POTENTIAL GROUND-WATER LEVEL CHANGES IN THE MISSISSIPPI RIVER ALLUVIAL AQUIFER IN RESPONSE TO PROPOSED NAVIGATION IMPROVEMENTS ON THE YAZOO RIVER IN MISSISSIPPI

By A. G. Lamonds and John Michael Kernodle

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

The following factors may be used to convert inch-pound units published herein to the International System of Units (SI):

Multiply	By	To Obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometers (km)
acre	4,047	square meter (m^2)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
cubic foot per second (ft^3/s)	0 .02832	cubic meter per second (m^3/s)

National Geodetic Vertical Datum of 1929 (NGVD of 1929). A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

POTENTIAL GROUND-WATER LEVEL CHANGES IN THE MISSISSIPPI RIVER ALLUVIAL AQUIFER IN RESPONSE TO PROPOSED NAVIGATION IMPROVEMENTS ON THE YAZOO RIVER IN MISSISSIPPI

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ABSTRACT

As part of a planning and feasibility study for construction of a navigation project on a 160-mile reach of the lower Yazoo River, the U.S. Army Corps of Engineers requested the U.S. Geological Survey to describe possible changes in ground-water levels that might occur as a result of constructing a lock and dam near Vicksburg, Mississippi, and completion of channel projects between Yazoo City and Greenwood, Mississippi. Construction of the proposed lock and dam and completion of ongoing channel projects will result in substantially higher minimum river stages in much of the reach of the river downstream of Yazoo City and lower stages in much of the reach between Yazoo City and Greenwood. Post-impoundment minimum stages would be more than 19 feet higher than pre-impoundment minimum stages at the proposed dam but would be only 2 to 4 feet higher than pre-impoundment minimum stages at Yazoo City. During periods of moderate and high flow, river stages in the reach downstream of Yazoo City would exceed the level of the proposed impoundment and would closely resemble pre-impoundment stages. At Greenwood and in much of the reach between Yazoo City and Greenwood, post-project river stages would be from 2 to 7 feet lower than pre-project stages.

Water-level measurements made monthly in 65 observation wells in the vicinity of the lower Yazoo River indicate that ground-water levels fluctuate seasonally from less than 10 to more than 30 feet. Ground-water level fluctuations were generally larger in wells very near the river and were generally larger in the lower reach near the location of the proposed dam, than in the upper reaches. Water generally moves from the river into the aquifer during periods of high stage and drains from the aquifer into the river during periods of low stage except in areas where ground-water levels have been lowered by pumping.

After completion of the proposed impoundment, minimum ground-water levels in wells very near the impoundment and the proposed dam will be more than 19 feet higher than pre-impoundment minimum levels. The increase in minimum ground-water levels near the river would decrease in an upstream direction to less than 4 feet at Yazoo City. The increase in minimum ground-water levels would also decrease with distance from the river and should not extend beyond the Bluff Hills to the east of the Whittington Auxillary Channel or other major drainage features to the west. Ground-water levels would generally be between 15 and 25 feet below land surface during the dry season but would be at or near land surface during the wet season.

Completion of the proposed impoundment and ongoing channel projects will have little effect on ground-water levels in the vicinity of Yazoo City but will result in lower ground-water levels in much of the reach between Yazoo City and Greenwood. Ground-water levels near the river will probably decline several feet and may be as much as 7 feet lower than pre-project levels at Greenwood. Ground-water level declines in this reach will decrease with distance from the river but may extend as far as the Bluff Hills to the east and to the areas of large ground-water withdrawals several miles to the west of the river.

INTRODUCTION

In 1968, the United States Congress passed the Rivers and Harbor Act which authorized the construction of a navigation project on the lower Yazoo River in west central Mississippi. The project, as authorized, provided for a navigation channel extending from the mouth of the Yazoo River at Vicksburg, Miss., to Greenwood, Miss., a distance of about 160 miles. Also included in the project is the construction of a lock and dam near Vicksburg (fig. 1).

Preconstruction planning for the navigation project was initiated in 1978 by the Vicksburg District of the U.S. Army Corps of Engineers in order to study the feasibility of the authorized project as well as several alternative plans that provided for additional locks and dams and varying minimum flows in the navigation channel. All of the project alternatives under consideration would require the impoundment of water in the Yazoo River by one or more locks and dams in order to maintain sufficient water depth to accomodate barge traffic. With the navigation project completed, water levels (stage) in the lower part of the Yazoo River during low flow periods would be appreciably higher than stages under natural conditions. During periods of high flow, stages of the Yazoo River have historically exceeded the levels proposed under the several alternative project plans. Consequently, the proposed navigation project would have little effect on the stage of the lower Yazoo River during the winter and spring when stages are normally high but would maintain higher than normal stages during the summer and fall seasons when river stages are usually low.

Purpose and Scope

Under the proposed project conditions, the higher river stages that would be maintained during the summer and fall seasons would affect ground-water levels in the adjacent agricultural lands. Because ground-water levels throughout the area are generally within 20 feet of land surface under natural conditions, the Vicksburg District Corps of Engineers was concerned over the potential for changing ground-water levels. In 1978, the Corps requested the U.S. Geological Survey to investigate the effect of the proposed navigation projects on ground-water levels in the adjacent alluvial aquifer.

The U.S. Geological Survey began this investigation in the fall of 1978. The investigation was limited to the collection of sufficient ground-water level data in the alluvial aquifer to determine the position of the ground-water surface and with respect to the land

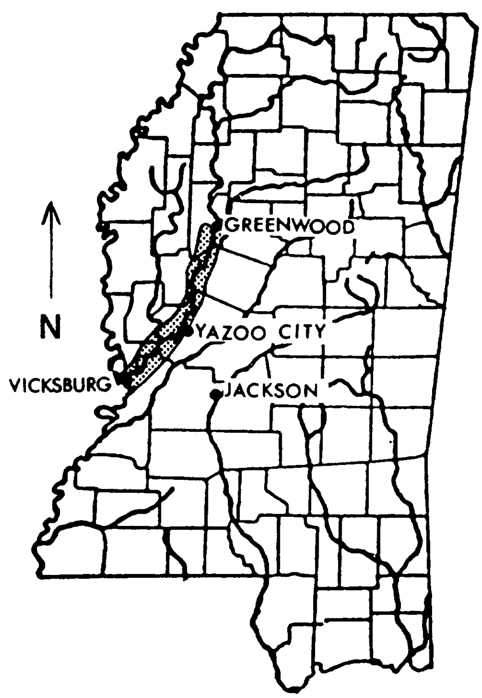

Figure 1.--Location of proposed navigation project on the Yazoo River, Mississippi.

surface, the direction of ground-water flow, and the response of ground-water levels to seasonal changes in river stage and climatic conditions. This report documents the results of that study and assesses the general direction and magnitude of ground-water level changes that might be expected if the navigation improvements are constructed. It does not attempt to describe the effect of those ground-water level changes on crops in the area nor does it attempt to map the areas of potential soil water-logging.

Methodology

In order to describe the existing ground-water conditions, identify the direction of ground-water flow, and analyze the response of ground-water levels to changes in river stage and seasonal rainfall and pumping patterns, 65 observation wells were drilled during the period August 1978 through March 1979. Sixteen lines of shallow observation wells were completed along and generally perpendicular to the Yazoo River between Vicksburg and Greenwood (fig. 2). Ground-water levels in these observation wells were monitored from the time of their completion until September 1981. Three of the observation wells were equipped with recorders which hourly recorded the depth to water. Water levels in the remaining wells were measured about once a month.

Description of the several well numbering systems used to identify the observation wells in this investigation were published in a report documenting the water-level data collected from 1978 to 1980, (Darden, 1982c). In this report the well numbers used are those in use by the Corps of Engineers. The well numbers consist of an "L" number designating the line of wells and a "Y" number designating the sequential number of the well in the line, numbering from west to east. Well number L14-Y2 would designate the second well from the west end of line 14.

The water-level data published in Darden's report as well as more recent data collected as part of this investigation are published in the U.S. Geological Survey's annual series of reports entitled "Water Resources Data for Mississippi".

Acknowledgments

The authors acknowledge the excellent cooperation and assistance provided by the Vicksburg District, Corps of Engineers, which drilled most of the observation wells used in this investigation and surveyed the elevations of the top of the casing for each well. The authors also express their appreciation to the many landowners who permitted observation wells to be installed on their property and allowed access to these wells throughout the investigation.

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DESCRIPTION OF THE AREA

The area of this investigation is that part of the lower Yazoo River basin between Vicksburg and Greenwood, in west-central Mississippi in the southern part of what is locally known as the Mississippi "Delta". The area is part of the Mississippi River alluvial plain, bounded on the west by the Mississippi River and on the east by bluffs that result from the erosion of Tertiary and younger sediments.

The terrain is generally flat and nearly level. Land-surface elevations range from about 130 feet above sea level near Greenwood to about 90 feet above sea level near the mouth of the Yazoo River at Vicksburg.

Abundant supplies of ground water are available throughout the area. Ground-water levels are generally within 20 feet of land surface under natural conditions. The coarse sands and gravels at the base of the alluvial aquifer make this one of the most productive aquifers in the State.

Because of the fertile soils, the availability of ground water, and a favorable climate, that part of the lower Yazoo River basin that lies in the alluvial plain is the most intensively cultivated area in the State. Principal crops in the area are soybeans, rice, cotton, and wheat. Irrigation of crops with ground water is common. The number of irrigation wells in the Yazoo River basin south of Greenwood yielding from 1,000 to 5,000 gal/min (gallons per minute) is known to exceed 700. Large quantities of ground water are also used for catfish farming which has become a major agricultural industry in the Delta, with about 65,000 acres in catfish ponds reported in 1982.

GEOLOGY

The Mississippi River valley alluvium consists of fluvially deposited gravel, sand, and silt, deposited by the meandering Mississippi River on an eroded surface of Eocene and younger sediments. Thickness of these alluvial deposits average about 140 feet (Dalsin, 1978), but ranges from about 100 to 200 feet in most of the valley, with a rapid thinning to zero near the erosional bluffs at the eastern edge of the alluvium.

The alluvium generally consists of a layer of gravel and coarse sand at the base, a layer of finer sand in the middle and an upper layer of silty clay. Throughout much of the area the surficial clays are relatively tight, making it possible to impound water for the production of rice and catfish. Locally, however, the surficial clay and fine silt are absent and the sand layer is exposed at the surface.

The Tertiary units that subcrop beneath the Mississippi River alluvium in the area of the proposed Yazoo River Navigation project are, from oldest to youngest, the Sparta Sand, the Cook Mountain Formation, the Cockfield Formation, the Jackson Group, and the Forest Hill Sand. Three of these units, the Sparta Sand, the Cockfield Formation and the Forest Hill Sand include extensive water-bearing sand beds that form aquifers. The Sparta Sand subcrops beneath the extreme northern part of the area of this investigation and underlies line 15 of the observation well network. The alluvium in the vicinity of line 14 is underlain by the Cook Mountain Formation, which is not considered to be an aquifer. The Cockfield Formation, a major aquifer in central Mississippi, subcrops beneath the alluvium in the area of lines 10-13 and the eastern parts of lines 8 and 9. In the vicinity of lines 1-7 in the southern part of the study area, the alluvium is underlain by clays in the Jackson Group except for the eastern end of line 2 where the Forest Hill Sand subcrops.

SURFACE-WATER HYDROLOGY

Because of the flat and nearly level topography in the Mississippi Delta, natural stream patterns in the area of this investigation are extremely irregular and meandering. The Yazoo River meanders for about 160 miles between Vicksburg and Greenwood, a straight line distance of about 90 miles, and has an average channel slope of about 0.35 foot per mile. Local flooding, as well as backwater flooding from the Mississippi River, has long been a problem because of the topography and low channel slopes.

Attempts to improve the drainage through the construction of levees, drainage ditches, and channel improvements, began in the early 1800's and have continued since that time (Speer and others, 1964). Drainage patterns probably have been altered more in the Yazoo River basin than in any other area of the State. Drainage improvements include the construction of levees, ditches, and canals, and channel clearing. Major channel excavation and clearing projects along with the construction of flood-water retarding and desilting dams on many of the smaller streams also have been completed in the upper part of the basin.

The channel of the Yazoo River is incised into the surficial clays and silts of the alluvium to a depth of abot 40 feet in the area of this investigation. Channel width is about 250 feet at Greenwood and 350 feet at Redwood, but varies throughout the reach. During periods of low flow, the depth of water in the channel is about 8 feet at Greenwood, 12 feet at Yazoo City, and 20 feet at Redwood.

Flow of the Yazoo River at the long term stream-gaging station at Greenwood averaged about 10,400 ft^3/s during the periods 1907-12 and 1927-80. During this period the flow ranged from a maximum of 72,900 ft^3/s in January 1932, to a minimum of 536 ft^3/s in October 1943. A review of streamflow records collected at the gage at Redwood in recent years suggests that the flow at that site, including flow diverted through Steele Bayou, might average about 20 percent greater than that at Greenwood.

A major channel construction project between Yazoo City and Greenwood is currently (1984) underway by the Corps of Engineers. This project, referred to as the Upper Yazoo Project by the Corps, provides for dredging and widening the channel to a bottom width of 150 feet and the excavation of several bendway cutoffs. This project has been under construction for several years and is expected to take another 5 to 10 years to complete. When the Upper Yazoo Project is completed, that part of Yazoo River between Yazoo City and Greenwood will meet the design criteria for the proposed "Navigation Project".

To date, the flood-control project that probably has had the largest beneficial impact on flooding in the lower Yazoo River was the creation of four large flood-control reservoirs on the major hill tributaries to the Yazoo River system by the Vicksburg District Corps of Engineers. Sardis, Arkabutla, Enid, and Grenada Reservoirs, which were completed between 1940 and the mid 1950's, have a combined total of more than 3.8 million acre-ft of storage available for flood control. Since their completion, discharges from the reservoirs have been limited during the normal flood season, December to May, to reduce the severity of downstream flooding. Floodwaters stored in these reservoirs during the flood season are released during the months of June to September, the first part of the low-flow season. The normal operation of these reservoirs have, therefore, resulted in lower flows in the Yazoo River basin during the flood season and significantly higher flows in the early part of the low-flow season.

A comparison of flow-duration data before and after reservoir operations indicate that moderately low flows -- those exceeded 70 to 90 percent of the time, -- have increased between about 1,000 and 4,000 ft^3/s since regulation began. Based on the current stage-discharge relation, regulation of the flow has resulted in an increase in stage of about 1 to 5 feet during periods of moderately low flow.

During the period of record, stage of the Yazoo River at Greenwood has ranged from a high of 127.6 feet above sea level in April 1980 to a low of 101.1 feet above sea level in May 1981. Minimum observed stages at Yazoo City and Redwood during the relatively short periods of record are 71.7 feet above sea level and 49.0 feet above sea level, respectively. Minimum stage at Greenwood, Yazoo City, and Redwood occurred in 1981. Flood profiles developed by the Vicksburg District Corps of Engineers indicate that the stage of the 100-year flood will be 127.2 feet above sea level at Greenwood, 108.2 feet above sea level at Yazoo City, and 104.6 feet above sea level at Redwood after the completion of the Upper Yazoo Project.

GEOHYDROLOGY

The alluvial aquifer in the Mississippi Delta is one of the most productive aquifers in the State. It is the primary source of water for irrigation and fish farming, a major source of water for cooling and other industrial uses, and the source for one public water supply (Vicksburg). In 1980, water was pumped from the alluvial aquifer in the Mississippi Delta at an average rate of 1,142 million gallons per day (Callahan, 1983). This was 74 percent of the total ground-water use in the State.

Large capacity wells commonly are screened in the coarse sand and gravel in the lower part of the alluvium. Yields of large-diameter wells in the alluvium range from 250 to 5,000 gal/min and wells yielding 2,000 gal/min are common. Specific capacities of wells in the alluvium range from 10 to 168 gal/min per foot of drawdown (Dalsin, 1978).

Under natural conditions, water levels in the alluvial aquifer in the area of this investigation were generally between 15 and 25 feet below land surface during low-water periods and less than 10 feet below land surface during high-water periods but fluctuated both seasonally and areally (figs. 3-20). Differences between high and low water levels during the period of this investigation ranged between 5 and 15 feet for most of the wells. In those wells adjacent to the Yazoo River or other major drainage features and in wells near large capacity irrigation wells, fluctuations in ground-water levels were larger. Several observation wells on lines 1-3 (fig. 2) had ground-water levels slightly above, at, or near land surface during periods of flooding and more than 30 feet below land surface during periods of low stage in the Yazoo and Mississippi Rivers.

The largest fluctuations in ground-water levels were generally in the lower part of the project area. Many of the wells in lines 1-4 (figs. 4-8) had water-level fluctuations of more than 20 feet during this investigation. Most of the wells north of line 4 had fluctuations of less than 15 feet and many wells had water-level fluctuations of less than 10 feet (figs. 8-20).

Potentiometric maps based on measurements made in the fall of 1980 (Wasson, 1980i), April 1981 (Darden, 1981), and September 1981 (Darden, 1982a) indicate that the direction of ground-water movement in the area of this investigation is generally toward the Yazoo River except during periods of high stage in the river. On the east side of the river, the direction of ground-water movement during periods of low stages in the Yazoo River was predominantly from the Bluff Hills to the west and southwest toward the river. On the west side of the river the direction of ground-water movement is generally to the southeast toward the river except in the areas of lines 9-12 (fig. 2) where the ground-water moves from the river toward the Whittington Auxillary Channel a few miles to the west. During periods of high stage in the Yazoo River, the water in the river moves into the aquifer, especially on the west side of the river. However, relatively steep gradients in the ground-water levels near the river indicate that the hydraulic connection between the river and the aquifer is poor in much of the area.

An analysis of the degree of connection between the surficial alluvial aquifer and underlying formations was beyond the scope of this investigation but there is potential for upward movement of ground water from Tertiary aquifers into the alluvial aquifer in that part of the area where the Cockfield Formation and Sparta Sand subcrop beneath the alluvium (in the vicinity of lines 8-13 and line 15). The degree of connection between the Tertiary aquifers and the alluvial aquifer is, however, highly variable. Well logs indicate that these aquifers are at places separated by several feet of clay which may significantly retard

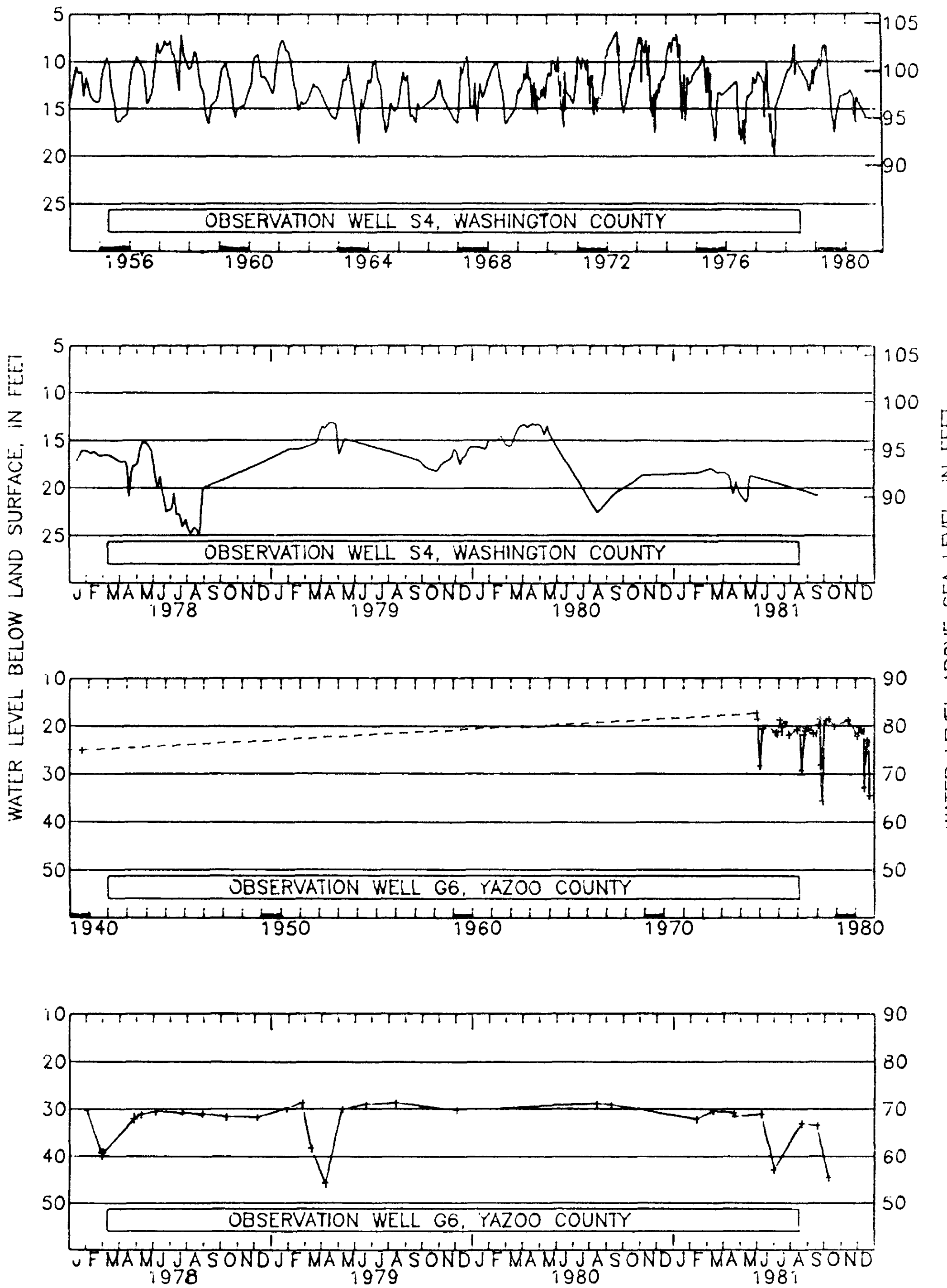


Figure 3.-- Ground-water-level hydrographs for long-term observation wells S4 in Washington County and G6 in Yazoo County.

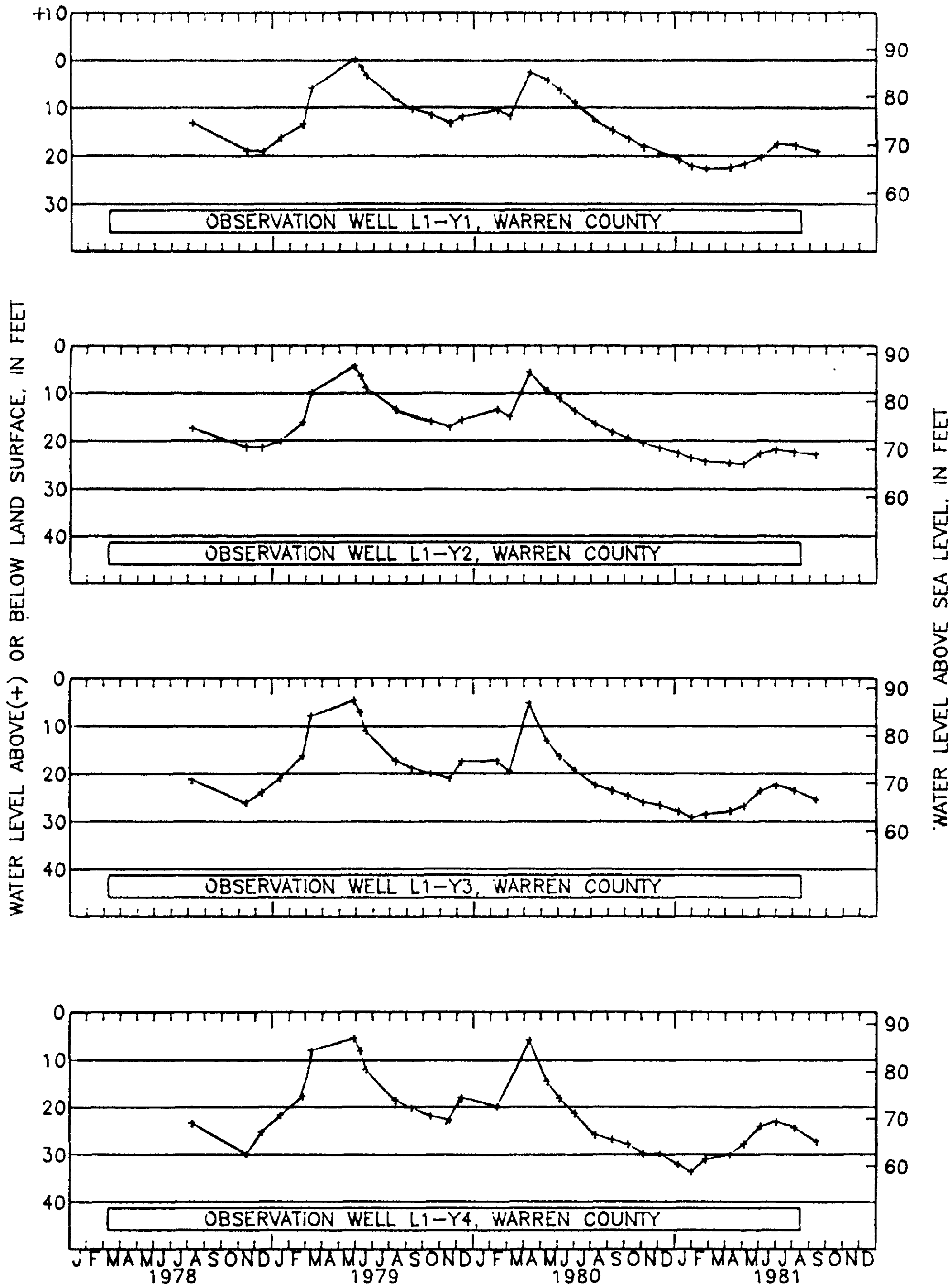


Figure 4.-- Ground-water-level hydrographs for observation wells L1-Y1, L1-Y2, L1-Y3, and L1-Y4 in Warren County.

