PRELIMINARY STAGE-DISCHARGE RELATIONS FOR TOMBIGBEE RIVER AT ALICEVILLE LOCK AND DAM, NEAR PICKENSVILLE, ALABAMA

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CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
acre-foot (acre-ft)	1,233	cubic meters (m^3)

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."

Water-surface elevation is referred to as stage in this report. Stage and elevations used in this report are referenced to NGVD of 1929.

River mileages used in this report were furnished by the U.S. Army Corps of Engineers, Mobile District.

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ABSTRACT

The construction of Aliceville lock and dam and other related channel alterations, completed in 1979, has resulted in changes to the stage-discharge relations in the vicinity. The scarcity of current-meter measurements, coupled with backwater conditions, makes definition of a single stage-discharge relation impossible. However, limit curves can be defined that would encompass such a relation. Backwater is defined as water backed up or retarded in its course as compared with water flowing under normal or natural conditions. This results in a rise in stage above normal water level while the discharge remains unaffected. Backwater is usually caused by temporary obstruction(s) to flow downstream. Backwater at Aliceville Dam results from a variety of river conditions. Some of these conditions are large tributary inflow, return of flood plain flows to the main channel during recessions, and operations at Gainesville Dam during low flows. The discharges obtained from 26 current-meter measurements, along with computed discharges through the dam, were plotted versus stage. The plot illustrates, by the scatter of data points, the variations in backwater. Curves were drawn to envelope the extreme plot patterns showing possible ranges of several feet in stage for any given discharge. The upper end of the curves were extrapolated based on the results of a step-backwater analysis.

INTRODUCTION

Aliceville lock and dam and related channel alterations are an intergral part of the Tennessee-Tombigbee Waterway project. Changes resulting from their completion have also resulted in changes in some streamflow characteristics in the vicinity. Definition for one characteristic, the stage-discharge relation, is needed for future planning.

The purpose of this report is to define the ranges in stage and discharge of potential stage-discharge relations (rating curves) for the pool and tailwater and to portray the scatter of the plotted data points by the use of limit curves. The scope of work was limited to plotting available current-meter measurements and numerous discharge values computed bi-hourly versus stage for several discharge events.

This report has been prepared by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Eningeers, Mobile District. Appreciation is expressed to the Corps for their assistance.

DESCRIPTION OF STUDY AREA

The Aliceville lock and dam is located on the Tombigbee River about 2 miles southwest of Pickensville, Pickens County (fig. 1). The lock is 110 feet wide, 600 feet long, and has a lift capability of 27 feet. The dam consists of a gatecontroled spillway section with four 60-foot wide radial gates and a 150-foot uncontrolled (fixed crest) spillway. Elevation of the gate-controlled spillway crest is 111 feet. Elevation of the uncontrolled spillway crest is 135.3 feet. The normal pool elevation is 136 feet. The facility is operated by the U.S. Army Corps of Engineers in accordance with guidelines identified by their Reservoir Regulation Section.

Drainage area at the dam is about 5,750 square miles. Aliceville Lake (fig. 1), formed by the dam, has a storage capacity of 60,400 acre-feet at normal pool elevation.

The reach of river downstream from the Aliceville lock and dam to Gainesville is about 47 miles in length (fig. 1). It is characterized by a well developed meandering channel with moderate to steep sloped banks. The channel is about 500 feet wide near Aliceville and gradually increases in width downstream. Its banks are densely covered with trees and thick undergrowth. The flood plain is relatively wide and level and is wooded except for scattered areas cultivated for crops or pasture. Major tributaries to the reach are Big Beaver, Bogue Chitto, and Lubbub Creeks, and Sipsey River.

Two major bendway cut-off channels completed in 1979 are located near Big Creek and Cooks Bend (fig. 1). Dredging of the channel to facilitate navigation will be performed routinely to maintain a minimum depth of 9 feet. Twenty-six sediment disposal areas are located at various sites to accommodate the dredged materials.

STAGE-DISCHARGE RELATIONS

Definition of a single stage-discharge relation for the pool or the tailwater is impossible due to the effects of backwater. Backwater is defined as water backed up or retarded in its course as compared with water flowing under normal or natural conditions. This results in a rise in stage above normal water level while the discharge remains unaffected. Backwater is usually caused by temporary obstruction(s) to flow downstream. Backwater at Aliceville Dam occurs in varying degrees caused primarily by large tributary inflows, flood plain flow returning to the main channel during recessions, and the operation of spillway gates at Gainesville Dam during low flows. At times, backwater may also be partially caused by seasonal changes in vegetation, minor changes in channel geometry, and occasionally by abnormal spillway gate operations at Aliceville and (or) Gainesville Dam.

