WATER BALANCE/WATER MANAGEMENT OF THE TENN-TOM WATERWAY

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INTRODUCTION

The completion of the Tenn-Tom Waterway affected the flows experienced in the Tombigbee River Basin. The drainage areas and geography of the upper portion of the East Fork Tombigbee River has been particularly modified by the construction of the navigation project. The waterway from near Amory, Mississippi, to near Belmont, Mississippi, is called the Canal Section. This segment of the waterway consists of a dike and excavated channel. Five locks and dams raise the water surface from 190 to 330 feet above sea level.

A divide cut connects the Canal Section of the waterway to the Tennessee River near Iuka, Mississippi. Bay Springs Lock and Dam, constructed across Mackeys Creek at the southern terminus of the divide cut, impounds Bay Springs Lake at the elevation of Pickwick Lake on the Tennessee River.

The River Section of the waterway is a conventional slackwater navigation system. There are four locks and dams in the river section of the waterway raising the water surface from 73 to 190 feet above sea level. All three sections of the waterway have had unique impacts on the flow regime of the Tombigbee River.

HISTORY

The planning, design, and construction of the waterway spans a period in our nation's history of the coming of age of environmental concerns in the late 1960s through the early 1980s. The waterway was, in general, built from the south northward. Construction was begun on Gainesville Lock and Dam in 1972. Completion and filling of segments of the waterway occurred in the late 1970's and early 1980's. The entire project was completed and began operation in 1985. In addition to the structural features that serve the navigation purpose of the project, many features are incorporated in the project to minimize or mitigate adverse impacts or to provide collateral benefits without jeopardizing the navigation purpose.

MAJOR PROJECT FEATURES

River Section

The purpose and operating mode of the River Section projects is to maintain a constant upstream pool level to create a "slackwater" navigation system. Water impounded at a dam extends upstream to the next dam creating a level water surface for navigators. Flow from each of the four river projects is controlled by 4 to 6 tainter gates measuring 26 feet high by 60 feet wide. The lock operator on duty adjusts gate openings as often as needed to maintain the elevation of the water surface within narrow limits. Outflow approximately equals inflow minus any losses or diversions which might occur.

An additional feature of all the River Section Dams is that they have facility to discharge continuous releases of high quality water. Table 1 shows the design rates of flow for each of the River Section dams.

Table 1

Dam	Minimum Continuous Flow, cfs
Gainesville	235
Bevill	200
Columbus	225
Aberdeen	200

At the Aliceville and Gainesville dams, the minimum flow is discharged over weirs which are slightly below the upstream water surface. At Columbus and Aberdeen, minimum flows are assured by special controllable outlet works. These outlet works discharge into segments of the old river channel which were cut off by the alignment of dams and navigation channels. The structures have been somewhat subject to blockage by drift, particularly during the first few years of operation.

Canal Section

The Canal Section of the Waterway has had a significant impact on the drainage patterns and flow regimes of the upper East Fork of the Tombigbee River. The changes to the upper East Fork are

illustrated in Figure 1. The tributaries to the upper East Fork of the waterway are collected in the various pools of the canal section. Flow from the waterway to the old East Fork is regulated at two points. Spillways at the B and E projects discharge primarily high flows to the old East Fork channel.

Five other structures were included which discharge continuous flow from five points along the canal waterway. The design of these structures is basically the same but dimensions are scaled to provide the desired flow from each. The discharges were designed to preserve flows in the major left bank East Fork tributaries which were cut off by the canal section dikes. Although the structures have low level gated inlets, there is little practical capability to adjust the outflows from these structures. In general, they are designed to discharge twice the estimated 7-Q-10 flows in the tributaries. In addition to preserving flows and aquatic environments in the tributaries, the minimum flows contribute toward a new enhanced low flow value for the East Fork itself. Moderate to low flow has always depended on the left bank tributaries and the operation of the waterway continues to assure the flow from the east. An example of this new low flow is seen at the East Fork Tombigbee River at Fulton. The natural 7-Q-10 flow was about 26 cfs and the minimum of record was 12 cfs. The minimum flow structures upstream of Fulton will now produce a flow of about 70 cfs. This change can be seen in the post-project daily flow duration graph in Figure 2.

Divide Cut

The Bay Springs Lock and Dam and the divide cut of the waterway to the Tennessee River allow for transfer of waters between the two basins. The transfers are insignificant to the flows in the Tennessee River but may be quite significant in the upper Tombigbee River.