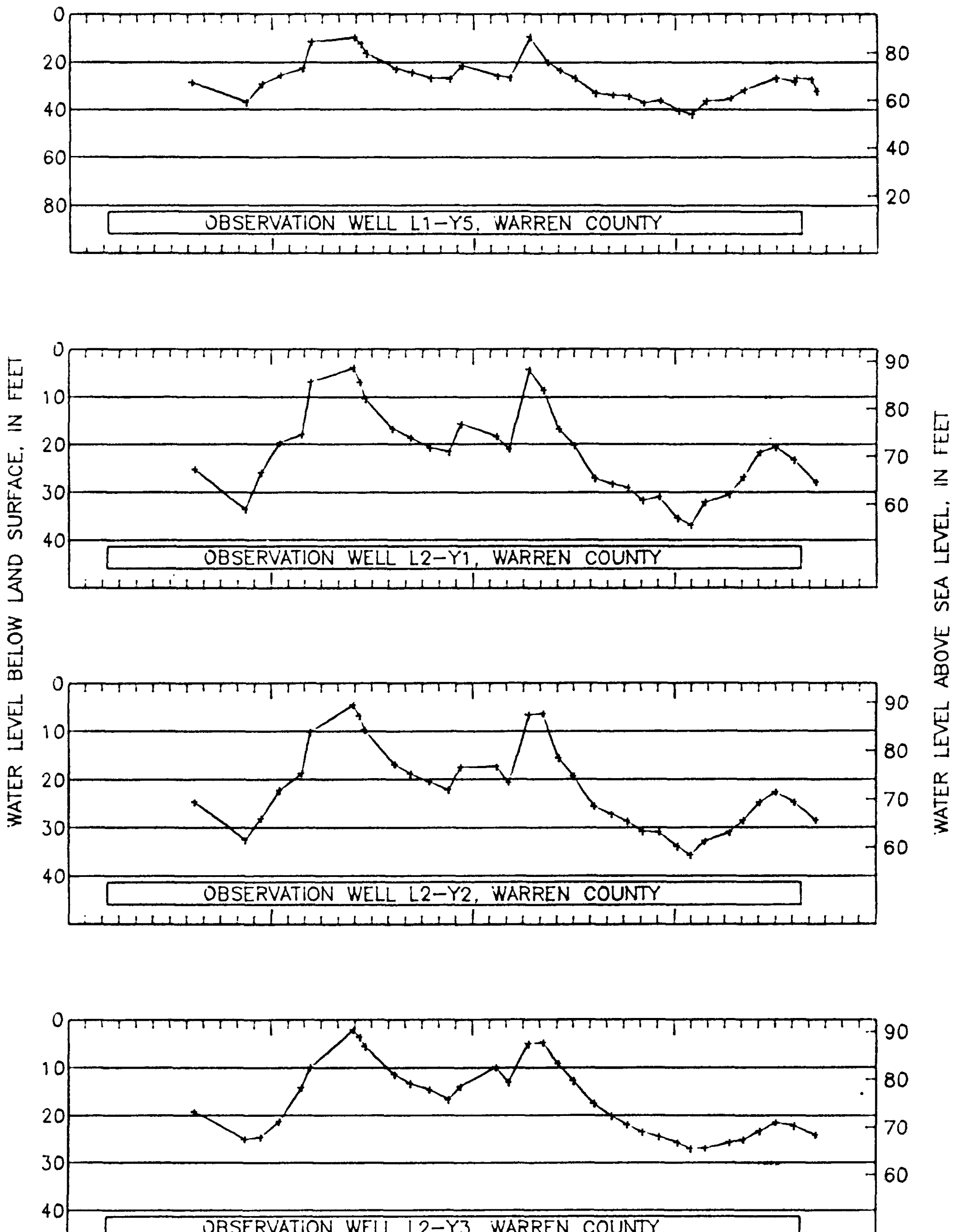


Figure 5.-- Ground-water-level hydrographs for observation wells L1-Y5, L2-Y1, L2-Y2, and L2-Y3 in Warren County.

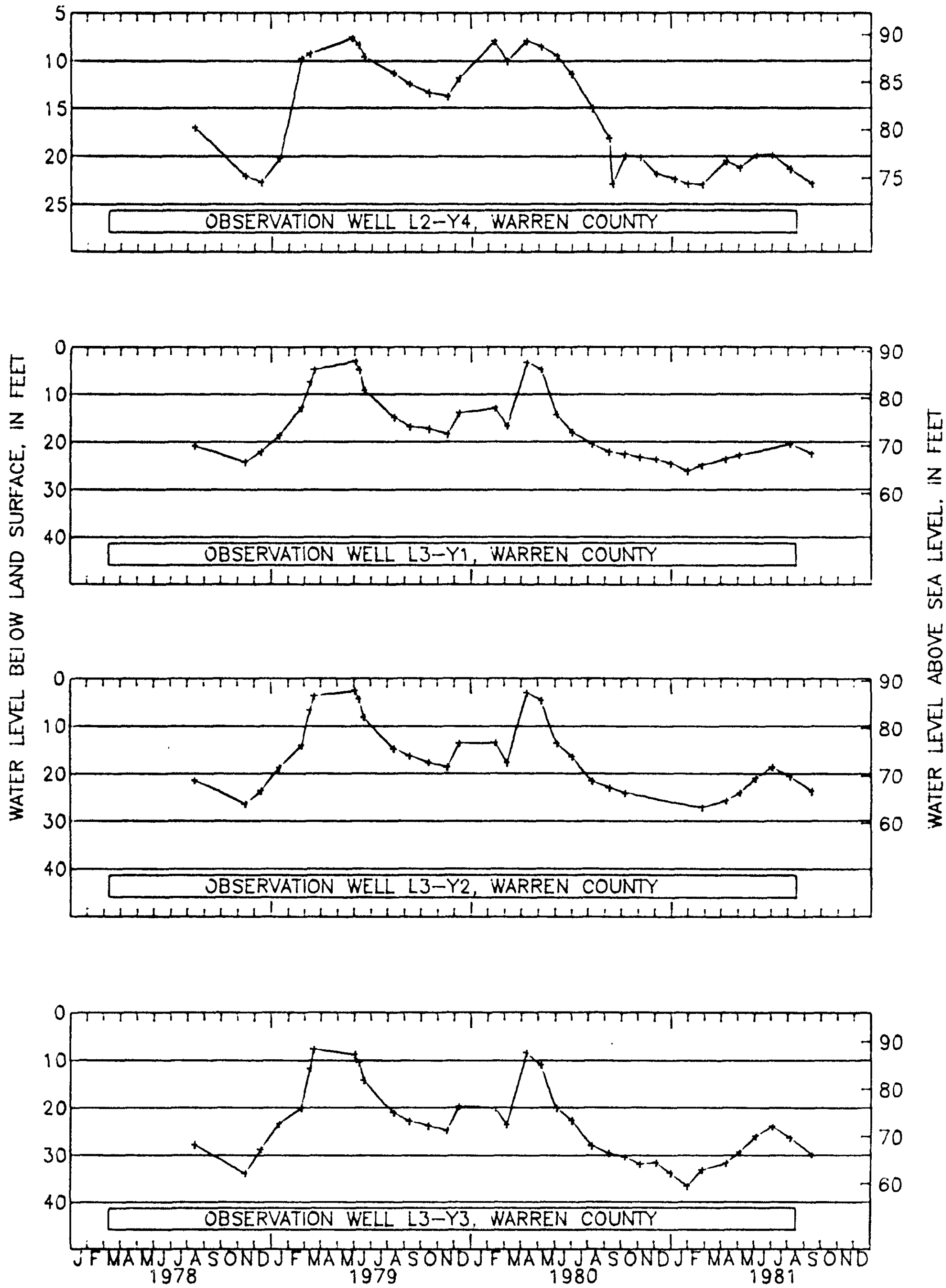


Figure 6.-- Ground-water-level hydrographs for observation wells L2-Y4, L3-Y1, L3-Y2, and L3-Y3 in Warren County.

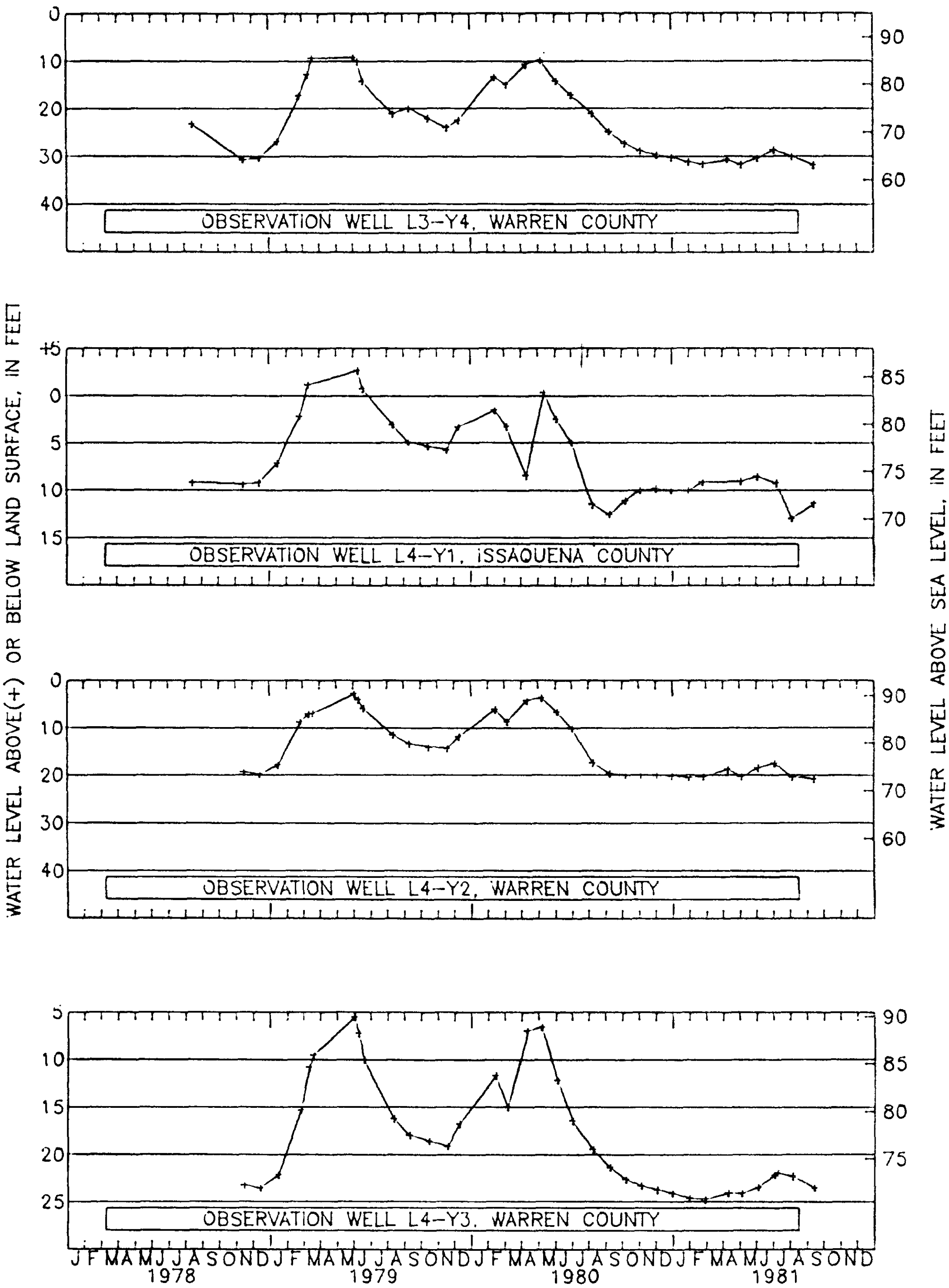


Figure 7.-- Ground-water-level hydrographs for observation wells L3-Y4, L4-Y2 and L4-Y3 in Warren County and L4-Y1 in Issaquena County.

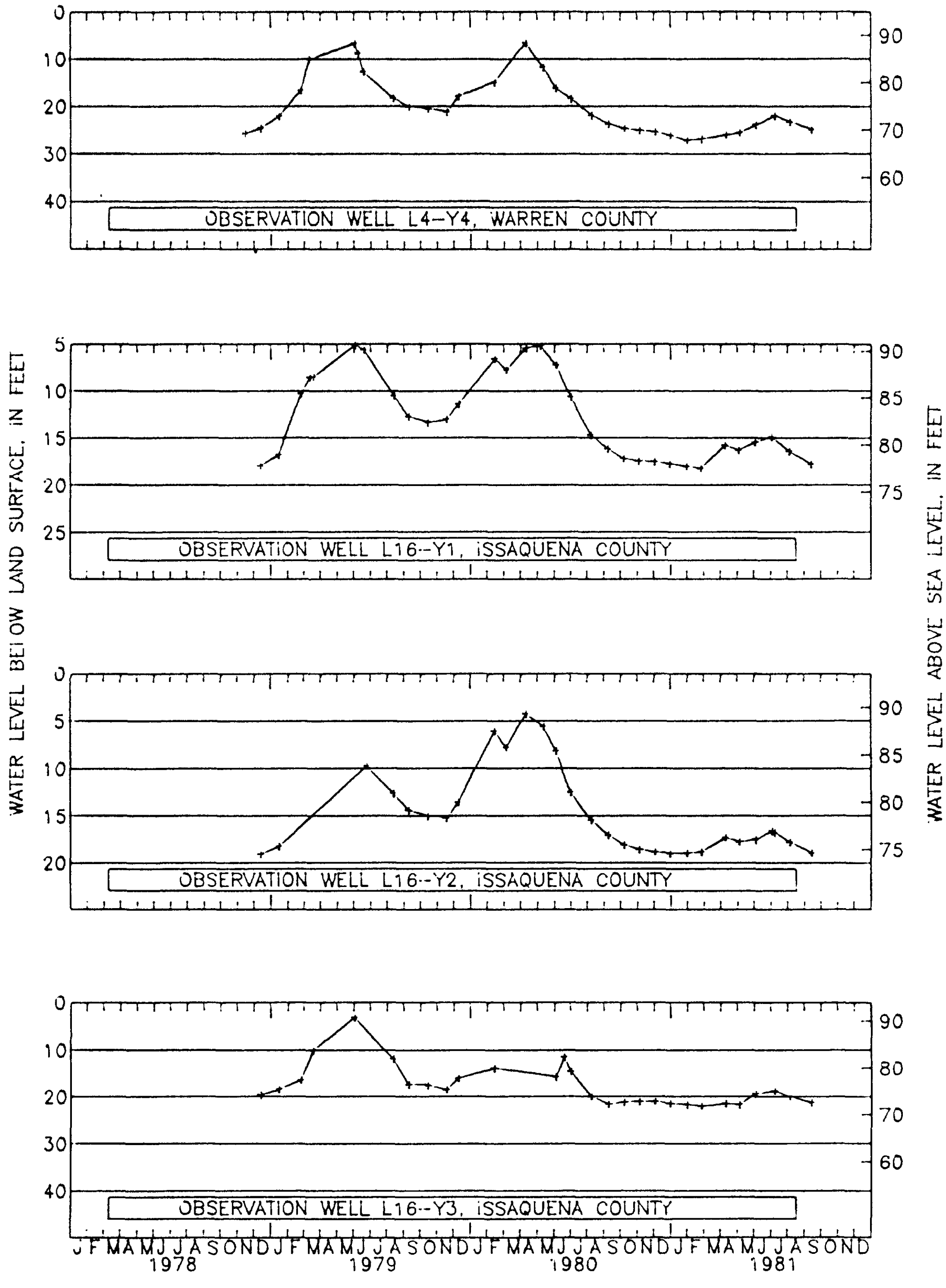


Figure 8.-- Ground-water-level hydrographs for observation wells L4-Y4 in Warren County and L16-Y1, L16-Y2 and L16-Y3 in Issaquena County.

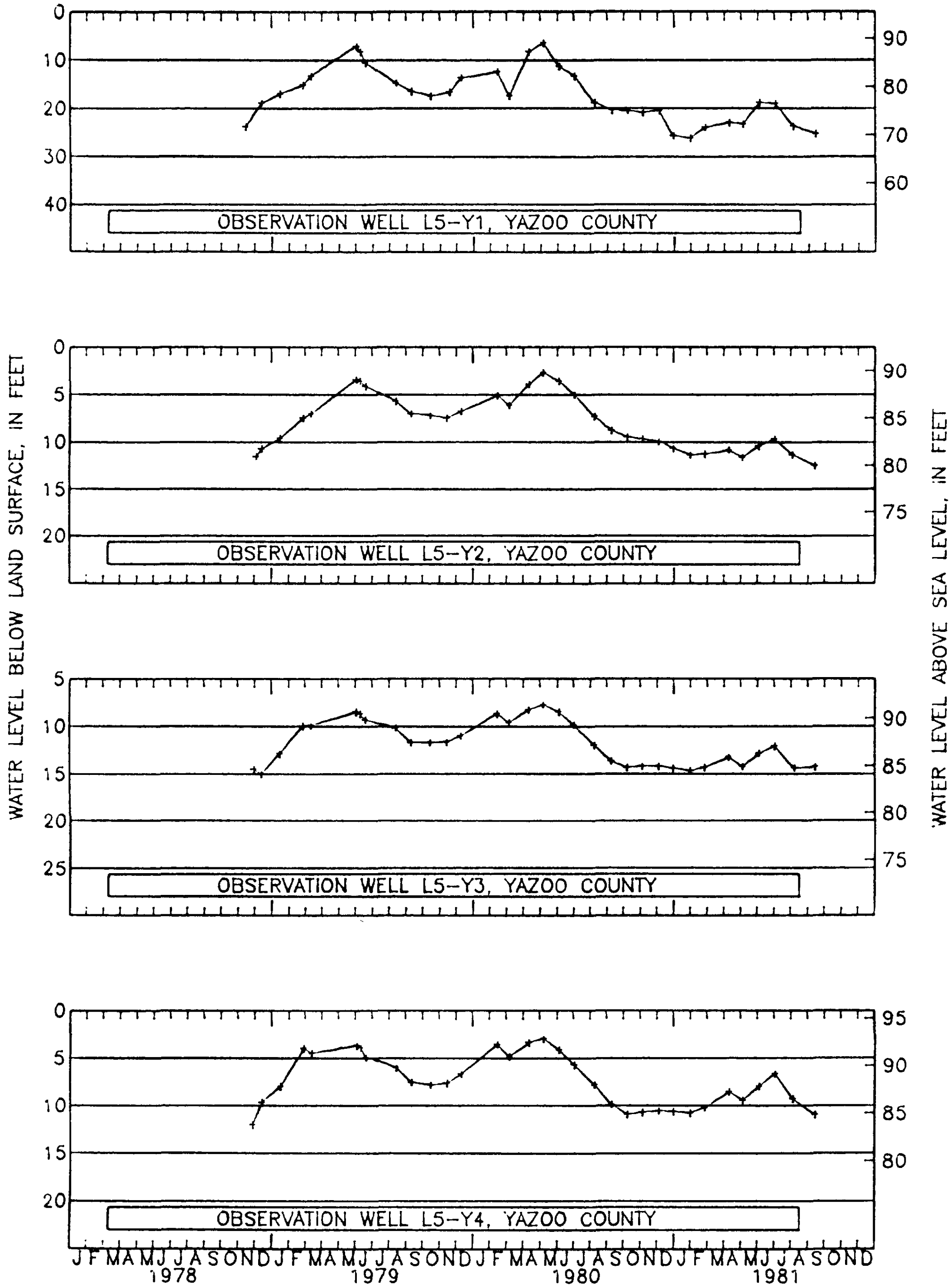


Figure 9.-- Ground-water-level hydrographs for observation wells L5-Y1, L5-Y2, L5-Y3, and L5-Y4 in Yazoo County.

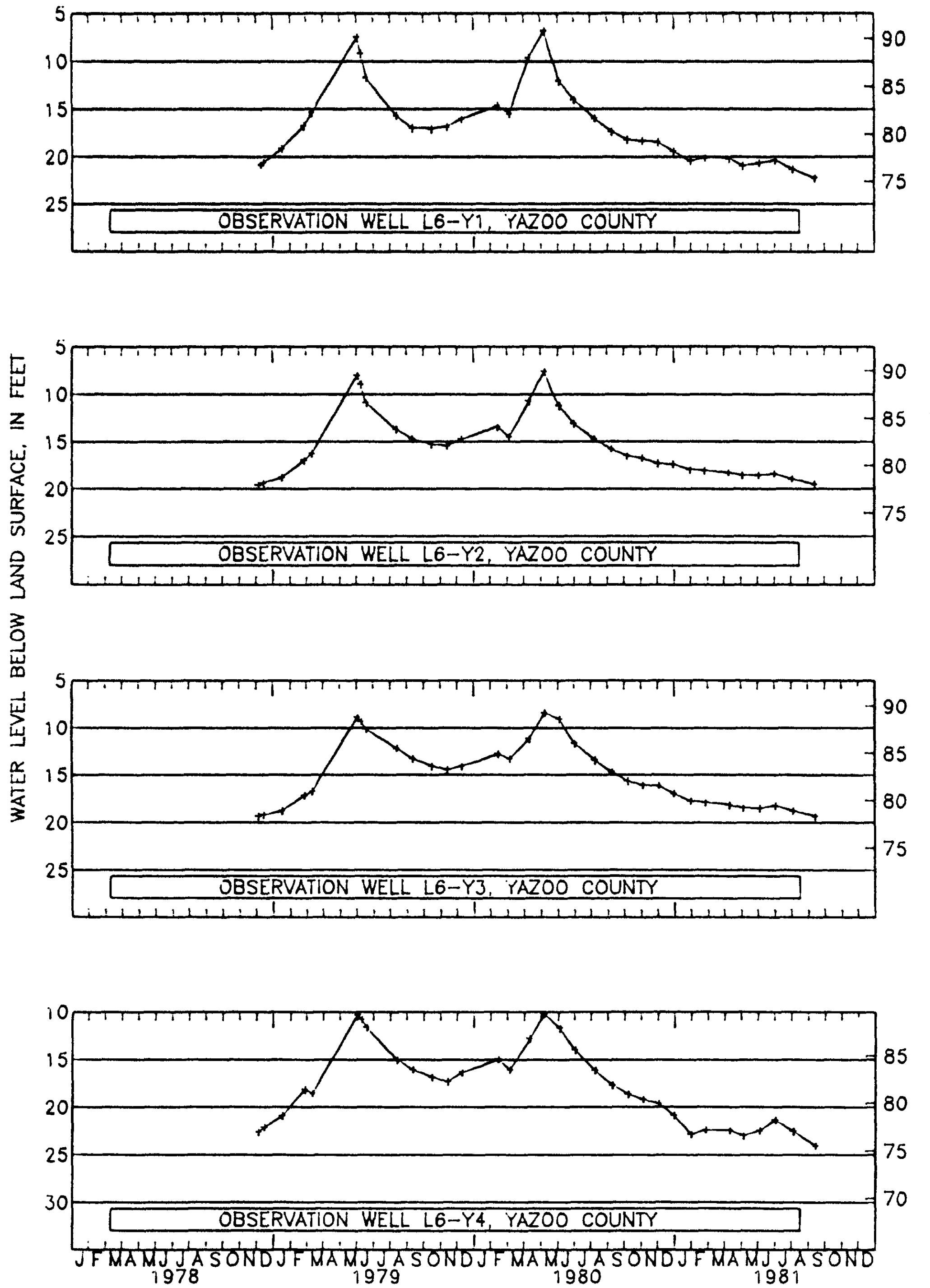


Figure 10.-- Ground-water-level hydrographs for observation wells L6-Y1, L6-Y2, L6-Y3, and L6-Y4 in Yazoo County.

