around 5/7/91) was about 5 days.

The third water-level profile corresponds to this event. This was the last rain event of the season that caused the Sunflower River to reach flood stage or higher. After approximately 5/7/91, the water levels in the aquifer continually fell, even through the irrigation season, to reach a low that occurred roughly on 11/12/91.

Sunflower Piezometers

The two lines at Sunflower each consist of four piezometers (Figure 4). The same numbering arrangement of the Doddsville piezometers applies to the Sunflower piezometers. Unfortunately, the storm events that occurred in late February and in April caused the roads to the SW line to be flooded for much of the time. As a result, data for this line are sparse; therefore, the SE line will be the main focus for this part of the discussion.

Since the fall of 1985, the water levels in the alluvial aquifer at Sunflower have continuously been below the bottom of the Sunflower River. Therefore, at no time, even during the spring months, does the aquifer recharge the river at this location.

Hydrographs for SE #1 (Figure 6) during all three rain events will show that at this location the Sunflower River has very little influence on the alluvial aquifer. According to a geological investigation of the Yazoo Basin (Smith 1979), the Sunflower River at Sunflower is located on the east side of an abandoned channel. Parts of these old channels may consist of tens of feet of clay, forming a characteristic "clay plug." During drilling for these piezometers on both sides of the river, approximately 50 to 55 feet of clay was penetrated.

Therefore, instead of being adjacent to an abandoned channel, the Sunflower River, at both SE and SW, flows through an abandoned channel or clay plug. This is probably the reason that there is very little contribution from the river to the aquifer at this location.

Conclusions and Recommendations

The DE #1 hydrographs for all three rain events indicate that the Sunflower River begins to significantly recharge the alluvial aquifer only when the river reaches flood stage or higher. A theory that has evolved over the years regarding this situation is that there is a tremendous amount of fine material (silts and clays) in suspension in the river. As the water in the river reaches low flow, the fines settle out and are deposited within the pore spaces of the upper sands of that part of the alluvium surrounding the river bed. These fines, therefore, essentially occlude the porosity and form a "seal" which hinders flow from the river to the aquifer. It is only at high river stages (flood stage or higher) when heads or pressures from the river are high enough to flush these fine materials on through the pore spaces.

If this is indeed the case, it would seem that when there are multiple rain events within a few months that cause the Sunflower River to reach flood stage or higher, the first such event would cause the fines to be flushed through the pore spaces. Then with successive rain events, the river should then be able to significantly recharge the aquifer even though it may not reach flood stage.

Also, apparently the head difference between the river and the water level in the alluvial aquifer determines the duration of time the river is a source of recharge. With each successive rain event, the water level peak in the aquifer is higher. Also, as each peak is higher, the slope of the "falling arm" on each hydrograph is slightly steeper. It is unclear why the river does not continue to significantly recharge the aquifer the entire time it is above the "critical stage" which is apparently flood stage.

There are many unanswered questions regarding the interaction between the Sunflower River and the alluvial aquifer. The installation of recorders on several of the piezometers would likely help answer some of these questions. The Yazoo Mississippi Delta Joint Water Management District (YMD) has installed a transducer on DE #1. With this we hopefully will be able to delineate much more closely at what stage the Sunflower begins to significantly recharge the aquifer, as well as when it ceases to be a source of recharge.

Streamflow measurements need to be made in the spring whenever possible, as well as in the fall, to determine areas of recharge from the aquifer to the stream and also the amount of recharge from aquifer to stream.

Finally, this study needs to be expanded to include perhaps the entire length of the Sunflower, from headwaters to mouth, rather than just certain reaches. All of this information would be extremely valuable in any water management decisions, as well as for updating the delta model.