Normally, little or no backwater effect is evident during the rising stage of a flood. The effect is often greatest during the recession. This results in different stages for a given discharge; usually a lower stage during rises and a higher stage during recessions. The most useful presentation of a stage-discharge relation at this time would be limit curves that are boundaries of possible rating curves.

Methods

Discharge versus stage was plotted to define limit curves for both pool and tailwater. Of the 26 current-meter measurements available (table 1), 15 were made using conventional methods from a boat near the dam and 11 were made using a current-meter in the spillway bays. Selected bi-hourly computed discharge values with corresponding stages were also used as additional data to better define the curves. These discharge values were computed by indirect methods (Collins, 1976) using vertical gate openings and recorded stages for the pool and the tailwater. Verification of and improvements to the curves will necessitate acquiring additional current-meter measurements.

Tailwater

Tailwater limit curves define a probable range in stage and discharge resulting from backwater (fig. 2). The curves are based on 24 discharge measurements made since February 1980 (table 1) and 61 computed discharges for three flood events since April 1980 (table 2). The limit curve representing rising stages is labeled "TR" and that representing falling stages is labeled "TF" (fig. 2).

To help define the shape of the tailwater curves above 60,000 ft^3/s, a step-backwater analysis was performed on the 47-mile reach downstream from Aliceville Dam. Initial discharges and stages used in the analysis came from the pool rating at Gainesville Dam. Twenty-six cross sections were used to define the reach. The channel portions were surveyed in the field and the flood plain portions were estimated using topographic maps. A field investigation of the sediment disposal sites made in November 1982 showed no significant accumulations of streambed material and thus no adjustment to the cross sections was necessary.

Pool

Pool stages at the dam are controlled by gate operation and flow over the fixed-crest spillway. During medium and high flow, the gates are raised to maintain a normal pool stage and to pass excessive flow, if necessary. If these measures are not adequate, the gates are raised above the water surface to allow the flood crest to pass. Following the flood crest, the gates are lowered into the water sufficiently to maintain a normal pool stage. Flow passes freely over the uncontrolled (fixed) spillway above a pool stage of 135.3 feet.

During floods when tributary inflow downstream is sufficiently large, backwater effects may extend upstream through the spillway gates. Using the same procedures as those used for the tailwater rating, limit curves were developed for the pool (fig. 3). Eighteen discharge measurements made since February 1980 (table 1) and twenty-six computed discharge values for two flow events since March 1980 (table 3) were plotted versus pool stages to define a probable range of stage for a given discharge. The curve representing the limit for rising stages is labeled "PR" and that representing the limit for falling stages is labeled "PF".

SUMMARY

The stage-discharge relation for both pool and tailwater at Aliceville Dam are affected by backwater that makes the development of a single stage-discharge relation impossible. Backwater is defined as water backed up or retarded in its course as compared with water flowing under normal or natural conditions. This results in a rise in stage above normal water level while the discharge remains unaffected. Backwater is usually caused by temporary obstruction(s) to flow downstream. As a useful alternative, limit curves have been developed to define possible extremes of a series of stage-discharge relations. Backwater at Aliceville Dam occurs in varying degrees caused primarily by large downstream tributary inflows, return of flood-plain flows to the main channel during recessions, and from operations at Gainesville Dam during low-flows. The curves are preliminary and represent conditions that existed between February 1980 and May 1983. Verification of and improvements to the curves will necessitate acquiring additional current-meter measurements.

REFERENCES

Collins, D. L., 1976, Computation of records of streamflow at control structures: U.S. Geological Survey Water Resources Investigations 77-8, 57 p.

U.S. Geological Survey, 1982, Water-resources data for Alabama, U.S. Geological Survey Water-Data Report AL 81-1, 540 p.

Table 1. List of current-meter measurements made at or near Aliceville lock and dam.