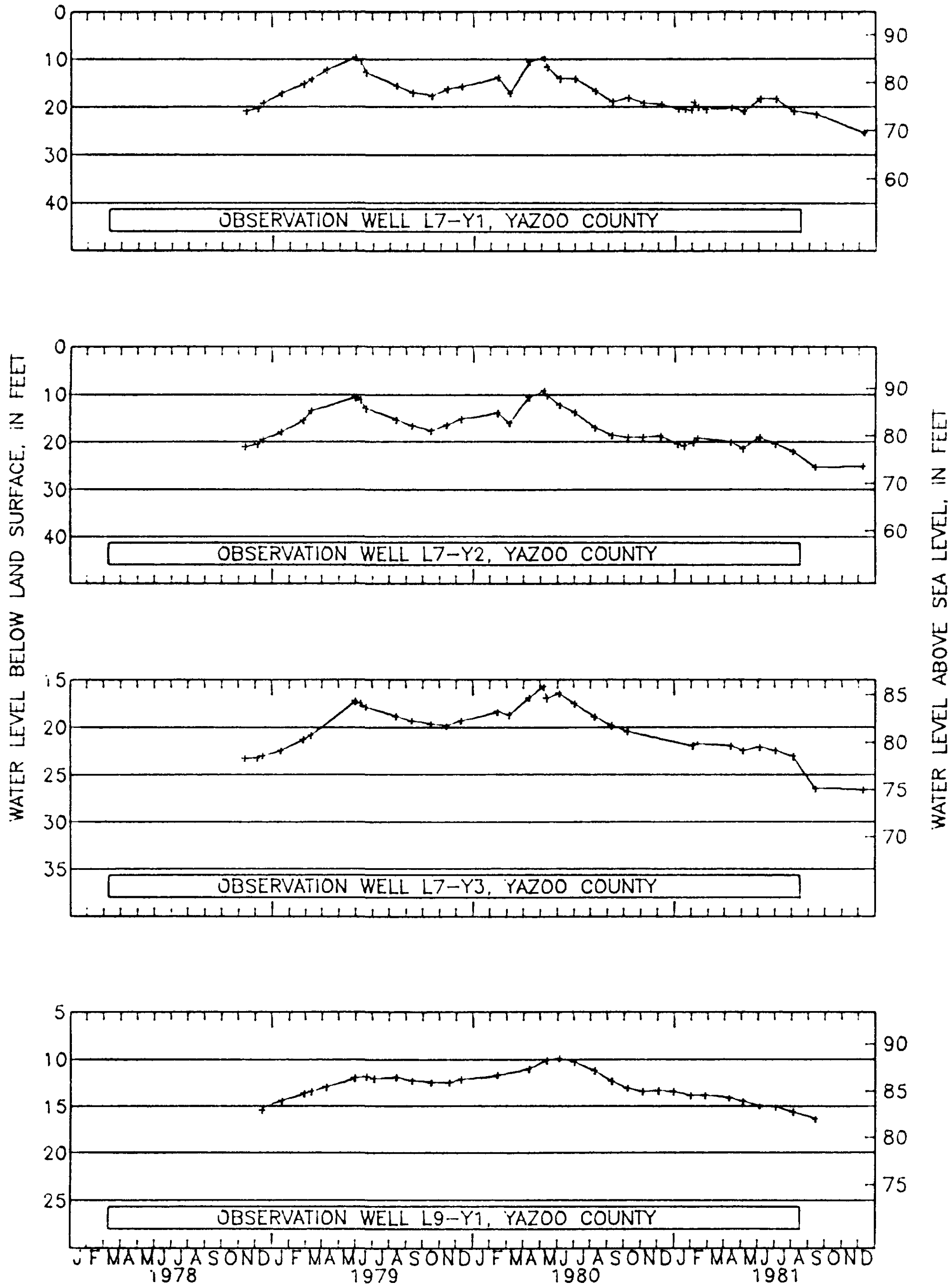


Figure 11.-- Ground-water-level hydrographs for observation wells L7-Y1, L7-Y2, L7-Y3 and L9-Y1 in Yazoo County.

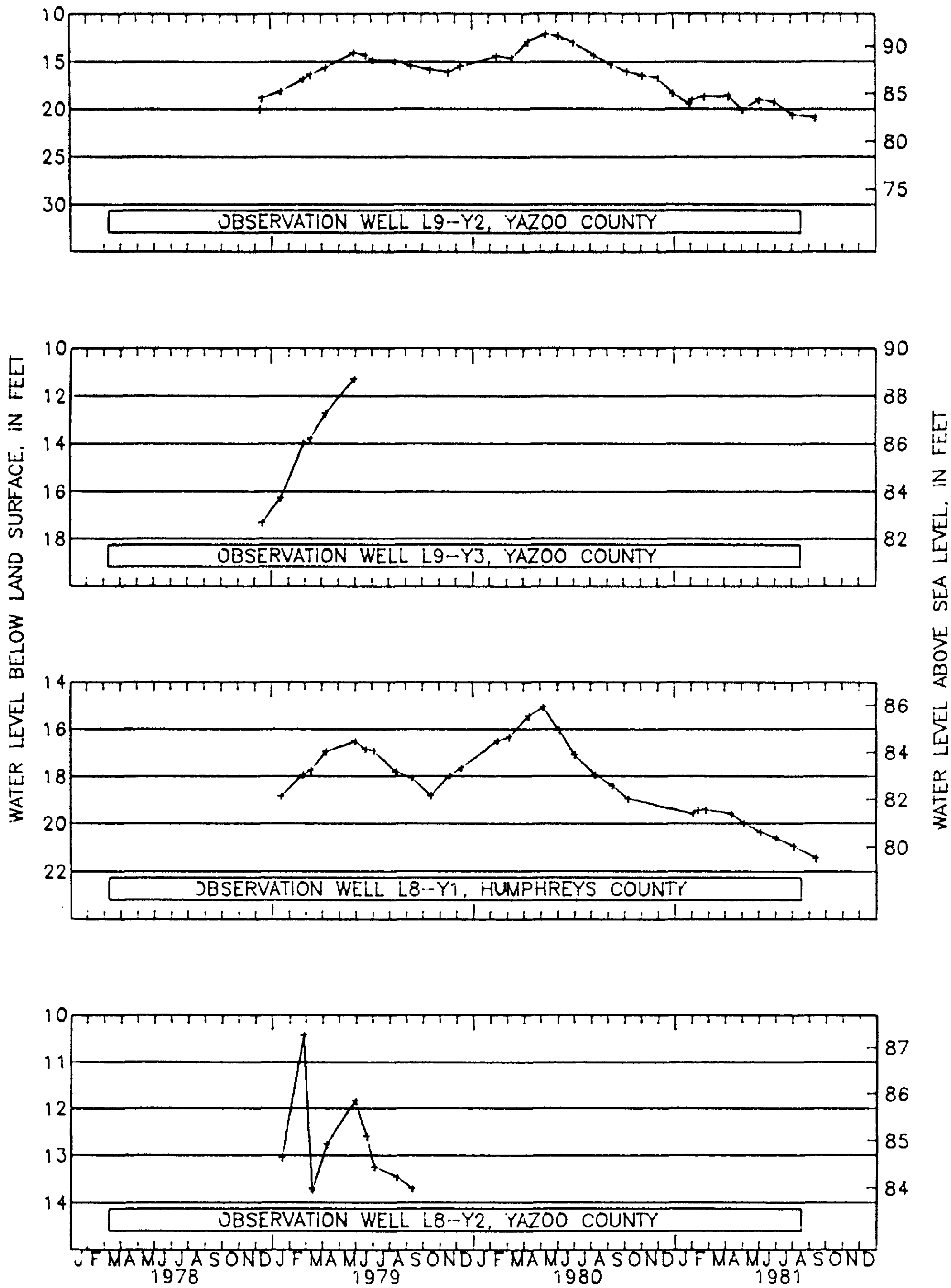


Figure 12.-- Ground-water-level hydrographs for observation wells L9-Y2, L9-Y3, and L8-Y2 in Yazoo County and L8-Y1 in Humphreys County.

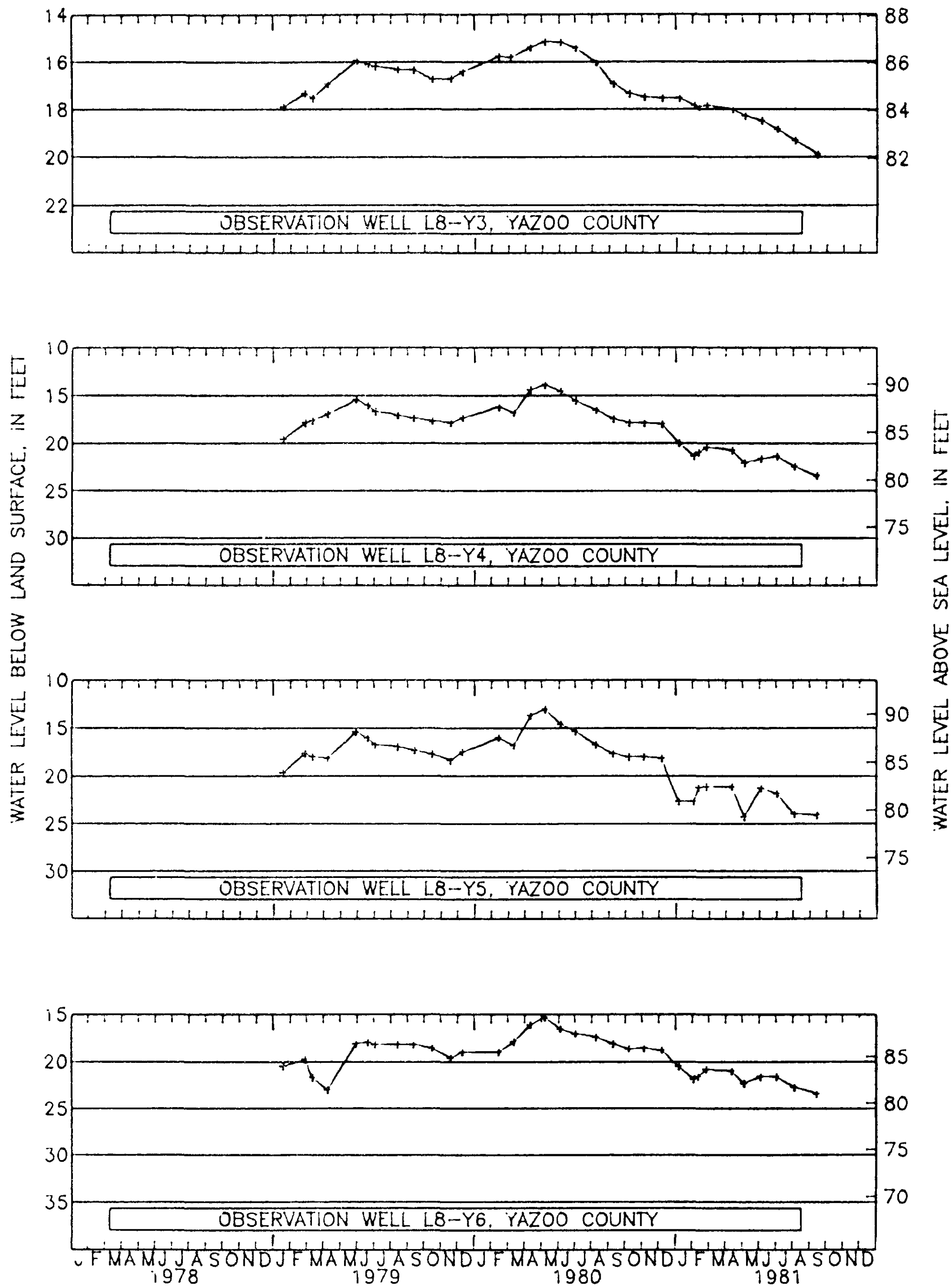


Figure 13.-- Ground-water-level hydrographs for observation wells L8-Y3, L8-Y4, L8-Y5, and L8-Y6 in Yazoo County.

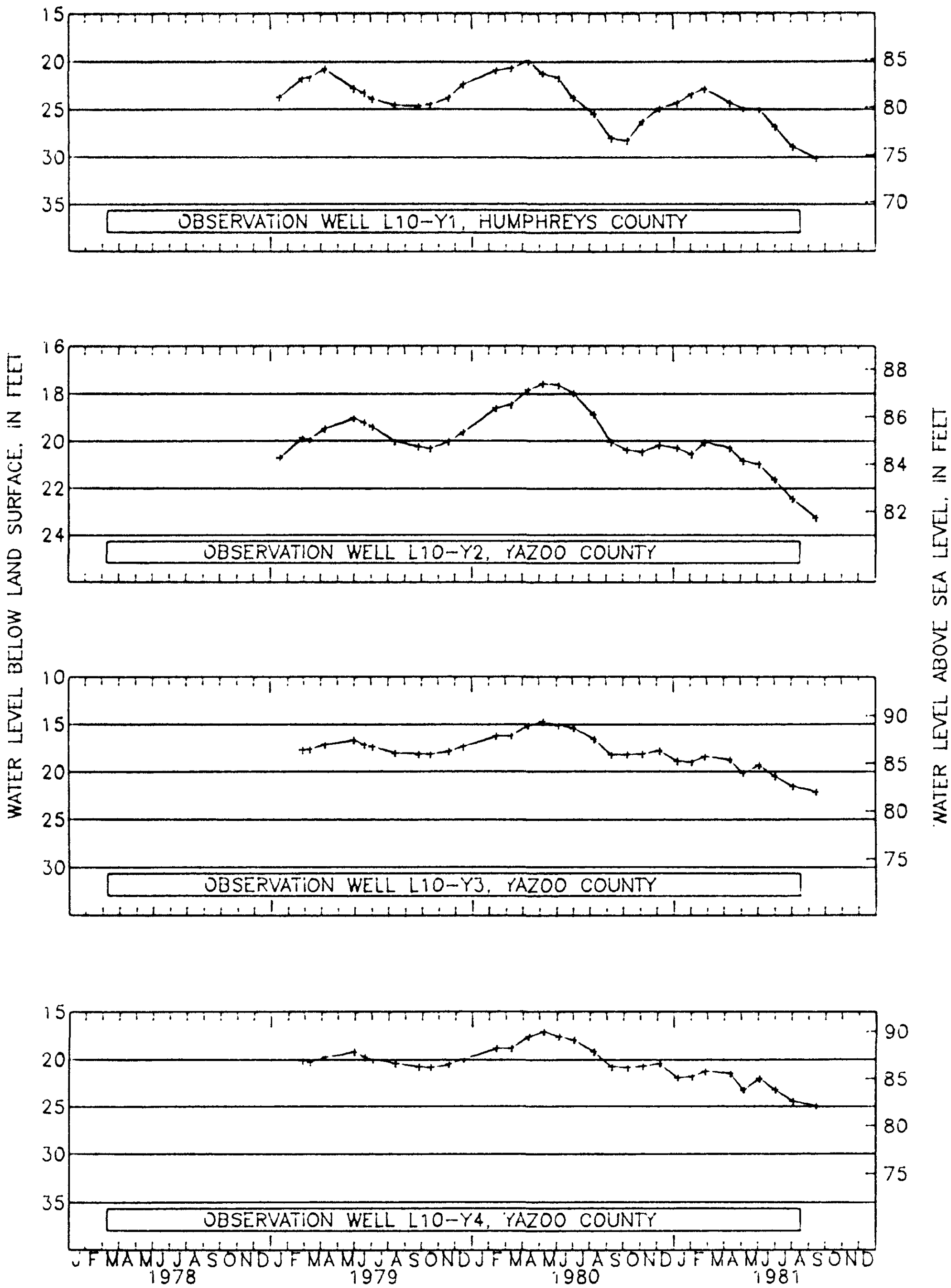


Figure 14.-- Ground-water-level hydrographs for observation wells L10-Y1 in Humphreys County and L10-Y2, L10-Y3, and L10-Y4 in Yazoo County.

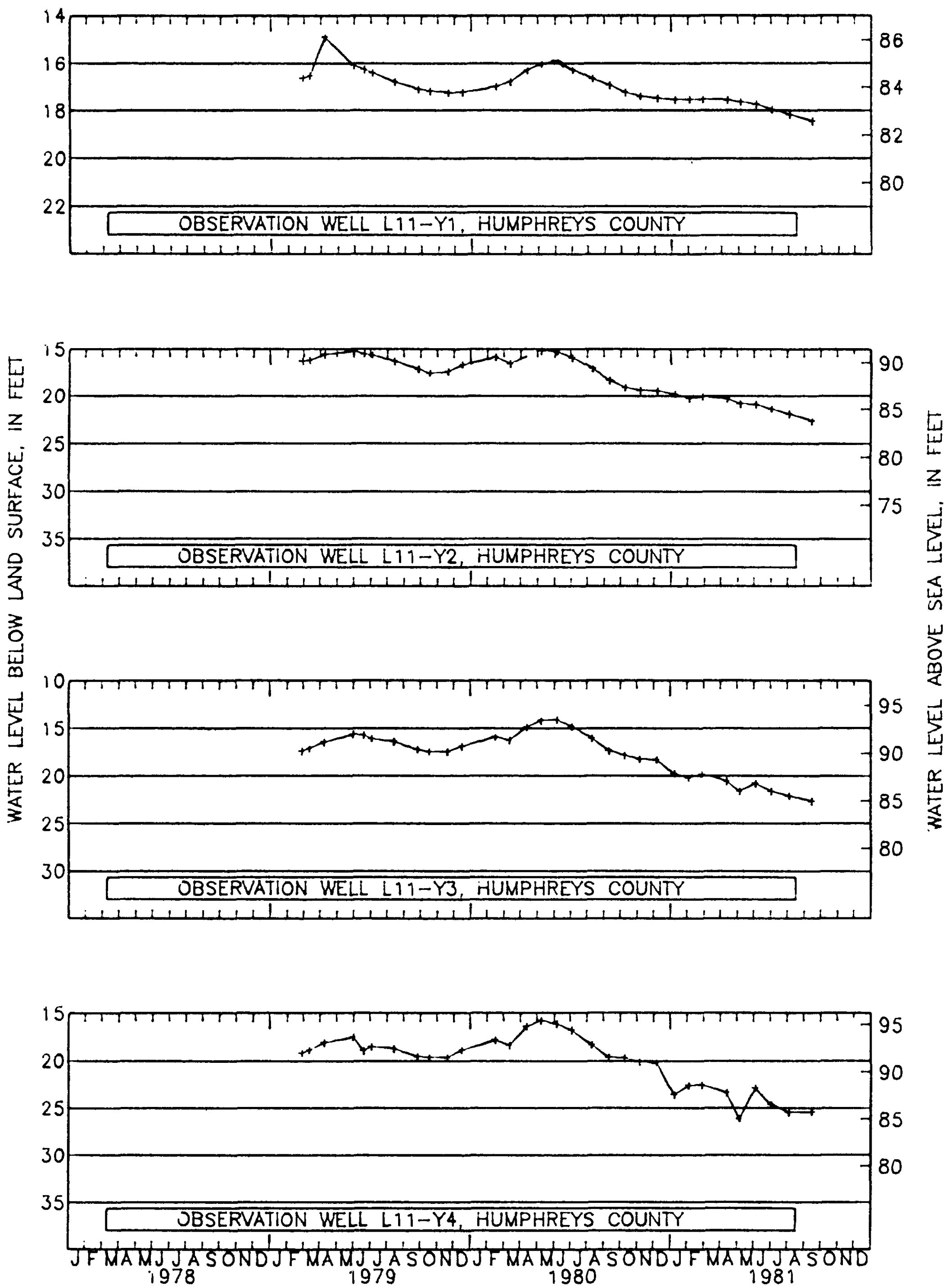


Figure 15.-- Ground-water-level hydrographs for observation wells L11-Y1, L11-Y2, L11-Y3, and L11-Y4 in Humphreys County.

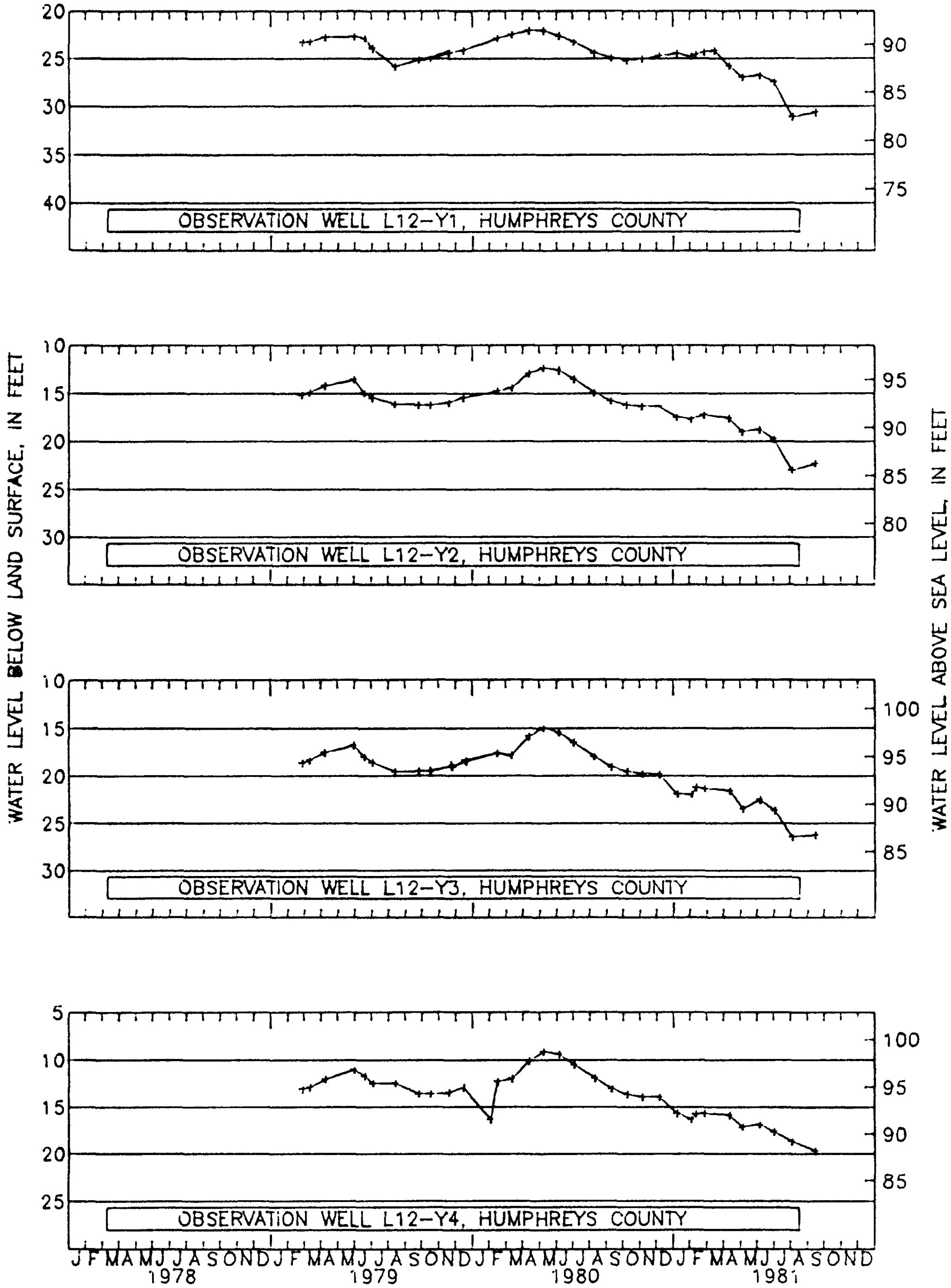


Figure 16.-- Ground-water-level hydrographs for observation wells L12-Y1, L12-Y2, L12-Y3, and L12-Y4 in Humphreys County.