Figure 1 shows the configuration of the Bay Springs Dam and Reservoir and the divide cut section of the waterway. Without lockage releases, the runoff from 66 square miles of drainage area flows into the Tennessee River from territory which once drained to the Tombigbee River. This amounts to a mean annual loss from the Tombigbee to the Tennessee Basin of approximately 130 cfs. On the other side of the ledger is the volume of the lockage water which flows from the Tennessee River to the Tombigbee. Each emptying of the lockage chamber moves about 140 acre-feet into the canal section of the waterway and subsequently on through the Tombigbee River Basin. Of course, with the Mackeys Creek impounded and connected to the Tennessee River, natural streamflow is no longer readily measurable. The Corps developed a regression relationship using long-term rainfall and nearby unregulated streamgage records to estimate natural flow which would have been in the Tombigbee River Basin in the absence of the waterway. Records have also been kept of the emptying of the Bay Springs lock chamber. Consequently, a comparison can be made of flows lost from the Tombigbee Basin to flows gained via the operation (lockages) of the waterway.

A tabulation of the Bay Springs water balance is given in Table 2 below. Figure 3 illustrates the seasonal variability in the balance of flows. In wetter months the natural flows routed to the Tennessee River may exceed the lockage releases. However, the prevailing pattern is for lockage releases to exceed the flow lost to the Tennessee. Over the past seven years about 220 percent of the flow now enters the Tombigbee Basin than would have occurred naturally.

Table 2
Natural Flow vs. Lockage Release--
Bay Springs Lock and Dam

Year	Estimated flow to Tenn.Rvr. cfs	Lockage Water Releases cfs	Net Transfer
1985	79	280	201
1986	104	323	219
1987	61	311	250
1988	50	357	307
1989	171	267	96
1990	189	267	78
1991	304	296	-8
Avg	137	300	63

EVAPORATION

The fact that more water is entering the upper end of the Tombigbee may not necessarily mean that flows throughout the basin are augmented. The impoundments of the canal section and the various river section lakes have created additional water surface which in itself can modify the hydrology. The lakes can induce groundwater recharge, raise water tables affecting transpiration, and increase evaporation from water surfaces. Quantifying these elements of the water budget would be difficult. However, to put in perspective the quantities given above average and peak evaporation and the cumulative evaporation is given in Table 3.

ADDITIONAL HYDROLOGIC EFFECTS

The waterway has produced some effects in addition to the effects on the water balance of the basin. The hydraulic effects of the channel itself are notable. Reductions in flood stages result in part from the greatly increased hydraulic conveyance of the navigation channel. Because the channel dimensions are established for navigation standards throughout the waterway and natural channel dimensions decrease as one moves upstream, the effects of the waterway on flood levels become more pronounced as one moves upstream reaches of the river section of the waterway. The waterway channel can carry much more flow at Aberdeen and Columbus than the river channel could carry at the same elevation.

The increased conveyance and straightening of the channel also result in shortening the travel times of flood waves passing through the basin. Flow arrives more quickly and stages rise and fall more quickly than occurred previously.

During low flows, the size of impoundments has just the opposite effect. A given volume of water moves much more slowly through the system. Whereas at low flow, water may have transited from Amory to the state line in a few days, it might take more than a month to pass through the impoundments of the waterway. Also, water movement in impoundments during low flows may be affected by winds and surges. Water motion may be at very low velocities and occasionally in the upstream direction. All these factors have implications on the water uses and water quality of the waterway.

REFERENCES

U.S. Army Corps of Engineers, Tennessee-Tombigbee River Basin Water Control Manual
- Appendix A, Gainesville, 1991
- Appendix B, Aliceville (Bevill), 1982
- Appendix C, Columbus, 1983
- Appendix D, Aberdeen, 1983
- Appendix E, Canal Section, 1985
- Appendix F, Bay Springs, 1985

U.S. Army Corps of Engineers, Design Memorandum No. 1, Basic Hydrology

U.S. Army Corps of Engineers, General Design Memorandum for Canal Section

Table 3.