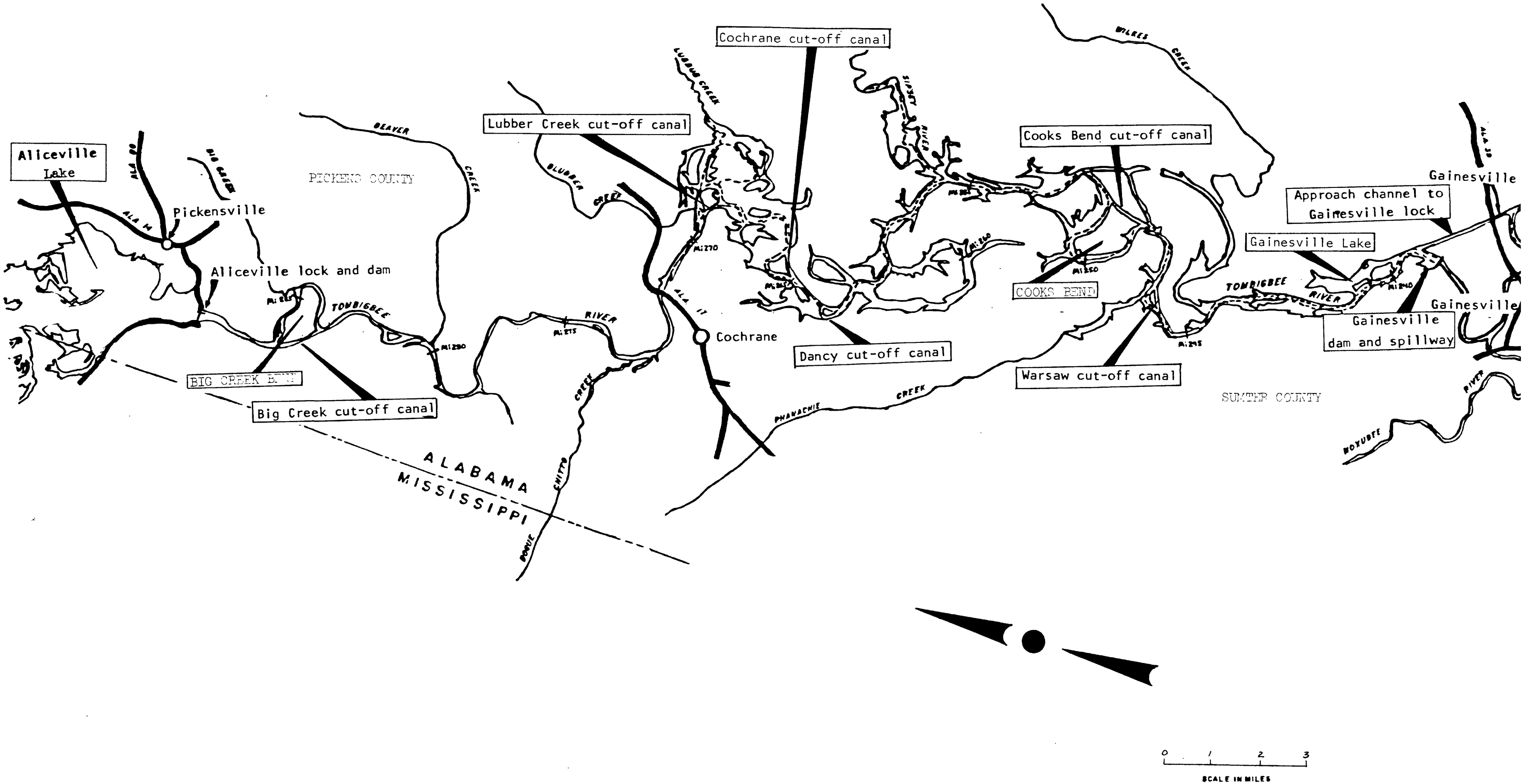
Date	Stage (ft) Pool	Stage (ft) Tailwater	Measured Discharge (ft^3/s)	Remarks
1980				
Feb 20	136.14	110.92	5,580	Measured at dam spillway
Feb 20	136.18	111.20	8,230	Measured at dam spillway
Mar 11	136.24	121.99	35,600	Measured at dam spillway
Apr 2	139.81	135.59	74,600	Measured from boat
Apr 5	135.96	125.74	34,200	Measured at dam spillway
Apr 6	136.16	119.44	17,900	Measured at dam spillway
Apr 7	136.09	115.86	13,700	Measured at dam spillway
Apr 7	136.24	114.84	10,600	Measured at dam spillway
1981				
Dec 3	136.16	--	3,840	Measured at dam spillway
Dec 3	136.10	--	3,810	Measured at dam spillway
1982				
Apr 26	136.00	116.78	20,500	Measured at dam spillway
Dec 31	139.74	136.57	99,300	Measured from boat
1983				
Jan 1	139.33	136.56	93,000	Measured from boat
Jan 26	135.99	113.66	13,800	Measured at dam spillway
Apr 7	136.08	130.39	76,300	Measured from boat
Apr 8	136.34	132.67	87,000	Measured from boat
Apr 8	136.57	132.91	91,000	Measured from boat
Apr 9	138.35	134.77	97,400	Measured from boat
Apr 10	140.02	136.75	116,000	Measured from boat
Apr 11	140.29	137.41	114,000	Measured from boat
Apr 12	139.33	136.74	97,200	Measured from boat
Apr 12	138.78	136.37	97,400	Measured from boat
May 23	141.59	138.86	138,000	Measured from boat
May 24	141.95	139.85	130,000	Measured from boat
May 25	141.25	138.89	108,000	Measured from boat
May 26	139.59	137.37	92,000	Measured from boat

