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RAI 160 Supplement 1

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Attachment 02.04.03-09D: Calc CDQ000020080050_Rev 1_Flood Operational Guide_11Aug09

Calculation **CDQ000020080050, Rev. 1**

Title **Flood Operational Guides**

EDMS Number: **L58 090819 001**

(64 Pages including Cover Sheet)

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Calc Title: Flood Operational Guides

	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
CURRENT	CN	NUC	GEN	CEB	CDQ000020080050	0	1	Entire calc ☒ Selected pages ☐
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QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS and/or ISFSI SAR/CoC AFFECTED
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Jeff Cundiff	8/5/09	pbs 8/14/09 K.R. Gates; K.R. Gates; 8/11/09	8/19/09

STATEMENT OF PROBLEM/ABSTRACT

To establish flood discharge rules (Flood Operational Guides) which the Tennessee River and Tributary Dams can be reasonable operated during a PMF storm event. Flood operational Guides are required as inputs to TVA's Simulated Open Channel Hydraulics (SOCH) and TRBROUTE computer codes, which perform the Hydrologic Routing.

This Calculation contains electronic attachments and must be stored in EDMS as an Adobe .pdf file to maintain the ability to retrieve the electronic attachments.

**22404 (SQN), 54018 (WBN), Later (BFN)

River Operations Concurrence: Charles L. Bail Date: 8/11/09

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REV 0 EDMS/RIMS NO.	EDMS TYPE:	EDMS ACCESSION NO (N/A for REV. 0)
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Calc Title: Flood Operational Guides

	TYPE	ORG	PLANT	BRANCH	NUMBER	CUR REV	NEW REV	REVISION APPLICABILITY
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ACTION	NEW ☒ REVISION ☐	DELETE ☐ RENAME ☐	SUPERSEDE ☐ DUPLICATE ☐	CCRIS UPDATE ONLY ☐ (Verifier Approval Signatures Not Required)	No CCRIS Changes ☐ (For calc revision, CCRIS been reviewed and no CCRIS changes required)

UNITS	SYSTEMS	UNIDS
N/A	N/A	N/A

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~~N/A~~ 22404(SQN), 54018(WBN), LATER(BFN)		E

pbs 6/2/09

QUALITY RELATED?	SAFETY RELATED? (If yes, QR = yes)	UNVERIFIED ASSUMPTION	SPECIAL REQUIREMENTS AND/OR LIMITING CONDITIONS?	DESIGN OUTPUT ATTACHMENT?	SAR/TS and/or ISFSI SAR/CoC AFFECTED
Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

PREPARER ID	PREPARER PHONE NO	PREPARING ORG (BRANCH)	VERIFICATION METHOD	NEW METHOD OF ANALYSIS
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William Clark	5/12/09	6/2/09 K.R. Spates	6-2-09

STATEMENT OF PROBLEM/ABSTRACT

6/2/09

To establish flood discharge rules (Flood Operational Guides) which the Tennessee River and Tributary Dams can be reasonable operated during a PMF storm event. Flood operational Guides are required as inputs to TVA's Simulated Open Channel Hydraulics (SOCH) and TRBROUTE computer codes, which perform the Hydrologic Routing.

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CALC ID	TYPE	ORG	PLANT	BRANCH	NUMBER	REV
	CN	NUC	GEN	CEB	CDQ000020080050	1

ALTERNATE CALCULATION IDENTIFICATION

BLDG	ROOM	ELEV	COORD/AZIM	FIRM BWSC	Print Report Yes ☐

CATEGORIES

KEY NOUNS (A-add, D-delete)

ACTION (A/D)	KEY NOUN	A/D	KEY NOUN

CROSS-REFERENCES (A-add, C-change, D-delete)

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CCRIS ONLY UPDATES:
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NPG CALCULATION RECORD OF REVISION

CALCULATION IDENTIFIER : CDQ000020080050

Title Flood Operational Guides

Revision No.	DESCRIPTION OF REVISION
0	Initial Issue Total pages 55
1	This calculation was revised to include flood operational guides for Wheeler and Tim's Ford Dams. Significant changes to the text are marked with a right hand margin revision bar. Changes and Additions: Content on pages 1-8, 10, 14, & 32-56 R0 was modified as indicated on pages 1- 8, 10, 14, & 33-61 R1. Pages 1a and 7a were added. Attachment 1 was revised to include Wheeler and Tim's Ford Data.

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NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080050 Revision 1

Method of verification used:

1. Design Review ☒
2. Alternate Calculation ☐
3. Qualification Test ☐

Verifier Jeff Cundiff Date 7/20/09

Comments:

The Calculation entitled "Flood Operational Guides, Revision 1" was verified by an independent design review. The process involved a critical review of the calculation to ensure that it is correct and complete, uses appropriate methodologies, and achieves its intended purpose. Backup files and documents were consulted as necessary to verify data and analysis details found in the calculation. Detailed comments and editorial suggestions were transmitted to the author and reviewer by email along with a marked up copy of the calculation.

NPG CALCULATION VERIFICATION FORM

Calculation Identifier CDQ000020080050 Revision 0

Method of verification used:

1. Design Review ☒
2. Alternate Calculation ☐
3. Qualification Test ☐

Verifier William Clark Date 03/ 24/2009

Comments:

TVAN COMPUTER INPUT FILE
STORAGE INFORMATION SHEET

Document CDQ000020080050	Rev. 1	Plant: GEN	

Subject:
Flood Operational Guides

☐ Electronic storage of the input files for this calculation is not required. Comments:

There are no electronic input files associated with this calculation.

☒ Input files for this calculation have been stored electronically and sufficient identifying information is provided below for each input file. (Any retrieved file requires re-verification of its contents before use.)

Attachment 1 - Flood operational Guides SOCH input data (Excel Spreadsheet, SOCH input data.xls)

These files are electronically attached to the parent ADOBE. pdf calculation file. All files are therefore stored in an Unalterable medium and reprievable through the EDMS number for this calculation.

☐ Microfiche/eFiche

1. Purpose

Develop Flood Operational Guides for all Tributary and Main River Dams that are part of the Simulated Open Channel Hydraulics (SOCH) or TRBROUTE computer codes for Probable Maximum Flood (PMF) routing. Provide tabulated Initial Reservoir Starting Levels for a Mid-March and June 1 event.

2. References.

1. Tennessee Valley Authority, Bellefonte Nuclear Plant – White Paper, Hydrological Analysis, Rev. 1, July 25 2008. EDMS No. L58 081219 800
2. River Operation Study (ROS), Flood Risk Evaluation Study for the Tennessee Valley Authority Phase III Report, Riverside Technology, Inc, January 2004.
3. Operational Guides, TVA website, http://www.tva.gov/river/lakeinfo/index.htm
4. Tennessee Valley Authority, SOCH Users Manual, Rev 0 Version 1.0.
5. Tennessee Valley Authority, UNITGRPH-FLDHYDRO-TRBROUTE-CHANROUT Users Manual, Rev 0 Version 1.0.
6. Tennessee Valley Authority, Calculation CDQ000020080001, Dam Rating Curve – Apalachia, R0, EDMS No. L58 090128 003
7. Tennessee Valley Authority, Calculation CDQ000020080002, Dam Rating Curve – Blue Ridge, R0, EDMS No. L58 090128 001
8. Tennessee Valley Authority, Calculation CDQ000020080003, Dam Rating Curve – Boone, R0, EDMS No. L58 090128 004
9. Tennessee Valley Authority, Calculation CDQ000020080004, Dam Rating Curve – Chatuge, R1, EDMS No. L58 090216 004
10. Tennessee Valley Authority, Calculation CDQ000020080005, Dam Rating Curve – Cherokee, R1, EDMS No. L58 090406 003
11. Tennessee Valley Authority, Calculation CDQ000020080006, Dam Rating Curve – Chickamauga, R0, EDMS No. L58 090224 005
12. Tennessee Valley Authority, Calculation CDQ000020080007, Dam Rating Curve – Douglas, R1, EDMS No. L58 090406 002
13. Tennessee Valley Authority, Calculation CDQ000020080008, Dam Rating Curve – Fontana, R1, EDMS No. L58 090216 002
14. Tennessee Valley Authority, Calculation CDQ000020080009, Dam Rating Curve – Fort Loudon, R0, EDMS No. L58 090304 001
15. Tennessee Valley Authority, Calculation CDQ000020080010, Dam Rating Curve – Fort Patrick Henry, R0, EDMS No. L58 090128 003
16. Tennessee Valley Authority, Calculation CDQ000020080011, Dam Rating Curve – Guntersville, R0, EDMS No. L58 090224 004
17. Tennessee Valley Authority, Calculation CDQ000020080012, Dam Rating Curve – Hiwassee, R0, EDMS No. L58 090216 001
18. Tennessee Valley Authority, Calculation CDQ000020080013, Dam Rating Curve – Melton Hill, R1, EDMS No. L58 090210 002
19. Tennessee Valley Authority, Calculation CDQ000020080014, Dam Rating Curve – Nickajack, R0, EDMS No. L58 090216 002

20. Tennessee Valley Authority, Calculation CDQ000020080015, Dam Rating Curve – Norris, R0, EDMS No. L58 090210 001
21. Tennessee Valley Authority, Calculation CDQ000020080016, Dam Rating Curve – Nottely, R1, EDMS No. L58 090216 003
22. Tennessee Valley Authority, Calculation CDQ000020080017, Dam Rating Curve – South Holston, R0, EDMS No. L58 090224 001
23. Tennessee Valley Authority, Calculation CDQ000020080018, Dam Rating Curve – Tellico, R0, EDMS No. L58 090304 002
24. Tennessee Valley Authority, Calculation CDQ000020080019, Dam Rating Curve – Watauga, R0, EDMS No. L58 090120 002
25. Tennessee Valley Authority, Calculation CDQ000020080020, Dam Rating Curve – Watts Bar, R0, EDMS No. L58 090224 002
26. Tennessee Valley Authority, Reservoir Operations Study – Final Programmatic EIS, 2004.
27. Tennessee Valley Authority, Calculation CDQ000020080021, Dam Rating Curve – Wheeler, R0, (Not Approved).
28. Tennessee Valley Authority, Calculation CDQ000020080022, Dam Rating Curve – Tim's Ford, R0, (Not Approved).

3. Background

TVA developed methods of analysis, procedures, and computer programs for determining design basis flood levels for nuclear plant sites in the 1970's. Determination of maximum flood levels included consideration of the most severe flood conditions that may be reasonably predicted to occur at a site as a result of both severe hydrometeorological conditions and seismic activity. This process was followed to meet Nuclear Regulatory Guide 1.59. At that time, there were no computer programs available that would handle unsteady flow and dam failure analysis. As a result of this early work and method development TVA developed a runoff and stream course modeling process for the TVA reservoir system. This process provided a basis for currently licensed plants (Sequoyah Nuclear Plant, Watts Bar Nuclear Plant, and Browns Ferry Nuclear Plant). The Bellefonte Nuclear Plant (BLN) Units 1 & 2 Final Safety Analysis Report (FSAR) was also based on this process. BLN Unit 3 & 4 Combined Operating License Application (COLA) was submitted using data and analysis that was determined for the original BLN FSAR (Unit 1 and Unit 2) and was documented in a 1998 reassessment. In 1998, the analysis process and documentation was brought under the nuclear quality assurance process for the first time. A quality assurance audit conducted by NRC staff in early 2007 raised several questions related to past work regarding design basis flood level determinations. This calculation supports a portion of the effort to improve this design basis.

The Tennessee Valley Authority (TVA) was formed in 1933 as a multipurpose federal corporation responsible for managing a range of programs in the Tennessee River Valley for the use, conservation, and development of the water resources related to the Tennessee River. In carrying out this mission, TVA operates a system of dams and reservoirs with associated facilities. As directed by the TVA Act, TVA uses this system to manage the water resources of the Tennessee River for the purposes of navigation, flood control, power production and consistent with those purposes, for a wide range of other public benefits.

BLN is located on the right (northwest) bank of Guntersville Reservoir at Tennessee River mile (TRM) 391.5. The site comprises approximately 1,500 acres between the Town Creek embayment and the Tennessee River, which is the major flooding source for the site. At the BLN site, the Tennessee River drains an area of 23,340 square miles (mi^2). Guntersville Dam is located downstream of the site at TRM 349.0. The drainage area at Guntersville Dam is 24,450 mi^2. The Tennessee River basin drainage area covers 40,910 mi^2 and is divided into two distinct regions. One region is approximately 21,400 mi^2 upstream of Chattanooga, Tennessee, east of the Cumberland Mountains; and the other is about 19,500 mi^2 downstream of Chattanooga. The drainage area lies mostly in the state of Tennessee with parts in six other states—Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi. (Ref 1).

3.1 River Operations

There are currently 24 reservoirs in the TVA system upstream from Wheeler Dam (Inclusive), 18 of which have substantial reserved flood detention capacity during the primary flood season. The flood detention capacity reserved in the TVA system varies seasonally, with the greatest storage available during the January through March flood season. The system flood detention capacity above BLN varies from 4.2 inches of runoff on January 1 to 4.1 inches of runoff on March 15, decreasing to 1.3 inches of runoff during the summer, then gradually increasing during the fall to January 1 allocation.

Reservoir operating guidelines are implemented as prescribed operating ranges of reservoir levels throughout the year. TVA represents these guidelines in graphs called guide curves, which show the reservoir levels for navigation, flood control, recreation, and other operating objectives. Guide curves also depict the volume of water available to TVA for hydropower generation and other beneficial uses.

Guide curves for mainstem and tributary reservoirs have different characteristics. Mainstem guide curves typically allow for a much smaller range of reservoir elevation change. Tributary guide curves include a larger change in reservoir elevations over the annual cycle. Because guide curves specify certain periods for raising or lowering the reservoirs, they substantially affect seasonal releases in tailwater areas downstream of the dams. Each project has its own guide curve.

These project-specific guide curves are based on original project allocations and subsequent modifications, many years of historical flows, flood season conditions, and experience with project and reservoir system operations. Reservoir operations based on the guide curves maintain project storage volume available for flood control within the watershed at any given time of year, as well as the amount of stored water needed to meet other purposes such as year-round navigation, power generation, reservoir recreation, water quality, waste assimilation, and other environmental resource considerations. Figures 1 and 2 show generic tributary and mainstem reservoir guide curves.

TVA operating guidelines must be flexible enough to respond to unusual or extreme circumstances in the system that are beyond TVA's control. The most important of these is variation in rainfall and runoff, at times resulting in low inflow conditions (droughts) or high inflow conditions (floods) that substantially increase the difficulty in meeting the multiple needs of the system. The upper limit of the discretionary operating zone is the flood guide. Reservoir levels are generally only allowed to temporarily exceed the flood guide for flood reduction and then returned to the flood guide to provide protection for succeeding events. By limiting reservoir elevations to a level equal to or lower than the flood guide, TVA is assured that flood storage necessary to minimize flood risk is available for use.

Reservoir operational changes have been made to the Tennessee River system over the years. In 1971, significant changes were made to the operating policy of ten tributary reservoirs, including raising the Jan. 1 flood guide level and adding a flood regulating zone above these levels at eight of the projects and increasing the normal minimum level at the nine of the projects. In 1991, TVA initiated the Lake Improvement Program study in which the operating policy for 10 major tributary projects delayed the unrestricted annual drawdown until after July 31, implemented minimum flow releases at many projects and increased dissolved oxygen concentrations in the release of 16 dams. Also in the early 1990's a review made by TVA as part of the Dam Safety Emergency Action Planning process indicated that at many projects access routes could become inundated and impassable during extreme flood situations. To ensure TVA staffs have access to the dams during such events, other means of transportation can be utilized including boat and helicopter access through TVA police or through local Emergency Management Agency (EMA) contacts. TVA has established working relationships with EMA's adjacent to and downstream of TVA dams for flood forecast notification, evacuation planning and general support. TVA also has an agreement with the United States Army Corps of Engineers (USACE) to make staff available to support gate operation at the main river dams. The USACE has responsibility for operation of locks at TVA projects. As a result, the agreement allows their staff to support TVA personnel with gate operations on main river dams on an as-needed basis. TVA and USACE staff have also conducted joint training exercises to define responsibilities and to ensure safety procedures are followed (Ref 1).

In 2001, TVA began its most comprehensive analysis ever, the Reservoir Operations Study (ROS) (Ref 2), to review all of the purposes for which the reservoir system was operated.