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References

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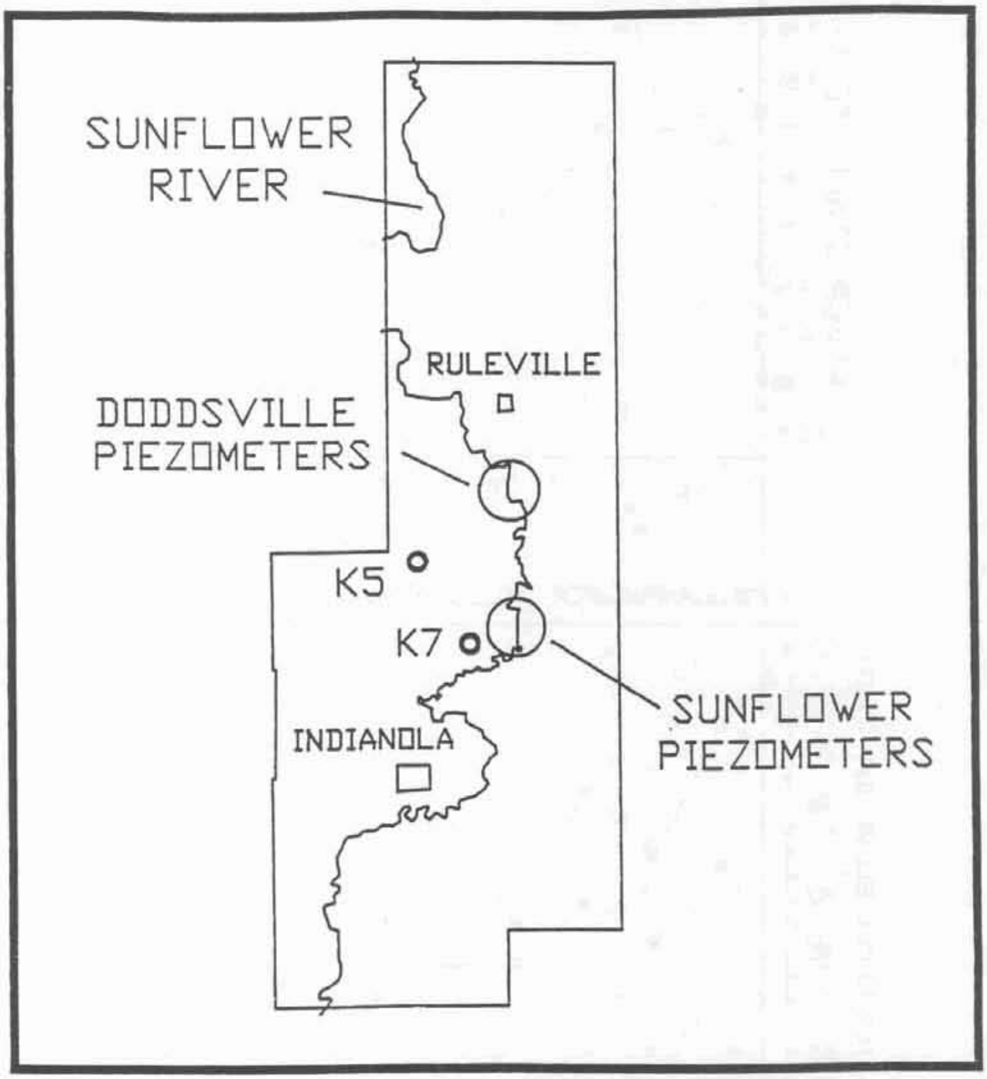
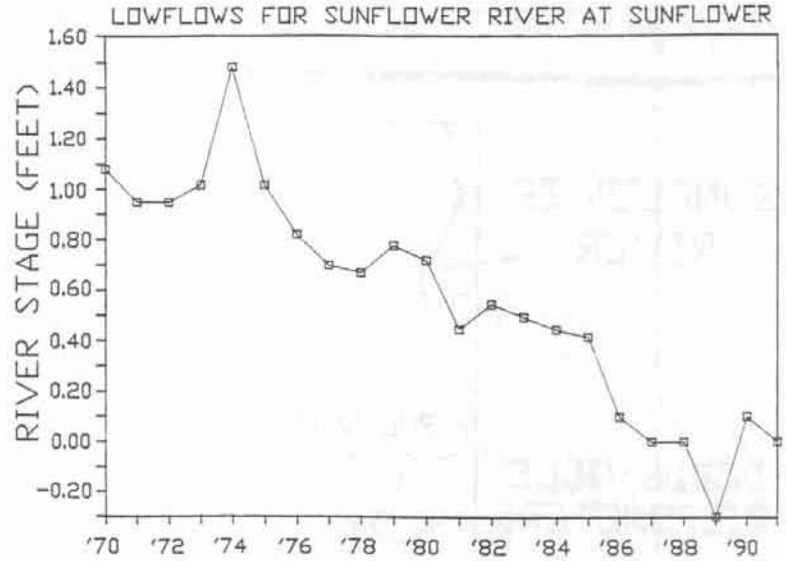