Table 2. List of computed discharge values for Aliceville lock and dam, tailwater

Date	Time	Tailwater Stage (ft)	Computed Discharge (ft^3/s)	Date	Time	Tailwater Stage (ft)	Computed Discharge (ft^3/s)
1980				1981			
Apr 1	2000	135.47	69,100	Mar 31	0200	121.60	37,100
Apr 4	1400	134.10	60,600	Mar 31	0600	121.20	36,200
Apr 4	1800	133.80	58,600	Mar 31	1600	120.70	34,200
Apr 4	2400	133.23	55,200	Apr 1	0200	120.32	33,200
Apr 5	--	131.54	49,800				
Apr 5	2000	130.24	45,800	1982			
Apr 5	2200	129.83	47,000	Apr 4	0800	114.38	19,200
Apr 5	2400	129.37	46,300	Apr 4	2400	115.09	22,600
Apr 6	0200	128.84	42,400	Apr 19	0800	115.30	22,600
Apr 6	0400	128.29	42,000	Apr 19	1000	115.95	28,100
Apr 6	0600	127.77	40,000	Apr 19	1400	117.87	33,300
Apr 6	1000	126.80	37,700	Apr 19	2000	121.12	44,100
Apr 6	1400	125.80	35,600	Apr 19	2400	123.88	51,800
Apr 6	1800	124.75	32,200	Apr 20	0200	125.20	56,900
Apr 6	2200	123.78	30,700	Apr 20	0400	126.88	62,900
Apr 6	2400	123.24	28,600	Apr 20	0600	127.60	65,000
Apr 7	0400	122.91	26,900	Apr 20	1000	129.00	62,000
Apr 7	0800	121.02	24,900	Apr 21	2000	131.00	56,800
Apr 7	1200	120.23	23,900	Apr 22	1200	131.34	56,600
Apr 7	1600	119.01	21,700	Apr 22	2200	131.00	55,200
Apr 7	2400	117.61	17,400	Apr 23	0600	130.16	57,600
Apr 8	0400	116.80	17,800	Apr 23	1600	129.05	56,900
Apr 8	1200	115.37	14,600	Apr 23	2400	127.89	52,700
				Apr 24	0600	126.76	47,200
1981				Apr 24	1000	126.04	45,300
Mar 30	0400	115.07	27,200	Apr 24	1600	124.91	42,400
Mar 30	0800	118.00	31,900	Apr 25	0200	122.83	36,400
Mar 30	1200	119.50	32,400	Apr 25	1200	121.02	31,200
Mar 30	1400	120.05	34,300	Apr 25	1600	120.30	29,000
Mar 30	1600	120.80	37,700	Apr 25	2000	119.50	26,700
Mar 30	2000	121.50	40,100	Apr 26	0200	118.60	25,800
Mar 30	2200	121.70	39,800	Apr 26	1000	117.01	20,600
Mar 30	2400	121.80	39,300				