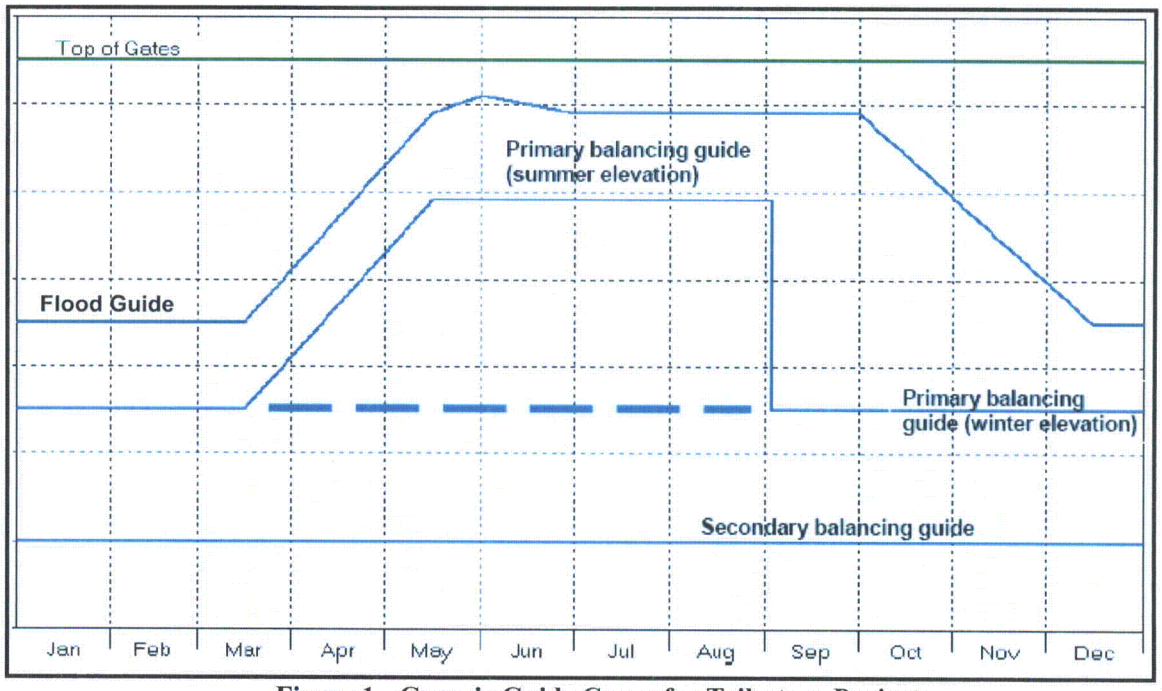


Figure 1 - Generic Guide Curve for Tributary Projects

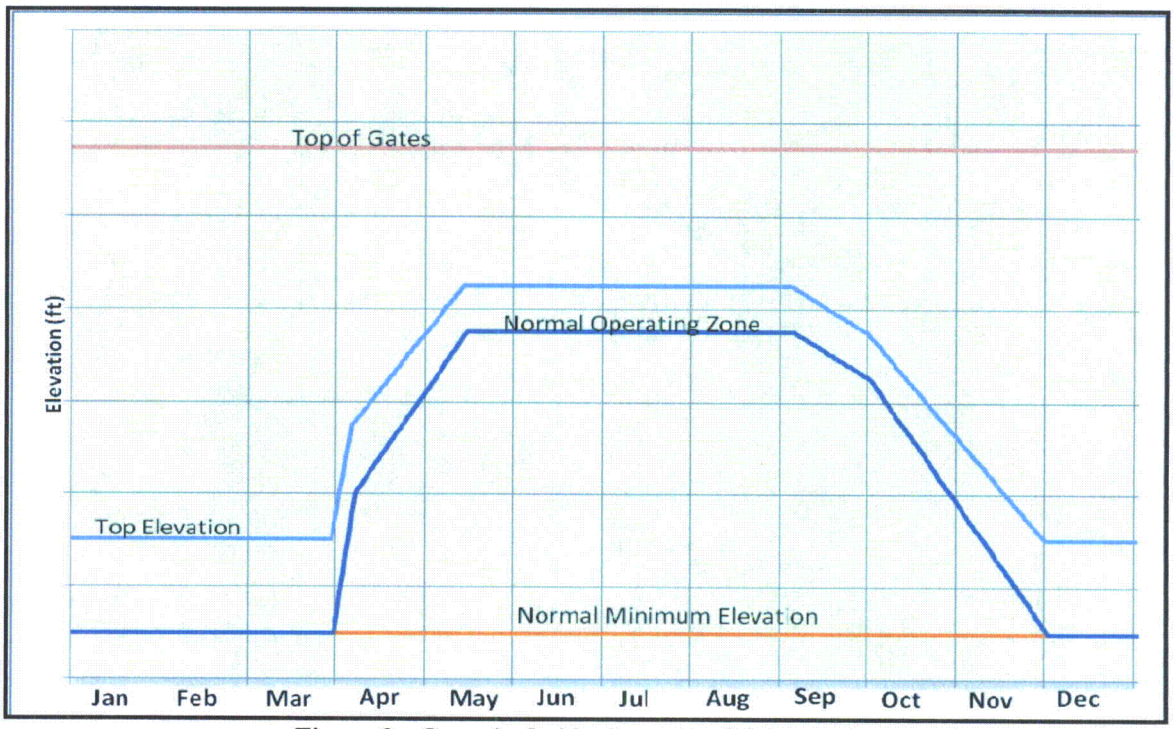


Figure 2 - Generic Guide Curve for Mainstem Reservoir

In 2004, the TVA Board of Directors approved changes to the reservoir operating policy. Consistent with the operating policies expressed in the TVA Act, these changes established a balance of reservoir system operating objectives that produced a mix of benefits more responsive to the values expressed by the public during the ROS. These changes included enhancing recreational opportunities while avoiding unacceptable effects on flood risk, water quality, and TVA power system costs. The winter flood guide was raised on 11 reservoirs; but, based on extensive analyses, these changes did not increase flood risk at downstream locations for floods of magnitudes up to and including the 500-year recurrence interval events. PMF levels at TVA's operating nuclear plants were also evaluated during the ROS and determined that the impact on the PMF levels at TVA Nuclear Plants was minimal. As an additional part of 2004 ROS during which the objection was to not increase flood elevations for storm up to a 500- year recurrence interval, a new set of Flood Operational Guides were developed. The ROS study provided a new logic for operation of tributary storage reservoirs which tended to store water earlier in major storms than the fixed rule used in the FSAR analysis.

A generic guide curve for tributary projects is shown on Figure 1 which reflects changes made to tributary project guide curves as a result of the ROS. The primary differences between the old guide curves and the new guide curves are the formalization of the Flood Guide throughout the year, and replacing the minimum operating guide (MOG) by the balancing guide.

4. Methodology

This calculation will review the reservoir operating rules from the 2004 ROS used as input into the SOCH and TRBROUTE computer codes; compare them with current knowledge, ongoing river operations and understanding of the TVA staff to produce a definitive set of Flood Operational Guides.

5. Assumptions

5.1 General Assumptions

None

5.2 Unverified Assumptions

The Dam Rating Curves for Wheeler and Tim's Ford have been completed, providing the discharge capacities for the dams.

Technical Justification: Preliminary discharges have been established for Wheeler and Tim's Ford Dams. This UVA will be removed following the issuance of the Wheeler and Tim's Ford Dam Rating Curves, CDQ000020080021 and CDQ000020080022, respectively.

6. Design Input

- Seasonal Operational Guides – provide normal pool starting elevations throughout the year (Ref 26). Initial Reservoir Starting levels are shown for each reservoir operating guide figure are summarized and tabulated in Table 1 for both the Mid-March and June 1 event.
- River Operations Study (Ref 2)
  - Reservoir operating guides
  - Dynamic Recovery Mode (Knuckle) description
- SOCH Computer codes (Ref 4)
  - Provides all iterative runs to establish Head Water (HW) elevations at decision points.
- TRBROUTE Computer codes (Ref 5)
  - Provides routing of upstream tributaries to determine upstream boundary discharge hydrographs for input into SOCH.
- Dam Rating Curves (Ref 6-25)

7. Calculation

TVA uses the Flood Operational Guide to facilitate planning studies, by using the Guides to "drive" computer simulation models. River Scheduling (RVS) staff is responsible for integrated operation of the TVA reservoir system. RVS staff uses state-of-art hydrologic data collection, weather forecasts, and computer models to derive an operating plan based on the latest observed and forecasted weather conditions while looking at the entire river system as an integrated unit. With redundant communication systems available and a backup command center available, the RVS staffs have never been out of communication with any plant for any extended period of time. The Flood Operational Guides are not intended to be implemented by plant staff for flood-control operations but merely used to simulate the realistic operations for modeling the Tennessee River System in the event of a major flood.

7.1 Flood Operational Guide

The Flood Operational Guide approach is used to simplify the complexities associated with real-time operation of main stem reservoirs and tributaries. In actual practice, there is no modeling boundary between tributary and main stem reservoirs. An iterative approach is applied throughout the river system, with the river scheduling staff considering various releases until arriving at an acceptable scenario of coordinated operations.

The Flood Operational Guide consists of an outflow vs. pool elevation curve describing appropriate operating combinations. The term "Guide" may be somewhat misleading, as the curve is dynamically modified based on an annual guide curve and the current and recent states of the reservoir. Nevertheless, given a curve that is Guide for the current time step, and the planned inflows from upstream projects, an achievable outflow – headwater pool elevation combination is determined. The application of the Flood Operational Guide for computer simulation requires prescribed inflows to the reservoir. For this reason, the Flood Operational Guide is applied beginning with the most-upstream tributary reservoirs first. Solution proceeds downstream through the remaining tributary and mainstem reservoirs.

Median initial reservoir elevations were used at the start of the storm sequence used to define the PMF to be consistent with statistical experience and to avoid unreasonable combinations of extreme events. Since the hypothetical PMF occurs in March the pool elevation will correspond to that of the Operations Guide (Ref 3).

Normal reservoir operating processes were used in the antecedent storm and main storm. This included use of turbine, sluice and/or spillway discharges as necessary in the tributary and mainstem reservoirs. Some Tributary turbine discharges may be eliminated during the main storm due to tailwater rise or flooding of the powerhouse from headwater overflow. Spillway gates and other outlet devices were determined to be capable of being placed in a fully opened position when needed during the flood. Gate crews would be called to respective dams during or before the first hours of the main storm when access would not be a problem. Normal practice of having gate crews remain at the dams, as necessary, during major floods would be followed. Gates on main river dams would eventually be fully raised, thus requiring no additional operations, by the last day of the main storm which is before the structures and access roads would be inundated.

The Primary and Summer Guide Curves define the operation of the project during flood events up to spillway capacity. At Fort Loudoun, Tellico and Watts Bar, a surcharge zone above top of gates elevation was added, effectively adding an additional two feet of storage in these projects. Similarly, surcharge zones were added at

Chickamauga and Guntersville of 1.56 and .56 foot, respectively. Historic flood event since the 1970's have demonstrated TVA's willingness to surcharge Fort Loudoun, Tellico, Watts Bar and Chickamauga reservoir to limit flooding at Chattanooga, Tennessee. Thus the new Guides more nearly reflect the expected operation of the reservoir system. The new Guides also used logic from the ROS study for the tributary system which better replicate TVA's policy of utilizing a greater amount of storage space in the tributary reservoirs earlier in a storm period to attempt to achieve significant reductions in the Chattanooga flood crest, as well as to address localized downstream flooding concerns below several of these projects.

Once a peak discharge - pool elevation occurs in the operations of a reservoir, operations enter the Recovery Mode of the Flood Operational Guide curve (Figure 3 and 4). In recovery mode for the antecedent storm, the Recovery Curve is to expedite, the recovery of the reservoir to a more normal state. For the main stem dams a two-segment connection is created in the curve from the peak discharge pool elevation first downward then over to a "Recovery Mode Elbow" (80% of discharge distance from recovery Mode Base point and 50% elevation distance from Recovery Mode Base Point). The slope of the first segment is parameterized to be rather steep, indicating willingness of the operator to maintain a higher flow rate to reduce pool elevations rapidly. The slope of the second segment indicates a rapid decline in flows, to a more normal rate, once a significant portion of the pool is recovered. The Tributary Dams use a more stepped approach to recovery. These scenarios allow the operating point to travel along this recovery curve, even up to a new peak point, until arriving at or below the base point. (Ref 2)

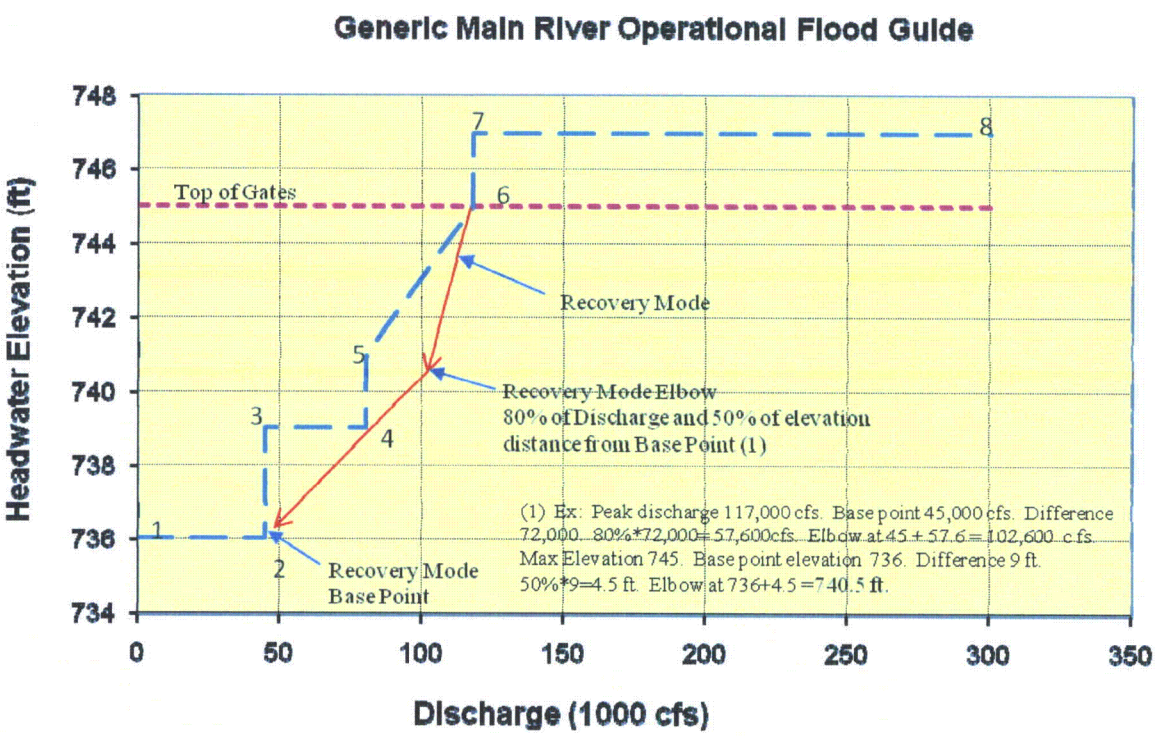


Figure 3 - Generic Mainstem Reservoir Recovery Mode

After the main storm, the Recovery Curve for main stem reservoirs will go back down the Primary Guide Curve to restore pool elevation. This allows water to be removed rapidly at the expense of recovering the main reservoir storage space. Ft Loudoun, Watts Bar and Chickamauga recovery will vary slightly from the Primary Guide Curve to account for the reduction of the South Chickamauga Creek flows impact on the total flow at Chattanooga. Recovery for the Tributary Dams follows the same stepped Curve as the antecedent storm and as shown in Figure 4.

7.2 TRBROUTE Code

The TRBROUTE code will follow the Flood Operational Guide during an antecedent storm, the 3-day dry period, and then during the main storm. There is a Flood Operational Guide for each Tributary project that is followed for the flood routing sequence.

7.3 SOCH Code

The SOCH computer code is executed on the mainstem reservoirs and selected major tributaries to compute the maximum flood stage and discharge for the PMF design storm and seismically induced dam failure events. The SOCH code has the capability to follow an operation guide as a part of a single run by prescribing the downstream boundary changes at the start of run simulation. There are times when the simulation will have to be interrupted to change boundary conditions, such as that required when the head water elevation or discharge reaches a given point or postulated failure of the structure occurs. When a change in the boundary condition is required, a starting line from the previous simulation can be saved for use in initiating the next simulation period with a new boundary condition prescribed.

The SOCH code will follow the Flood Operational Guide during the antecedent storm, the 3-day dry period, and during the main storm for each project. There is a Flood Operational Guide for each mainstem project that is followed for the flood routing sequence.

8.0 Results

8.1 Main River

The Flood Operational Guides use a curve of discharge vs. pool elevation describing the combination of outflow and pool elevation conditions that are appropriate. Figures 5 thru 13 describe two curves for each Main River Dam consisting of the Winter Primary Guide Curve (PGC), the Summer PGC (June 1). The Recovery Curve with knuckle is not shown but can be calculated as shown in Figure 3 for the antecedent storm. Otherwise, the Recovery Curve will follow the PGC after the main storm. The two curves (winter and summer) include a variety of:

1. Horizontal segments, where operators would like to maintain a given pool as long as a range of outflows can do so.

2. Vertical segments, where operators will allow the pool to rise within a certain range if it can be done without requiring an increase in discharge from a constant level.