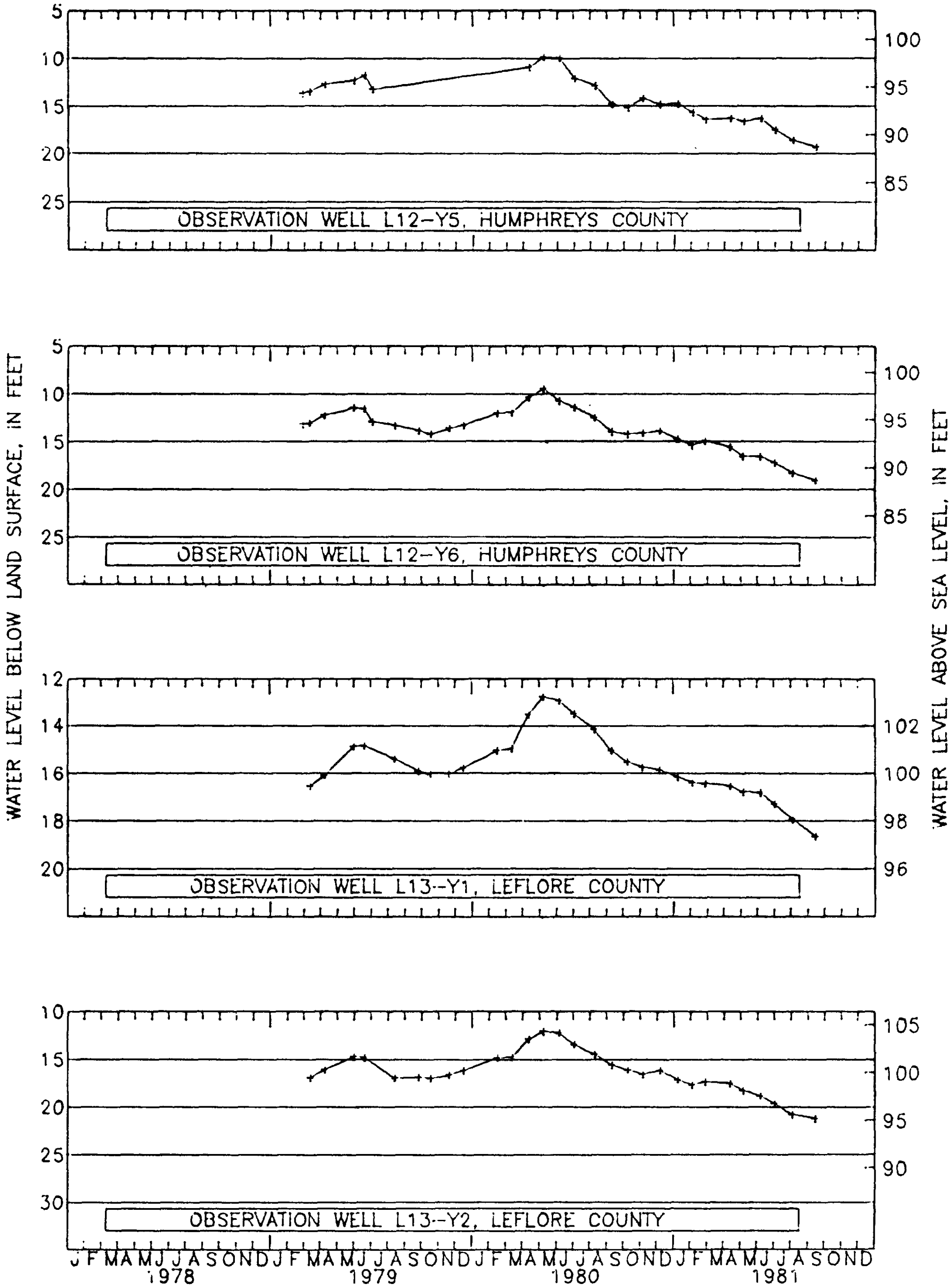


Figure 17.-- Ground-water-level hydrographs for observation wells L12-Y5 and L12-Y6 in Humphreys County, and L13-Y1 and L13-Y2 in Leflore County.

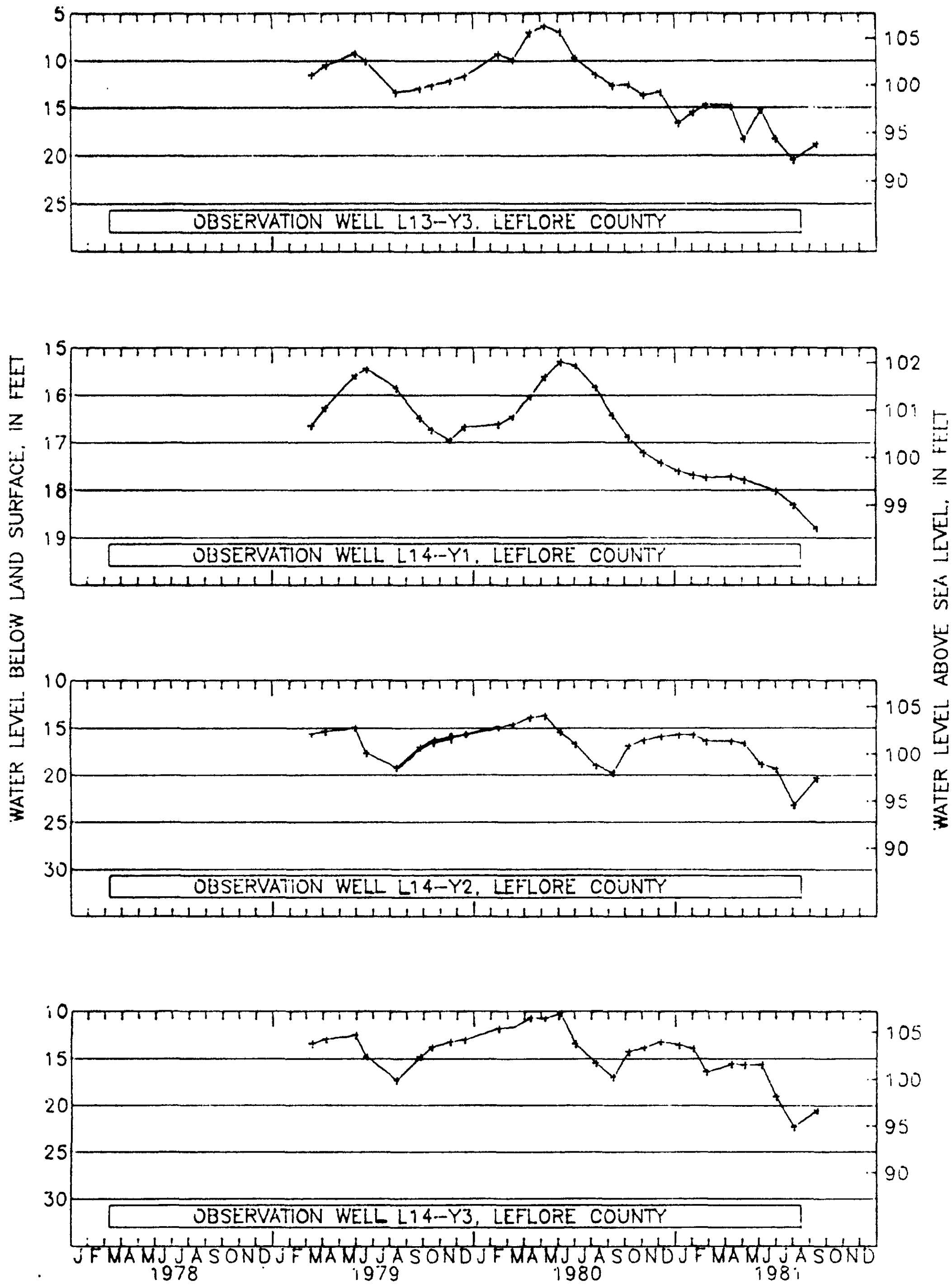


Figure 18.-- Ground-water-level hydrographs for observation wells L13-Y3, L14-Y1, L14-Y2 and L14-Y3 in Leflore County.

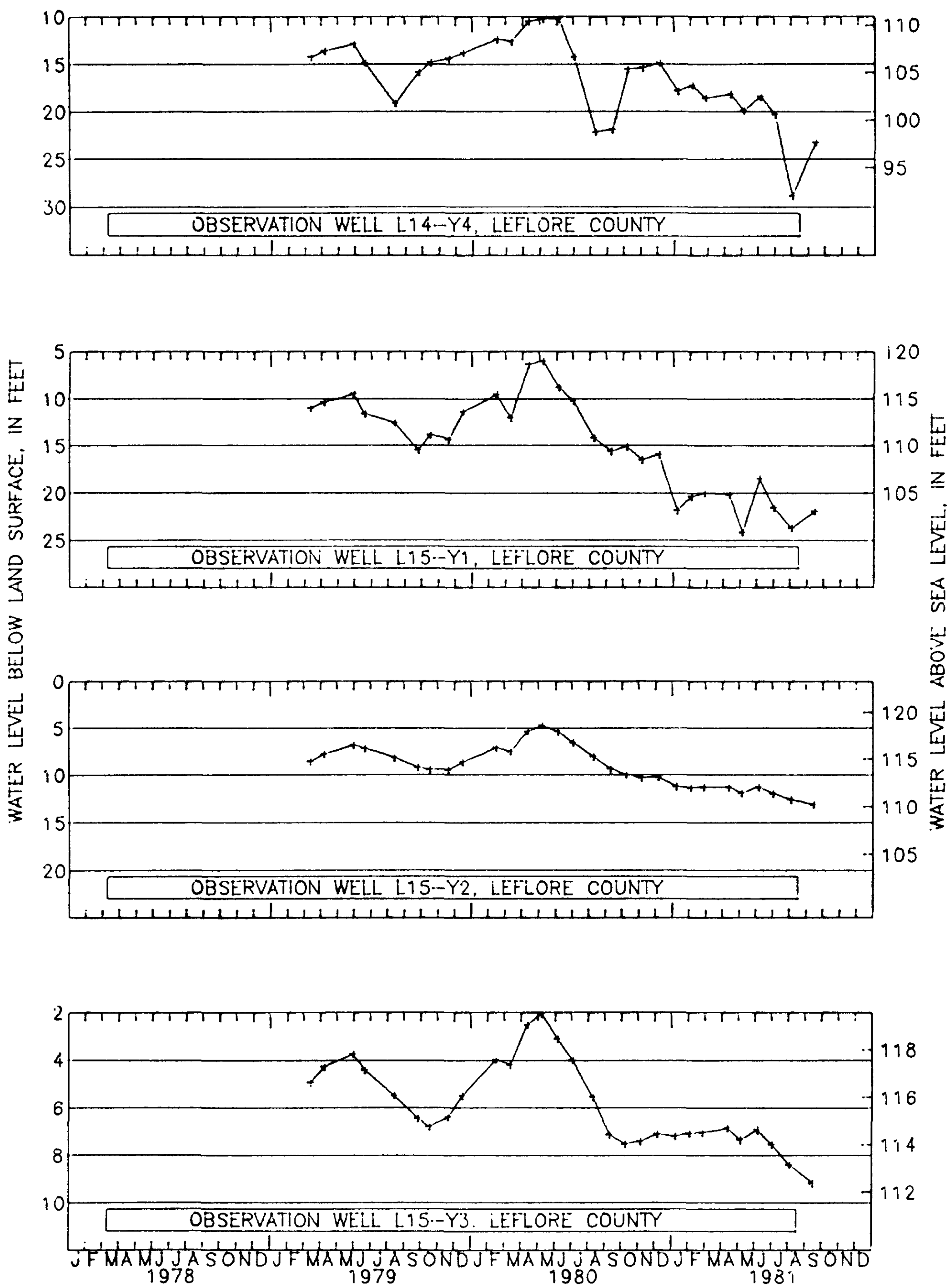


Figure 19.-- Ground-water-level hydrographs for observation wells L14-Y4, L15-Y1, L15-Y2 and L15-Y3 in Leflore County.

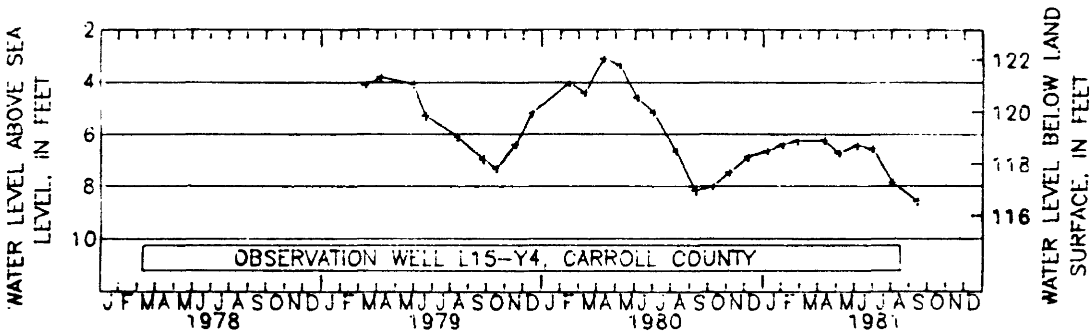


Figure 20.-- Ground-water-level hydrographs for observation wells L15-Y4 in Carroll County.

or prevent the upward movement of ground water. Where the clay separation is absent, ground water moves from the underlying Tertiary aquifers into the alluvium but the hydraulic head driving the upward movement of ground water is generally less than 20 feet except near the eastern edge of the Delta where the head may be slightly higher.

Potentiometric levels in the Cockfield Formation and Sparta Sand that subcrop beneath the alluvial aquifer in part of the area of this investigation were once above land surface, but have declined steadily in these aquifers over many years and now generally stand only a few feet above water levels in the alluvial aquifer. In September 1980, the water level in a well in the Cockfield aquifer was less than one foot higher than that in the nearby alluvial aquifer observation well L10-Y1. Water levels in the Sparta Sand aquifer generally are higher than those in the Cockfield aquifer; therefore, the potential for the upward movement of water into the alluvial aquifer is greater in the area where the Sparta Sand subcrops than in the area where the Cockfield aquifer subcrops. In October 1980 the water level in a Sparta Sand well near Greenwood was about 13 feet higher than that in alluvial observation well L15-Y2 a few miles away. Potentiometric levels in the Cockfield Formation and Sparta Sand will to continue to decline because of pumping and, eventually, the water levels in these Tertiary aquifers will be lower than those in the alluvium. When that happens the upward movement of ground water from the Tertiary aquifer to the alluvium, where it occurs, will be reversed.

Water levels in the Mississippi River alluvial aquifer fluctuate in response to changes in elevation of water surfaces in nearby lakes and rivers, recharge from precipitation and in some places the underlying Tertiary aquifers, evapotranspiration, and withdrawal of water by wells. These factors are highly seasonal and cause corresponding seasonal changes in ground-water levels. Under natural conditions ground-water levels are usually highest in the spring and lowest in the late fall, but local variations may occur depending on the relative effect of the various factors.

Changes in ground-water levels in the 65 wells installed during this project and in the two long-term observation wells (S4 and G6) in the area are shown in figures 3-20. The hydrographs of the two long-term observation wells (fig. 3) are identified by the name of the owner, the county in which the wells are located, and a sequential number. Well S4 was equipped with a recorder while G6 was measured periodically. The hydrographs of the remaining wells are identified by well numbers used by the Corps of Engineers (page 4). Tick marks (+) on the hydrographs indicate actual water-level measurements. Two hydrographs are given for each of the two long-term observation wells; one shows water levels for the entire period of record for the well and the other for the same period as for the other 65 wells (1978-81).

The period of observation included several extremes of water level, both highs and lows, each attributable to a particular set of climatic conditions. The water levels in the late fall of 1978 are the lowest of record for the long-term observation well Washington County S4 and the next lowest of record for the long-term observation well Yazoo County G6. They are also the lowest of record for many of the project observation wells. These low ground-water levels occurred at the end of a very dry summer and fall, that caused very low river stages on both the Mississippi and lower Yazoo Rivers. Of particular significance is the direct influence that the stage of the Mississippi has on the stage of the Yazoo River. A prolonged low Mississippi River stage, indicative of a dry season for the eastern two-thirds of the nation, reduces the controlling stage for the Yazoo River at and for a considerable distance above the confluence, which in turn allows ground water to drain into the lowered streams.

Ground-water levels recorded during the following spring (February-June, 1979) illustrate the influence of the Mississippi River. The season was not unusually wet in the Yazoo River basin, as shown by only moderate water-level recovery in the northern part of the study area (well lines 8-15). However, the Mississippi River caused substantial backwater flooding in the southern part of the area. The high stages associated with this flooding resulted in increased recharge through the saturated soil, as well as through stream channels, halted ground-water discharge, and thus raised water levels in the aquifer to near or above land surface in many areas. Water levels were slightly above land surface in well L1-Y1, which was surrounded by flood waters, and in well L4-Y1 which was on the dry side of a flood-retention levee. Water levels in several other wells may also have risen above land surface, but measurements could not be made because the wells were inaccessible during the flood.

After the flood waters receded, ground-water levels declined through the summer and fall of 1979. However, the late winter and early spring of 1980 were abnormally wet in the headwaters of the Yazoo River. The large flood-retention reservoirs prevented major flooding of the lower Yazoo River basin, but the prolonged release of the impounded water kept the stage of the Yazoo River very near the flood stage until June 1980. The prolonged high stage, together with some flooding of cropland in the northern part of the study area, caused ground-water levels to rise to near record levels. This is most evident for northern wells in lines 8 to 15 (figs. 11-19). Wells in the south were less affected because the stage of the Mississippi was lower than in the previous year, allowing the lower reaches of the Yazoo River also to remain at a low stage.

The water-level decline after spring, 1980, was similar to that of the previous year except that it continued until the summer of 1981 and then recovered only slightly. The year 1981 was unusually dry, both locally and in the drainage area of the Mississippi River. The stages of the Mississippi and Yazoo Rivers remained low during the late winter and early spring of 1981, a time when the stages normally would be high.

In addition to the lack of recharge from streams, there was little direct recharge to the aquifer from precipitation. As a result, ground-water levels continued to decline during the season in which they would normally rise, eventually reaching record lows in most wells.

A close examination of the hydrographs reveals that (1) the largest fluctuations in ground-water levels (30 feet or more) and in river stages occurred along the lower reach of the Yazoo River (in the vicinity of lines 1-4); (2) ground-water level fluctuations in wells near the Bluff Hills on the east side of the river and in wells west of the river north of line 4 were generally less than 15 feet; (3) within each line of wells, those wells nearest the Yazoo River or other major drainage features generally had the largest fluctuations in ground-water levels (4) water levels in some wells such as L14-Y2 were affected by nearby large-capacity irrigation wells, and (5) the shapes of the hydrographs in the southern part of the project area differed somewhat from those in the northern part of the area in that hydrographs of wells in lines 1-4 generally had sharper peaks and fluctuated more than those in lines 5-15. These observations indicate that although ground-water levels throughout the area are affected to some extent by the stage in the Yazoo River and other deeply incised drainage features, the degree of hydraulic connection between these streams and the alluvial aquifer is higher in the lower part of the project area than in the upper part of the area.

Profiles showing the relationship between ground-water levels and water-surface elevations in the Yazoo River and other streams, canals, or lakes at each of the lines of observation wells (except line 7) are shown in figures 21-35. The vertical exaggeration on all profiles is 264:1. Line 7 was omitted because of insufficient vertical control between streams. Each figure shows land surface elevations from topographic maps, the location of perennial bodies of water, the location of wells along the profile, a profile of the highest and lowest water levels, and one or two intermediate water-level profiles. The direction of slope of the ground-water surface indicates one component of the ground-water flow vector. For example, if a profile shows a slope to the west this does not necessarily mean that the absolute direction of ground-water flow is due west. The direction of flow could be to the southwest or the northwest.

Line 1 (fig. 21)--The profiles in this figure show that both the Mississippi and the Yazoo Rivers affect water levels in the alluvial aquifer. This is most evident for the water surface on January 30, 1981, when ground water drained toward each river from a divide about midway between the two.

Line 2 (fig. 22)--The rapid rise in land-surface elevation to the east is the erosional bluff which marks the eastern edge of the Mississippi River alluvial aquifer. The bluff is composed of the Vicksburg Group, which supplies some water to the alluvial aquifer and ultimately to the Yazoo River much of the time. In periods of high stage, Chickasaw Bayou is a major source of recharge to the aquifer.

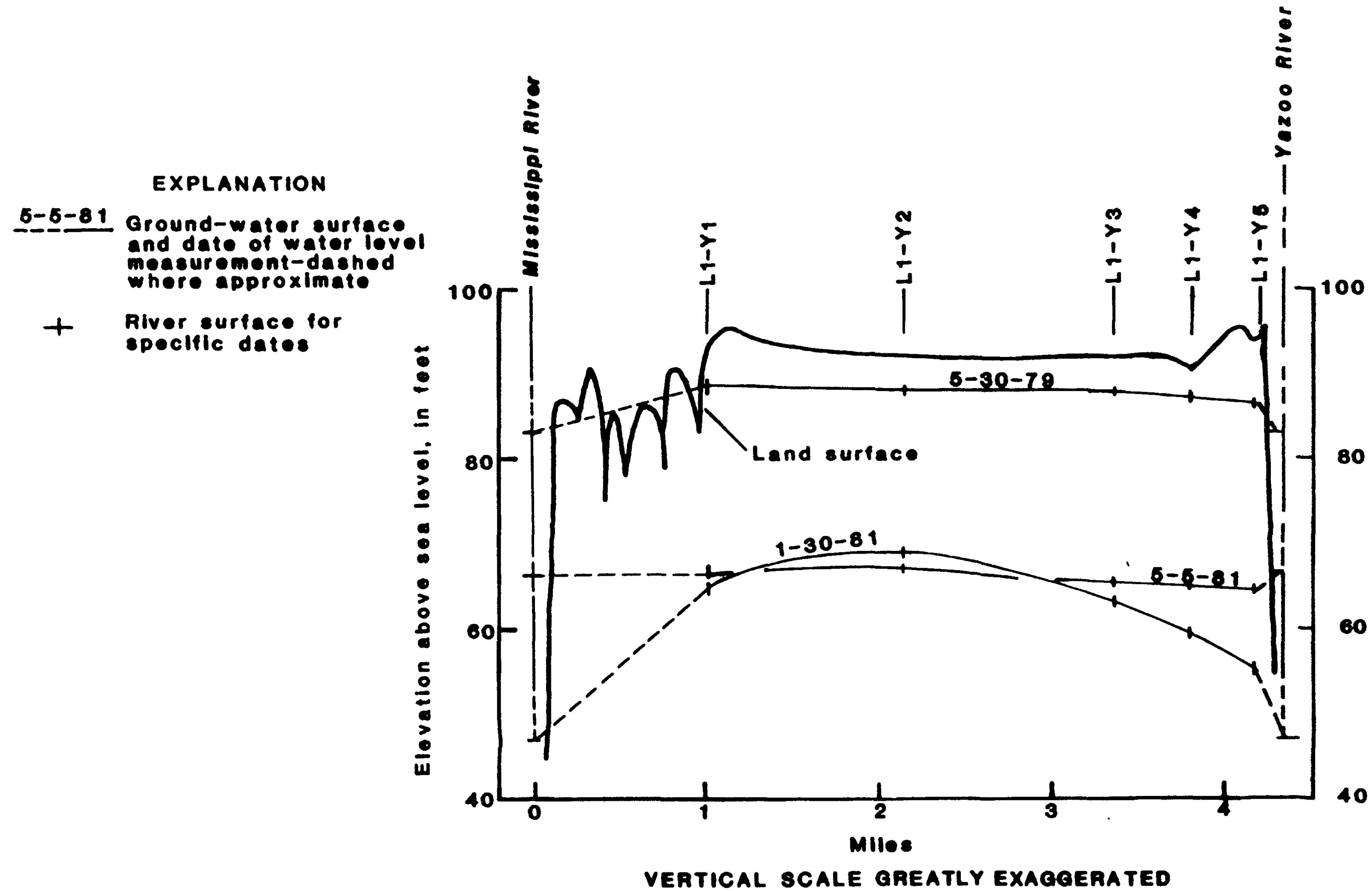


Figure 21.--Water-level profiles from southwest to northeast along line 1.