Table 3. List of computed discharge values for Aliceville lock and dam, pool

Date	Time	Pool Stage (ft)	Computed Discharge (ft^3/s)
1980			
Apr 2	0200	139.98	68,800
Apr 3	1800	139.38	64,500
Apr 4	0200	139.25	65,400
Apr 4	1200	138.44	61,100
Apr 4	1600	138.20	59,600
Apr 4	1800	137.96	58,600
Apr 4	2200	137.49	55,300
Apr 5	0400	137.20	55,500
Apr 5	0600	137.02	54,200
Apr 5	0800	136.91	55,500
Apr 5	1000	136.68	55,700
Apr 5	1200	136.32	54,300
Apr 5	1400	136.10	49,800
Apr 5	2400	135.93	46,300
Apr 6	0200	136.00	42,400
Apr 6	0800	135.98	40,700
Apr 6	1200	136.06	36,100
1982			
Apr 19	0800	136.08	22,600
Apr 19	1000	136.13	28,100
Apr 19	1400	136.08	33,300
Apr 19	2000	136.12	44,100
Apr 19	2400	136.14	51,800
Apr 20	0200	136.13	56,900
Apr 20	0400	136.08	62,900
Apr 20	0600	136.07	65,000
Apr 20	1000	136.10	62,000


Aliceville Lake
Pickensville
Aliceville lock and dam
PICKENS COUNTY
BEAVER CREEK
TOMBIGBEE RIVER
BIG CREEK BEND
Big Creek cut-off canal
Lubber Creek cut-off canal
Cochrane cut-off canal
Cochrane
Dancy cut-off canal
ALABAMA
MISSISSIPPI
COOKS BEND
Cooks Bend cut-off canal
Warsaw cut-off canal
SUMTER COUNTY
Approach channel to Gainesville lock
Gainesville Lake
Gainesville dam and spillway
Gainesville
0 1 2 3
SCALE IN MILES

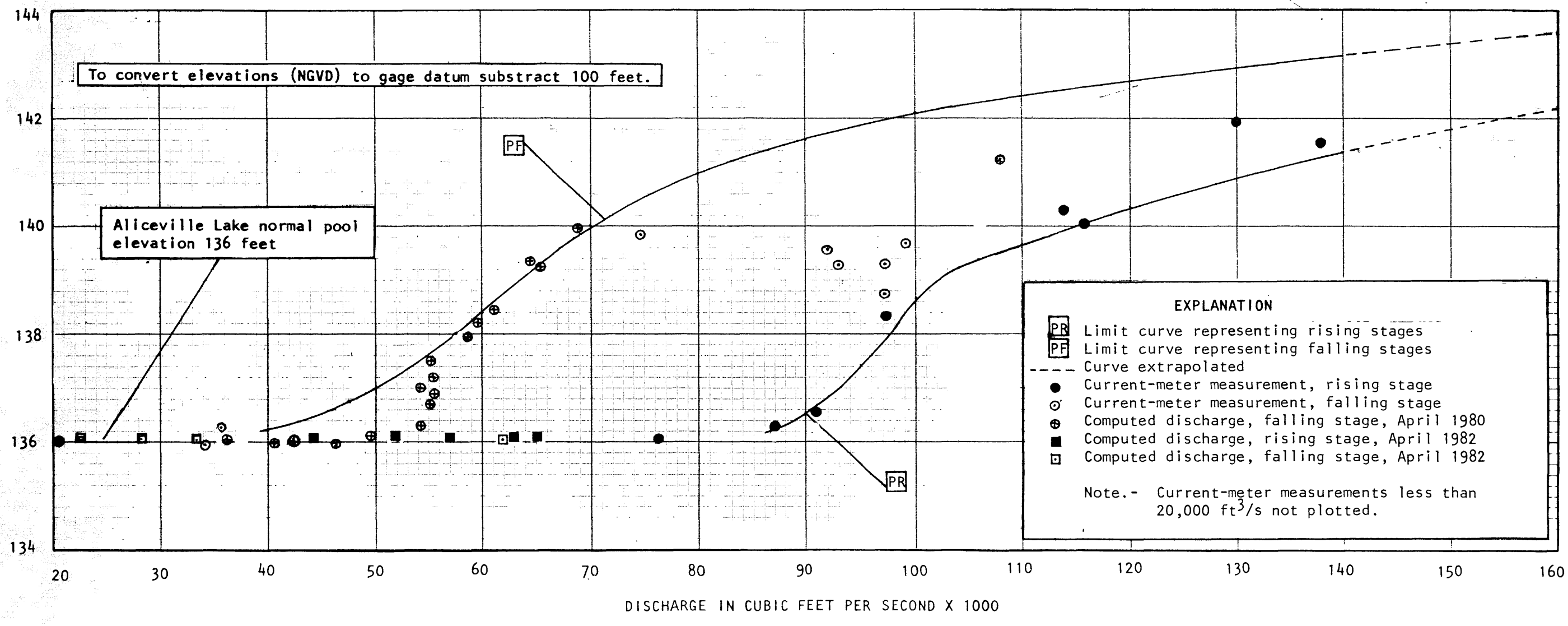


Figure 3.- Limit curves defining the ranges in stage for Tombigbee River at Aliceville lock and dam, pool.