3. Diagonally sloped segments where pool and discharge increase together.

In all cases, the curves are parameterized with an initial vertical line with discharge 0, followed by a horizontal portion, and a final horizontal line with a pool elevation equal to fully-surcharged pool elevation. This curve can be adjusted for seasonal operations based on a "normal operations" guide curve. The guide curve fluctuates throughout the year. During certain "low guide" periods, the bottom horizontal line may "float" down, leaving the remainder of the curve unchanged. When the guide rises up above a user defined threshold, the entire curve scales, so as to ensure that the pool elevation associated with the first horizontal segment of the curve remains equal to the guide curve pool elevation. At each timestep, the guide curve is determined dynamically in this fashion. (Ref 1)

The horizontal and vertical segments may cause the SOCH computer code to stop after twenty (20) iterations in an attempt to converge to the next point on the curve. To help the SOCH user, the Flood Operational Guide points, as shown in Figures 5-11, can be modified to alleviate the issues with convergence (See Attachment 1). Discharges are modified by a relatively small amount above and below the vertical discharge value and elevations are changed by a relatively small amount above and below the horizontal elevation value.

8.2 Tributary Operation Guide

The generic tributary guide curve is comprised of two primary curves and two decision points:

1. The Primary Guide Curve (PGC), designed for use in the antecedent flood, and/or in the unlikely event that the pool is fully recovered to its initial elevation before the main storm occurs (curve A,B,C,D,E,F and beyond).
2. The Recovery Curve (RC), designed for flood recovery for the antecedent storm and for operation during the early portion and flood recovery portion of the main storm (until top-of-gates elevation is reached) (curve a1, a2, a3, a4, a5, a6, F and beyond).

Point A on the PGC represents the starting elevation based on simulated March 15 elevations from the 2004 Reservoir Operations Study (ROS) (Ref 2), and a discharge corresponding to ½ of full turbine capacity.

Point B on the PGC represents the elevation at which it is assumed that the reservoir operators will reduce the discharge to zero cfs (Point C) to alleviate downstream flooding.

The reservoir will remain at zero cfs discharge until one of two things happen:

a. Decision #1 the reservoir local precipitation has ceased for 12 or 24 hours depending on the tributary, at which time the discharge will be transitioned to the recovery curve ($a_1 \ldots a_6$), at the corresponding reservoir elevation which has been attained on the PGC, or
b. The reservoir elevation will increase to the elevation depicted at Point D on the PGC, at which time the reservoir discharges will be increased as shown on segment D-E on the PGC.

In the latter case (b) above, if the elevation corresponding to point E is reached, the discharge will continue to be increased as necessary to hold TOG elevation, until the outlet capacity of the project is exceeded (Point F), at which time the simulation will continue beyond Point F based on the Dam Rating Curve. This is not anticipated to occur during the antecedent storm but will occur during the primary storm at most locations.

Decision #2 occurs after 12 hours into the main storm. The pool elevation is determined and if the elevation is inside the upper transition zone, reservoir operation will continue along the RC for the remainder of the storm, including the main storm. When TOG is reached, the simulation will continue as above to Point F, and then beyond as necessary according to the outlet rating. If the pool elevation is not within the upper transition zone then the reservoir operation transfers back to the PGC at that elevation and will continue to pt D and beyond. This Tributary Flood Operational Guide will be typical for all Reservoirs. Figure 4 shows a Generic Tributary Guide with the PGC and RC only.

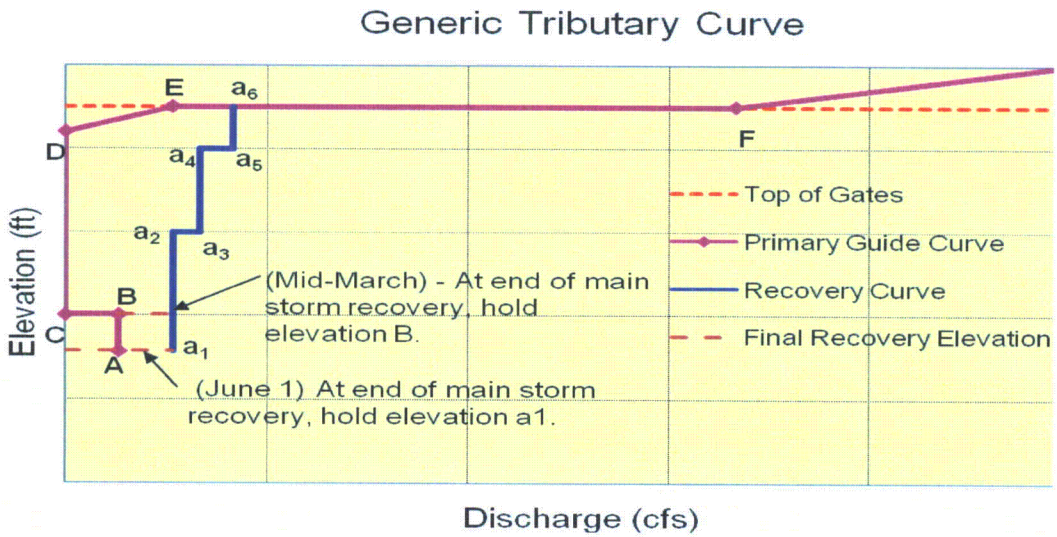


Figure 4 – Generic Tributary Curve

9.0 Summary

TVA has never experienced a flood event approaching the magnitude of the PMF, thus it is difficult to fine tune an operation guide for these simulations. However, we expect for events of PMF magnitude that any operating policy driver will rapidly converge to unregulated conditions at most projects.

The following reservoirs are used in the modeling of the PMF storm event. Other reservoirs exist but do not represent significant storage capacity and therefore are not used in the computer models. All SOCH computer model input points are represented in the Tributary Reservoir curves except Chilhowee. Chilhowee will be operated as a pass through where the inflows are the outflows.

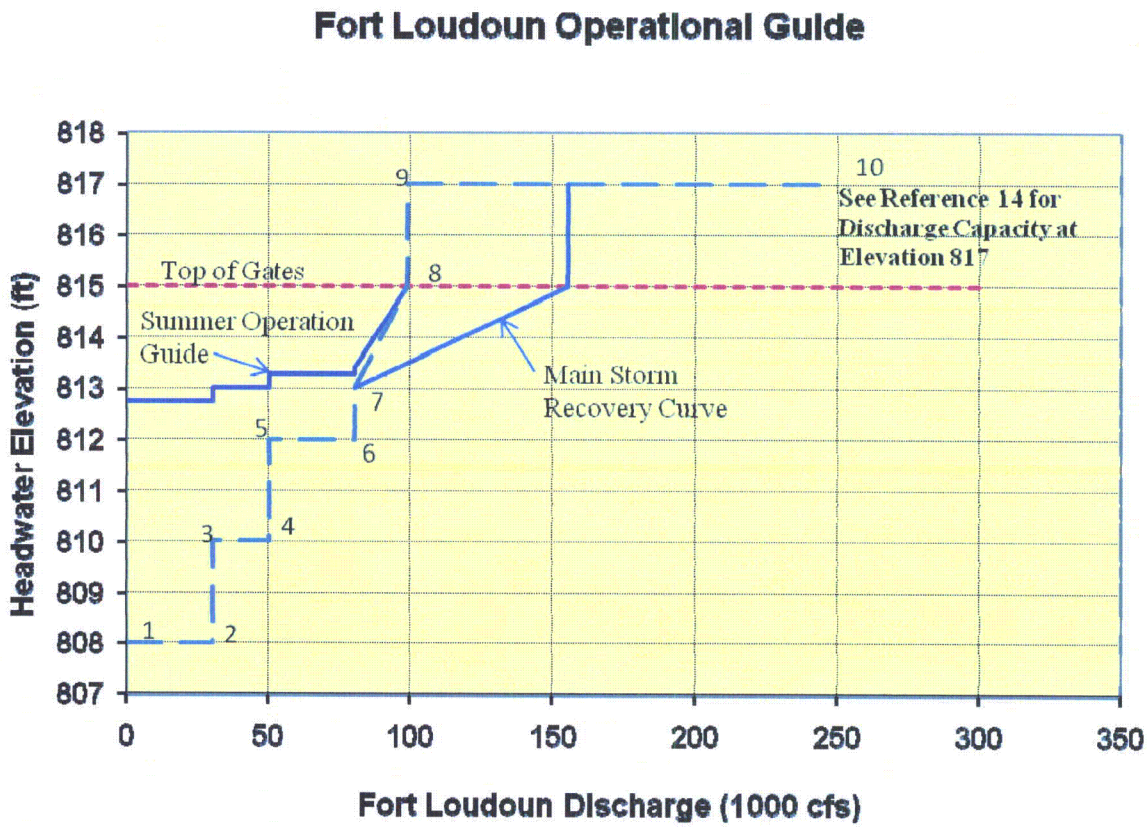
Attachment 1 (electronic) has the same data that is represented in the tables but in SOCH usable format (excel spreadsheet). The Mainstem Dam points account for the convergence issues, while Tributary Dams data is usable as shown in the Figures.

9.1 Main Stem (or SOCH Modeled) Reservoirs

The Figures 5 thru 13 that follow represents the best available information and knowledge to date on how the individual Mainstem (or SOCH Modeled) Dams will operate during a PMF event.

9.2 Tributary Reservoirs

The Figures 14 thru 39 that follow represents the best available information and knowledge to date on how the individual Tributary Dams will operate during a PMF event.



Mid-March Guide										
Pt	1	2	3	4	5	6	7	8	9	10
Elevation (Ft)	808	808	810	810	812	812	813	815	817	817
Discharge (1000 cfs)	0	30	30	50	50	80	80	98.75	98.75	*

* - See Reference 14 for discharge capacity.

June 1 Guide										
Pt	1	2	3	4	5	6	7	8	9	10
Elevation (Ft)	812.75	812.75	813	813	813.3	813.3	813.43	815	817	817
Discharge (1000 cfs)	0	30	30	50	50	80	80	98.75	98.75	*

Figure 5 – Fort Loudoun Flood Operational Guide

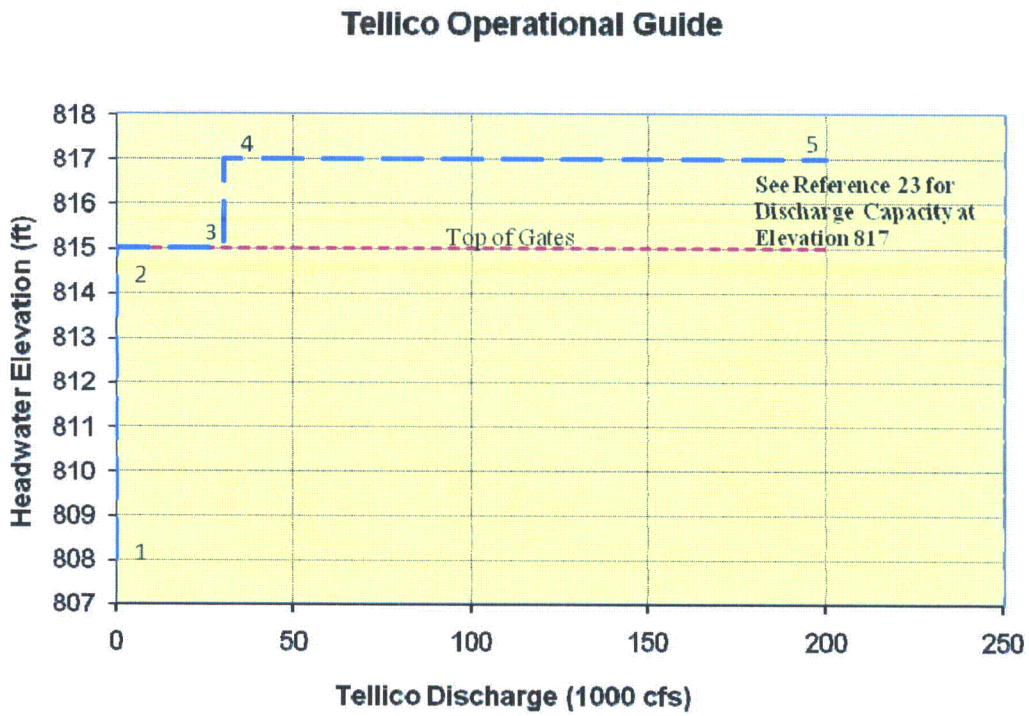
Fort Loudoun Flood Operational Guide

The sequence for Fort Loudoun will follow the Flood Guide shown on Figure 5. As a flood develops the operation at Fort Loudoun as the downstream boundary in SOCH, will follow the numbers shown on Figure 5 as defined below: (numbers given are for the Mid-March Guide)

- Hold elevation 808 until the discharge equals 30,000 cfs.
- Hold the discharge at 30,000 cfs until the head water elevation 810 is reached.
- Hold elevation at 810 until the discharge equals 50,000 cfs
- Hold discharge at 50,000 cfs until the head water elevation 812 is reached.
- Hold elevation 812 until the discharge equals 80,000 cfs.
- Hold the discharge 80,000 cfs until elevation 813 is reached.
- Elevation and discharge increase until the headwater reaches gate top elevation of 815 and discharge of 98,750 cfs.
- Hold discharge at 98,750 cfs at Fort Loudoun until head water elevation 817 is reached.
- Hold elevation 817 until Fort Loudoun discharge capacity is reached.

Recovery after Main Storm

Fort Loudoun will follow the PGC down to elevation 817 and 155,000 cfs.
Then hold 155,000 cfs until elevation 815 is reached.
After 815 is reached elevation and discharge decrease until elevation 813 and 80,000 cfs is reached.
Recovery Curve at pt 7 follows PGC back down to normal pool elevation and discharge.



	Mid-March and June 1 Guide				
Pt	1	2	3	4	5
Elevation (Ft)	808	815	815	817	817
Discharge (1000 cfs)	0	0	30	30	*

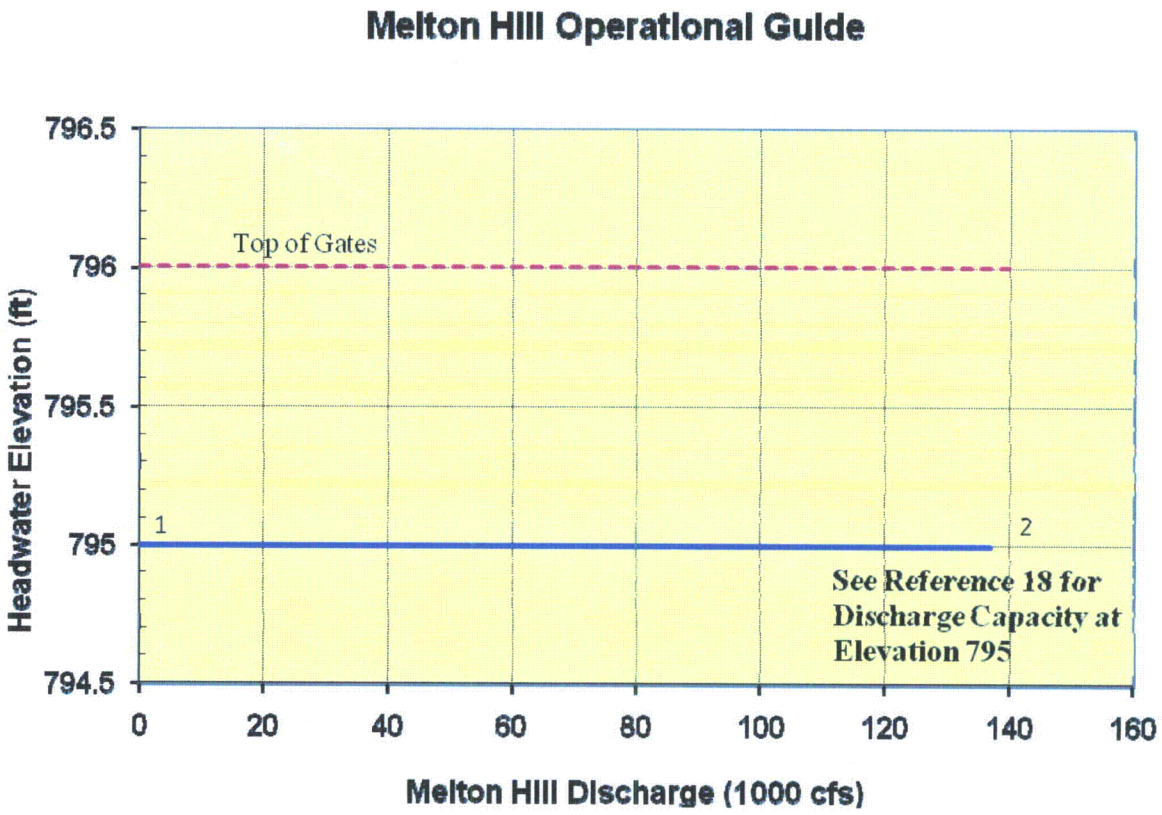
* - See Reference 23 for discharge capacity.

Figure 6 – Tellico Flood Operational Guide

Tellico Flood Operational Guide

The sequence for Tellico will follow the Flood Guide shown on Figure 6. As a flood develops the operation at Tellico as the downstream boundary in SOCH, will follow the numbers shown on Figure 6 as defined below:

- Hold discharge at zero until elevation 815 is reached.
- Hold elevation 815 until the discharge equals 30,000 cfs.
- Hold discharge at 30,000 cfs until elevation 817 is reached.
- Hold elevation 817 until Tellico discharge capacity is reached.