Lake Evaporation on Lakes of the Tenn-Tom Waterway

Lake	Surface Area	Average Evaporation	Average Cumulative	Maximum Evaporation	Maximum Cumulative
	acres	cfs(1)	cfs	cfs(2)	cfs
Pool E	855	4.1	4.1	7.2	7.2
Pool D	1980	9.6	13.7	16.6	23.8
Pool C	1630	7.9	21.6	13.7	37.5
Pool B	2750	13.3	34.9	23.2	60.7
Pool A	900	4.4	39.3	7.66	8.2
Aberdeen	4100	19.8	59.1	34.5	102.8
Columbus	8900	43.1	102.2	74.9	177.7
Bevill	8300	40.2	142.4	69.9	247.6
Gainesville	6400	31.0	173.3	53.9	301.5

(1) Assumes 42 inches/year
(2) Assumes peak day .2 inch

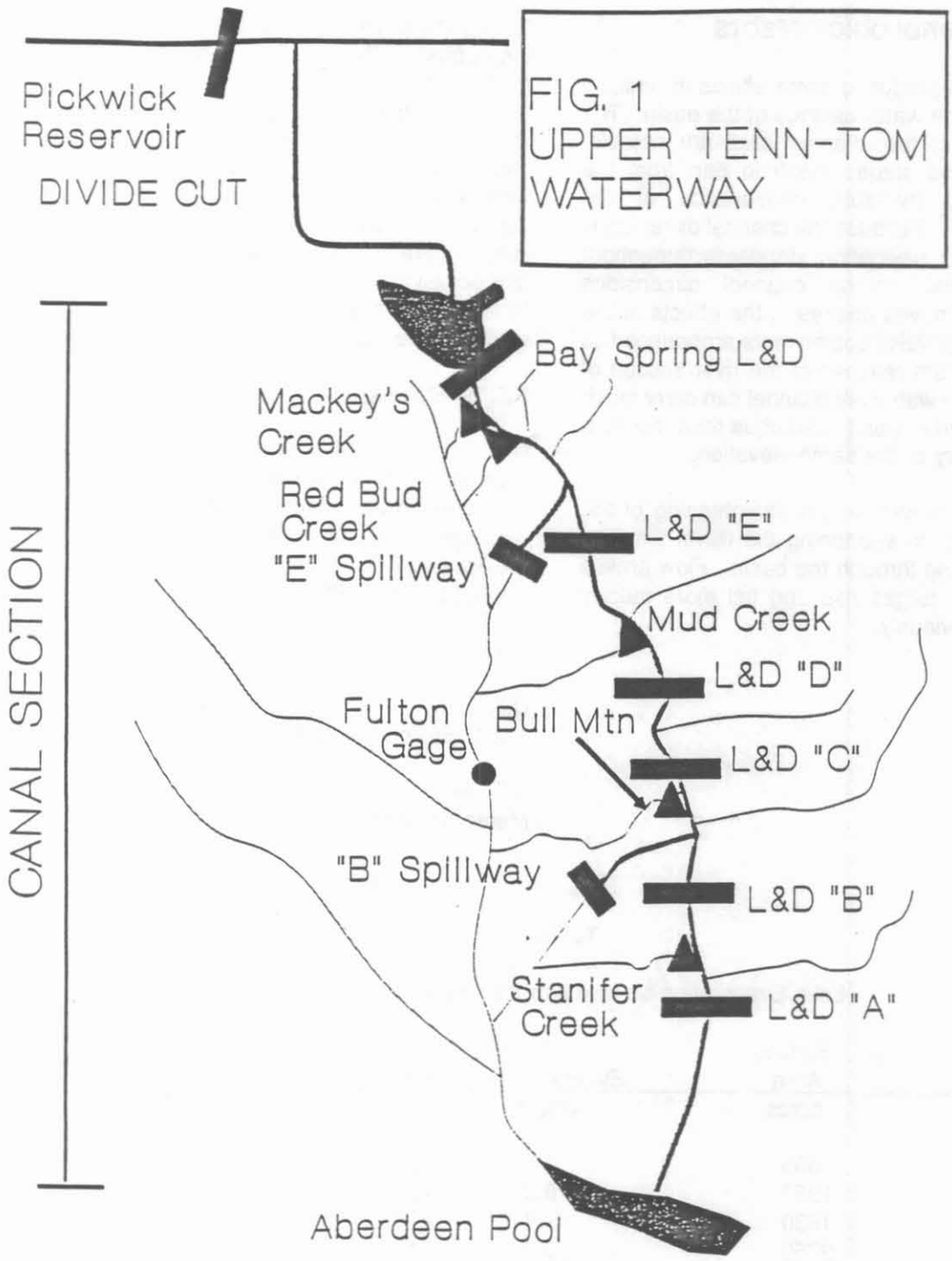

FIG. 1
UPPER TENN-TOM
WATERWAY

FIGURE 2.