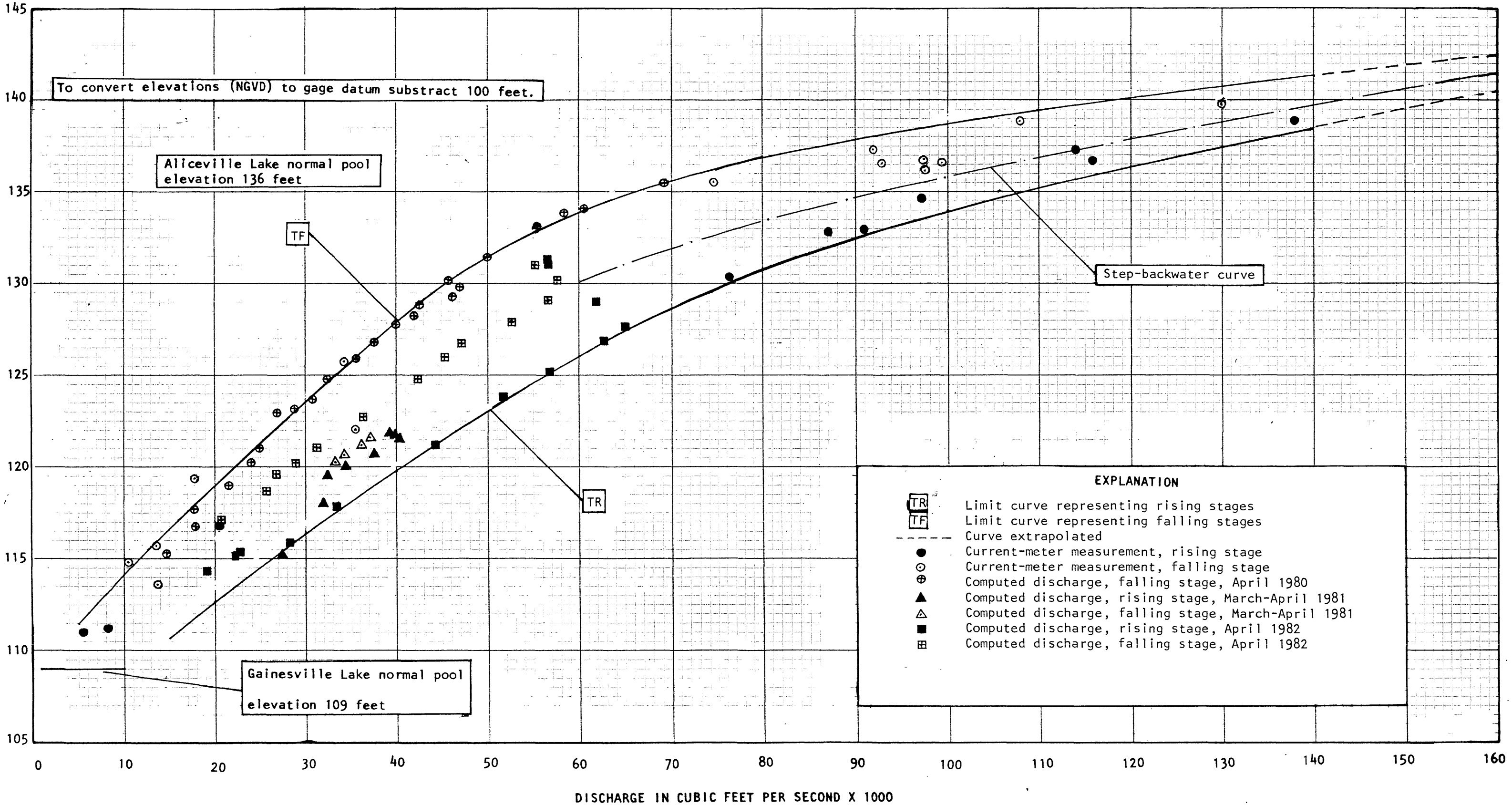


Figure 2.- Limit curves defining the ranges in stage for Tombigbee River at Aliceville lock and dam, tailwater.