Mid-March and June 1 Guide		
Pt	1	2
Elevation (Ft)	795	795
Discharge (1000 cfs)	0	*

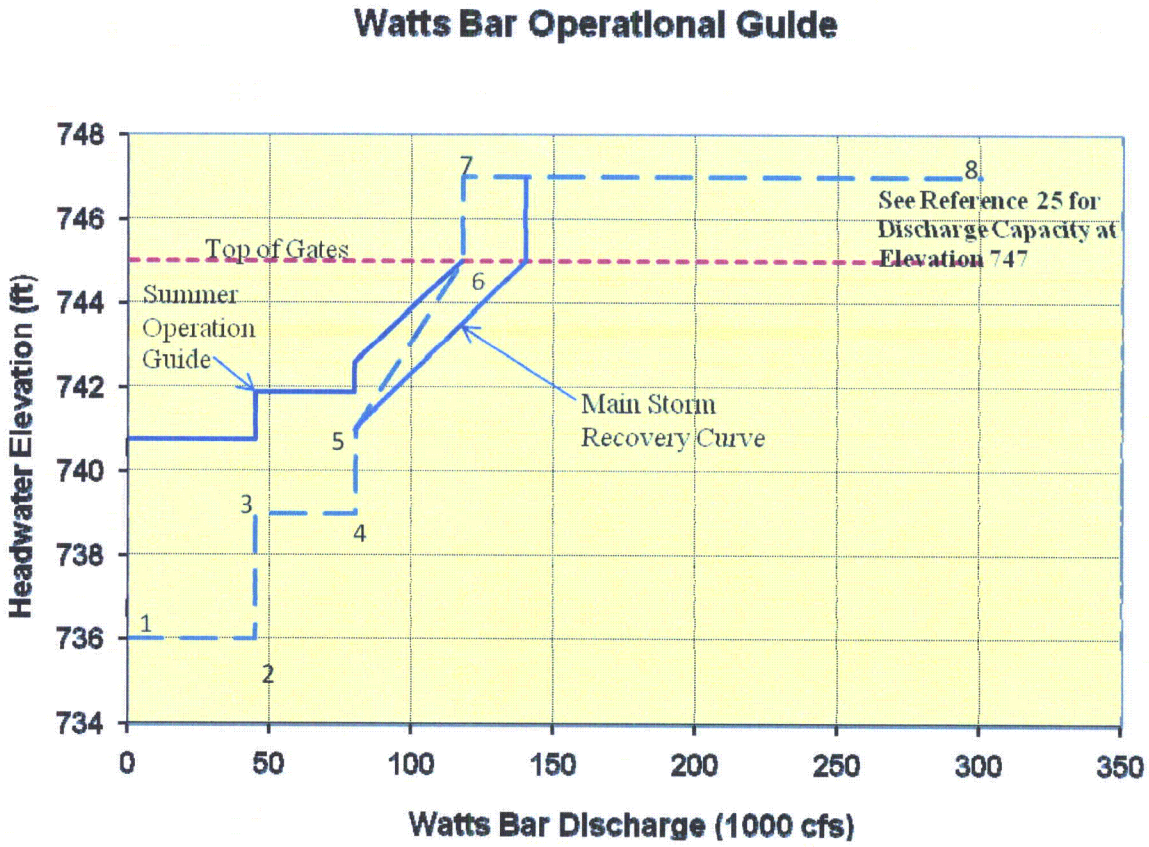
* - See Reference 18 for discharge capacity.

Figure 7 – Melton Hill Flood Operational Guide

Melton Hill Flood Operational Guide

The sequence for Melton Hill will follow the Flood Guide shown on Figure 7. As a flood develops the operation at Melton Hill will follow the numbers shown on Figure 7 as defined below:

- Hold elevation 795 until Melton Hill discharge capacity is reached.



Mid-March Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	736	736	739	739	741	745	747	747
Discharge (1000 cfs)	0	45	45	80	80	117.5	117.5	*

* - See Reference 25 for discharge capacity.

June 1 Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	740.75	740.75	741.85	741.85	742.58	745	747	747
Discharge (1000 cfs)	0	45	45	80	80	117.5	117.5	*

Figure 8 – Watts Bar Flood Operational Guide

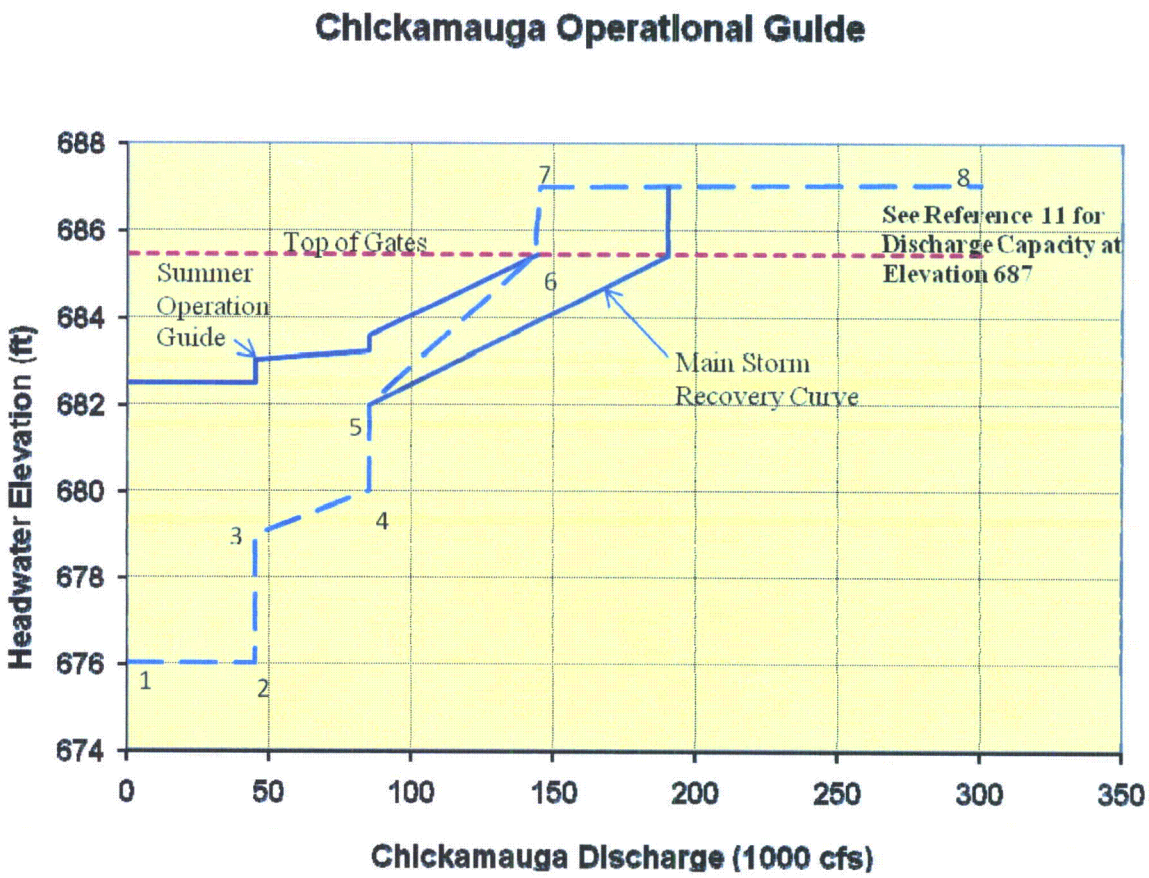
Watts Bar Flood Operational Guide

The sequence for Watts Bar will follow the Flood Guide shown on Figure 8. As a flood develops the operation at Watts Bar, as the downstream boundary in SOCH, will follow the numbers shown on Figure 8 as defined below: (numbers given are for Mid-March guide)

- Hold elevation 736 until the discharge equals 45,000 cfs.
- Hold discharge 45,000 cfs until elevation 739is reached.
- Hold elevation 739 until the discharge equals 80,000 cfs.
- Hold discharge 80,000 cfs until head water reaches elevation 741.
- Elevation and discharge increase until gate top elevation of 745 and discharge of 117,500 cfs is reached.
- Hold discharge at 117,500 cfs until elevation 747 is reached.
- Hold elevation 747 until Watts Bar discharge capacity is reached.

Recovery after Main Storm

Watts Bar will follow the PGC down to elevation 747 and 140,000 cfs.
Then hold 140,000 cfs until elevation 745 is reached.
After 745 is reached elevation and discharge decrease until elevation 741 and 80,000 cfs is reached.
Recovery Curve at pt 5 follows PGC back down to normal pool elevation and discharge.



Mid-March Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	676	676	679	680	682	685.44	687	687
Discharge (1000 cfs)	0	45	45	85	85	145	145	*

* - See Reference 11 for discharge capacity.

June 1 Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	682.5	682.5	683.04	683.23	683.59	685.44	687	687
Discharge (1000 cfs)	0	45	45	85	85	145	145	*

Figure 9 – Chickamauga Flood Operational Guide

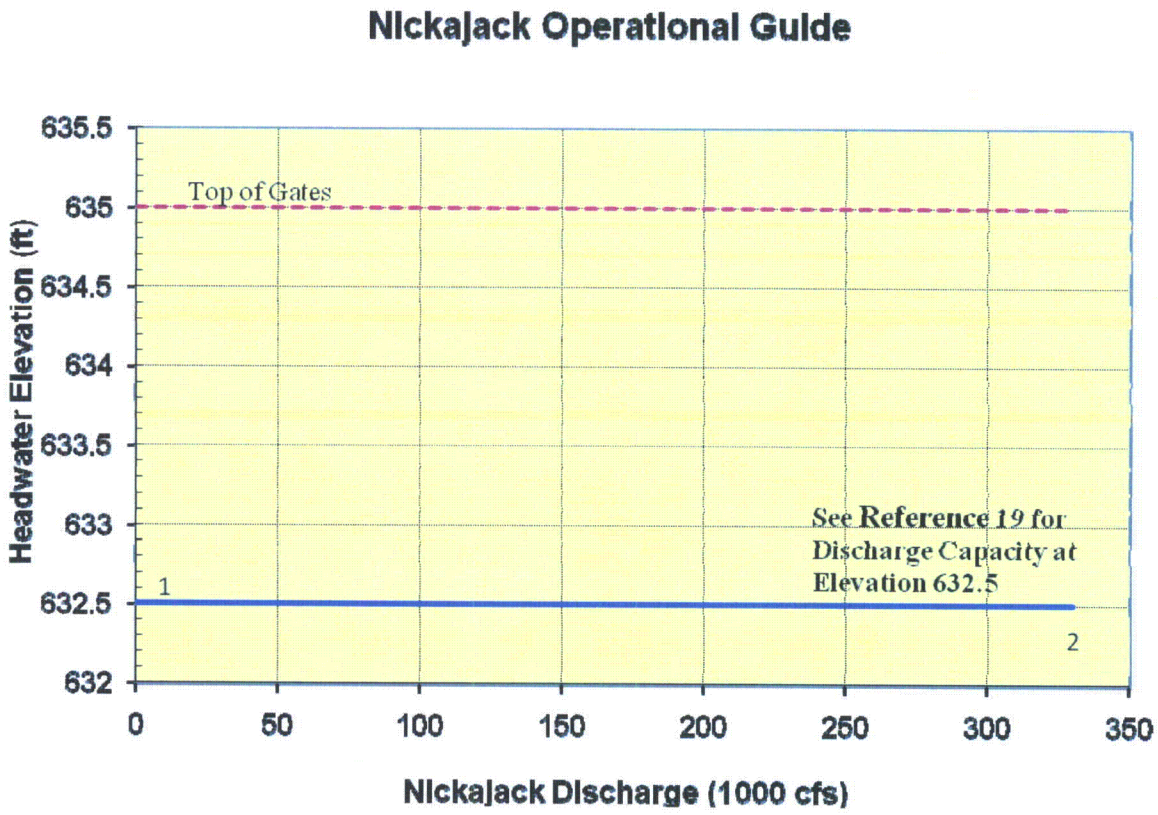
Chickamauga Flood Operational Guide

The sequence for Chickamauga will follow the Flood Guide shown on Figure 9. As a flood develops the operation at Chickamauga as the downstream boundary in SOCH, will follow the numbers shown on Figure 9 as defined below: (numbers given are for Mid-March guide)

- Hold elevation 676 until the discharge equals 45,000 cfs.
- Hold discharge 45,000 cfs until elevation 679 is reached.
- Elevation and discharge increase until elevation of 680 and discharge of 85,000 cfs is reached.
- Hold discharge 85,000 cfs until elevation 682 is reached.
- Elevation and discharge increase until gate top elevation of 685.44 and discharge of 145,000 cfs is reached.
- Hold discharge 145,000 cfs until elevation 687 is reached.
- Hold elevation at 687, until Chickamauga discharge capacity is reached.

Recovery after Main Storm

Chickamauga will follow the PGC down to elevation 687 and 190,000 cfs.
Then hold 190,000 cfs until elevation 685.44 is reached.
After 685.44 is reached elevation and discharge decrease until an elevation of 682 and a discharge of 85,000cfs is reached.
Recovery Curve at pt 5 follows PGC back down to normal pool elevation and discharge.



Mid-March and June 1 Guide		
Pt	1	2
Elevation (Ft)	632.5	632.5
Discharge (1000 cfs)	0	*

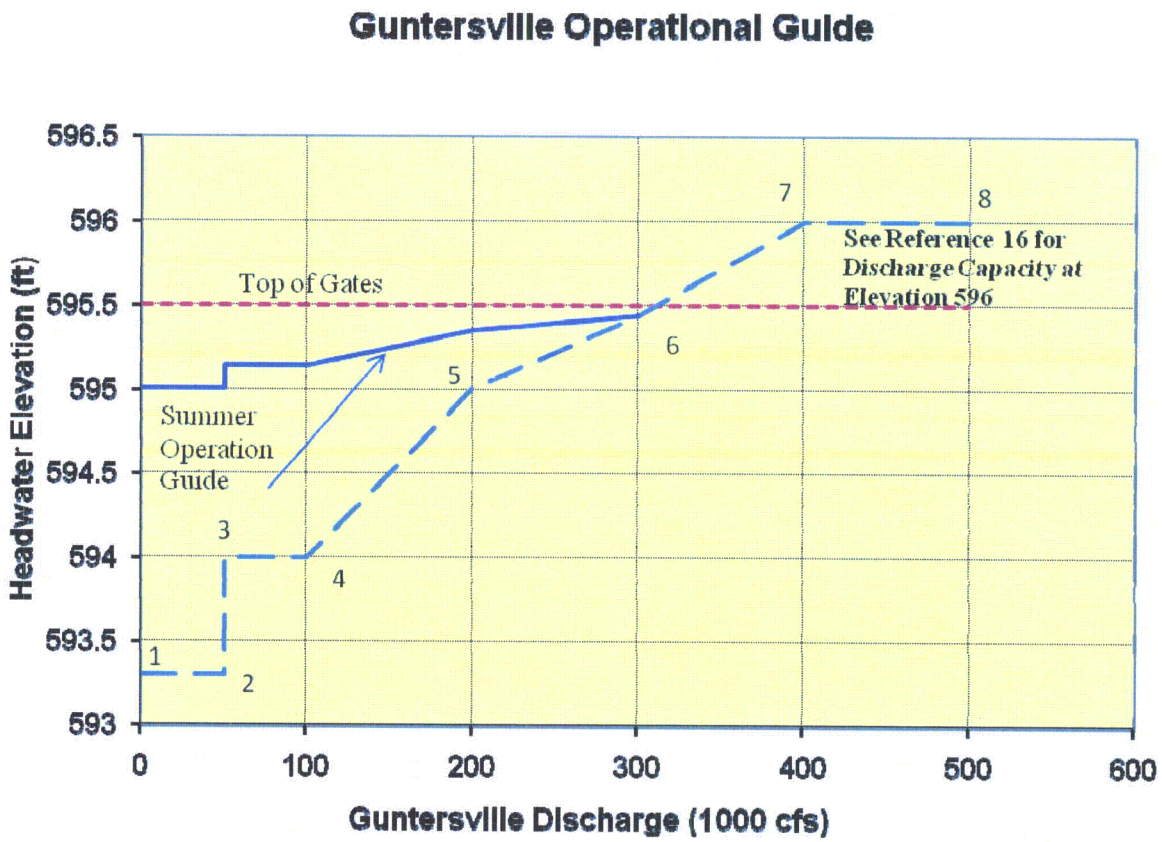
* - See Reference 19 for discharge capacity.

Figure 10 – Nickajack Flood Operational Guide

Nickajack Flood Operational Guide

The sequence for Nickajack will follow the Flood Guide shown on Figure 10. As a flood develops the operation at Nickajack will follow the numbers shown on Figure 10 as defined below:

- Hold elevation 632.5 until Nickajack discharge capacity is reached.



Mid-March Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	593.3	593.3	594	594	595	595.44	596	596
Discharge (1000 cfs)	0	50	50	100	200	300	400	*

* - See Reference 16 for discharge capacity.