Figure 1. Location map.


LOWFLOWS FOR SUNFLOWER RIVER AT SUNFLOWER
RIVER STAGE (FEET)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
'70
'72
'74
'76
'78
'80
'82
'84
'86
'88
'90

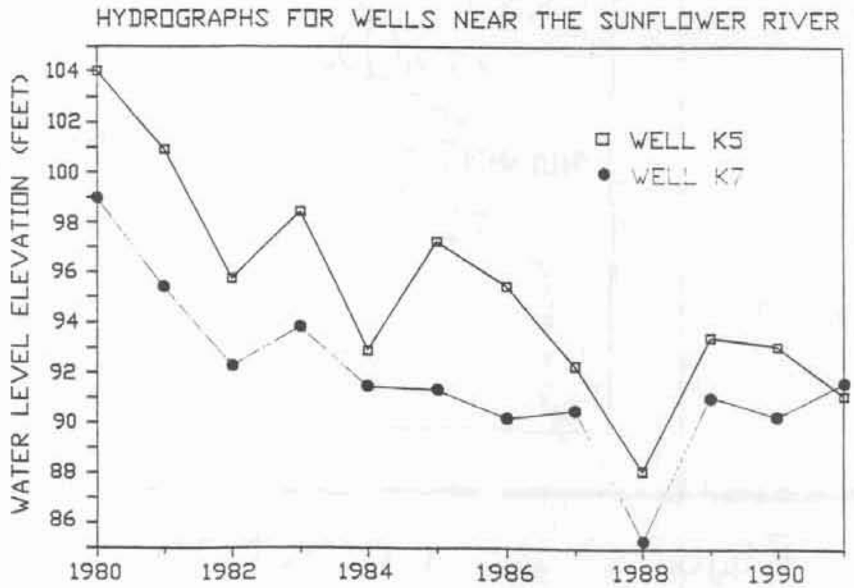

HYDROGRAPHS FOR WELLS NEAR THE SUNFLOWER RIVER
WATER LEVEL ELEVATION (FEET)
WELL K5
WELL K7
104
102
100
98
96
94
92
90
88
86
1980
1982
1984
1986
1988
1990