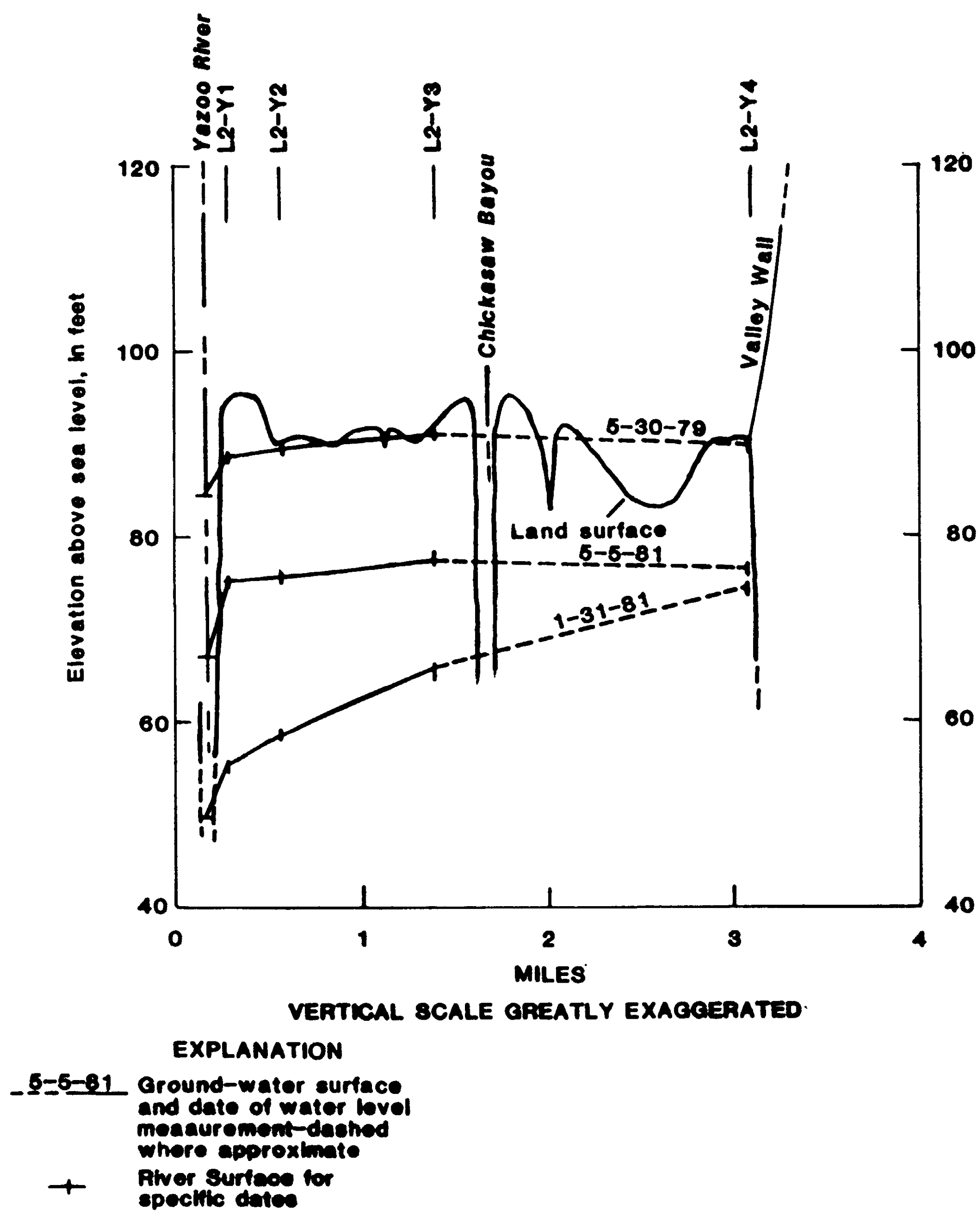


Figure 22.— Water-level profiles from northwest to southeast along line 2.

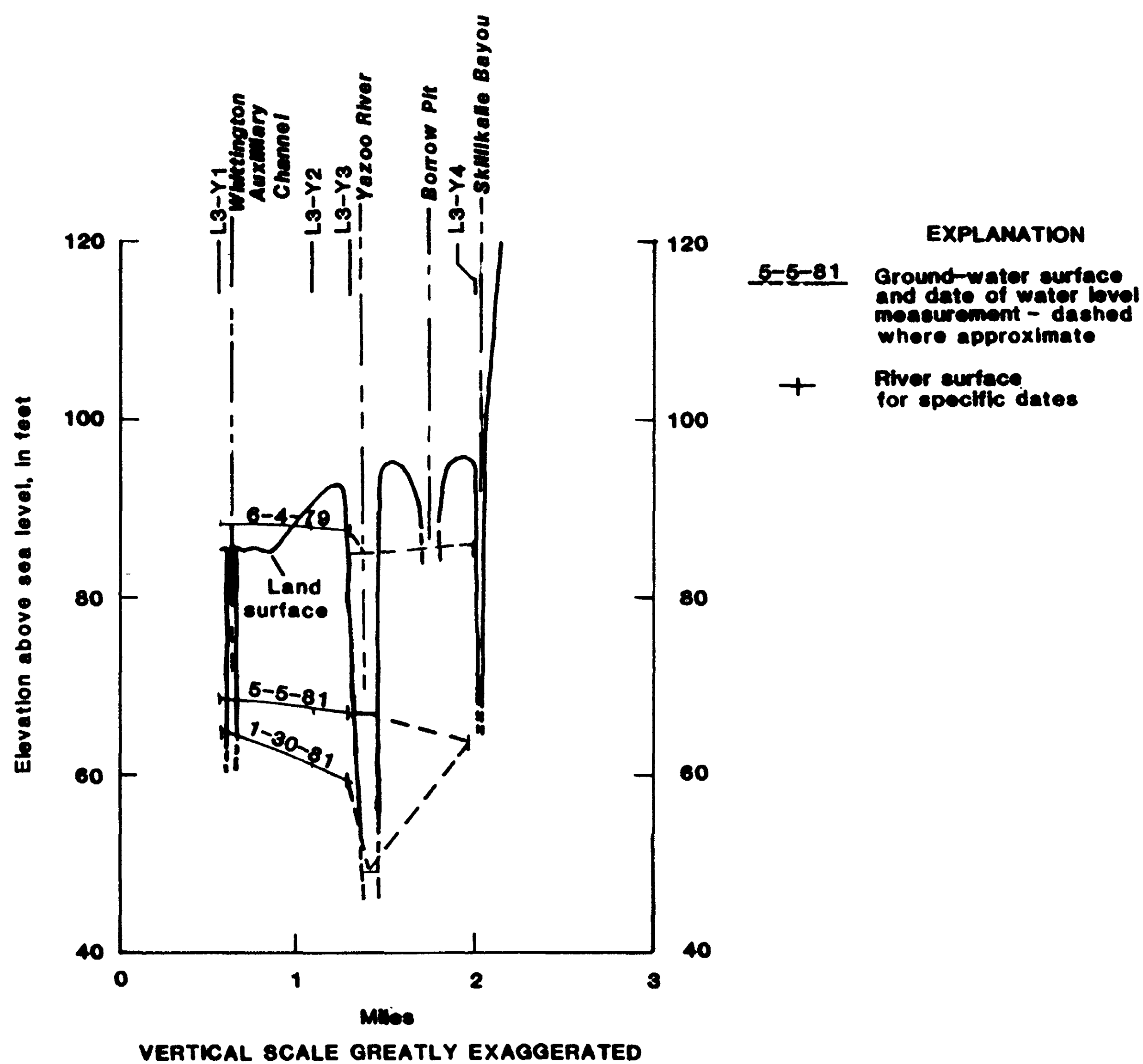


Figure 23.-- Water-level profiles from northwest to southeast along line 3.

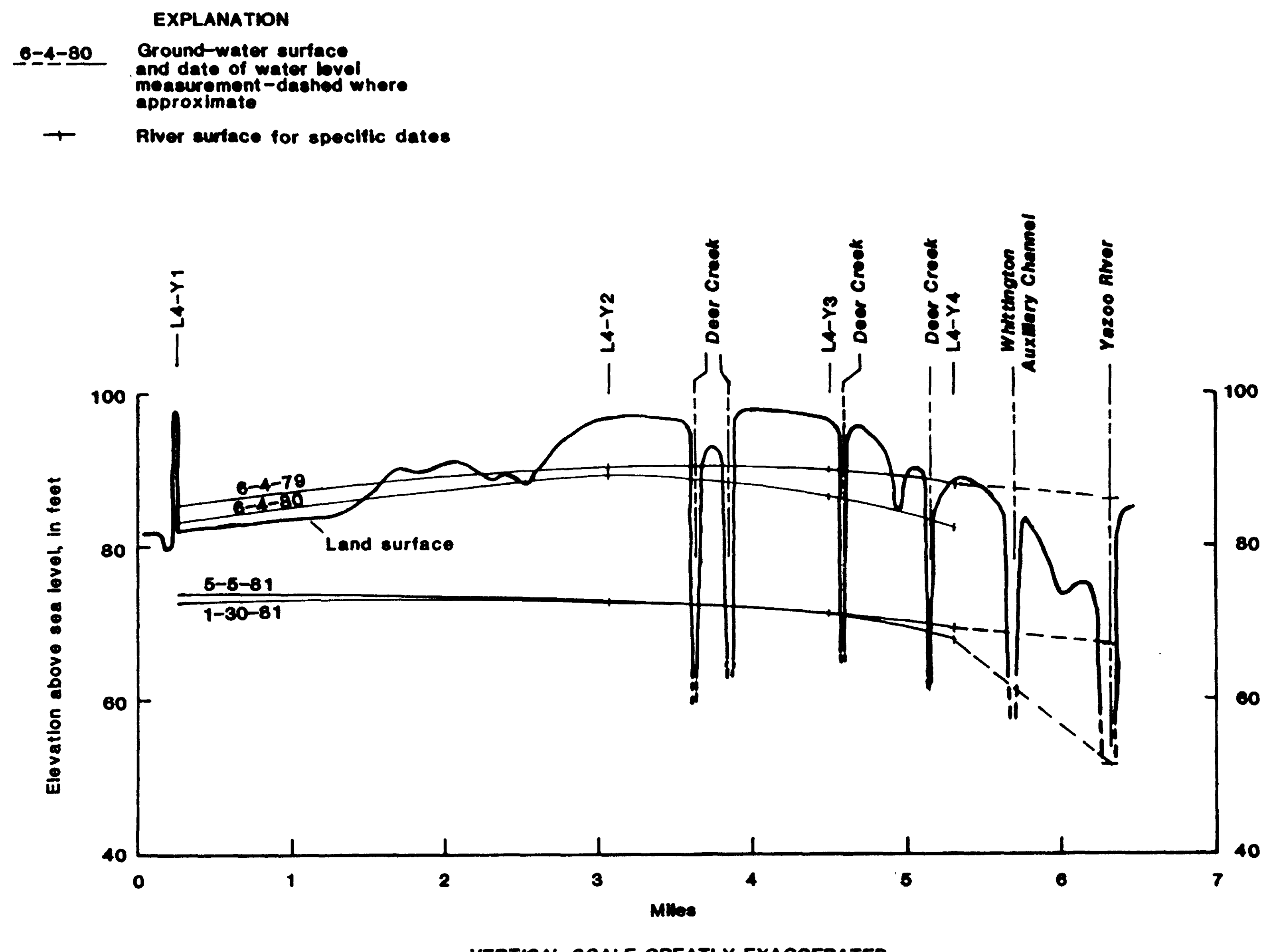


Figure 24.-- Water-level profiles from west to east along line 4.

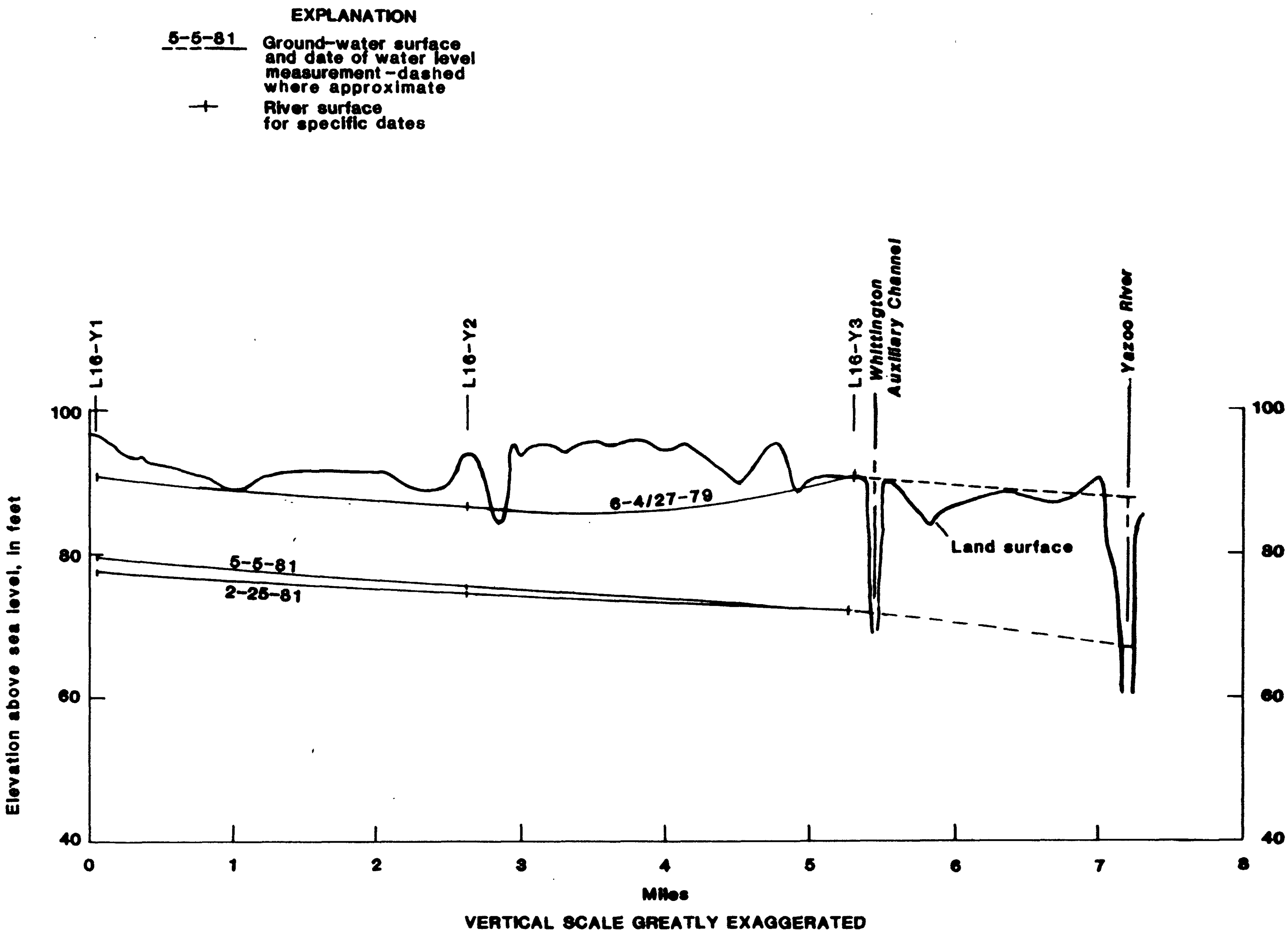


Figure 25.-- Water-level profiles from northwest to southeast along line 16.

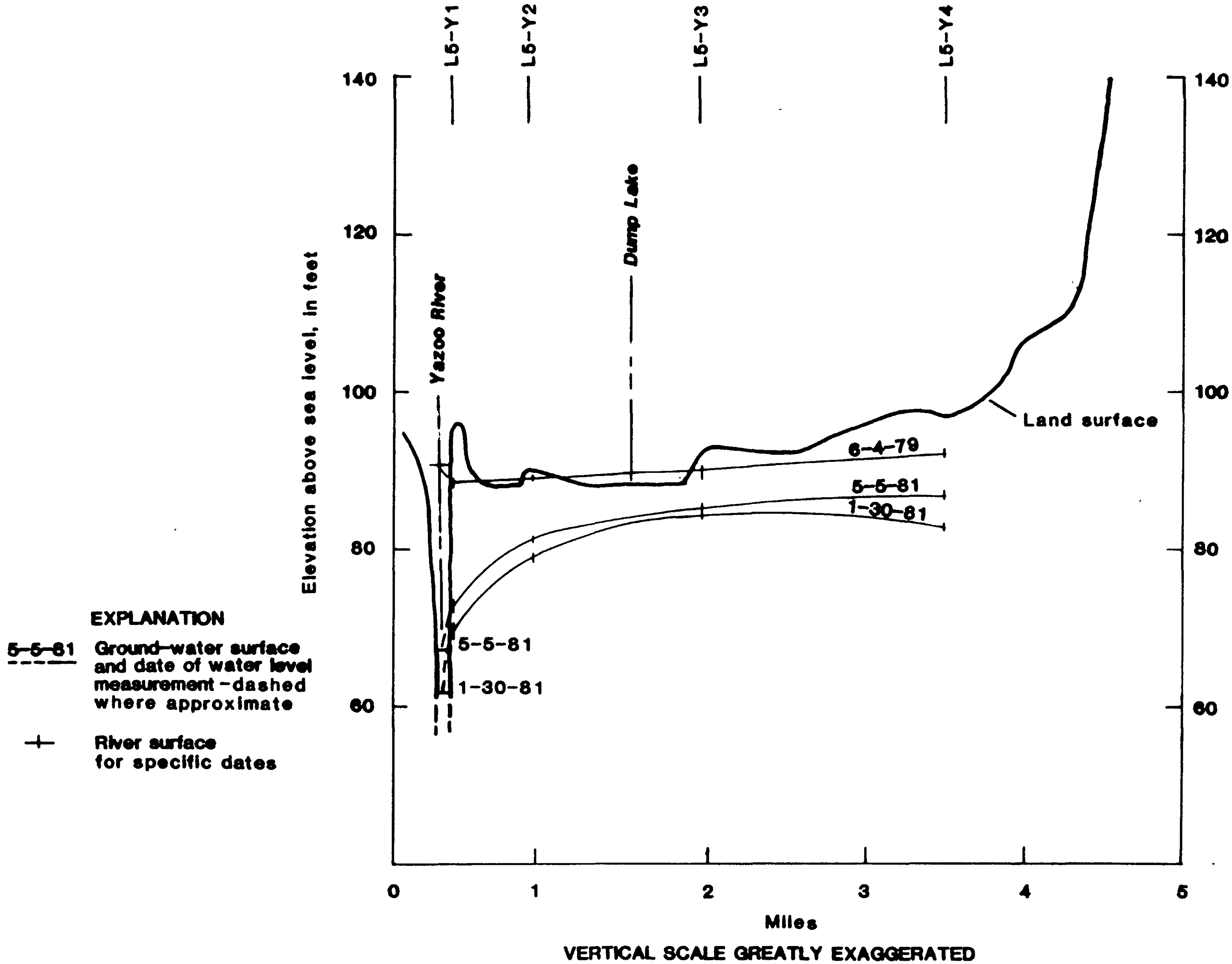


Figure 26.-- Water-level profiles from northwest to southeast along line 5.

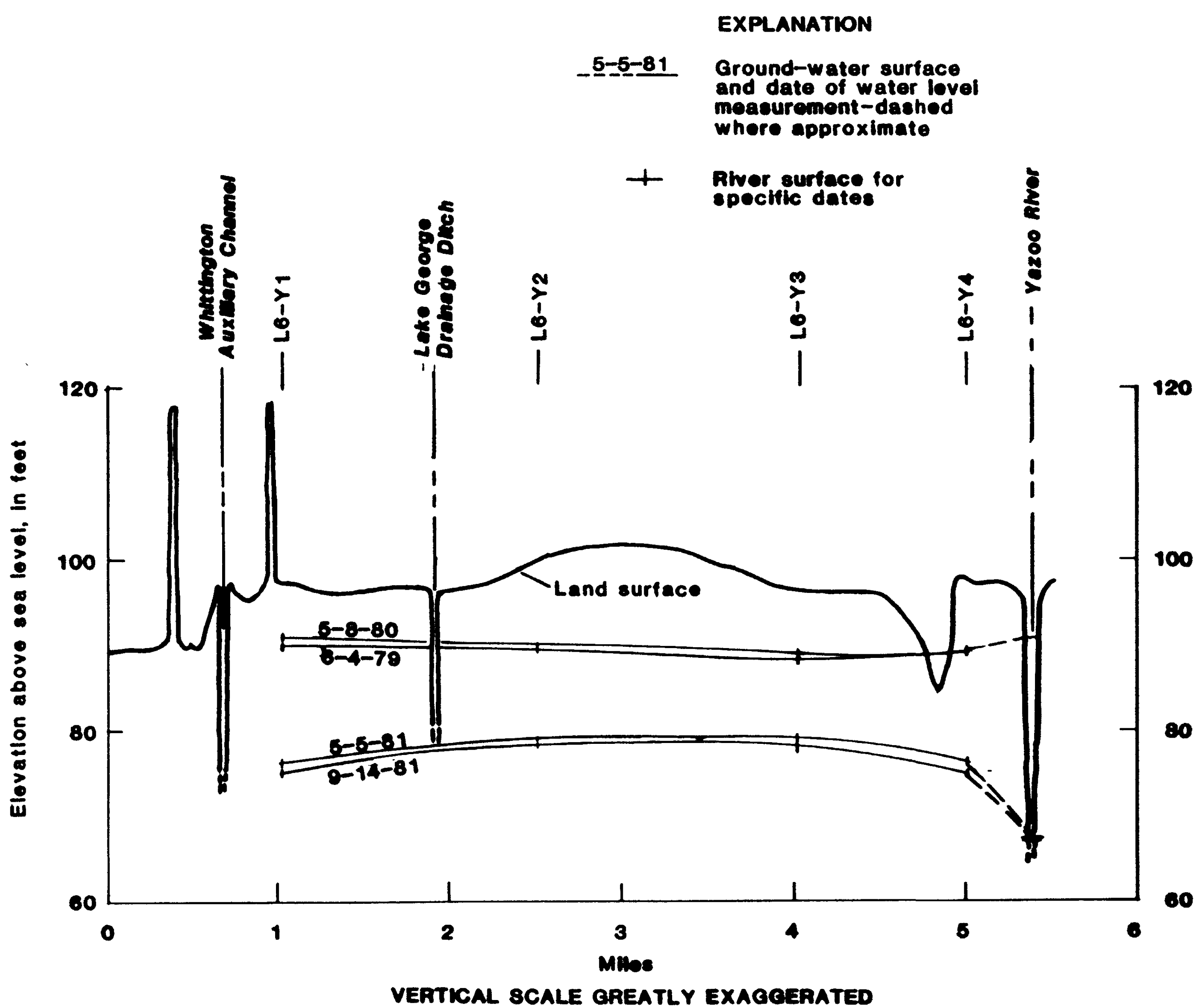
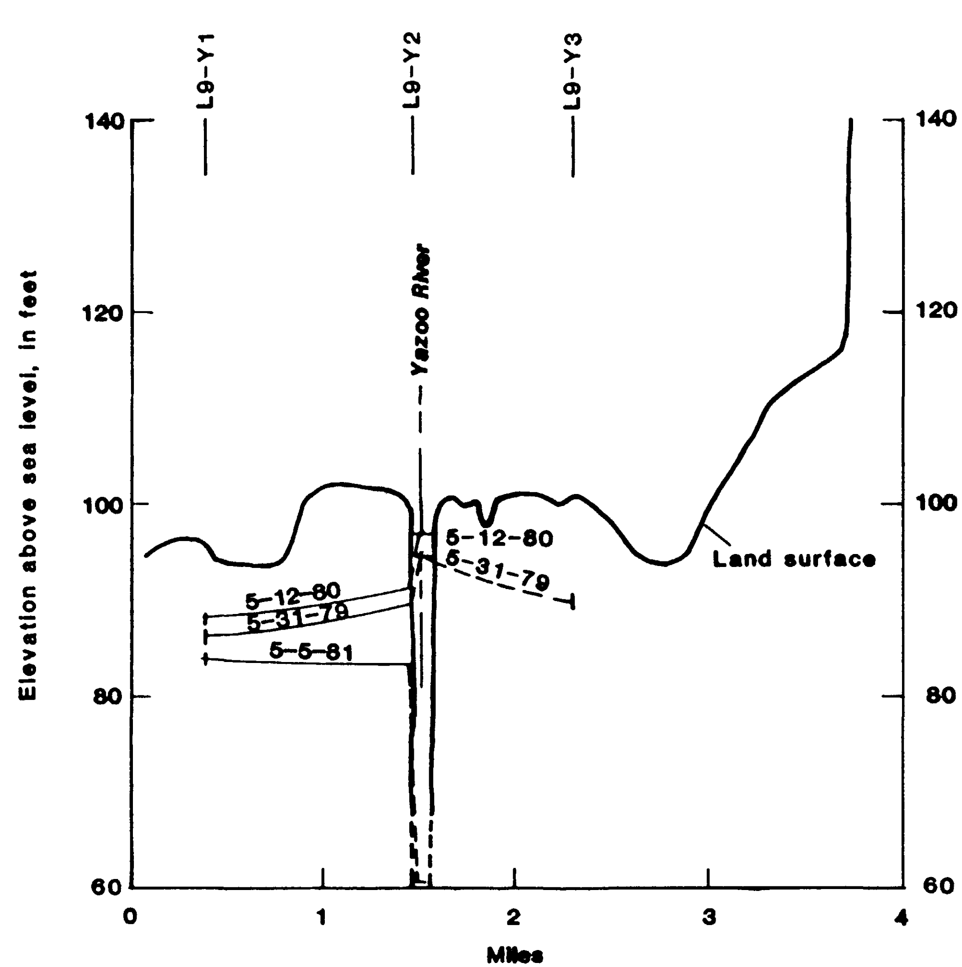


Figure 27.-- Water-level profiles from northwest to southeast along line 6.



