PRELIMINARY STAGE-DISCHARGE RELATIONS FOR TOMBIGBEE RIVER AT GAINESVILLE DAM, NEAR GAINESVILLE, ALABAMA

By G. H. Nelson, Jr. and C. O. Ming

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JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
520 19th Avenue
Tuscaloosa, Alabama 35401

Copies of this report can be purchased from:

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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 meter (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 references to NGVD of 1929.

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ABSTRACT

The construction of Gainesville Dam and other related channel alterations, completed in 1979, has resulted in changes to the stage-discharge relations in the vicinity. The lack 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 the flow downstream. Backwater at Gainesville Dam is due to large tributary inflow and return of flood plain flows to the main channel during recessions. The discharges obtained from 105 computations of flow through the dam for the tailwater and 59 for the pool were plotted versus stage. These plots illustrate, by the scatter of these 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 for both the pool and the tailwater.

INTRODUCTION

Gainesville Dam and related channel alterations are an integral 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 164 computed discharge values for the pool and the tailwater 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 Engineers, Mobile District. Appreciation is expressed to the Corps for their assistance.

DESCRIPTION OF STUDY AREA

The Gainesville Dam is located on the Tombigbee River about 2 miles northwest of Gainesville, Sumter County (fig. 1). The dam consists of a gate-controlled spillway section with five 50-foot wide radial gates and a 225-foot uncontrolled (fixed crest) spillway. Elevation of the gate-controlled spillway crest is 75 feet. Elevation of the uncontrolled spillway crest is 108.5 feet. The normal pool elevation is 109 feet. A navigation lock is located apart from the dam about 1.5 miles to the southeast (fig. 1). The dam 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 7,200 square miles. Gainesville Lake (fig. 1), formed by the dam, has a storage capacity of 45,290 acre-feet at a normal pool elevation.

The reach of river downstream from Gainesville Dam to Demopolis is about 68 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 Gainesville 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 Noxubee River, Trussels, Brush, and Factory Creeks.

A major bendway cut-off channel completed in 1976 is located downstream near Demopolis at Rattlesnake Bend (fig. 1). Dredging of the channel to facilitate navigation will be performed routinely to maintain a minimum depth of 9 feet. Thirty-four 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 the flow downstream. Backwater at Gainesville Dam occurs in varying degrees caused primarily by large tributary inflows and flood plain flow returning to the main channel during recessions. At times, backwater may also be partially caused by season changes in vegetation and minor changes in channel geometry. Occasionally the stage-discharge relations may be affected by abnormal spillway gate operation at 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 the boundaries of possible rating curves.

Methods

Discharge versus stage was plotted and used to define limit curves for both tailwater and pool. The discharge values were obtained from bi-hourly computations of flow through the dam spillway. These discharge values were computed by indirect methods (Collins, 1976) using vertical gate openings and recorded stages for the pool and the tailwater. No current-meter measurements of total flow are available for the site. Verification and improvement to the curves will necessitate acquiring current-meter measurements at or near the dam.

Tailwater

Tailwater limit curves define a probable range in stage and discharge resulting from backwater (fig. 2). The curves are based on 105 computed discharges for four flood events since April 1979 (table 1). The limit curve representing rising stages is labeled "TR" and that representing falling stages is labeled "TF" (fig. 2).

Table 1. List of computed discharge values for Tombigbee River at Gainesville Dam, tailwater.