Figure 2

DODDSVILLE EAST #1 AND SUNFLOWER RIVER HYDROGRAPHS

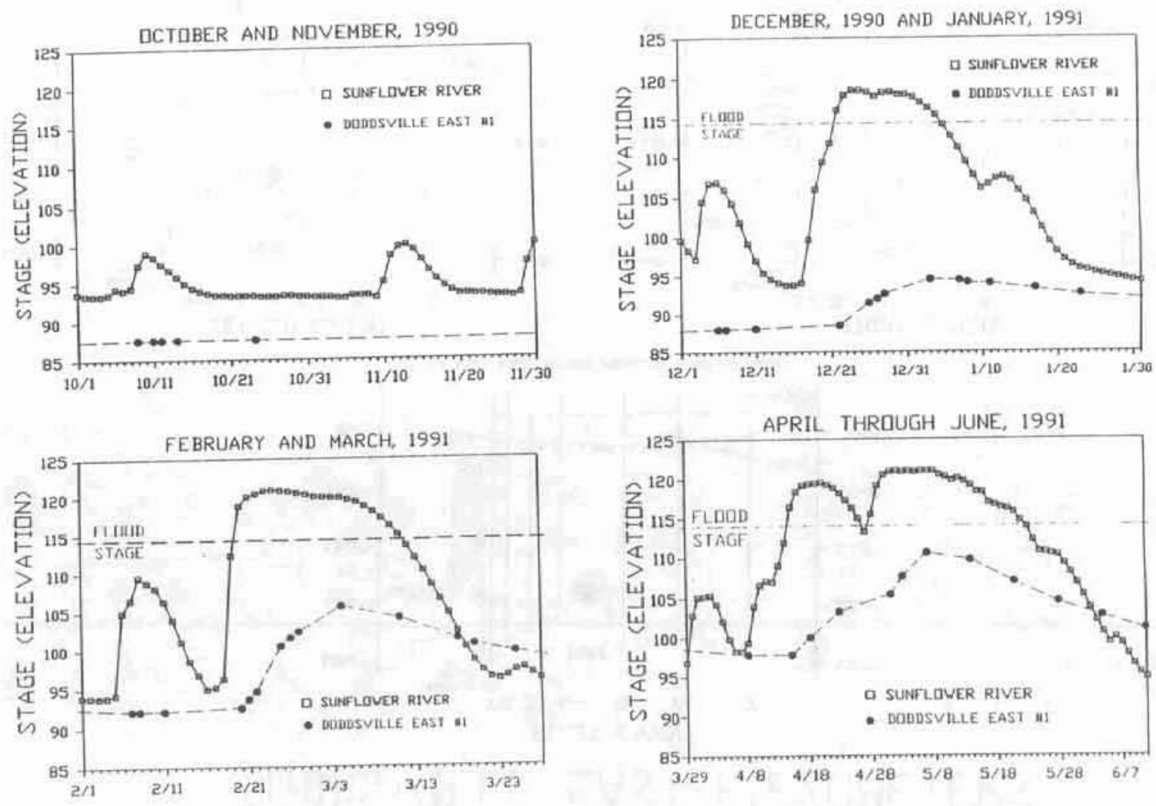


Figure 3