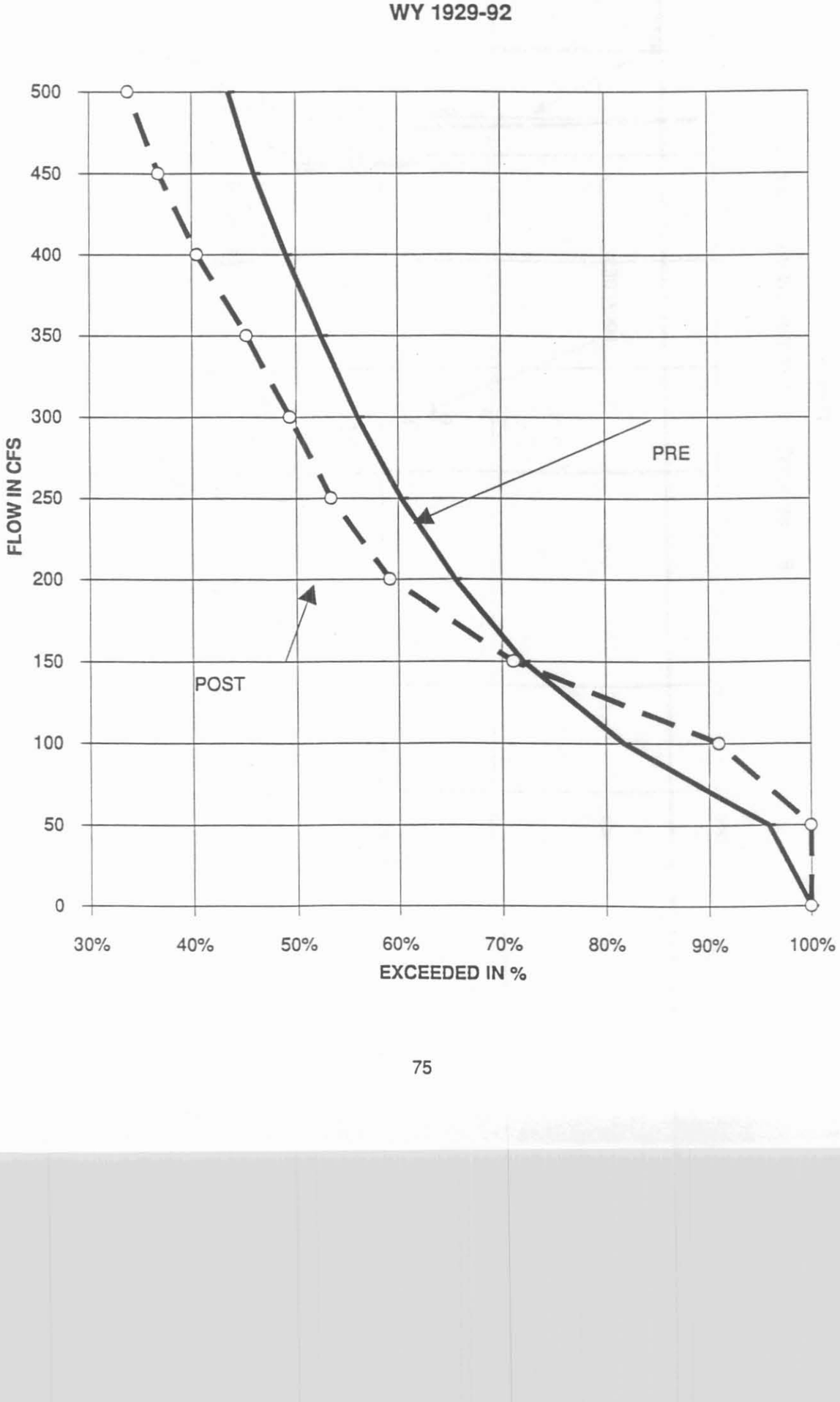
TOMBIGBEE RIVER AT FULTON
% DURATION FLOW ID02431000
WY 1929-92
500
450
400
350
300
250
200
150
100
50
0
FLOW IN CFS
PRE
POST
30%
40%
50%
60%
70%
80%
90%
100%
EXCEEDED IN %

FIGURE 3.

BAY SPRINGS NATURAL INFLOW VS. LOCKAGES