Date	Time	Tailwater Stage (ft)	Computed Discharge (ft^3/s)
1979			
Apr. 2	0400	78.85	8,670
Apr. 2	1600	80.04	10,600
Apr. 2	1800	82.15	16,500
Apr. 3	0600	84.24	15,600
Apr. 3	1800	88.56	26,900
Apr. 4	1200	92.23	33,400
Apr. 6	1400	93.93	36,400
Apr. 7	1200	92.74	34,600
Apr. 8	1200	92.35	36,100
Apr. 8	1600	93.61	39,500
Apr. 8	1800	94.39	42,000
Apr. 8	2400	95.22	40,400
Apr. 10	1000	93.97	32,900
Apr. 12	1200	95.37	45,200
Apr. 12	1400	99.37	61,500
Apr. 12	1600	103.02	57,400
Apr. 12	2400	108.39	103,000
Apr. 22	0200	110.50	71,700
Apr. 22	0600	109.91	69,000
Apr. 22	0800	109.59	67,300
Apr. 22	1000	109.22	65,700
Apr. 22	1400	107.40	51,400
Apr. 22	2400	104.15	42,000
Apr. 23	0200	103.69	42,900
Apr. 23	1400	98.80	29,300
Apr. 23	1600	97.91	24,400
Apr. 23	1800	97.12	25,100
Apr. 24	0800	91.52	13,600
Apr. 24	1600	87.96	9,770
Apr. 24	2400	85.42	10,700
Apr. 25	1200	83.51	11,200
Apr. 26	0600	81.96	11,600
1980			
Mar. 25	--	114.11	108,000*
Apr. 15	--	111.65	107,000*
Apr. 16	--	112.47	101,000*
Apr. 17	--	113.06	96,500*
Apr. 19	--	113.02	93,800*
Apr. 20	--	111.76	84,500*
Apr. 21	--	108.63	65,000*
Apr. 21	0200	110.45	78,000
Apr. 21	0400	110.16	74,600
Apr. 21	1200	109.04	66,400

* Mean daily

Table 1. List of computed discharge values for Tombigbee River at Gainesville Dam, tailwater (continued).

Date	Time	Tailwater Stage (ft)	Computed Discharge (ft^3/s)
1980			
Apr. 21	1600	108.31	63,200
Apr. 21	2200	106.45	52,200
Apr. 22	--	101.90	42,700*
Apr. 22	0600	104.03	45,500
Apr. 22	1200	102.09	42,600
Apr. 22	2000	98.78	32,300
Apr. 23	1200	94.46	30,700
Apr. 24	1200	87.28	22,000
Apr. 24	1600	86.59	20,800
Apr. 24	2200	85.62	19,700
Apr. 25	0400	84.70	16,700
Apr. 25	0800	84.28	13,600
Apr. 25	1600	83.20	10,500
1981			
Mar. 29	0200	77.93	7,430
Mar. 30	0200	79.73	15,700
Mar. 30	0400	84.25	21,600
Mar. 30	0600	86.00	24,000
Mar. 30	0800	88.37	28,700
Mar. 30	1000	89.84	31,900
Mar. 30	1200	91.47	33,400
Mar. 30	1800	94.72	39,800
Mar. 30	2200	95.51	43,900
Mar. 31	0600	96.82	46,300
Apr. 1	0200	97.46	47,200
Apr. 1	0800	98.80	49,000
Apr. 1	1400	99.75	46,100
Apr. 2	0400	100.87	49,700
Apr. 2	2400	100.01	47,300
Apr. 3	0800	99.20	44,800
Apr. 3	1800	97.73	43,900
Apr. 4	1000	96.12	40,200
Apr. 6	1200	92.87	29,000
Apr. 6	1800	91.73	25,100
Apr. 7	1400	89.51	22,500
Apr. 7	2200	88.19	18,800
Apr. 8	1200	86.66	15,500
Apr. 9	0800	85.14	16,700
Apr. 10	0200	83.07	12,900
Apr. 10	0800	81.95	9,990
Apr. 10	1200	80.52	8,200

* Mean daily

Table 1. List of computed discharge values for Tombigbee River at Gainesville Dam, tailwater (continued).

Date	Time	Tailwater Stage (ft)	Computed Discharge (ft^3/s)
1982			
Apr. 17	1200	79.92	13,900
Apr. 18	1200	82.30	16,700
Apr. 19	1200	84.59	22,600
Apr. 19	1800	85.85	25,200
Apr. 19	2400	89.06	37,100
Apr. 20	0600	93.43	46,900
Apr. 20	1200	96.95	56,800
Apr. 20	1800	100.19	65,300
Apr. 20	2400	102.26	68,000
Apr. 21	0600	104.30	71,900
Apr. 21	1200	105.53	82,800
Apr. 21	1800	106.95	98,700
Apr. 21	2400	107.56	97,700
Apr. 22	0600	108.00	102,000
Apr. 22	1200	108.27	98,000
Apr. 23	1200	108.62	92,200
Apr. 24	1000	106.87	81,000
Apr. 24	1600	106.05	74,300
Apr. 25	0600	103.65	59,500
Apr. 26	1200	99.42	40,800
Apr. 27	0800	94.65	29,800
Apr. 28	1200	89.50	18,800
Apr. 29	2400	85.70	14,600

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 crest) spillway above a pool stage of 108.5 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). The curves are based on 59 computed discharge values (table 2) for flood events since April 1979 and were plotted versus pool stages to define the 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".