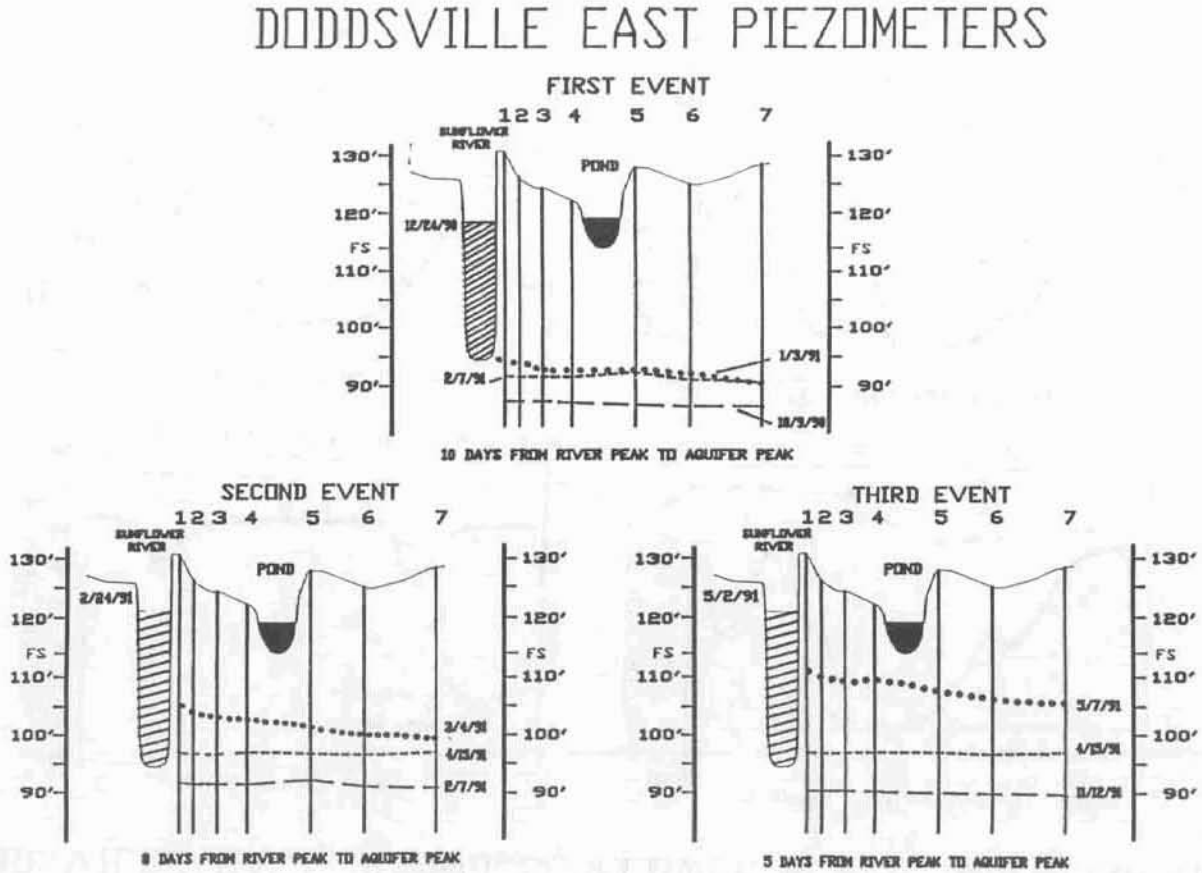


Figure 4. Cross-section of Doddsville East with water-level profiles for the three large rain events.