VERTICAL SCALE GREATLY EXAGGERATED

EXPLANATION

5-5-81 — Ground-water surface and date of water level measurement - dashed where approximate

┴ — River surface for specific dates

Figure 28.-- Water-level profiles from northwest to southeast along line 9.

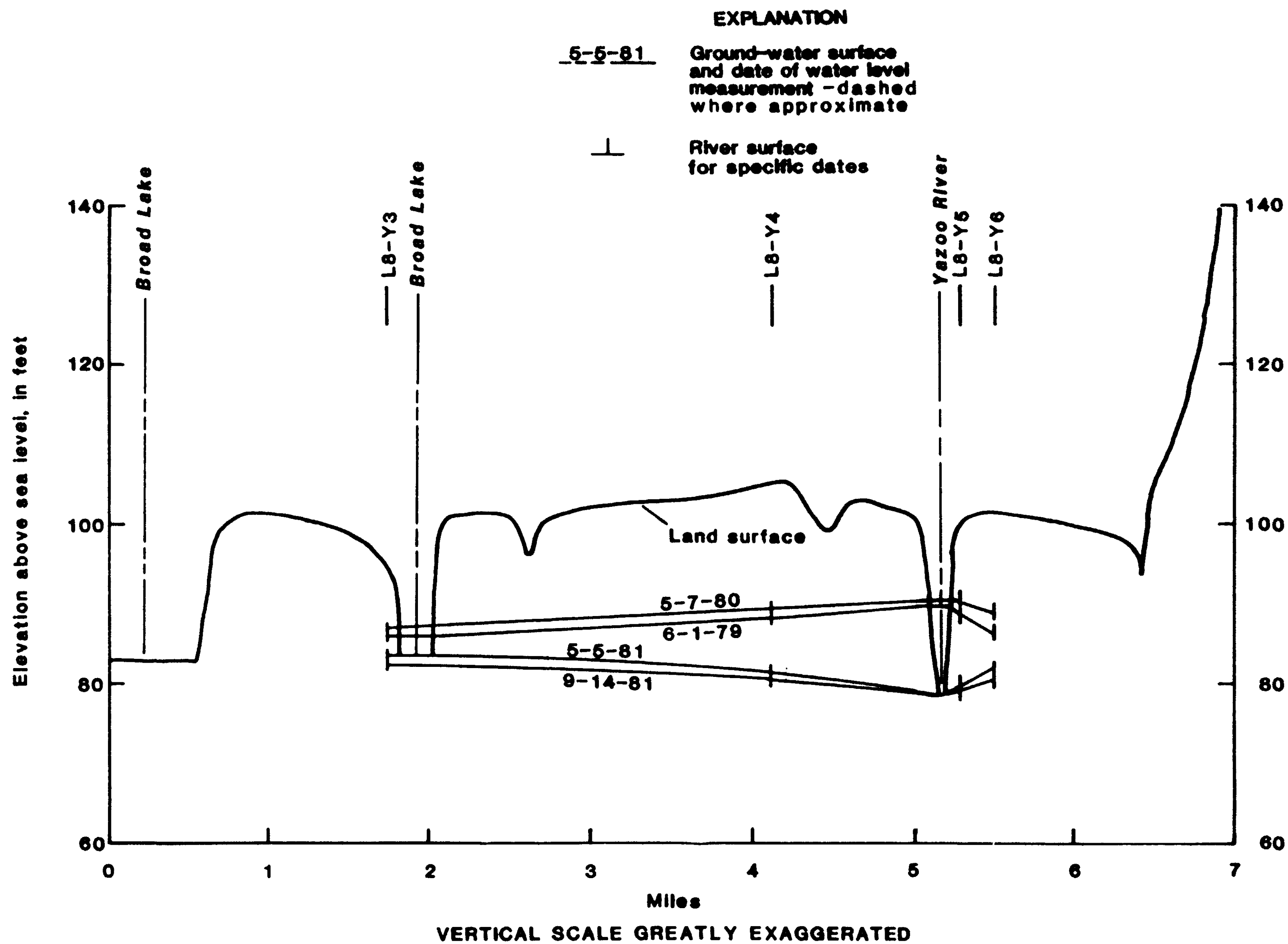


Figure 29.-- Water-level profiles from northwest to southeast along line 8.

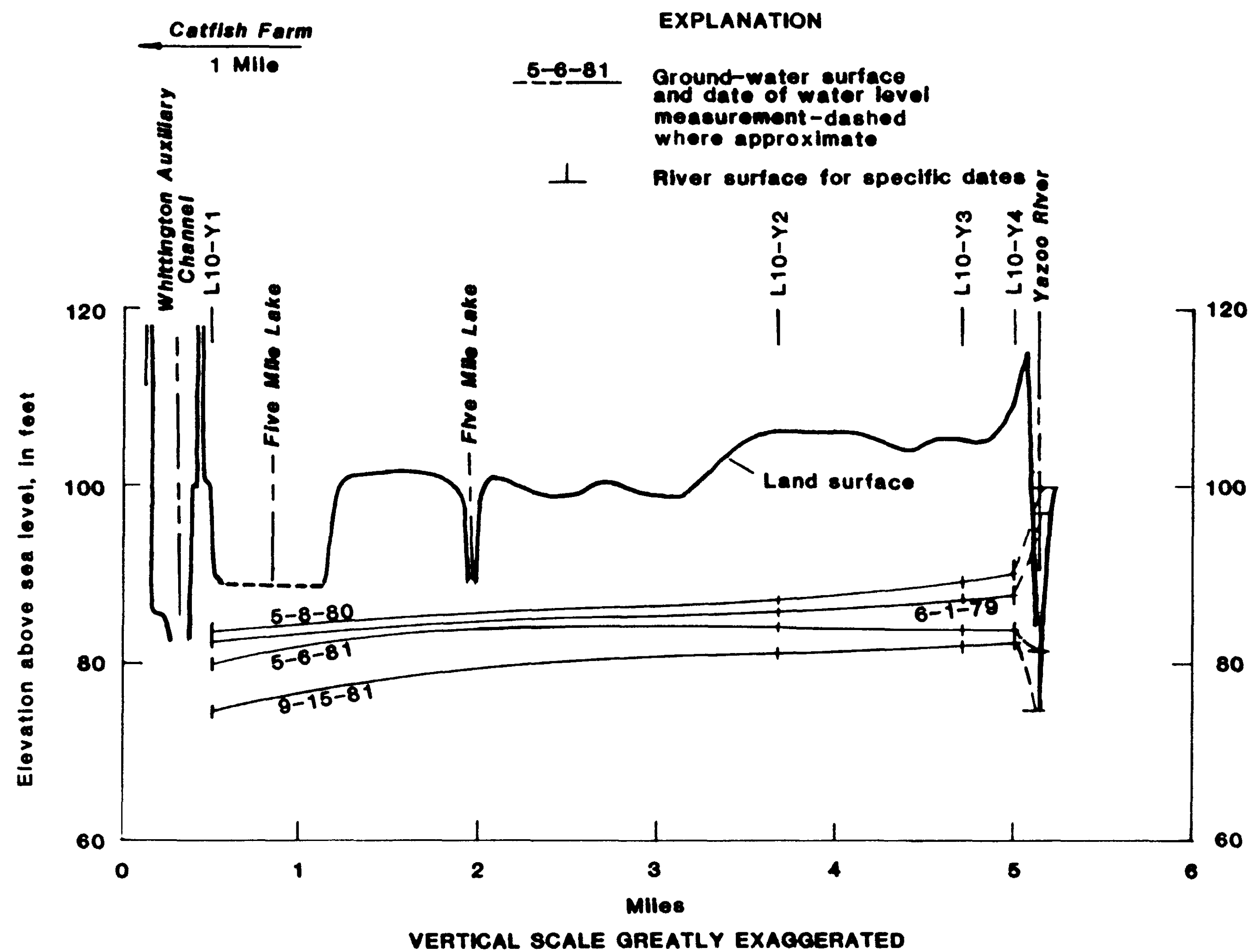


Figure 30.-- Water-level profiles from west to east along line 10.

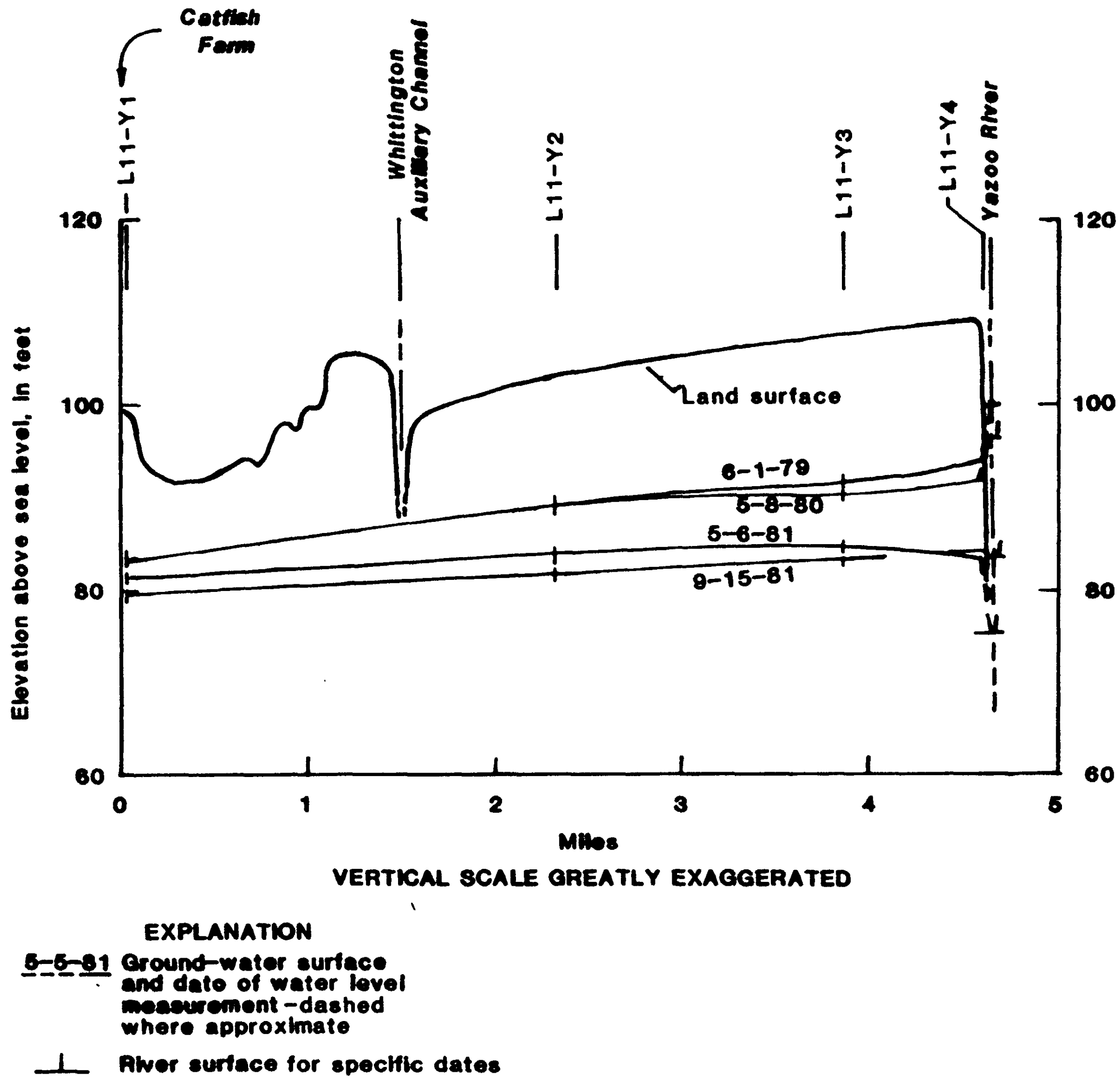


Figure 31.-- Water-level profiles from southwest to northeast along line 11.

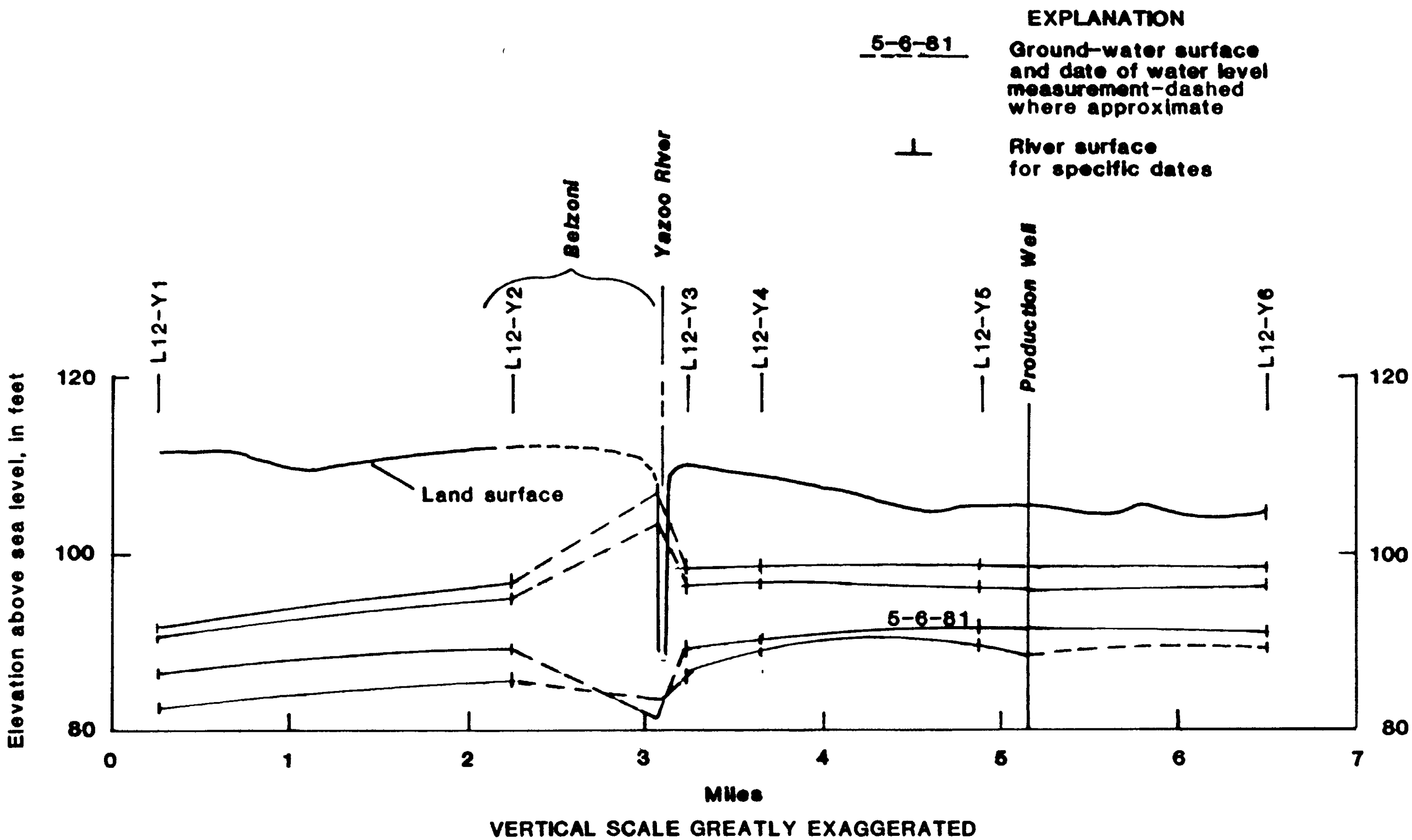


Figure 32.-- Water-level profiles from northwest to southeast along line 12.

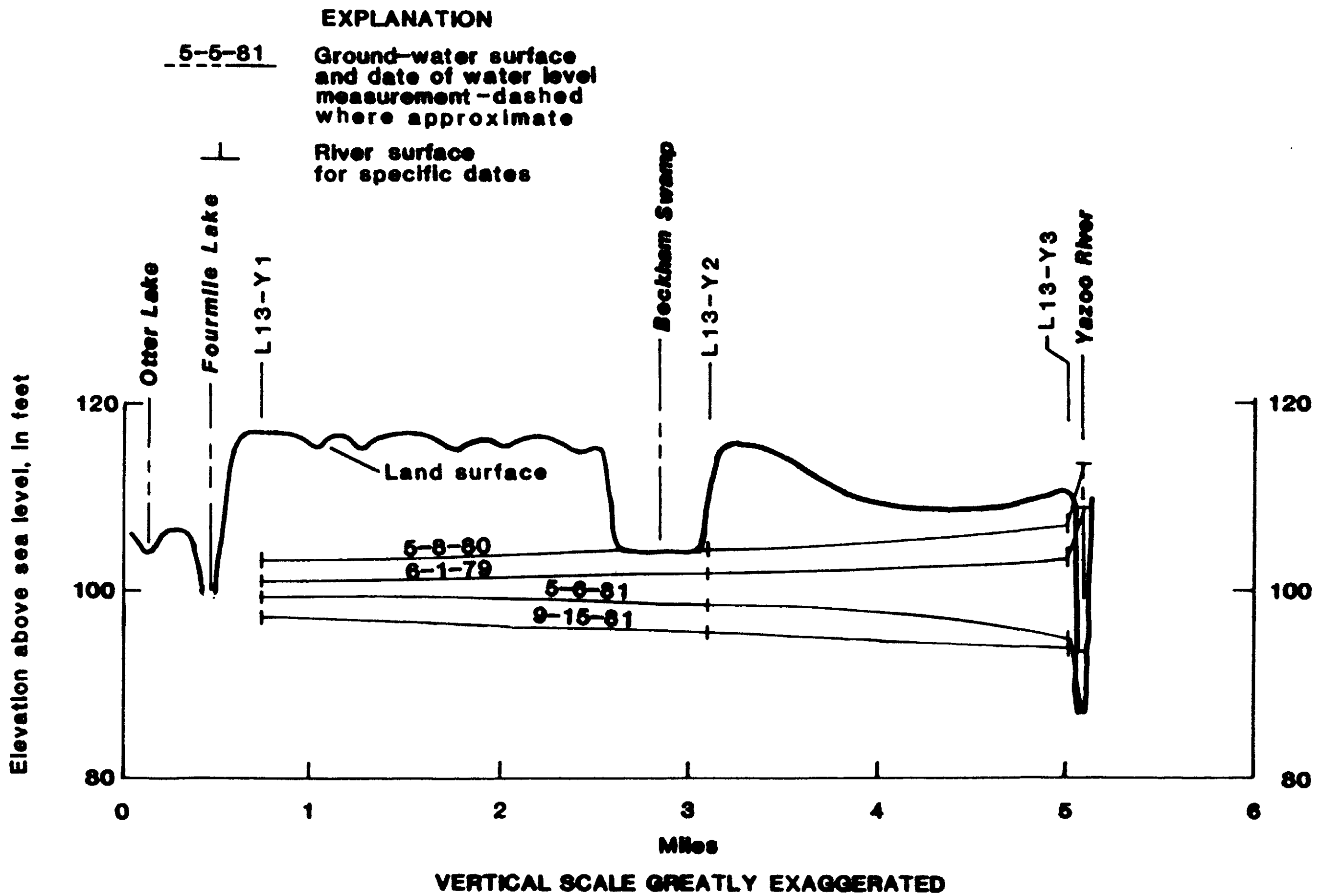


Figure 33.-- Water-level profiles from northwest to southeast along line 13.

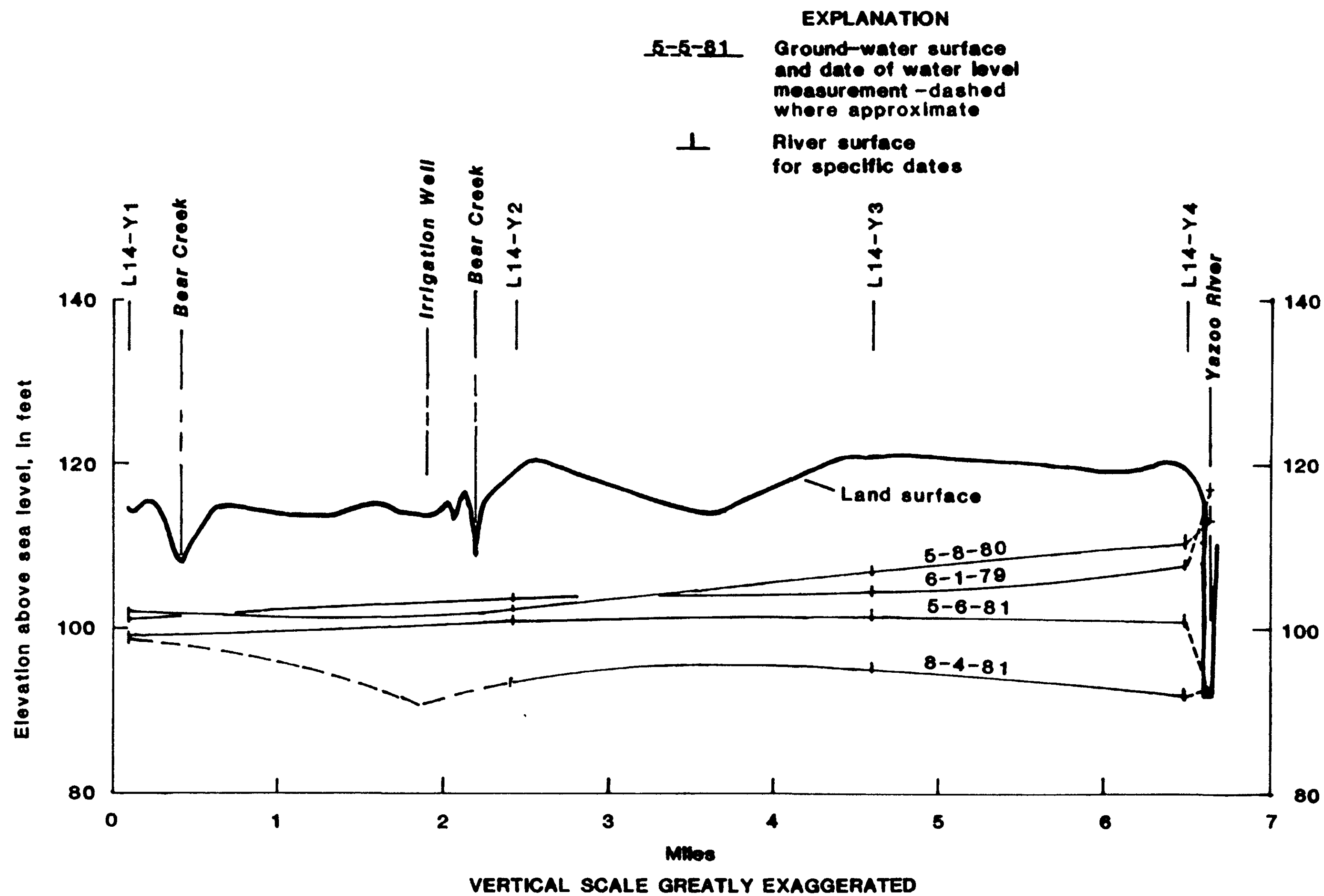


Figure 34.-- Water-level profiles from west to east along line 14.