June 1 Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	595	595	595.14	595.14	595.35	595.44	596	596
Discharge (1000 cfs)	0	50	50	100	200	300	400	*

Figure 11 – Guntersville Flood Operational Guide

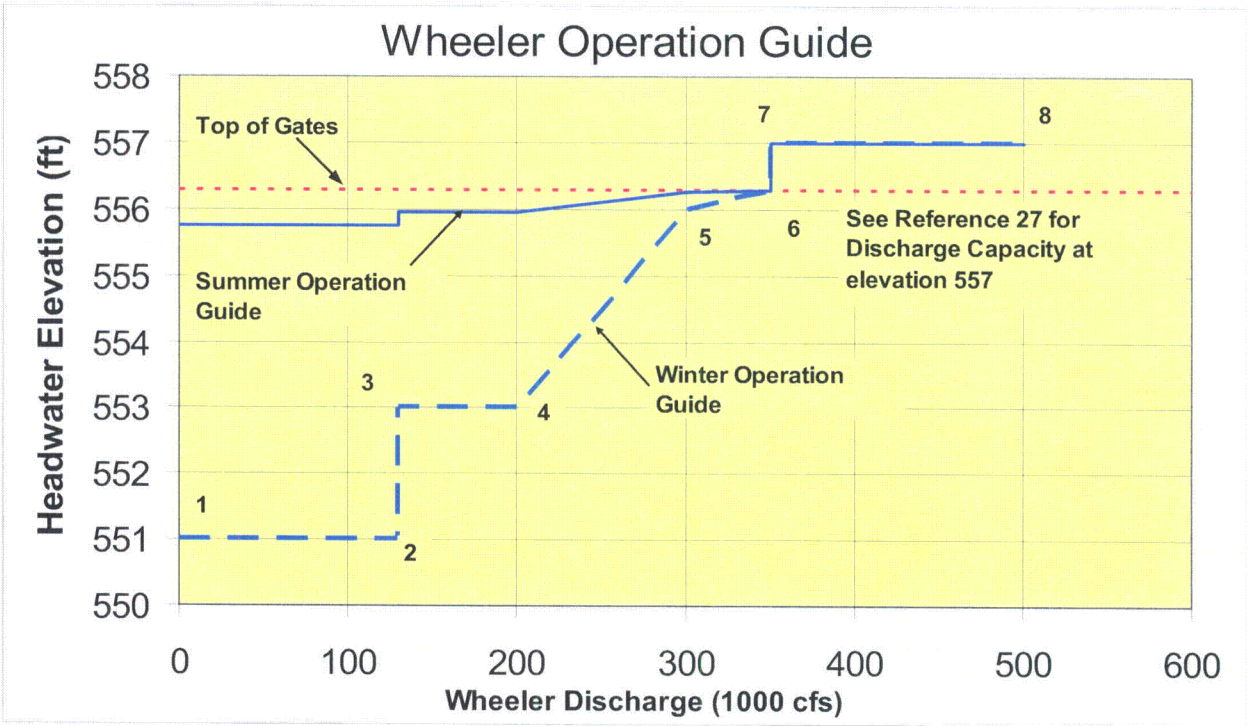
Guntersville Flood Operational Guide

The sequence for Guntersville will follow the Flood Guide shown on Figure 11(numbers given are for Mid-March guide):

- Hold elevation 593.3 until the discharge equals 50,000 cfs.
- Hold discharge 50,000 cfs until elevation 594 is reached.
- Hold elevation 594 until discharge equal 100,000 cfs.
- Elevation and discharge increase until elevation 595 and discharge is 200,000 cfs
- Elevation and discharge increase until gate top elevation of 595.44 and discharge of 300,000 cfs.
- Elevation and discharge increase until the surcharge elevation 596.
- Hold elevation 596 until Guntersville discharge capacity is reached.

Recovery after Main Storm

Guntersville will follow the PGC.



Mid-March Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	551	551	553	553	556	556.28	557	557
Discharge (1000 cfs)	0	130	130	200	300	350	350	500

* - See Reference 27 for discharge capacity.

June 1 Guide								
Pt	1	2	3	4	5	6	7	8
Elevation (Ft)	555.75	555.75	555.95	555.95	556.25	556.28	557	557
Discharge (1000 cfs)	0	130	130	200	300	350	350	500

Figure 12 – Wheeler Flood Operational Guide

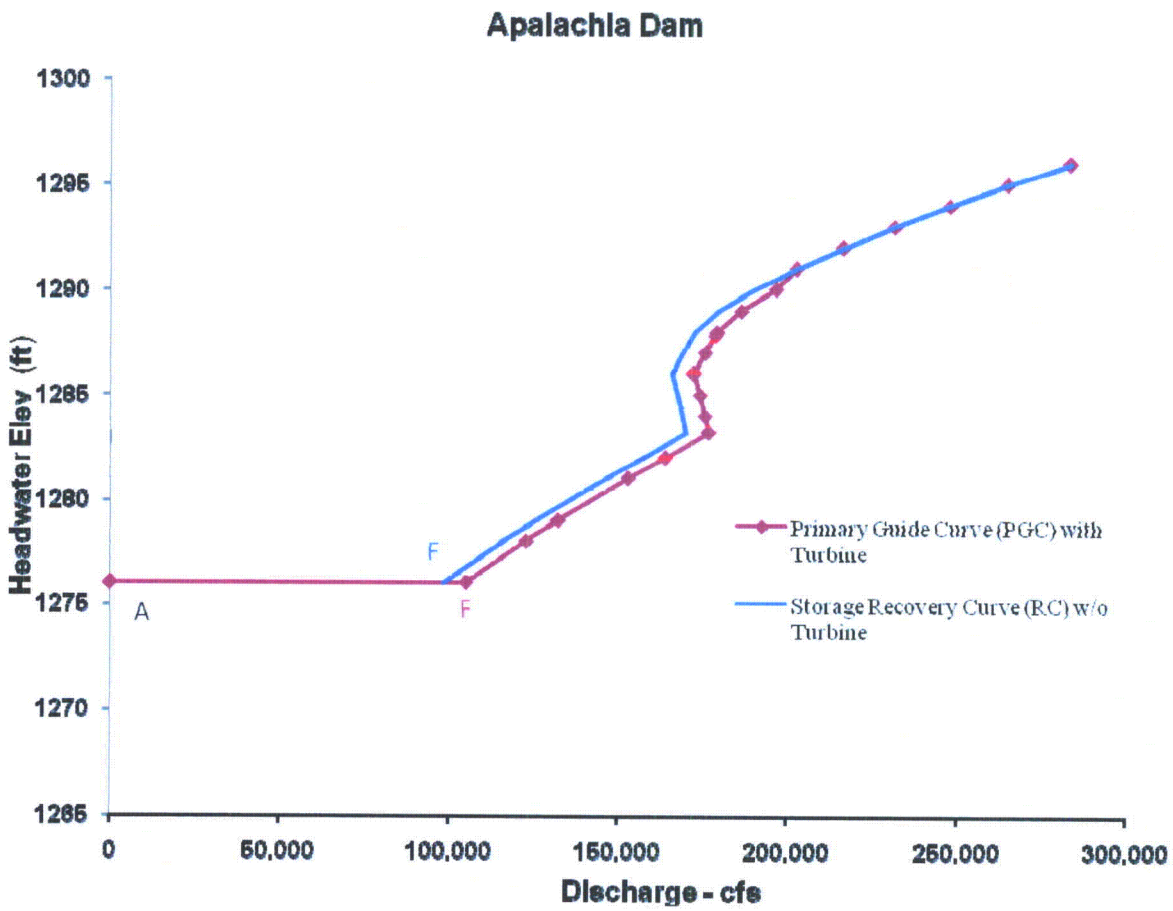
Wheeler Flood Operational Guide

The sequence for Wheeler will follow the Flood Guide shown on Figure 12. As a flood develops the operation at Wheeler as the downstream boundary in SOCH, will follow the numbers shown on Figure 12 as defined below: (numbers given are for Mid-March guide)

- Hold elevation 551 until the discharge equals 130,000 cfs.
- Hold discharge 130,000 cfs until elevation 553is reached.
- Hold elevation 553 until discharge equal 200,000 cfs.
- Elevation and discharge increase until elevation 556 and discharge is 300,000 cfs
- Elevation and discharge increase until gate top elevation of 556.28 and discharge of 350,000 cfs.
- Elevation and discharge increase until the surcharge elevation 557.
- Hold elevation 596 until Guntersville discharge capacity is reached.

Recovery after Main Storm

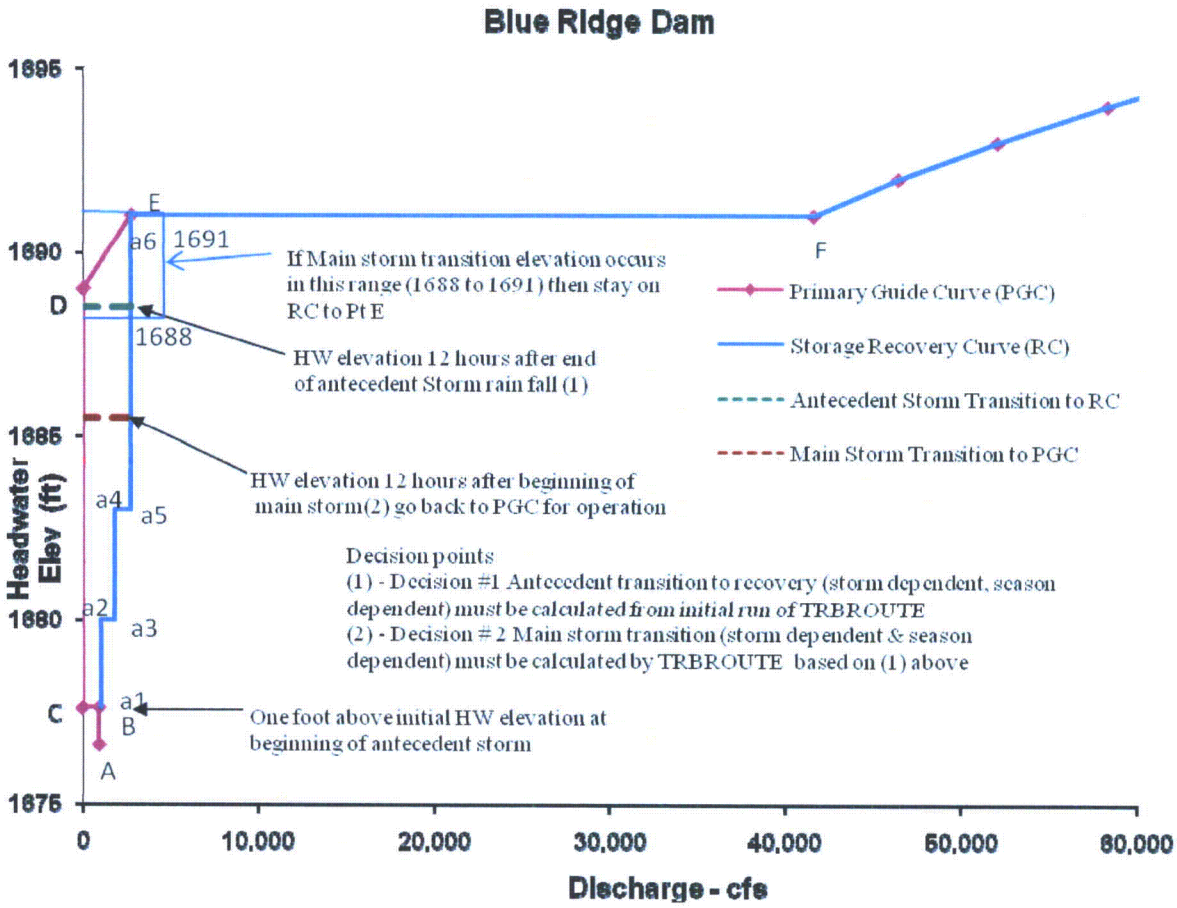
Wheeler will follow the PGC.



Pt	A	F
Elevation (ft)	1276	1276
Discharge (cfs)	0	*

* - See Reference 6 for elevation/discharge at point F.

Figure 13 – Apalachia Mid-March and June 1 Flood Operational Guide



Notes:

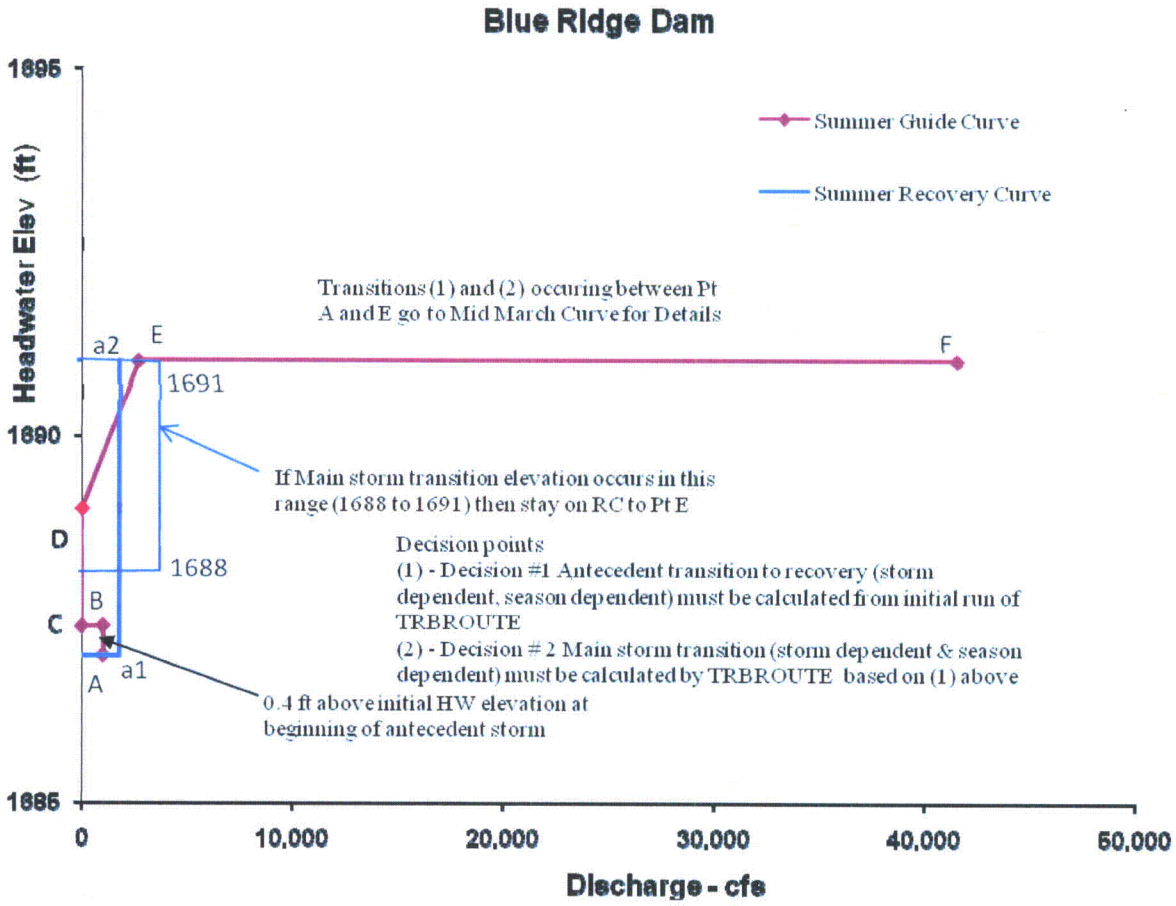
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1676.6	1677.6	1677.6	1689	1691	1691	1677.6	1680	1680	1683	1683	1691
Discharge (cfs)	900	900	0	0	2,700	*	900	1,000	1,800	1,800	2,700	2,700

* - See Reference 7 for elevation/discharge at point F.