Table 2. List of computed discharge values for Tombigbee River at Gainesville Dam, pool.

Date	Time	Pool Stage (ft)	Computed Discharge (ft^3/s)
1979			
Apr. 12	1200	110.00	45,200
Apr. 12	1400	109.12	61,500
Apr. 12	1600	109.41	57,400
Apr. 12	1800	108.27	63,500
Apr. 12	2200	110.25	73,000
Apr. 22	0200	111.09	71,700
Apr. 22	0600	110.49	69,000
Apr. 22	0800	110.19	67,300
Apr. 22	1000	109.81	65,700
Apr. 22	1400	109.70	51,400
Apr. 22	1600	109.80	51,400
Apr. 22	2400	110.25	42,000
Apr. 23	0200	110.13	42,900
Apr. 23	1400	110.21	29,300
Apr. 23	1600	110.08	24,400
Apr. 23	1800	110.05	25,100
Apr. 23	2000	109.90	25,200
Apr. 24	0800	108.28	13,600
Apr. 24	1400	108.87	15,000
Apr. 24	1600	109.07	9,770
Apr. 24	2400	109.43	10,700
Apr. 26	0600	109.69	11,600
1980			
Mar. 25	--	114.90	108,000*
Mar. 25	--	114.88	106,000*
Apr. 15	--	112.64	107,000*
Apr. 16	--	113.27	101,000*
Apr. 17	--	113.75	96,500*
Apr. 18	--	114.01	95,500*
Apr. 19	--	113.69	93,800*
Apr. 20	--	112.34	84,500*
Apr. 21	--	109.75	65,000*
Apr. 21	0200	111.05	78,000
Apr. 21	0600	110.36	69,000
Apr. 21	1200	109.53	66,400
Apr. 21	1600	108.92	63,200
Apr. 21	1800	109.27	59,500
Apr. 21	2200	109.11	52,200
Apr. 22	--	109.11	42,700*
Apr. 22	0200	108.70	55,900
Apr. 22	0600	108.86	45,500
Apr. 22	0800	109.03	44,000
Apr. 22	1200	109.07	42,600

* Mean daily

Table 2. List of computed discharge values for Tombigbee River at Gainesville Dam, pool (continued).

Date	Time	Pool Stage (ft)	Computed Discharge (ft^3/s)
1980			
Apr. 22	2000	109.74	32,300
Apr. 23	1200	109.11	30,700
Apr. 23	1800	109.20	27,400
Apr. 23	2400	109.05	24,600
Apr. 24	1200	109.08	22,000
Apr. 25	0800	109.00	13,600
Apr. 25	1600	109.00	10,500
1982			
Apr. 21	0600	109.11	71,900
Apr. 21	1800	109.10	98,700
Apr. 21	2400	109.11	97,700
Apr. 22	0600	109.27	102,000
Apr. 22	1200	109.41	98,000
Apr. 23	1200	109.60	92,000
Apr. 24	1000	109.02	81,000
Apr. 24	1600	109.60	74,300
Apr. 25	0600	109.00	59,500
Apr. 26	1200	108.99	40,800

SUMMARY

The stage-discharge relation for both pool and tailwater at Gainesville Dam are affected by backwater that makes defining 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 the flow downstream. As a useful alternative, limit curves have been developed to define possible extremes of a series of stage-discharge relations. Backwater at Gainesville Dam occurs in varying degrees caused primarily by large downstream tributary inflows and return of flood plain flows to the main channel during recessions. The curves are preliminary and represent conditions that existed between April 1979 and April 1982. Verification of and improvement to the curves will necessitate acquiring current-meter measurements near the dam.

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