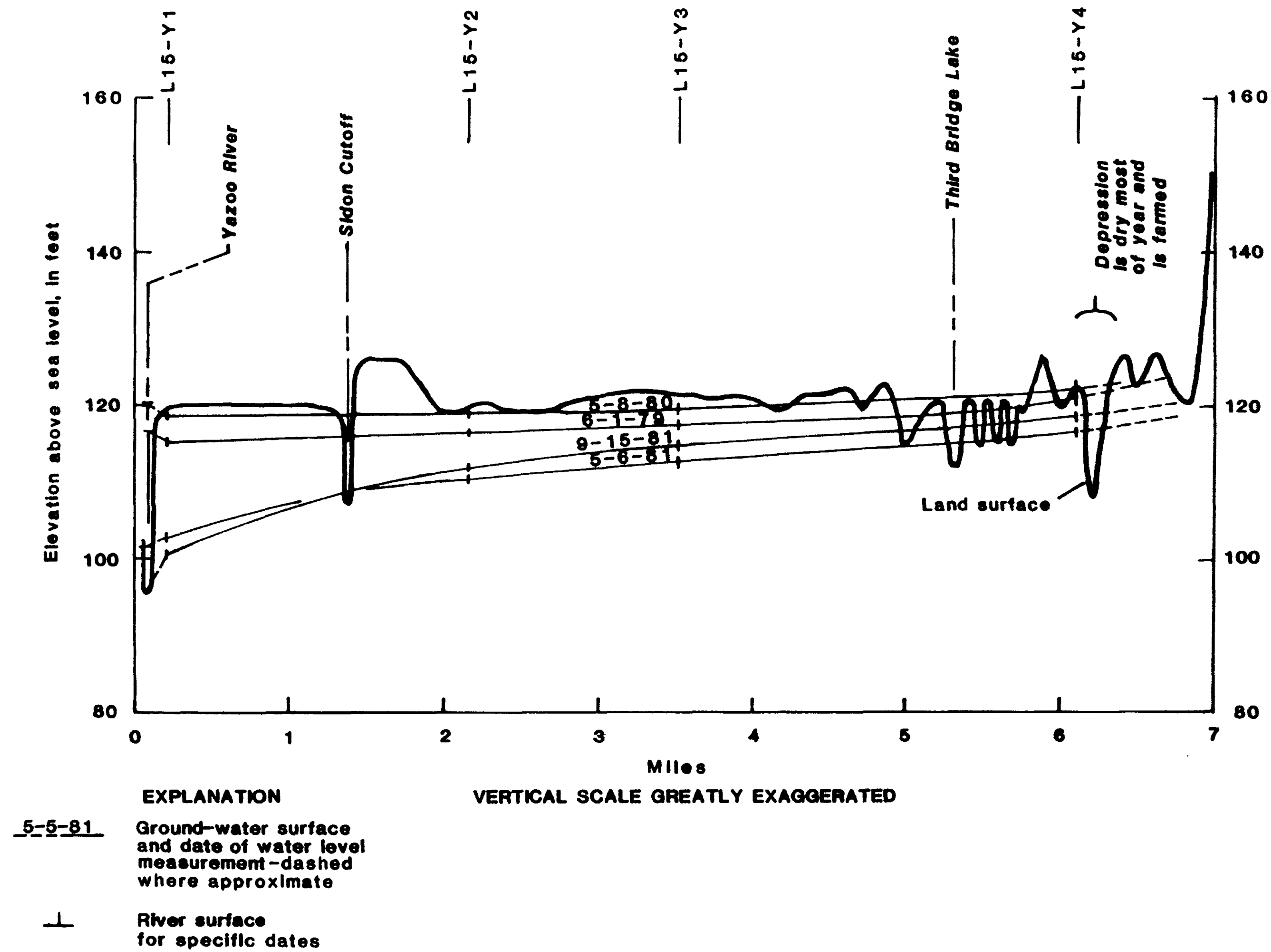


Figure 35.-- Water-level profiles from west to east along line 15.

Line 3 (fig. 23)--The Whittington Auxilary Channel is located just east of well L3-Y1. At all times there is a gradient away from the channel toward the Yazoo River. In this vicinity there may be an exchange of water from the channel to the river by ground-water flow. However, there is also indication of recharge to the aquifer from the bluff at the east end of the profile.

Line 4 (fig. 24)--This line extends from a flood-retention levee on the west, crosses the meandering Deer Creek several times, then crosses the Whittington Auxiliary Channel and ends at the Yazoo River. The profiles show that during wet seasons a ground-water mound develops beneath the meander belt of Deer Creek. During drier times, the ground-water mound decays to become a uniform slope from west to east. In June 1979 and June 1980, the area west of the levee was under several feet of water. However, recharge from Deer Creek maintained a water-level gradient toward the flooded area.

Line 16 (fig. 25)--This line extends across 5 miles of swampy land. Wells L16-Y2 and L16-Y3 were inaccesible during wet periods. Throughout most of the period of record, the ground-water gradient was from west to east toward the Whittington Auxiliary Channel and the Yazoo River. During June 1979, water-level measurements made over a 3-week period when streams were near flood stage, indicate a gradient reversal with water moving from the streams into the aquifer.

Line 5 (fig. 26)--This set of profiles is an example of ground-water recharge entering the alluvial aquifer from precipitation on the surface near the erosional bluff and from streams that enter from the bluff. Recharge from these sources is dominant most of the time but the profile for January 30, 1981, shows that under dry conditions Dump Lake is more dominant as a source of recharge. Throughout the period of record the gradient near the Yazoo River was toward the river.

Line 6 (fig. 27)--This line extends from the Whittington Auxiliary Channel across the Lake George drainage ditch to the Yazoo River. During periods of high stream levels, both the channel and the river recharge the aquifer. During periods of low stream levels, the channel and river become discharge outlets leaving a higher ground-water level between streams.

Line 9 (fig. 28)--The water-level profiles show that fluctuations in river stage are much larger than ground-water fluctuations and the water-level gradients near the river are very steep during periods of high and low stages. This indicates relatively poor hydraulic connection between the river and the aquifer. Well L9-Y3 was accidentally destroyed in May 1979.

Line 8 (fig. 29)--In the eastern half of the line, Broad Lake is in fair hydraulic connection with the aquifer and may act as a boundary to ground-water level change. Flow directions are away from the Yazoo River during periods of high stage, and are toward the river during periods of low stage. Because of the accidental destruction of well L8-Y2, flow patterns in the western half of the line are unknown.

Line 10 (fig. 30)--These profiles illustrate the relationship between the Yazoo River and the Whittington Auxiliary Channel, and the impact of ground-water withdrawal on water levels. A catfish farm located approximately 1 mile due west of the channel, requires substantial quantities of ground water. This withdrawal creates a cone of depression in the ground-water potentiometric surface and induces recharge from both the auxiliary channel and the Yazoo River. Except during extreme low-flow periods, all gradients are away from the river and toward the channel. During dry periods the gradient projects beneath the channel toward the cone of depression around the pumped wells at the catfish farm.

Line 11 (fig. 31)--This figure supports figure 30 in illustrating the impact of ground-water withdrawal on water levels in the alluvial aquifer. Water levels in well L11-Y1, located immediately adjacent to a catfish farm and approximately 200 feet from one of the supply wells, show that water-level gradient slopes from the Yazoo River, beneath the Whittington auxiliary channel, and toward the wells which supply water to the fish ponds. The steep gradients between the river and well L11-Y4 indicate poor hydraulic connection.

Line 12 (fig.32)--Profiles along this line show a fairly consistent gradient from southeast to northwest toward an area of large ground-water withdrawal. Much of the time, the Yazoo River receives ground-water discharge from the southeast and recharges the aquifer to the northwest. However, the very steep water-level gradients between the river and well L12-Y3 indicates poor hydraulic connection.

Line 13 (fig. 33)--The profiles in this figure show the varying degrees to which ground water is connected to surface-water bodies. Although, the steep water-level gradients between the river and well L13-Y3 indicate that the hydraulic connection between the river and the aquifer is not good, the water levels in well L13-Y3 and in the aquifer adjacent to the river are related to some extent to the river stage. The alluvial aquifer receives recharge during periods of high river stage and drains to the river during periods of low stage. In contrast, water levels in well L13-Y2, which is adjacent to Beckham Swamp, are unrelated to the relatively stable water surface of the swamp.

Line 14 (fig. 34)--Along this line, the lagging water-level responses to changing river stages are similar to those along line 13: a gradient toward the Yazoo River at times of low stage and away at times of high stage. The profile for August 4, 1981, shows a typical cone of depression centered on an irrigation well. Recharge induced by high river stages (usually during the winter) refills the depression and ground water is retained in storage until withdrawn by the well the following growing season or returned to the river as base flow at lower stages.

Line 15 (fig. 35)--These profiles, like those along lines 2 and 5, indicate almost continuous recharge to the alluvial aquifer in the area adjacent to the erosional bluff at the east margin of the alluvial valley. As the distance from the Yazoo River increases, fluctuations in water-levels decrease from nearly 20 feet near the river to about 6 feet near the valley wall. Near well L15-Y4, a land-surface depression is dry (and used as cropland) even though it lies below the ground-water potentiometric surface of the aquifer. The surfical clay in this depression is sufficiently low in permeability to prevent the vertical movement of ground water.

The water-level profiles demonstrate the complex combinations of factors which govern the direction of flow of ground water in the Mississippi River alluvial aquifer. The study area can, however, be divided into three areas based on the major factors which influence ground-water levels.

In the study area south of Belzoni (fig. 2) and west of the Yazoo River water levels are strongly influenced by water-surface elevations of the nearby Whittington Auxiliary Channel and the Mississippi River. Both the Mississippi River and the auxiliary channel act as boundaries to flow of ground-water to or from the Yazoo River; the effect of change in stage of the Yazoo River does not extend beyond either. Because the auxiliary channel usually has a lower water-surface elevation than the Yazoo River, the direction of ground-water flow is generally away from the river and toward the auxiliary channel.

The second area is between the Yazoo River and the erosional bluffs on the eastern edge of the alluvial valley. Recharge along the bluffs maintains a water-level gradient toward the river. At most locations the is head is high enough and recharge is large enough to maintain the gradient toward the river even during periods of high river stage. Water-level responses to changes in river stage are attenuated with increasing distance from the river. Whether or not this is a short-term response depends on several factors, including the magnitude of the recharge flux, the differences in head, the saturated thickness of the aquifer, the amount of increase in surface evapotranspiration due to higher water levels, and the hydraulic properties of the materials that comprise the bluffs.

The third area, which partly overlaps both the first and second, begins between Yazoo City and Belzoni and extends northward to Greenwood. It is characterized by extensive use of ground water for irrigation and catfish farming. The profiles for lines 10 to 15 show that most water which is withdrawn for these uses is ultimately derived from the river by induced recharge. Cones of depression in the ground-water potententiometric surface that center around areas of intensive pumping to the west of the Whittington Auxillary Channel appear to be the boundary controlling ground-water levels in the area of lines 10-11 whereas the Whittington Auxillary Channel or some other surface-water body is often the boundary in areas south of Yazoo City. This area also has several examples of (1) ground-water levels that are continuously higher than land surface without any apparent waterlogging, and (2) ground-water levels which fluctuate independently of surface swamps and lakes. This indicates that locally, clay soils may severely limit the exchange of water between the aquifer and surface drainage features. A comparison of the profiles in lines 10-15 with those of lines 1-9 and 16 also indicates that the hydraulic connection between the river and the aquifer is not as good in the north end of the study area as in the south end. Water-level gradients near the river are generally much steeper in the area of lines 10-15 than elsewhere.

DESCRIPTION OF THE PROPOSED NAVIGATION PROJECT

The Yazoo Navigation Project authorized by Congress in 1968 provides for a 160-mile channel 9 feet deep with a bottom width of 150 feet in the Yazoo River between Vicksburg and Greenwood. A lock and dam will be constructed a few miles above the mouth of the river at Vicksburg. The minimum pool elevation immediately upstream of the dam will be about 70 feet above sea level. With a minimum flow of about 3,000 ft^3/s, the elevation of the minimum stage in the channel at Greenwood, the upstream end of the project, would be about 96 feet above sea level (from base flow profiles furnished by Corps of Engineers).

The channel of the Yazoo River will be dredged to project dimensions and realigned by "cutoffs" through some of the sharp bends in the river channel. Except in the "cutoffs" and in a 20-mile reach just downstream of Greenwood, dredging would be primarily for channel widening as the depth of the Yazoo River currently exceeds 9 feet in much of the project area.

Current plans call for a minimum flow of 3,000 ft^3/s to be maintained in the navigation channel. In order to maintain this flow during low-flow periods (summer and fall) stored water would be released from Sardis, Enid, and Grenada Lakes in the headwaters of the Yazoo River basin. The storage requirement would be met by increasing the storage in Sardis Lake by 600,000 acre-ft (U.S. Corps of Engineers, oral commun., 1983).

EFFECTS OF PROPOSED NAVIGATION PROJECT ON THE STAGE OF THE YAZOO RIVER

Construction of the proposed lock and dam on the Yazoo River near Vicksburg and the release of water from storage to maintain a minimum flow of 3,000 ft^3/s at Greenwood would affect the flow and stage of the river during periods of low flow. Flow duration data furnished by the Corps of Engineers indicate that the flow of the Yazoo River at Greenwood and at Yazoo City currently exceeds 3,000 ft^3/s about 95 percent of the time. The release of additional water from storage to maintain a minimum flow of 3,000 ft^3/s would therefore be required about 5 percent of the time and would probably occur most frequently during September and October, the most common low-flow months. The water required to augment natural flows during periods of low flow would be stored during the flood season. The retention of these flood waters could therefore potentially result in a reduction of high flows during the flood season.

The proposed navigation project and the "Upper Yazoo Project" currently under construction will significantly impact the stages of the river in the area. The navigation pool above the dam will have a minimum pool elevation of 70 feet above sea level. At a flow of 3,000 ft^3/s the water surface of this pool will be relatively flat for a distance of about 50 miles upstream from the dam. From that point the water surface will slope gently upward to an elevation of about 75 feet above sea level at Yazoo City and about 96 feet above sea level at Greenwood (fig. 36).

At Redwood, a few miles upstream from the proposed dam, the minimum pool elevation would be 21 feet higher than the lowest river level observed during this investigation (49 feet above sea level in January 1981) and 26 feet higher than the record low stage. Stage-duration curves provided by the Corps of Engineers for both the completed navigation project and the baseline conditions (without the navigation pool but with the Upper Yazoo Project completed), indicate that with the navigation project completed, stages at Redwood would be higher than baseline conditions about 65 percent of the time (fig. 37). The navigation pool would be more than 10 feet higher about 40 percent of the time and more than 20 feet higher about 10 percent of the time.

At Yazoo City the minimum stage after the completion of the navigation project and the Upper Yazoo project will be about 3 feet higher than the lowest stage observed during this investigation and about 6 feet higher than the record low stage. Duration data provided by the Corps of Engineers indicate that with the navigation pool completed, stages of the river at Yazoo City would be higher than baseline conditions (without the navigation pool but with the Upper Yazoo Project completed) about 10 percent of the time (fig. 38). The maximum increase in stage over baseline conditions would be about 2 feet.

In much of the reach between Yazoo City and Greenwood the river stage will not be be affected by the navigation pool but will be significantly affected by the Upper Yazoo Project now under construction. When the channel dredging and widening are completed, river stages in this reach will be significantly lower than pre-project stages throughout the range of discharge. The largest decrease in stage would occur in that part of the reach nearest Greenwood where the channel will be deepened as well as widened. The reduction in stage will be smaller in the lower part of the reach (near Yazoo City) where channel modifications will consist largely of widening. The reduction in stage in the reach just upstream of Yazoo City will also be partially offset by the small increases in stage due to the navigation pool.

Stage-discharge relations provided by the Corps of Engineers indicate that at Greenwood the Upper Yazoo Project will reduce river stages by about 7 feet at a flow of 3,000 ft^3/s (fig. 39). At greater flows the reduction in stages will be smaller. At a discharge of 40,000 ft^3/s the reduction in stage will be less than 2 feet.

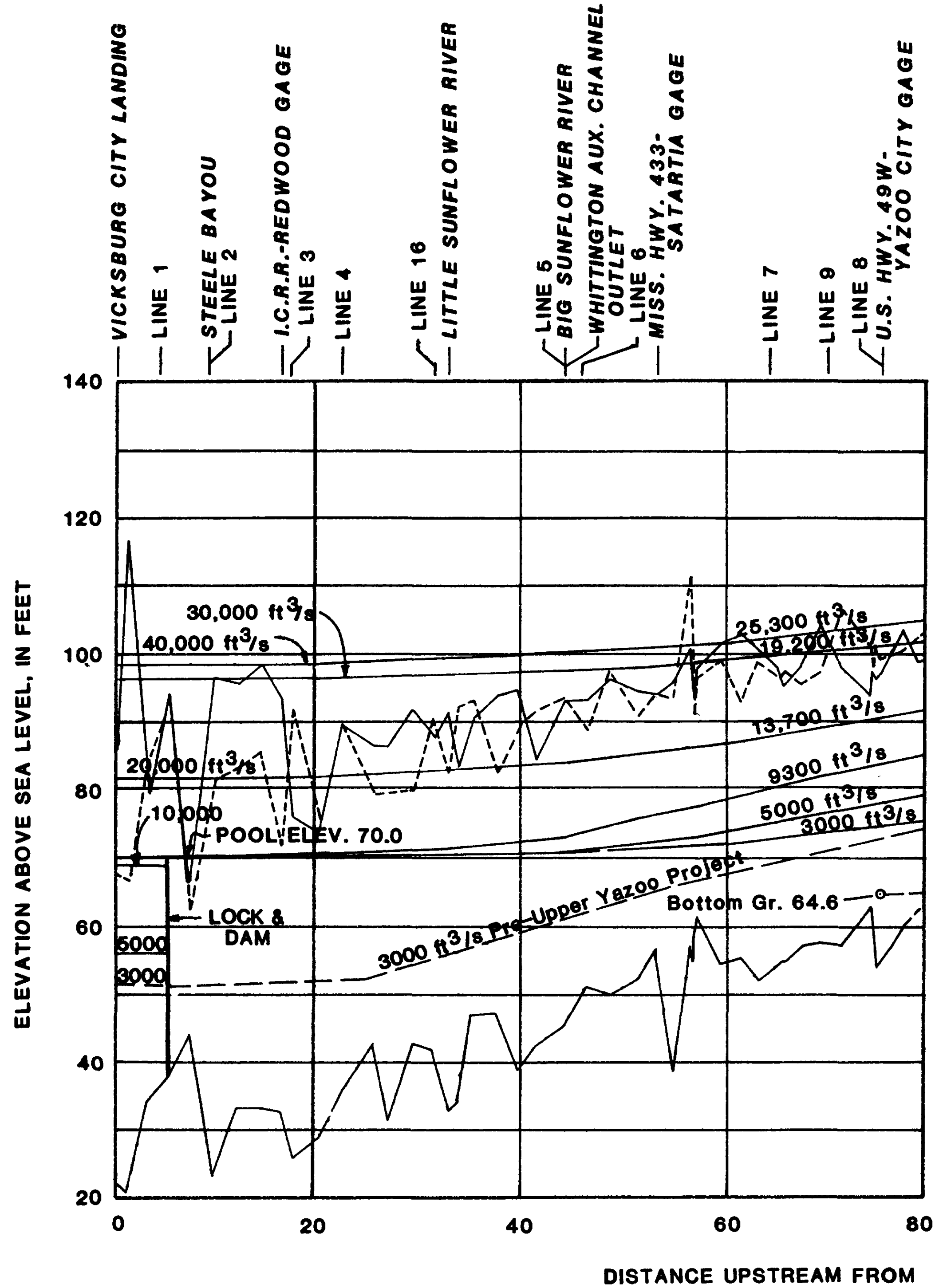
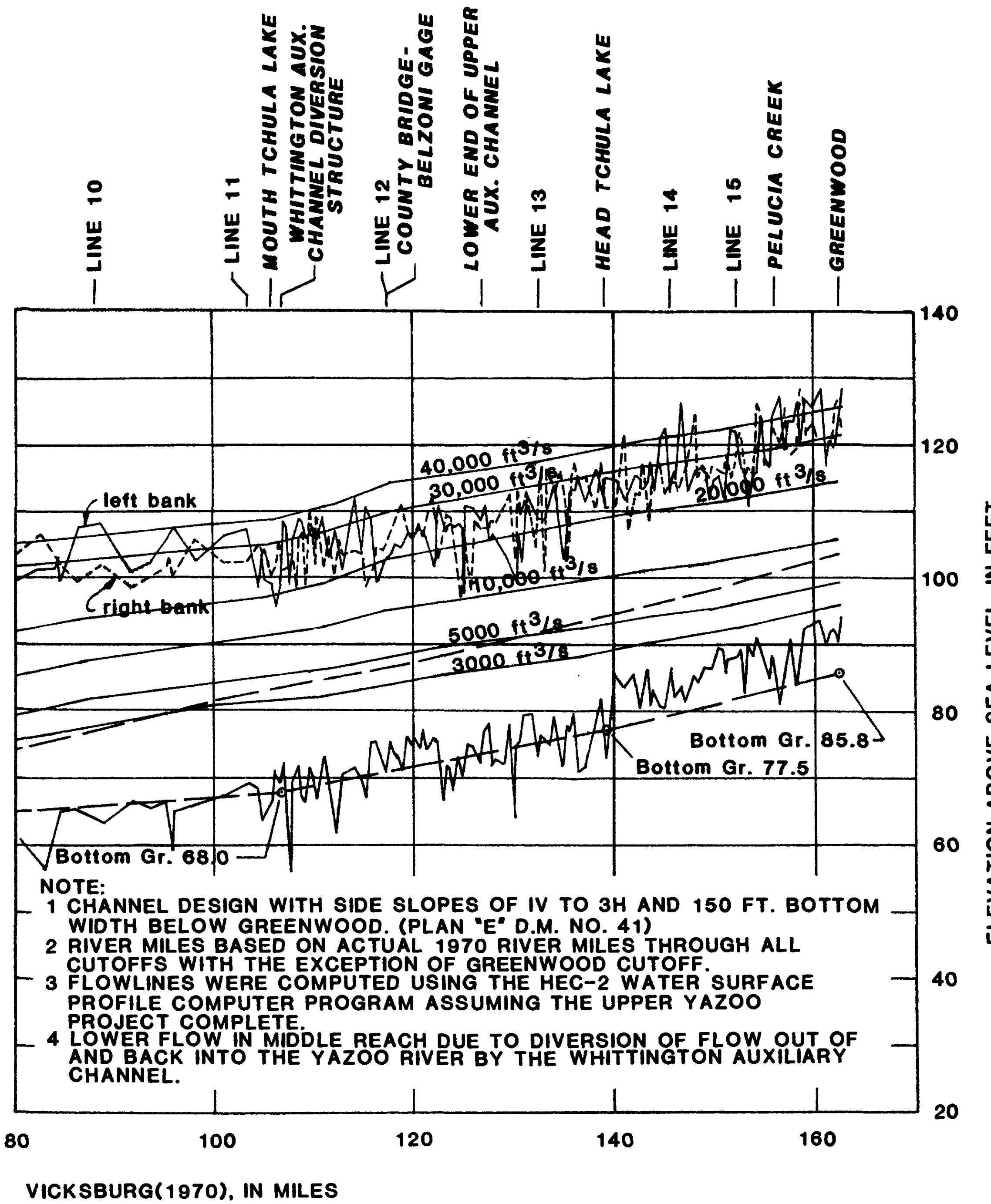


Figure 36.--Projected flow profiles for the Yazoo
(Modified from data provided by U.S.



River after completion of the navigation improvements. Army Corps of Engineers, Vicksburg District)

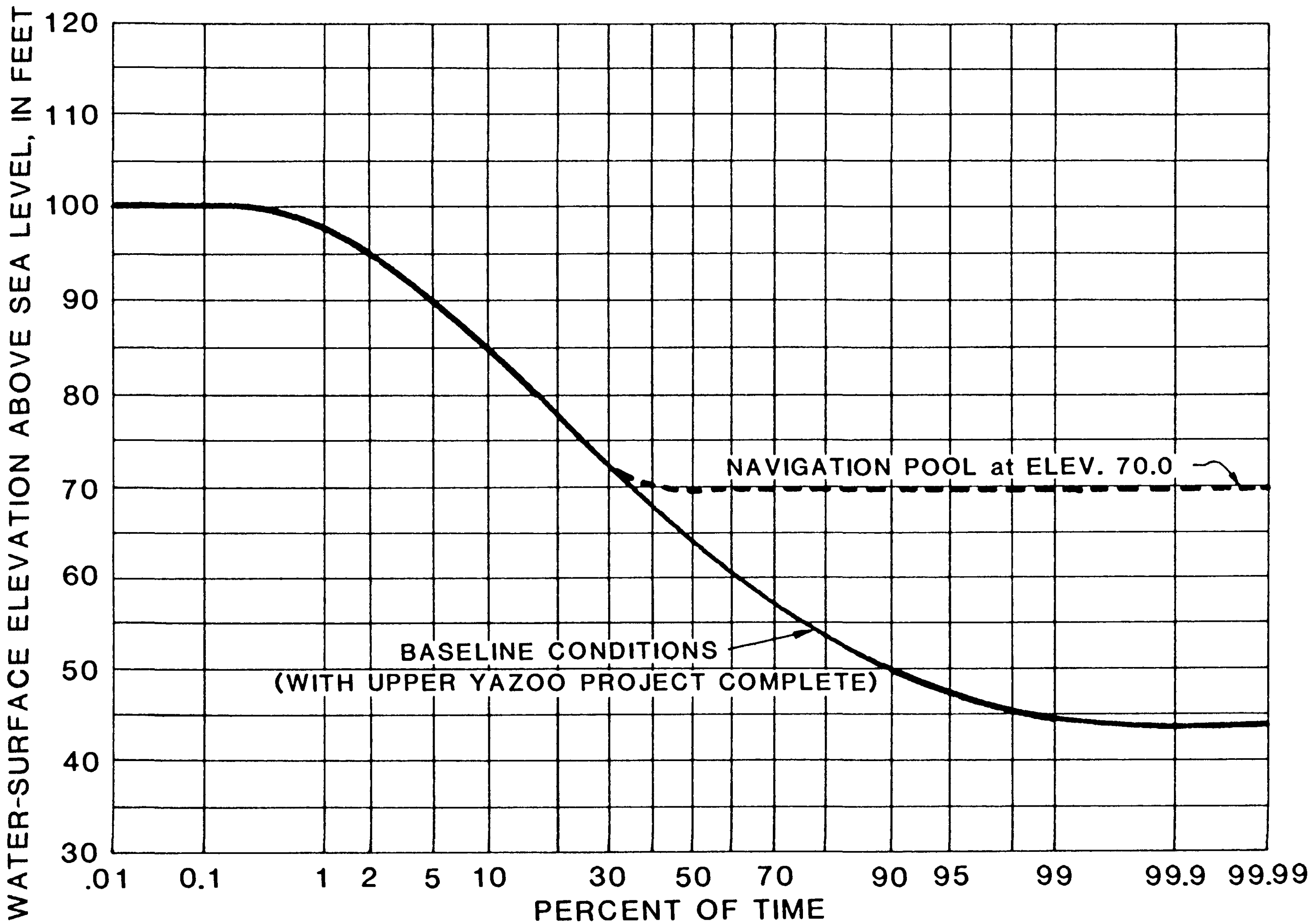


Figure 37.--Stage-duration curves for Yazoo River at Redwood, Mississippi with and without navigation pool. (From U.S. Corps of Engineers, Vicksburg District.)