Figure 14 – Blue Ridge Mid-March Flood Operational Guide

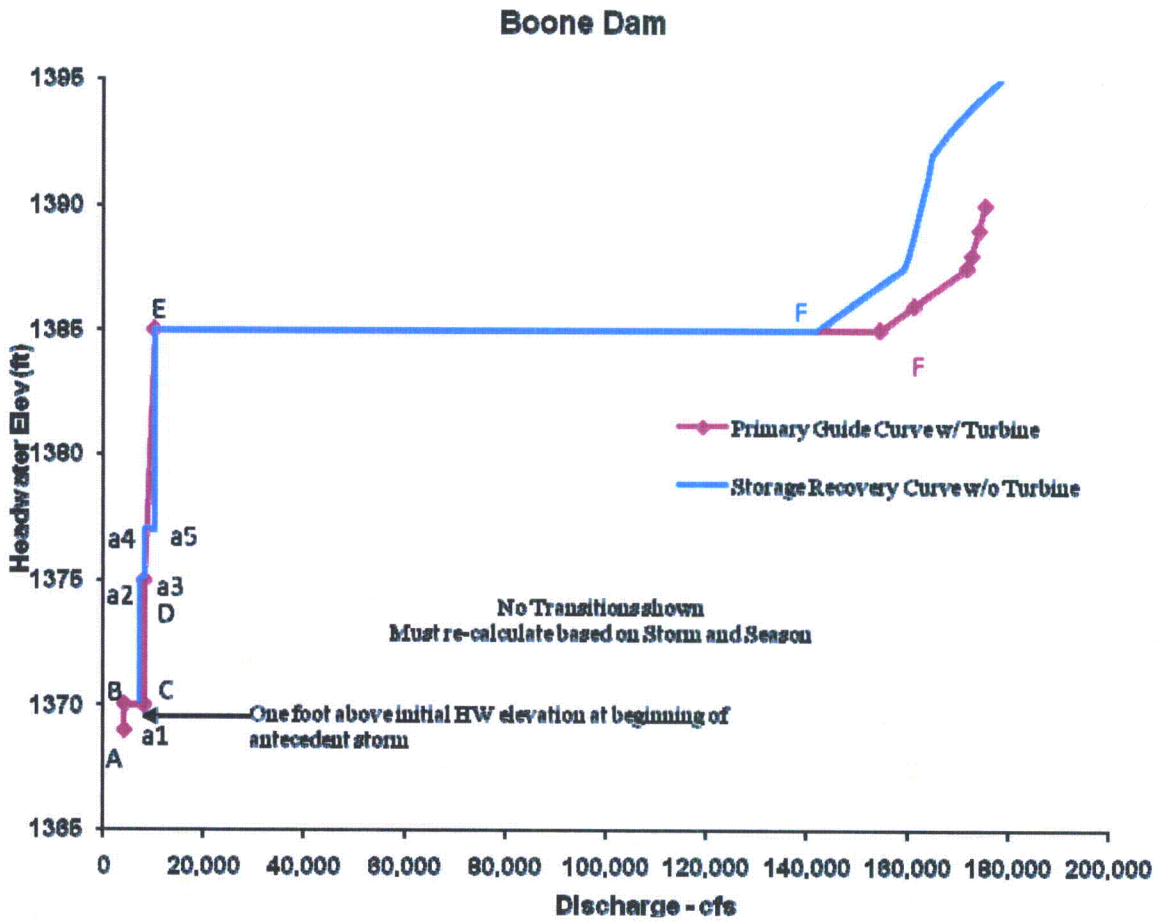


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1687	1687.4	1687.4	1689	1691	1691	1687	1691	N/A	N/A	N/A	N/A
Discharge (cfs)	1,000	1,000	0	0	2,700	*	1,800	1,800	N/A	N/A	N/A	N/A

* - See Reference 7 for elevation/discharge at point F.

Figure 15– Blue Ridge June 1 Flood Operational Guide



Notes:

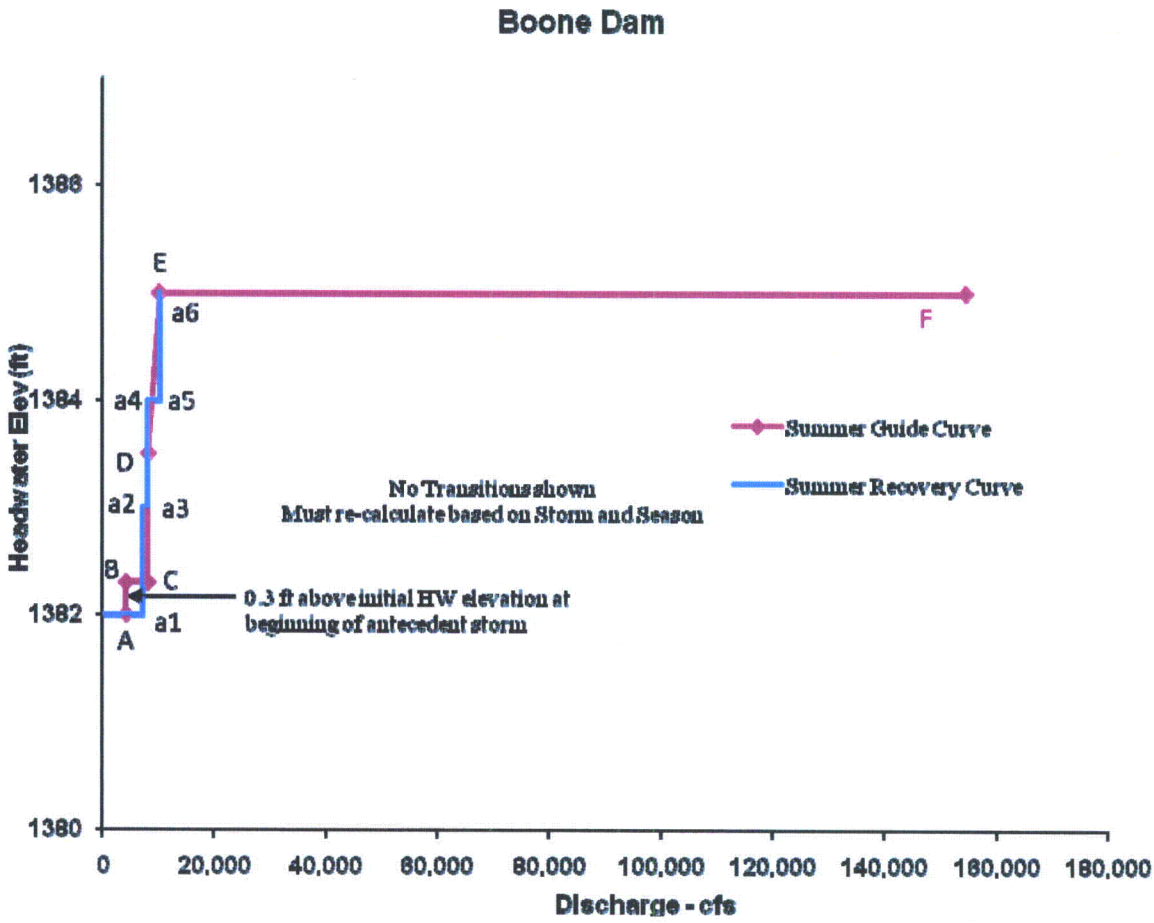
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1369.1	1370.1	1370.1	1375	1385	1385	1370.1	1375	1375	1377	1377	1385
Discharge (cfs)	4,000	4,000	8,000	8,000	10,000	*	7,000	7,000	8,000	8,000	10,000	10,000

* - See Reference 8 for elevation/discharge at point F.

Figure 16 – Boone Mid-March Flood Operational Guide

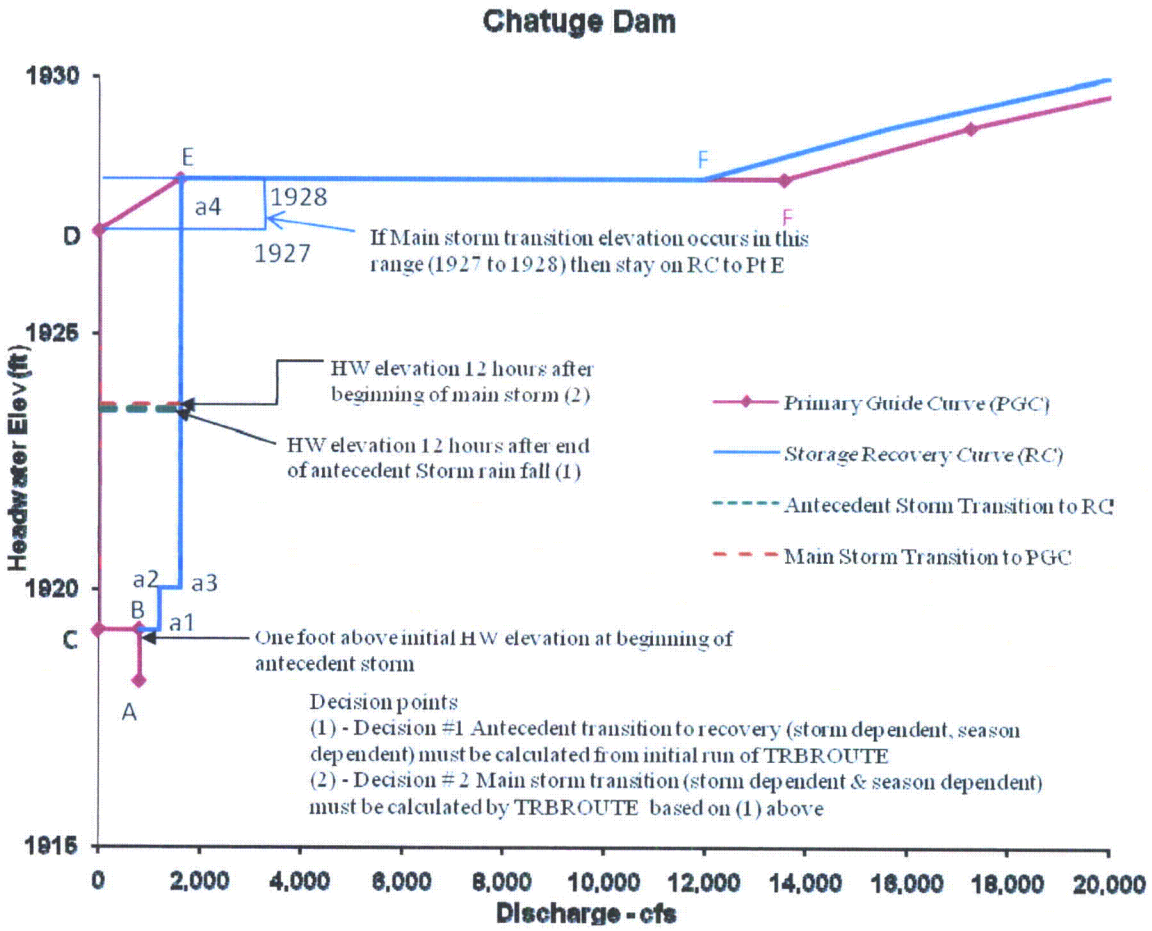


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1382	1382.3	1382.3	1383.5	1385	1385	1382	1383	1383	1384	1384	1385
Discharge (cfs)	4,000	4,000	8,000	8,000	10,000	*	7,000	7,000	8,000	8,000	10,000	10,000

* - See Reference 8 for elevation/discharge at point F.

Figure 17– Boone June 1 Flood Operational Guide



Notes:

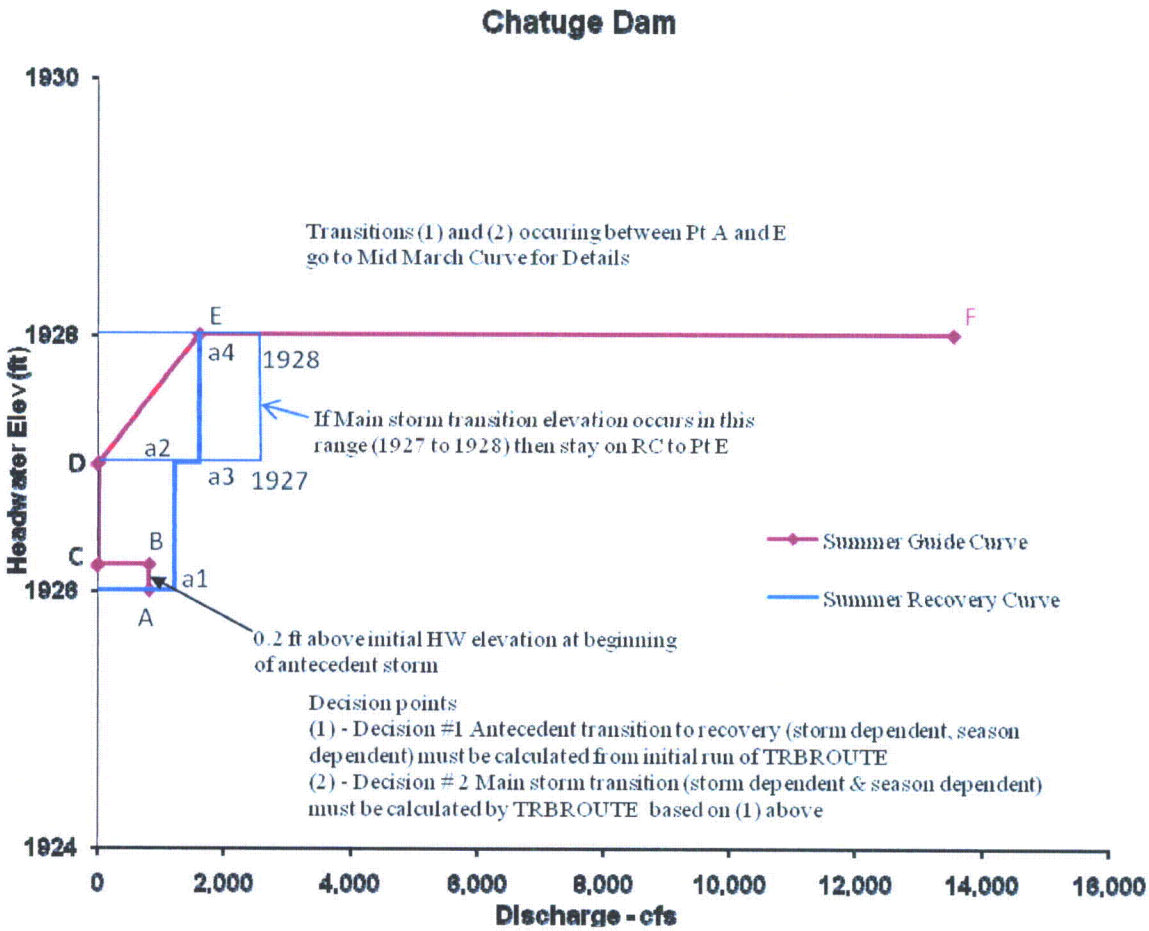
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1918.2	1919.2	1919.2	1927	1928	1928	1919.2	1920	1920	1928	N/A	N/A
Discharge (cfs)	800	800	0	0	16,000	*	1,200	1,200	1,600	1,600	N/A	N/A

* - See Reference 9 for elevation/discharge at point F.

Figure 18 – Chatuge Mid-March Flood Operational Guide

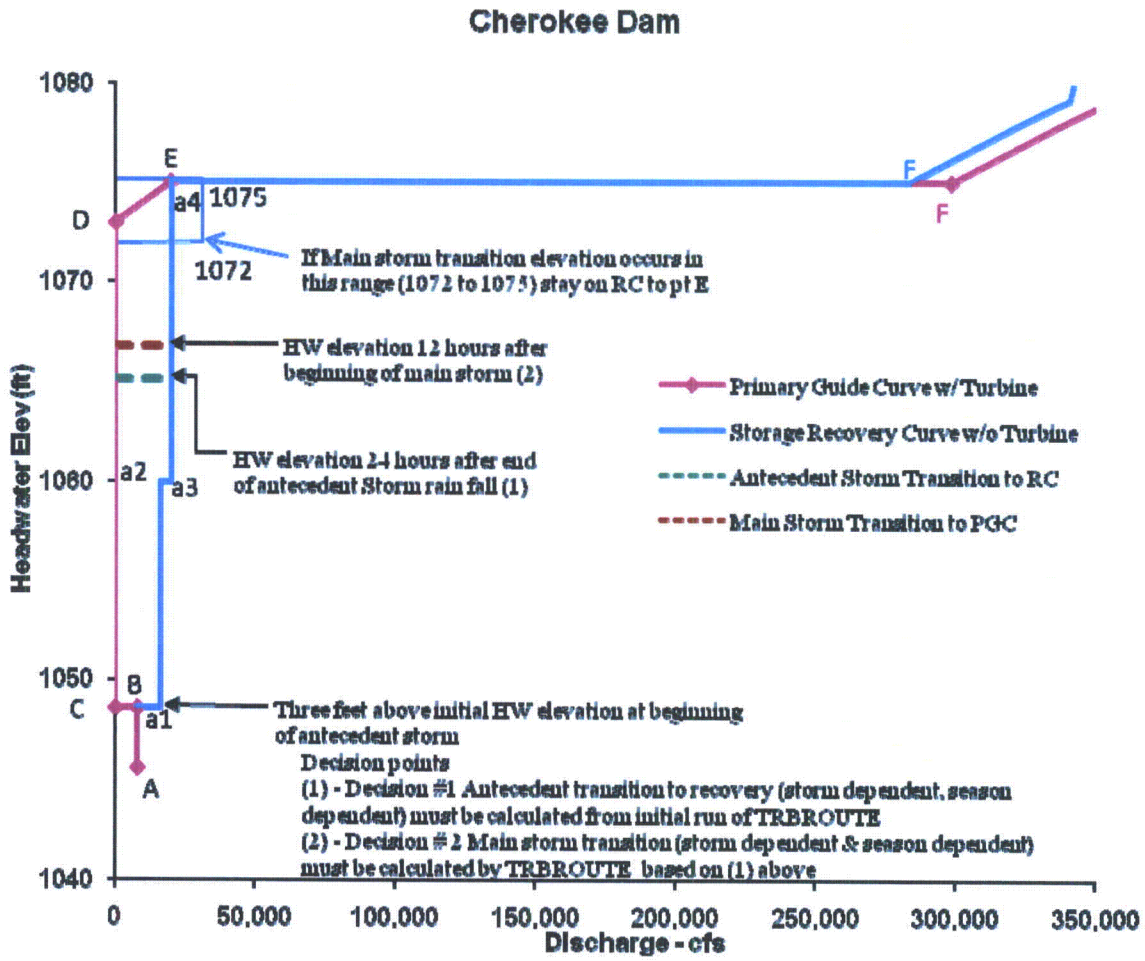


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1926	1926.2	1926.2	1927	1928	1928	1926	1927	1927	1928	N/A	N/A
Discharge (cfs)	800	800	0	0	1,600	*	1,200	1,200	1,600	1,600	N/A	N/A

* - See Reference 9 for elevation/discharge at point F.

