PRELIMINARY STAGE-DISCHARGE RELATIONS FOR BLACK WARRIOR RIVER AT WARRIOR DAM NEAR EUTAW, 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 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 Warrior Dam, completed in 1962, 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 without considerable error. 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 Warrior Dam results from a variety of river conditions. Some of these conditions are large tributary inflow and return of flood plain flows to the main channel during recessions. The discharges obtained from 7 current-meter measurements, along with 37 computed discharges through the dam, were plotted versus stage. The plot illustrates, 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.

INTRODUCTION

Warrior Dam is an integral part of the Black Warrior River navigational system. Changes resulting from its completion have 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 tailwater and to portray the scatter of the plotted data points by use of limit curves. The scope of work was limited to plotting the seven available current-meter measurements and 37 discharge values computed bi-hourly versus tailwater 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

Warrior Dam is located on the Black Warrior River about 5.0 miles east of Eutaw, Greene County (fig. 1). The dam consists of a gate-controlled spillway section with six 60-foot wide radial gates. The gates are 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 5,800 square miles. Warrior Lake (fig. 1), formed by the dam, has a storage capacity of 49,100 acre-feet at normal pool elevation.

The reach of river downstream from Warrior Dam to Demopolis is about 54 miles in length (fig. 1). It is characterized by a well developed meandering channel with moderate to steep sloped banks. The channel is about 600 feet wide near Eutaw 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 Needham, Hines, and Big Prairie Creeks. The Black Warrior River joins the Tombigbee River just north of Demopolis. Demopolis lock and dam is located on the Tombigbee River about 2 miles west of Demopolis.

STAGE-DISCHARGE RELATIONS

Definition of a single stage-discharge relation for 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 Warrior Dam is caused primarily by large tributary inflow and flood plain flow returning to the main channel during recessions. At times, backwater may also be partially caused by the seasonal changes in vegetation and minor changes in channel geometry. Occasionally, stages at the dam may be affected by abnormal gate operations.

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 and used to define the limit curves for the tailwater. In addition to discharge obtained from seven current-meter measurements (table 1), 37 computed discharges (table 2) through the gates along with corresponding tailwater stages were also used in the definition. The current-meter measurements were made using conventional methods from either Alabama Highway 14, (4 miles upstream) or from the walkway which spans the dam spillway section. Discharge was computed through the dam by indirect methods (Collins, 1976) using vertical gate openings and recorded stages for the pool and tailwater. Verification of and improvements to the curves will necessitate acquiring additional current-meter measurements, especially when the flow exceeds 90,000 ft^3/s.

Tailwater

Tailwater limit curves define a probable range in stage and discharge resulting from backwater (fig. 2). The curves are based on seven current-meter measurements (table 1) and 37 computed discharges (table 2) for four flood events since 1977. The limit curve representing rising stages is labeled "TR" and that representing falling stages labeled "TF". The limit curves are extrapolated to 222,000 ft^3/s based on estimated mean daily discharge for the flood of April 16, 1979.

SUMMARY

The stage-discharge relation for the tailwater at Warrior Dam is affected by backwater that makes defining a single stage-discharge rating 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 obstructions(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 Warrior Dam occurs in varying degrees caused primarily by large tributary inflow and return of flood plain flows to the main channel during recessions. The curves are preliminary and represent conditions that existed between March 1977 and April 1983. Verification of and improvements to the curves will necessitate acquiring additional current-meter measurements, especially when the flow exceeds 90,000 ft^3/s.

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 AL81-1, 540 p.

Table 1. List of current-meter measurements for Black Warrior River at or near Warrior Dam.

Date	Tailwater Stage (ft)	*dh/dt	Measured Discharge (ft^3/s)	Remarks
1976				
March 19	101.92	-.03	66,300	Measured 4.0 miles upstream from Dam
April 2	102.50	+.05	79,000	Measured at Dam
April 5	99.80	-.07	54,400	Measured at Dam
April 7	94.70	-.20	35,800	Measured at Dam
1977				
April 8	104.50	0	93,700	Measured 4.0 miles upstream from Dam
1983				
April 26	96.80	-.05	54,300	Measured at Dam
April 26	96.64	-.04	51,800	Measured at Dam

* Rate of change in stage per hour during measurement.

Table 2. List of computed discharge values for Black Warrior River at Warrior Dam.

Date	Time	Tailwater Stage (ft)	Computed Discharge (ft^3/s)
1977			
Mar. 29	1600	83.13	21,400
Mar. 31	2000	95.10	37,100
Apr. 6	0600	99.70	60,600
Apr. 6	2200	102.00	76,000
Apr. 8	1200	104.55	91,500
Apr. 8	2200	104.45	90,600
Apr. 11	0200	101.63	58,200
Apr. 13	0400	95.23	43,900
Apr. 14	1800	87.11	23,400
1979			
Mar. 3	2400	90.28	29,700
Mar. 5	0200	97.08	74,200
Mar. 5	1800	99.40	88,100
Mar. 6	1600	102.10	105,000
Mar. 7	2000	103.70	122,000
Mar. 9	0400	102.97	97,500
Mar. 9	2000	101.95	83,400
Mar. 10	1800	99.98	66,500
Mar. 12	0200	95.95	45,800
Mar. 12	1800	92.12	23,700
1980			
Apr. 12	1800	89.42	37,600
Apr. 13	1200	95.73	58,000
Apr. 14	1800	100.33	87,800
Apr. 16	1800	104.13	119,000
Apr. 18	0600	102.99	94,600
Apr. 19	2000	100.09	57,700
Apr. 21	0800	95.50	24,100
1982			
Apr. 18	1200	80.16	17,900
Apr. 19	1200	85.49	29,100
Apr. 20	1200	90.30	37,600
Apr. 21	1200	95.16	52,500
Apr. 21	1800	95.65	53,100
Apr. 22	1200	95.67	54,200
Apr. 23	1200	96.96	52,400
Apr. 24	1200	95.72	46,300
Apr. 25	1200	92.38	30,200
Apr. 26	1200	90.33	30,600
Apr. 27	1000	89.23	28,500