DODDSVILLE WEST #1 AND SUNFLOWER RIVER HYDROGRAPHS

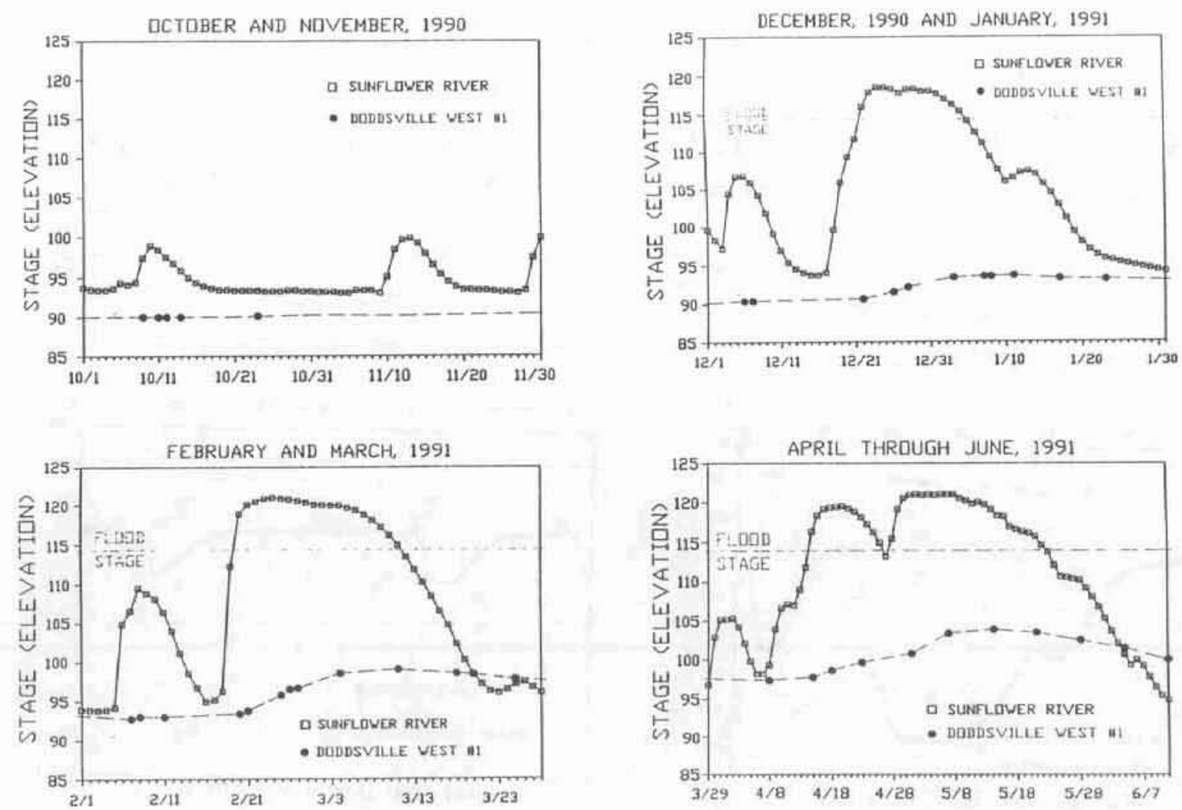


Figure 5

SUNFLOWER EAST #1 AND SUNFLOWER RIVER HYDROGRAPHS

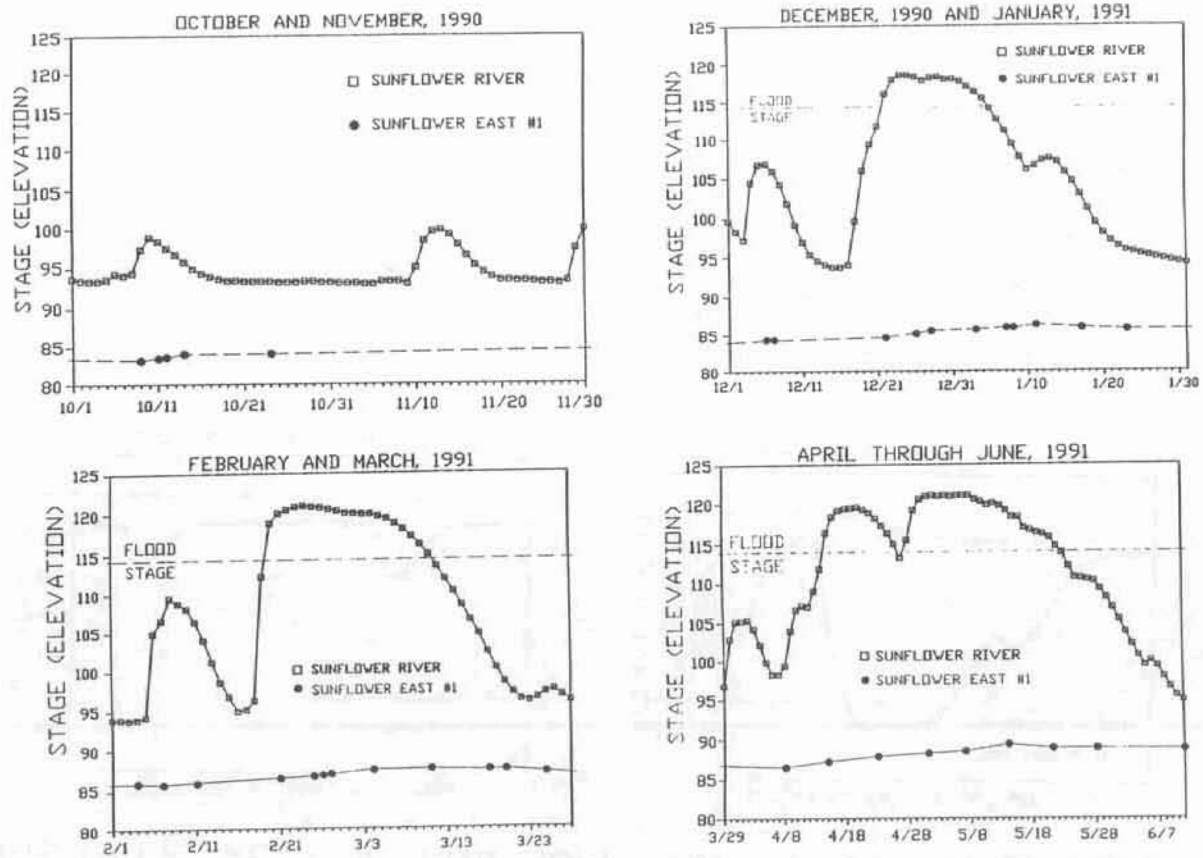


Figure 6