Figure 19 – Chatuge June 1 Flood Operational Guide



Notes:

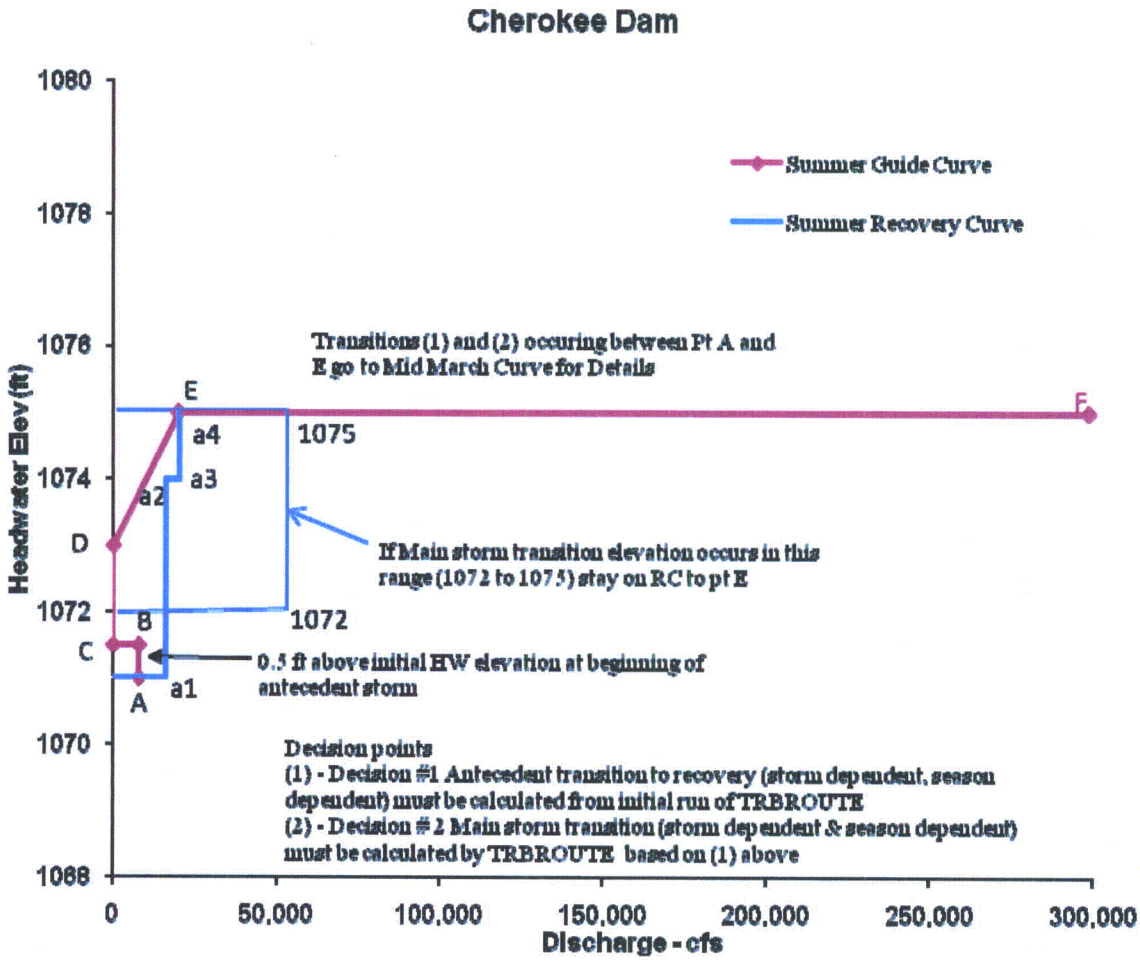
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1045.6	1048.6	1048.6	1073	1075	1075	1048.6	1060	1060	1075	N/A	N/A
Discharge (cfs)	8,000	8,000	0	0	20,000	*	16,000	16,000	20,000	20,000	N/A	N/A

* - See Reference 10 for elevation/discharge at point F.

Figure 20 – Cherokee Mid-March Flood Operational Guide

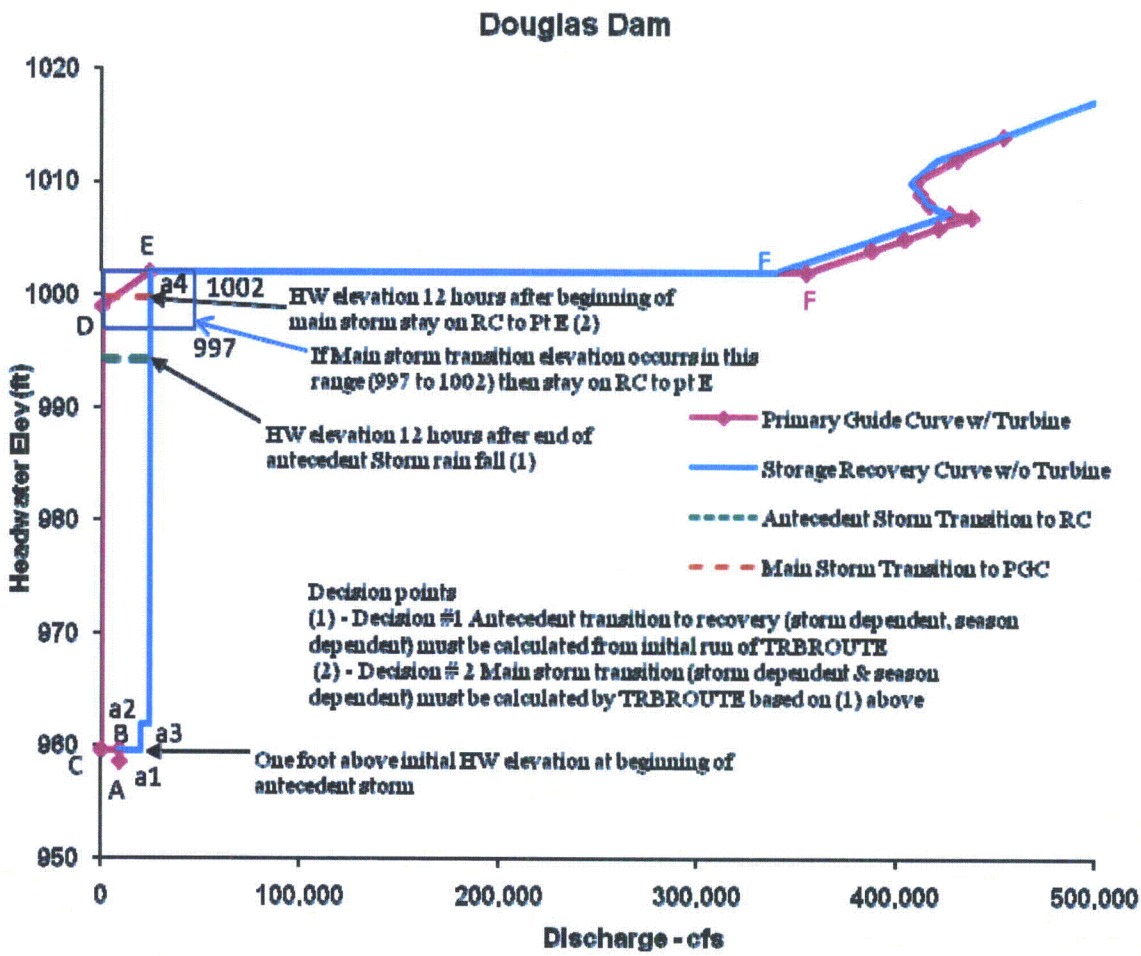


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1071	1071.5	1071.5	1073	1075	1075	1071	1074	1074	1075	N/A	N/A
Discharge (cfs)	8,000	8,000	0	0	20,000	*	16,000	16,000	20,000	20,000	N/A	N/A

* - See Reference 10 for elevation/discharge at point F.

Figure 21 – Cherokee June 1 Flood Operational Guide



Notes:

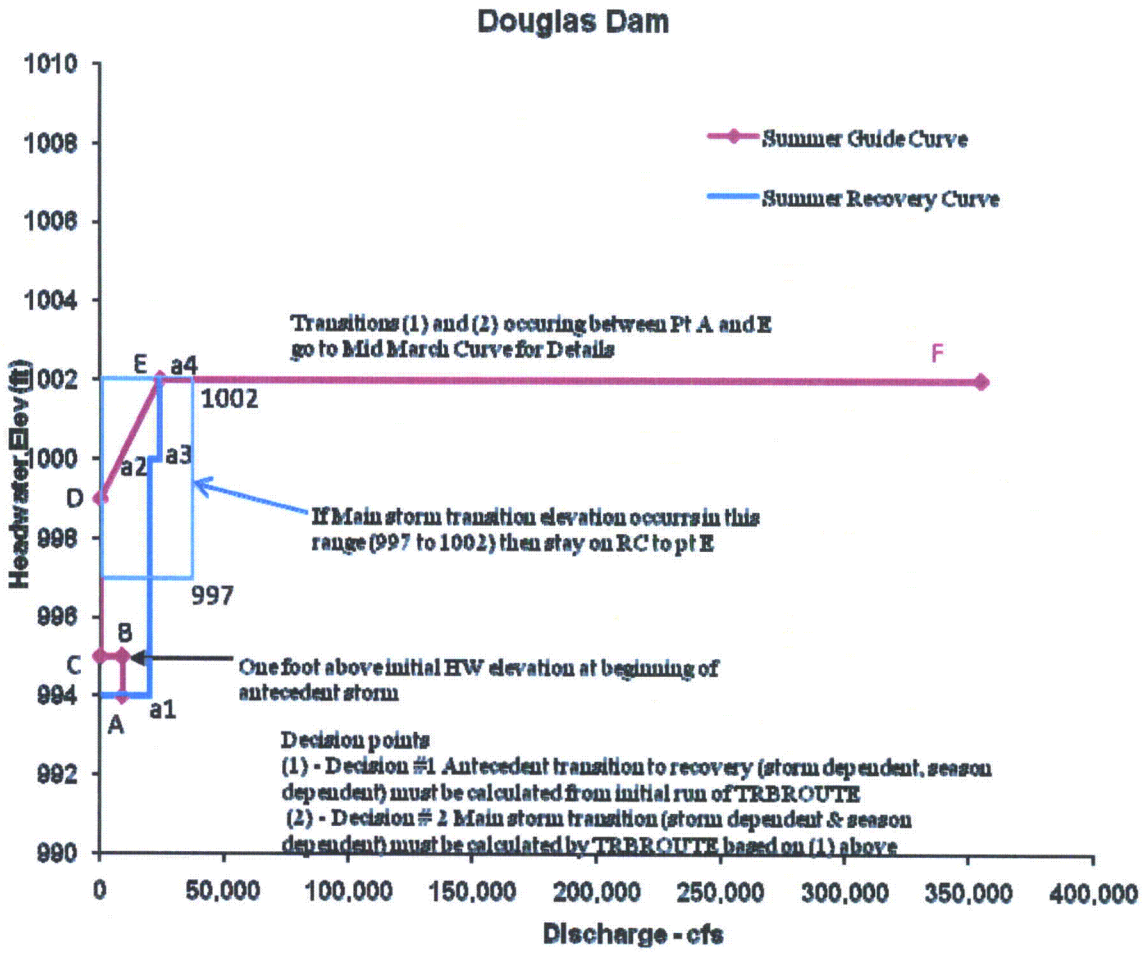
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	958.6	959.6	959.6	999	1002	1002	959.6	962	962	1002	N/A	N/A
Discharge (cfs)	9,000	9,000	0	0	24,000	*	20,000	20,000	24,000	24,000	N/A	N/A

* - See Reference 12 for elevation/discharge at point F.

Figure 22 – Douglas Mid-March Flood Operational Guide

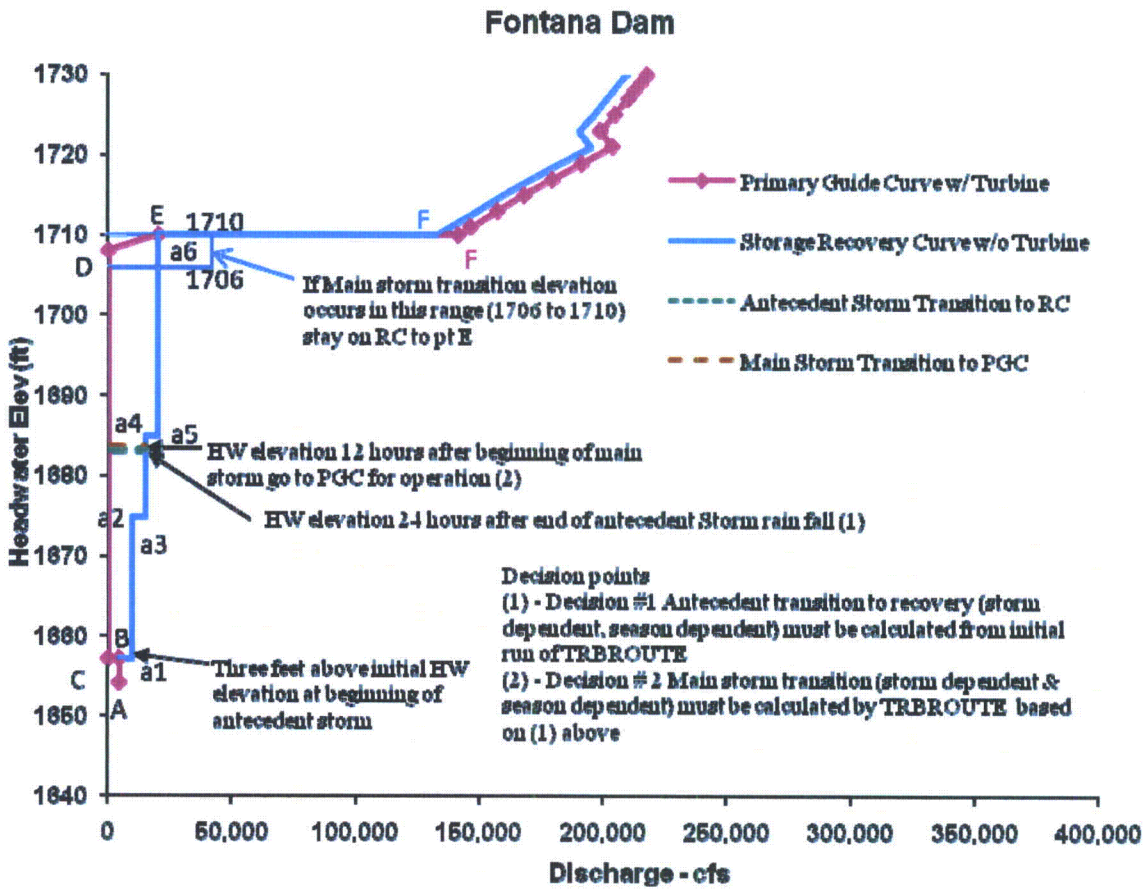


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	994	995	995	999	1002	1002	994	1000	1000	1002	N/A	N/A
Discharge (cfs)	9,000	9,000	0	0	24,000	*	20,000	20,000	24,000	24,000	N/A	N/A

* - See Reference 12 for elevation/discharge at point F.