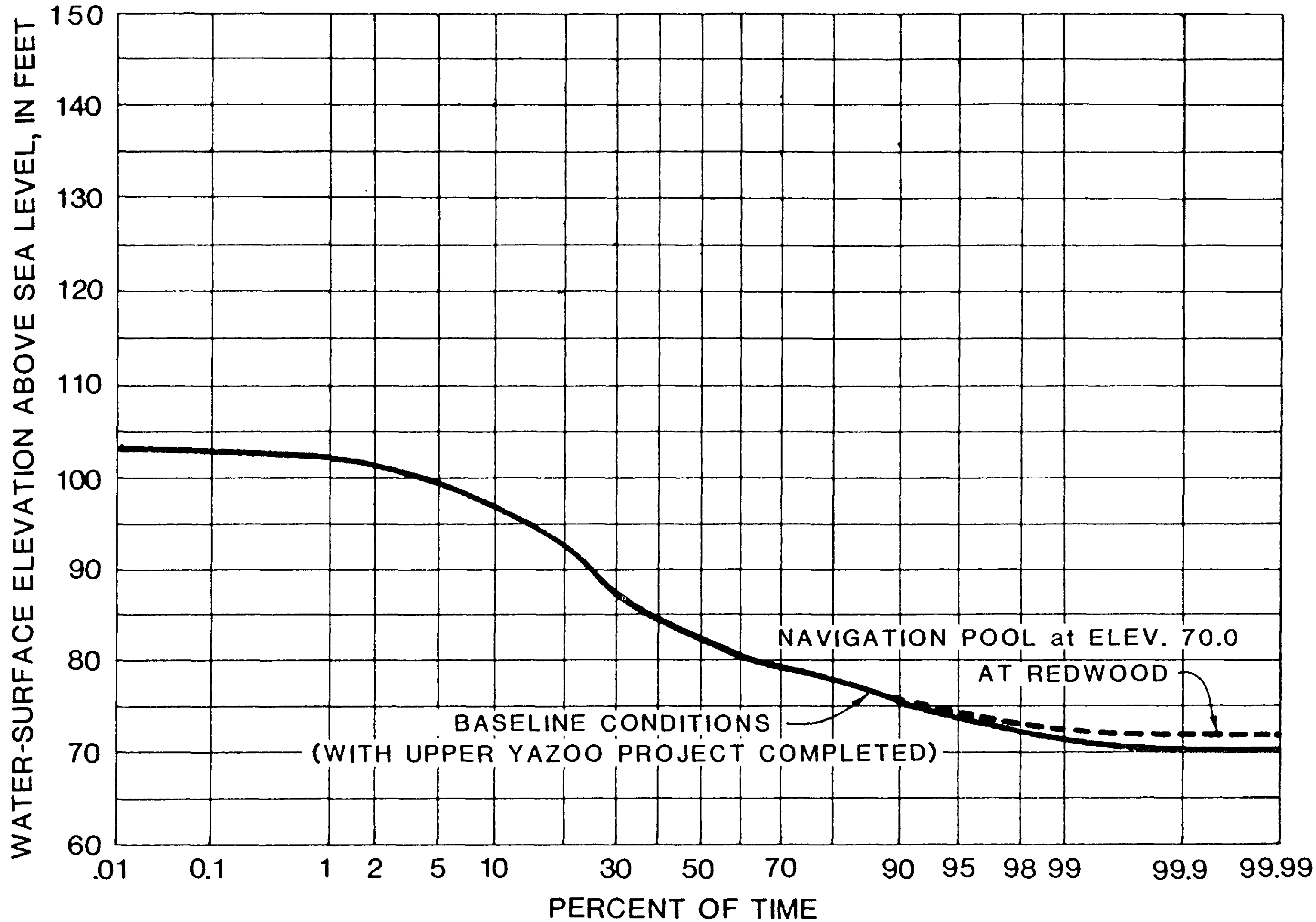


Figure 38.--Stage duration curves for Yazoo River at Yazoo City, Mississippi, with and without navigation pool. (From U.S. Army Corps of Engineers, Vicksburg District.)

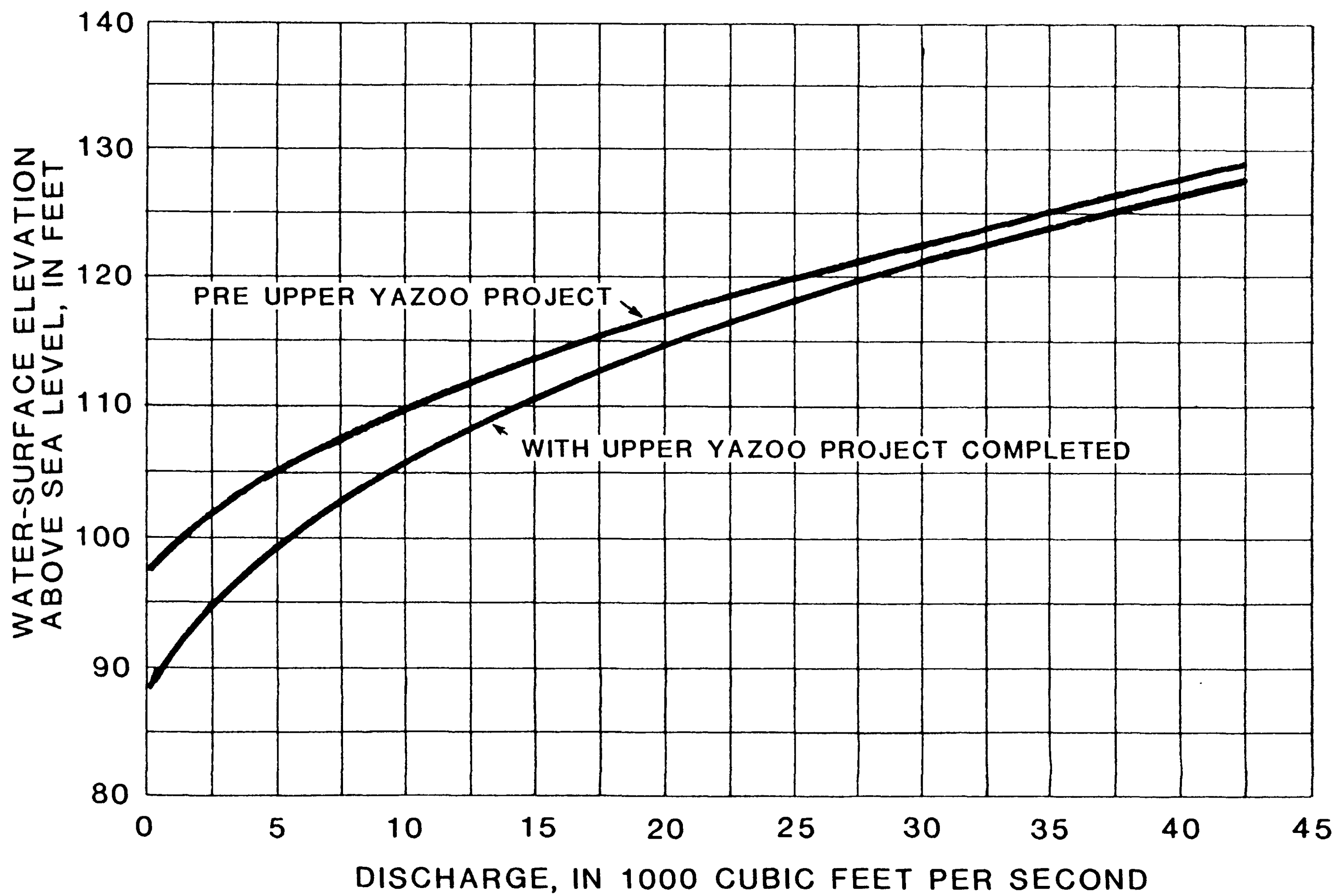


Figure 39.--Stage-discharge relations for Yazoo River at Greenwood, Mississippi, with and without Upper Yazoo Project. (From U.S. Army Corps of Engineers, Vicksburg District.)

The completion of the Upper Yazoo and the navigation projects will result in significantly higher stages in the area of navigation pool during a part of the year and lower stages throughout the year in most of the reach between Yazoo City and Greenwood. An analysis of flow profiles and other data provided by the Corps of Engineers, indicate that at a discharge of 3,000 ft^3/s, differences between post-project and pre-project river stages range from about a 19-foot increase in the vicinity of observation well line 1 to zero near line 10 just north of Yazoo City to a 7-foot decrease at Greenwood. Changes in river stages in the vicinity of each line of observation wells and at the three principal gages are given in table 1.

EFFECTS OF PROPOSED NAVIGATION PROJECT ON GROUND-WATER LEVELS

Ground-water levels in the alluvial aquifer adjacent to the Yazoo River will be affected by the Upper Yazoo and Navigation projects throughout much of the project area because of increased recharge to or drainage from the aquifer. In the southern part of the project area ground-water levels will be higher for at least part of the year because of the proposed navigation pool. In the northern part of the project area, ground-water levels will be lower throughout the year as a result of lower river stages and better hydraulic connection in new channels or cutoffs following completion of the Upper Yazoo Project.

The greatest impact on ground-water levels will occur near the proposed lock and dam where the increases in minimum river stage will be largest and where river stages will be above pre-project conditions for a larger percent of the time. A discussion of anticipated changes in ground-water levels in the vicinity of observation well lines follows.

Line 1 -- Ground-water levels very near the Yazoo River will reflect and respond to changes in river stages and therefore should not fall below the elevation of the navigation pool (70 feet above sea level) or about 20-25 feet below land surface. High ground-water levels within about 10 feet of land surface similar to those measured in May 1979 (fig. 21) will occur during periods of high stages on the Yazoo and Mississippi Rivers. As the stages of these streams fall, ground water will drain to the streams leaving a higher ground-water level in the alluvium between the streams. Ground water will drain toward both streams until the water-surface elevation reaches the elevation of the navigation pool. Further drainage will be toward the Mississippi River. The hydrograph for well L1-Y2 (fig. 4) shows that the lowest ground-water level at this site during this investigation was about 4 feet lower than the proposed pool level. At extreme low stages on the Mississippi River the ground-water surface could slope from the Yazoo River to the Mississippi River but the slope would be relatively flat for 2 to 3 miles from the Yazoo River. During low flow the elevation of the navigation pool will be about 19 feet higher than the pre-project elevation (table 1). The changes in ground-water levels due to the construction of the navigation pool theoretically would range from 19 feet near the River to zero at the aquifer boundary which in this

Table 1.--Estimated water-surface elevations along the Yazoo River at a discharge of 3,000 cubic feet per second before and after completion of the Upper Yazoo and Navigation Projects

[based on data provided by the U.S. Army Corps of Engineers, Vicksburg District]

	Approximate water-surface elevation in feet above sea level		
Location	Before Upper Yazoo and navigation projects	After Upper Yazoo and navigation projects*	Change in water-surface elevation in feet
Line 1	51	70	+19
Line 2	52	70	+18
Redwood Gage	52	70	+18
Line 3	52	70	+18
Line 4	53	70	+17
Line 16	56	70	+14
Line 5	61	71	+10
Line 6	62	71	+9
Line 7	70	73	+3
Line 9	71	74	+3
Yazoo City Gage	73	75	+2
Line 8	73	75	+2
Line 10	78	78	0
Line 11	83	81	-2
Line 12	87	84	-3
Line 13	92	88	-4
Line 14	97	91	-6
Line 15	99	93	-6
Greenwood Gage	103	96	-7

* with pool elevation at 70 ft above sea level.

case is the Mississippi River about 5 miles to the west. Midway between the Yazoo and Mississippi Rivers the change in ground-water levels would be half that or about 10 feet. Although theoretical ground-water level changes of 19 feet near the Yazoo River and about 10 feet at a distance of about 2.5 miles from the river may be considered to be relatively large, these changes are theoretical maximum changes based on heads that would exist for only about 10 percent of the time. Ground-water level changes due to the navigation pool would be smaller much of the time.

Line 2 -- East of the Yazoo River ground-water levels naturally occur at or very near land surface during high water periods and generally slope from the valley wall west toward the river during periods of low flow (fig. 22). The navigation pool would result in somewhat higher ground-water levels during that part of the year when the stage of the Yazoo River would normally be below an elevation of 70 feet above sea level (about 65 percent of the time). During that period, the navigation pool would reduce the drainage of ground water from the alluvium by reducing the gradient. Theoretical maximum change in ground-water levels would be about 18 feet near the Yazoo River (table 1). Minimum observed water levels in well L2-Y4 near the valley wall (fig. 22) indicate that with the navigation pool in place the lowest ground-water levels would slope from an elevation of about 75 feet above sea level near the valley wall to 70 feet above sea level at the navigation pool. Thus, the lowest ground-water levels with the navigation pool in place would be 15 to 20 feet below land surface. Ground-water levels would be higher throughout much of the year and would be at or near land surface during periods of high river stages but the impact of the navigation pool on ground-water levels would decrease as the stage of the river increases.

Line 3 -- Ground-water profiles in figure 23 indicate that water generally moves toward the Yazoo River from the area of the Whittington Auxillary Channel about 1 mile to the west of the river. The effect of maintaining a navigation pool at 70 feet above sea level would be to reverse the gradient and induce water to move from the Yazoo River toward the auxillary channel during periods of low stage. On the east side of the river, a bayou near the valley wall less than one mile from the river acts as a drain during periods of low stages. With the navigation pool in place, the ground-water table would slope downward from pool elevation to the elevation of the water surface in the bayou. The minimum water level observed in well L2-Y4 (fig. 7) near the bayou indicates that the slope of the ground-water surface would be relatively flat at low stages. The lowest ground-water levels with the navigation pool in place would be between 15 and 20 feet below land surface in the alluvium on either side of the river. Ground-water levels during periods of high flow would be near land surface similar to those measured in June 1979.

Line 4 -- Ground-water profiles in figure 24 indicate that during periods of low flow ground water generally moves from an area of high water levels near well L4-Y1 to the east toward the Whittington Auxillary Channel and the Yazoo River. Well L4-Y1 is about midway between the auxillary channel and the Sunflower River (not shown) about 4 miles to the west. During low-flow periods both of these streams act as drains, leaving an area of high levels near L4-Y1. Maintaining a navigation pool at 70 feet above sea level would reverse the direction of flow between the Yazoo River and the auxillary channel during low flow periods and water would move from the river toward the channel about 1 mile to the west. Ground-water levels west of the auxillary channel probably would not be affected. Between the auxillary channel and the river, minimum ground-water levels would reflect the stages in the navigation pool or the auxillary channel. During low-flow periods the effects of the navigation pool would include ground-water level increases, ranging from about 17 feet near the navigation pool to near zero at the auxillary channel. Minimum ground-water levels near the navigation pool would be about 15 feet below land surface, similar to those measured in May 1981. During periods of high flow the navigation pool would not appreciably affect ground-water levels and water levels would be very near land surface similar to those measured in June 1979.

Line 16-- As with line 4, the impact of maintaining a navigation pool at elevation 70 feet above sea level (about 14 feet higher than pre-construction stages at a discharge of 3,000 ft^3/s) would not extend beyond the auxillary channel about 1.7 miles to the west of the river (fig. 25). The water levels measured in well L16-Y3 in February and May 1981 (fig. 20) indicate that during periods of low flow the ground-water level between the river and the auxillary channel should be relatively flat and near the elevation of the navigation pool (70 feet above sea level). This would be 15 to 20 feet below land surface. Ground-water levels would not be affected significantly during periods of high flow by the navigation project but would be at or near land surface similar to those measured in 1979.

Line 5 - Ground-water profiles in figure 26 indicate that ground-water levels sloped from the base of the Bluff Hills to the Yazoo River throughout this investigation. Although the navigation pool would be about 10 feet higher than low-flow stages experienced during this investigation (table 1), ground-water levels east of the river would be affected by the navigation pool only very near the river. During this investigation the lowest water level measured in well L5-Y1 which is adjacent to the river was 2 feet lower than the elevation of the proposed navigation pool (fig. 8). Minimum water levels in wells east of the river would not have an elevation of less than 70 feet above sea level with the navigation pool in place; however, the steep slope of the ground-water surface near the river and the relatively flat slope at distances of more than a mile from the river indicate that the effects of the navigation pool would extend less than 1 mile from the river.

Line 6 -- Ground-water profiles in figure 27 indicate that during periods of low flow, when the level of the navigation pool would be about 9 feet higher than stages now experienced, the Yazoo River and the auxillary channel would act as drains, leaving an area of high ground-water levels between the streams. Maintaining a navigation pool at an elevation of 70 feet above sea level would flatten the potentiometric surface near the river but would not reverse the direction of movement. Minimum ground-water levels with the navigation project completed would be no more than a few feet higher than those measured in May and September 1981 when the stage of the river was only a few feet below the level of the proposed navigation pool. In this case, minimum ground-water levels would be about 20 feet below land surface. Ground-water levels during periods of high flow would not be appreciably affected and should be similar to those measured in June 1979 and May 1980.

Lines 8 and 9--In the vicinity of lines 8 and 9 the completion of the navigation project would result in slightly higher stages in the Yazoo River during the low-flow season. Table 1 indicates that for a discharge of 3,000 ft^3/s the post-project water surface would be about 2 or 3 feet higher than the pre-project level. Ground-water levels should not be significantly different from those shown in figure 28 and 29. The direction of movement of ground water during periods of low flow will remain toward the river from the recharge area at the base of the Bluff Hills and from the area of high ground-water levels between the river and the auxillary channel to the west.

Lines 10, 11, and 12 --In the vicinity of lines 10, 11, and 12, the increase in stage that would result from the higher minimum flows specified for in the navigation project would be largely offset by the reduction in stage that will result from the channel work underway in the Upper Yazoo Project. At a discharge of 3,000 ft^3/s, post-navigation project stages will be essentially the same as pre-project stages at that discharge at line 10 and 2 to 3 feet lower at lines 11 and 12 (table 1). During periods of low flow the discharge of the river is occasionally less than 3,000 ft^3/s and the stages at lines 10, 11, and 12, are lower than the minimum stages proposed for the navigation project. The minimum stage with the navigation project completed would be at an elevation of about 78 feet above sea level at line 10, 81 feet above sea level at line 11, and 84 feet above sea level at line 12. The lowest stage of the river observed at these sites during this investigation were 3 to 4 feet lower. The navigation project would result in stages that would, on occasion, be several feet higher than pre-project stages and would increase ground-water levels slightly during those periods. Because the impact of the project on the stage is an increase of only a few feet during brief periods of low flow, the impact on ground-water levels should not be significant in this reach.

Minimum ground-water levels with the proposed navigation project in place should be similar to those measured in September 1981. Ground-water levels would generally slope from the river toward the cone of depression caused by irrigation pumping to the west of the auxillary channel.

Lines 13, 14, and 15--In the vicinity of lines 13, 14, and 15, the completion of the channel improvements in the Upper Yazoo Project will substantially reduce stages in the river for a given discharge. Data provided by the Vicksburg District Corps of Engineers indicate that the stage at the Greenwood gage a few miles upstream of line 15 will be as much as 7 feet lower during periods of low flow and about 2 feet lower during periods of high flow after completion of the channel modifications now in progress (fig. 39). Similar changes in the stage-discharge relation will occur in the vicinity of lines 13, 14, and 15. At a discharge of 3,000 ft^3/s the channel work will result in stages that are from 4 to 7 feet lower than pre-construction stages in the vicinity of lines 13, 14, and 15 (table 1).

Even with the proposed higher minimum discharge of 3,000 ft^3/s in the navigation project, the minimum stage in the river near lines 13, 14, and 15 would be at or near the lowest stages observed at these sites during this investigation. The lower stages in the river would permit additional ground water to drain from the aquifer and this will result in lower ground-water levels on both sides of the river. The decline in ground-water levels very near the river should exceed 2 feet and may approach 7 feet in places. The ground-water level declines will decrease with distance from the river, but the measurable impact of the channel changes may extend as far as the Bluff Hills to the east and to the area of heavy pumping several miles to the west of the river. The direction of ground-water movement on the east side of the river should remain toward the river throughout the year. On the west side of the river ground-water movement will continue to be toward the river during low-flow periods and from the river toward the cones of depression to the west during high-flow periods.

SUMMARY AND CONCLUSIONS

The proposed construction of a lock and dam on the Yazoo River near Vicksburg and completion of channel improvements in the reach of the river between Yazoo City and Greenwood will result in a substantially higher minimum stage in much of the reach downstream of Yazoo City and lower stages in much of the reach between Yazoo City and Greenwood. Post-impoundment minimum stage would be only a few feet higher than pre-impoundment minimum stages at Yazoo City but would be more than 19 feet higher than pre-impoundment low stages at the proposed dam near Vicksburg. During periods of moderate and high flow, river stages would exceed the level of the proposed impoundment and would closely resemble pre-impoundment stages. At Greenwood and in much of the reach between Yazoo City and Greenwood, post-project river stages will be from 2 to 7 feet lower than pre-project stages.

Analyses of water-level measurements made monthly during the period 1978 to 1981 in 65 shallow observation wells in sixteen lines perpendicular to the Yazoo River indicate that seasonal fluctuations of ground-water levels range from less than 10 feet in some wells near the Bluff Hills on the east side of the river to more than 30 feet in some wells adjacent to the lower reach of the river. Water moves from the river into the aquifer on both sides of the river during periods of high stage and drains from the aquifer to the river during periods of low stage. On the east side of the river, the predominant direction of ground-water movement is from recharge areas at the base of the Bluff Hills toward the river. On the west side of the river, the predominant direction of ground-water movement is toward the river in the lower reach and away from the river north of line 10 near Yazoo City. In the vicinity of lines 10-15 in the upper reach of the study area, the predominant direction of regional ground-water movement is from east to west toward a depression in the ground-water surface caused by large withdrawals of ground water for irrigation and fish farming.

The changes in river stages that will result from the proposed navigation project will affect ground-water levels in the highly productive alluvial aquifer that underlies the area. Ground-water levels near the river will not fall below the elevations of the water surface in the navigation pool or the river. Minimum ground-water levels in wells very near the river in the vicinity of lines 1-6 and 16 may be from about 9 to more than 19 feet higher than pre-project levels, but would be between 15 and 25 feet below land surface. The effect of the proposed navigation pool on ground-water levels would decrease with distance from the river and generally would not extend beyond the Bluff Hills to the east or the Whittington Auxillary Channel or other major drainage feature to the west. During periods of high flow ground-water levels would be at or near land surface as they have been in the past. In the middle reach of the study area (lines 8-12), the impact of the navigation project on ground-water levels would not be large. During low-flow periods, post-project river stages and ground-water levels very near the river would be within 2 to 3 feet of pre-project levels. In the upper reach of the river (lines 13, 14, and 15), ground-water levels near the river will probably decline several feet and may be as much as 7 feet lower than pre-project levels at times.

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