

PRELIMINARY STAGE-DISCHARGE RELATIONS FOR BLACK WARRIOR RIVER
AT HOLT LOCK AND DAM, NEAR HOLT, 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:

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
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 Holt lock and dam completed in 1969 has resulted in changes to the stage-discharge relations in the vicinity. The lack of current-meter measurements coupled with backwater conditions make 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 Holt 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. Sixty-seven computed discharge values through the dam and (or) generator turbines were selected for five flood events since 1977 and 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.

INTRODUCTION

Holt lock and dam is an integral part of the Black Warrior River navigational system. Changes resulting from its completion has 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 section and to portray the scatter of the plotted data points by the use of limit curves. The scope of the work was limited to plotting 67 computed discharge values versus tailwater stage for 5 flood events.

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

DESCRIPTION OF STUDY AREA

Holt lock and dam is located on the Black Warrior River about 2.3 miles northeast of Holt, Tuscaloosa County (fig. 1). The facility consists of a navigation lock, a gated spillway section and a hydroelectric plant. The lock is 110 feet wide and 600 feet long with a maximum vertical lift capability of 64.1 feet. The gated spillway section has fourteen 40-foot wide radial gates. The gates are operated to maintain a normal pool elevation of 187 feet. Elevation of the gated spillway crest is 152.5 feet.

The hydroelectric plant, constructed by the Alabama Power Company, is operated by them for the production of electricity. It has one generator turbine which discharges about 10,000 ft³/s while operating at maximum capacity. The generator is operated continuously as long as there is sufficient head difference between the pool and tailwater.

Drainage area at the dam is 4,230 square miles. Holt Lake (fig. 1), formed by the dam, has storage capacity of 117,990 acre-feet at normal pool elevation.

The reach of the river downstream to Oliver lock and dam is approximately 9 miles (fig. 1). The reach is characterized by a straight well developed main channel with moderately sloped banks. The main channel is about 600 feet wide near the Holt lock and dam, and gradually increases downstream. Its banks are heavily covered with trees and undergrowth. The flood plain is relatively wide and level and is mostly wooded. Major tributaries to the reach are Hurricane Creek and North River.

STAGE-DISCHARGE RELATION

Definition of a single stage-discharge relation for the dam tailwater section 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 for the river above normal water level while the discharge remains unaffected. Backwater is usually caused by temporary obstruction(s) to the flow downstream. Oliver lock and dam controls stages at Holt Dam tailwater when flow is below 50,000 ft³/s. During floods when the flow exceeds about 50,000 ft³/s and Oliver Dam becomes submerged, backwater at Holt Dam occurs in varying degrees resulting from large tributary inflows and flood plain flow returning to the main channel during recessions. At times, backwater during floods may also be partially caused by the seasonal changes in vegetation, and minor changes in channel geometry. The stage-discharge relation may also be momentarily affected by abnormal spillway gate operations at Holt 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 to define limit curves for the tailwater. Sixty-seven computed discharge values with corresponding tailwater stages (table 1) were used in the definition. These discharge and stage values were furnished by the Alabama Power Company. Verification of and improvements to the curves will necessitate acquiring current-meter measurements at or near the dam.

Tailwater

The tailwater limit curve defines a probable range in stage and discharge resulting from backwater (fig. 2). The curves are based on 67 computed discharge values selected from 5 flood events since April 1977. The curve representing rising stages is labeled "TR" and that representing falling stages is labeled "TF".

SUMMARY

The stage-discharge relation at Holt lock and dam tailwater section is 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 Holt 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 1977 and April 1981. Verification of and improvements to the curves will necessitate acquiring occasional current-meter measurements.

Table 1. List of computed discharges for Black Warrior River at Holt lock and dam, tailwater.

Date	Time	Tailwater stage (ft)	Discharge (ft ³ /s) x 10 ³
1977			
Apr. 3	0100	129.42	26.7
Apr. 3	0400	131.20	40.0
Apr. 3	0700	133.38	59.4
Apr. 3	1600	136.00	78.2
Apr. 3	1700	138.00	92.2
Apr. 3	1900	137.40	88.3
Apr. 3	2100	136.14	67.5
Apr. 3	2400	135.45	67.5
Apr. 4	1300	133.67	51.2
Apr. 4	1500	134.60	71.8
Apr. 4	1700	144.00	123.0
Apr. 4	1800	146.00	137.0
Apr. 4	2000	149.87	146.0
Apr. 4	2300	147.98	113.0
Apr. 5	0100	148.02	132.0
Apr. 5	0500	147.48	118.0
Apr. 5	1500	146.20	111.0
Apr. 5	2400	143.75	89.6
Apr. 6	0600	142.32	77.2
Apr. 8	0900	129.80	16.9
Apr. 8	1200	129.07	13.0
Apr. 8	1300	128.45	11.4

Table 1. List of computed discharges for Black Warrior River at Holt lock and dam, tailwater--Continued.

Date	Time	Tailwater stage (ft)	Discharge (ft ³ /s) x 10 ³
1979			
Apr. 12	1100	128.02	15.6
Apr. 12	1200	131.50	29.3
Apr. 12	1300	136.17	78.0
Apr. 12	1400	138.83	99.8
Apr. 12	1500	141.30	108.0
Apr. 12	1600	142.98	124.0
Apr. 12	1700	145.00	134.0
Apr. 12	1800	149.20	157.0
Apr. 12	2000	151.00	174.0
Apr. 12	2100	151.80	174.0
Apr. 12	2200	153.00	171.0
Apr. 12	2300	153.20	164.0
Apr. 12	2400	153.40	163.0
Apr. 13	0300	153.65	162.0
Apr. 13	0800	155.62	173.0
Apr. 13	0900	157.48	181.0
Apr. 13	1000	159.82	206.0
Apr. 13	1100	159.75	239.0
Apr. 13	1200	158.77	223.0
Apr. 13	1300	158.20	179.0
Apr. 13	1400	157.80	177.0
Apr. 13	2300	156.25	158.0

Table 1. List of computed discharges for Black Warrior River at Holt lock and dam, tailwater--Continued.

Date	Time	Tailwater stage (ft)	Discharge (ft ³ /s) x 10 ³
1979			
Apr. 14	0700	152.25	136.0
Apr. 14	2000	148.45	119.0
Apr. 14	2400	147.25	103.0
Apr. 16	1200	137.92	58.5
Apr. 16	2300	133.10	32.0
1980			
Mar. 12	0100	128.28	16.4
Mar. 12	1000	129.66	25.7
Mar. 12	1400	134.13	38.0
Mar. 12	1500	135.95	68.9
Mar. 12	1900	138.46	79.1
Mar. 12	2300	142.80	103.0
Mar. 13	0100	143.35	105.0
Mar. 13	0200	142.60	78.0
Mar. 13	0300	140.00	65.7
Mar. 13	0900	143.00	108.0
Mar. 14	1600	134.00	42.1
Mar. 15	1300	131.18	21.7

Table 1. List of computed discharges for Black Warrior River at Holt lock and dam, tailwater--Continued.

Date	Time	Tailwater stage (ft)	Discharge (ft ³ /s) x 10 ³
1981			
Mar. 30	0400	133.00	39.0
Mar. 30	0900	140.70	106.0
Mar. 30	1100	136.40	75.2
Mar. 31	1200	132.76	47.9
Apr. 1	1100	131.18	34.1
Apr. 1	1800	130.12	22.9