Figure 23 – Douglas June 1 Flood Operational Guide



Notes:

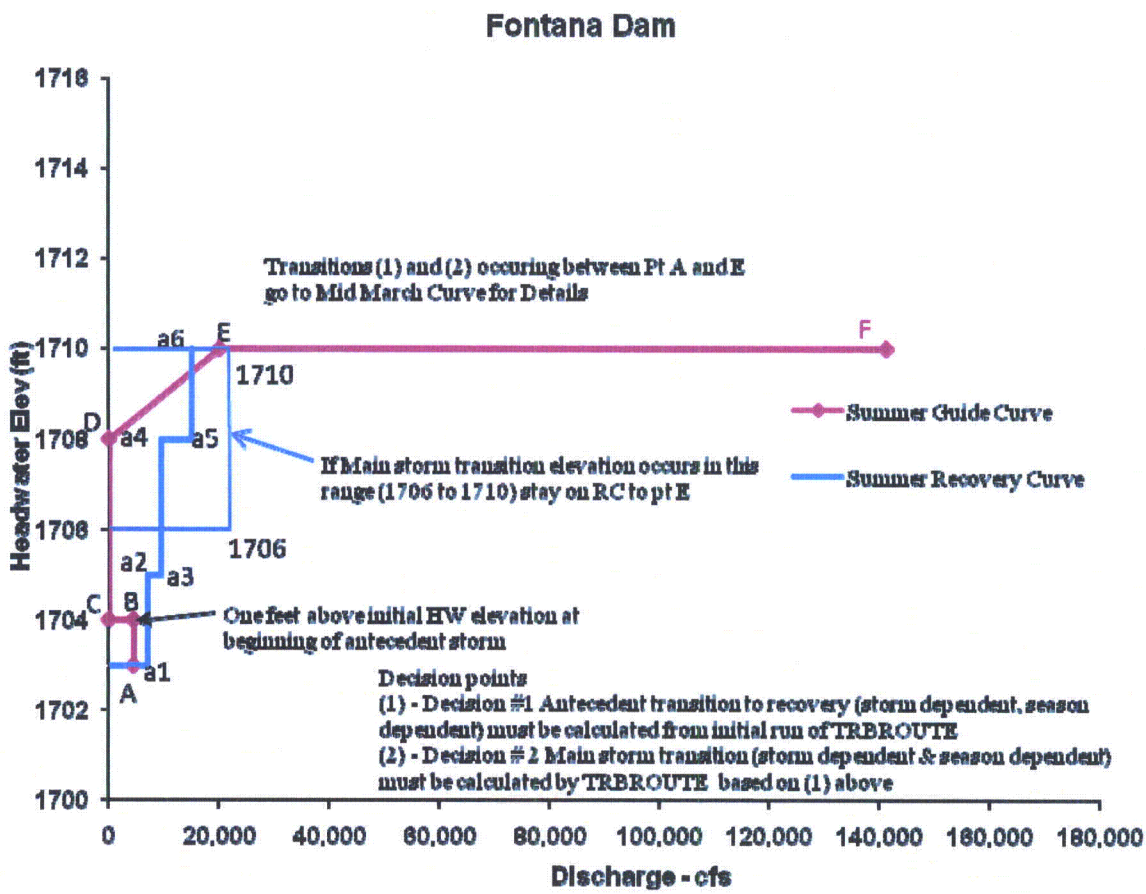
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1654.2	1657.2	1657.2	1708	1710	1710	1657.2	1675	1675	1685	1685	1710
Discharge (cfs)	4,500	4,500	0	0	20,000	*	9,500	9,500	15,000	15,000	20,000	20,000

* - See Reference 13 for elevation/discharge at point F.

Figure 24 – Fontana Mid-March Flood Operational Guide

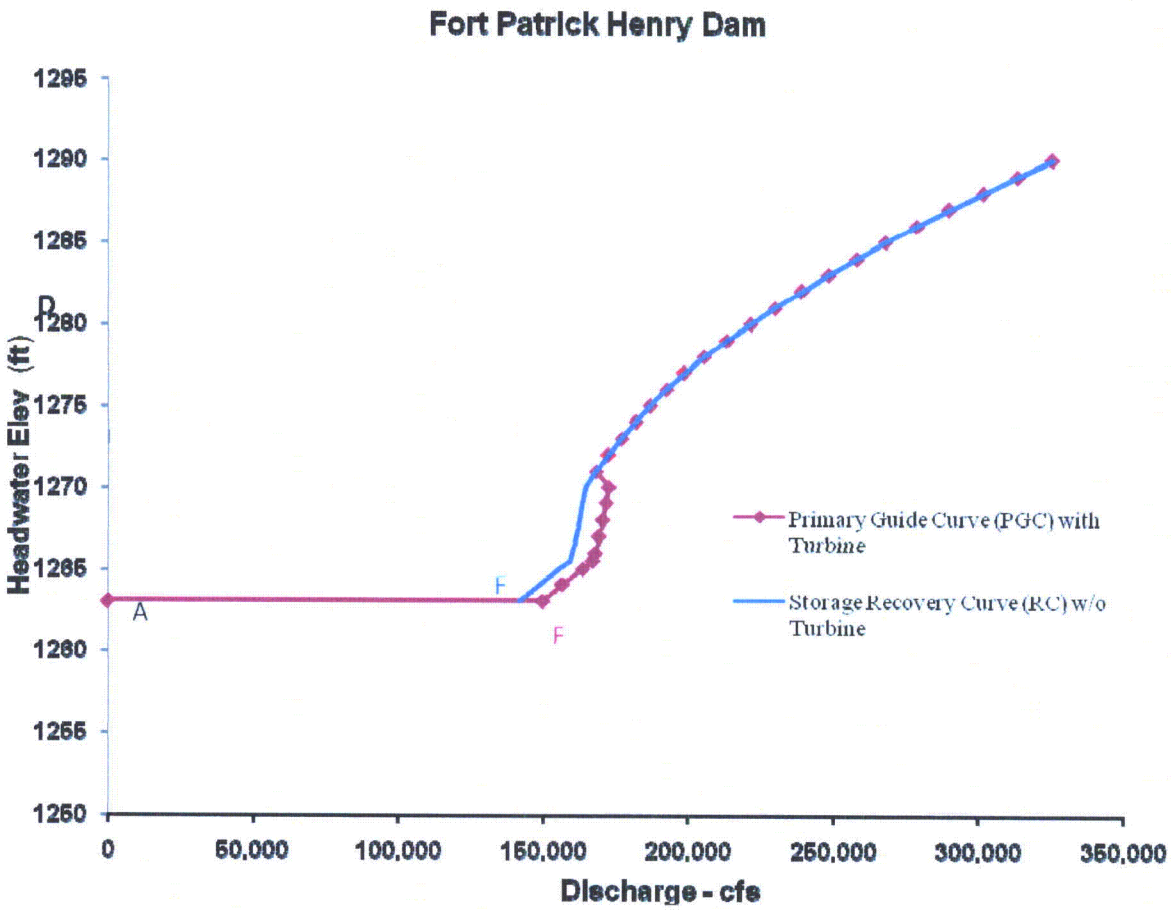


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1703	1704	1704	1708	1710	1710	1703	1705	1705	1708	1708	1710
Discharge (cfs)	4,500	4,500	0	0	20,000	*	7,000	7,000	9,500	9,500	15,000	15,000

* - See Reference 13 for elevation/discharge at point F.

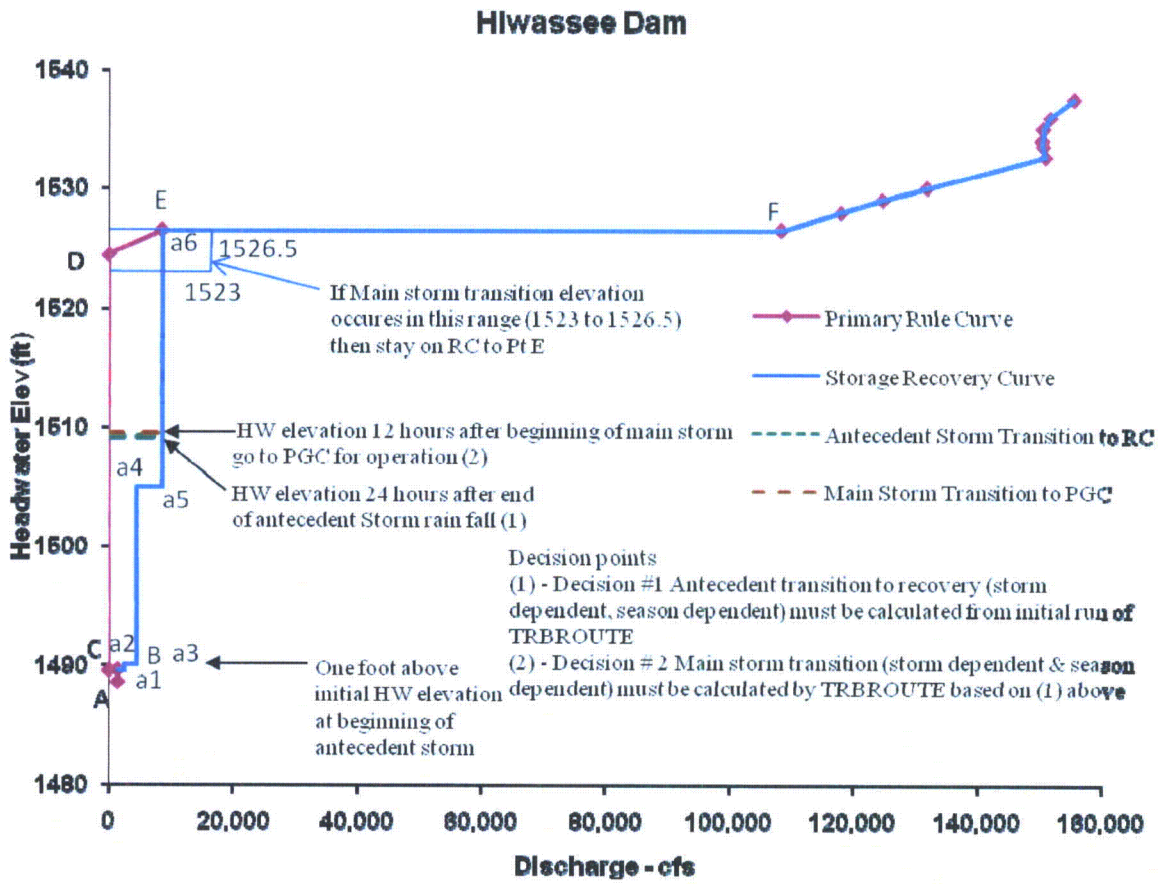
Figure 25 – Fontana June 1 Flood Operational Guide



Pt	A	F
Elevation (ft)	1263	1263
Discharge (cfs)	0	*

* - See Reference 15 for elevation/discharge at point F.

Figure 26– Ft Patrick Henry Mid-March and June 1 Flood Operational Guide



Notes:

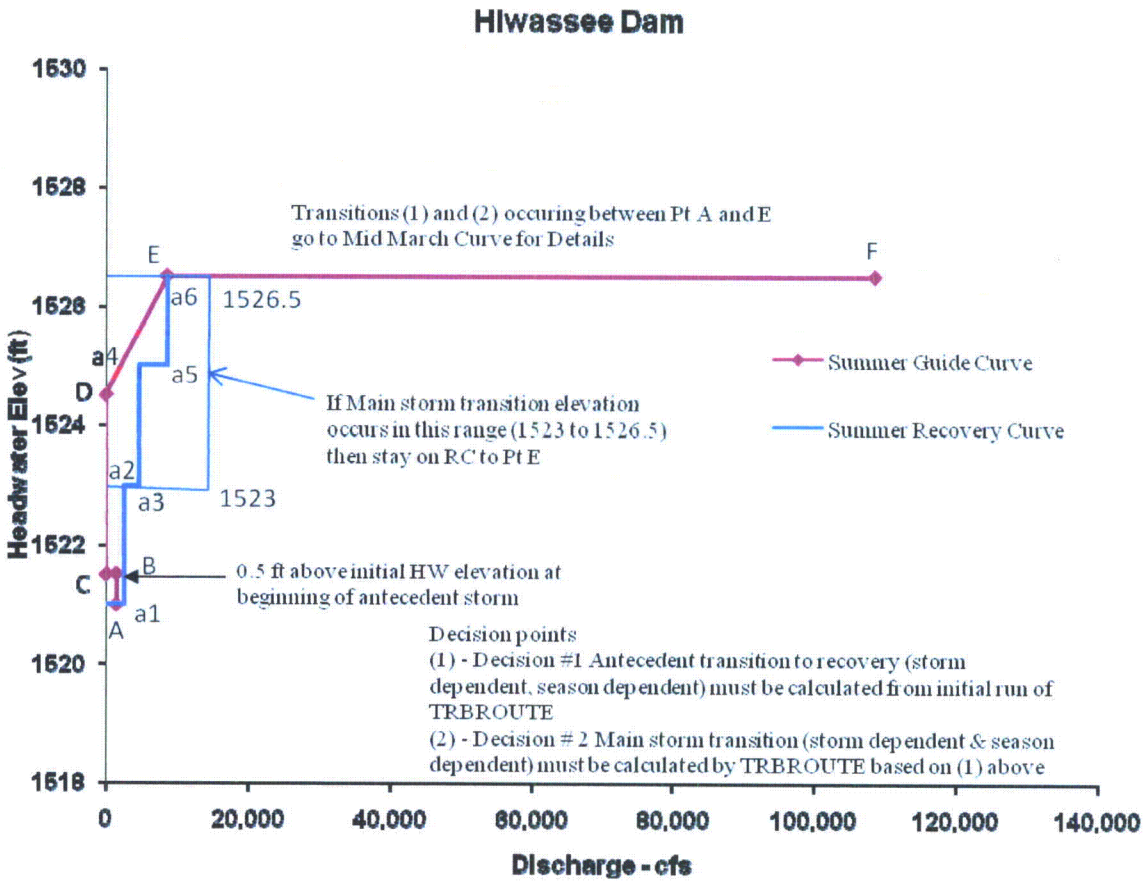
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1488.5	1489.5	1489.5	1524.5	1526.5	1526.5	1489.5	1490	1490	1505	1505	1526.5
Discharge (cfs)	1,400	1,400	0	0	8,500	*	2,500	2,500	4,500	4,500	8,500	8,500

* - See Reference 17 for elevation/discharge at point F.

Figure 27 – Hiwassee Mid-March Flood Operational Guide

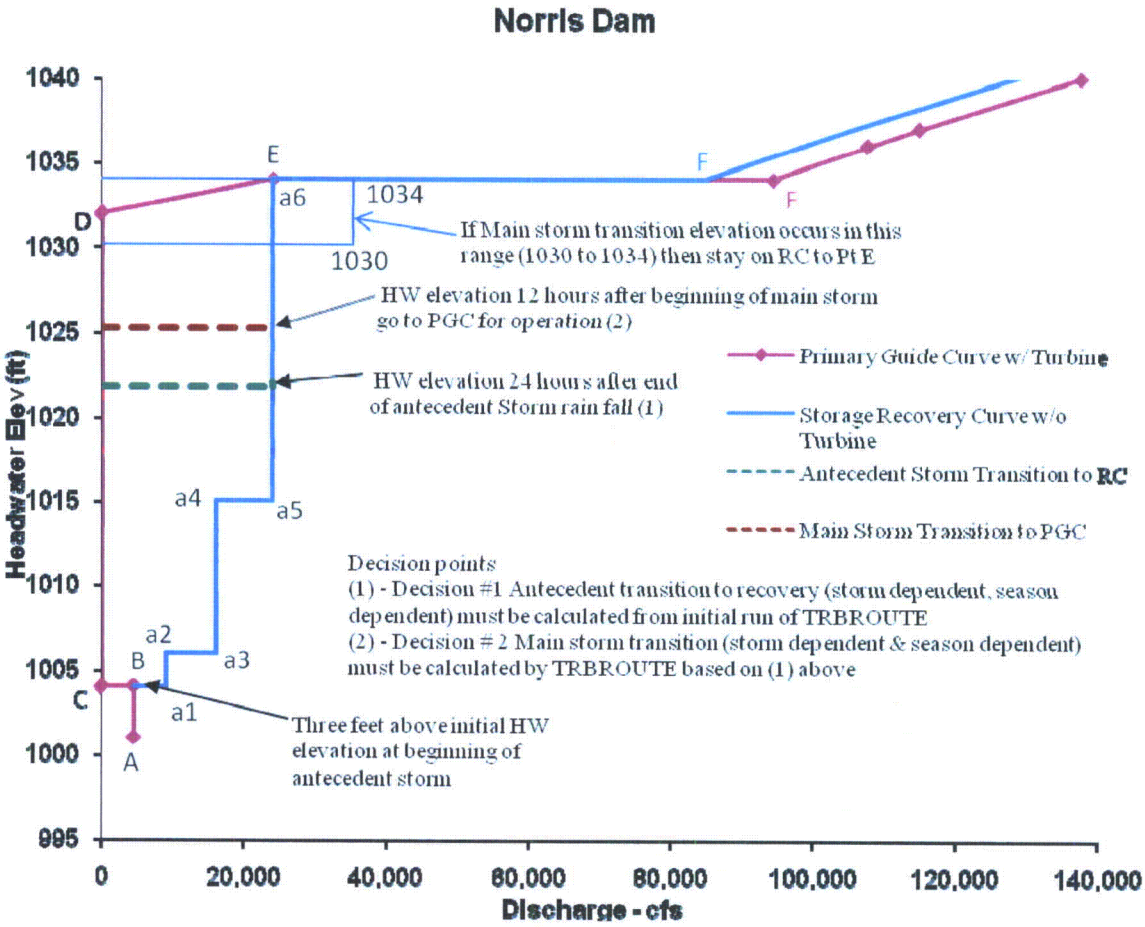


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1521	1521.5	1521.5	1524.5	1526.5	1526.5	1521	1523	1523	1525	1525	1526.5
Discharge (cfs)	1,400	1,400	0	0	8,500	*	2,500	2,500	4,500	4,500	8,500	8,500

* - See Reference 17 for elevation/discharge at point F.

Figure 28 – Hiwassee June 1 Flood Operational Guide



Notes:

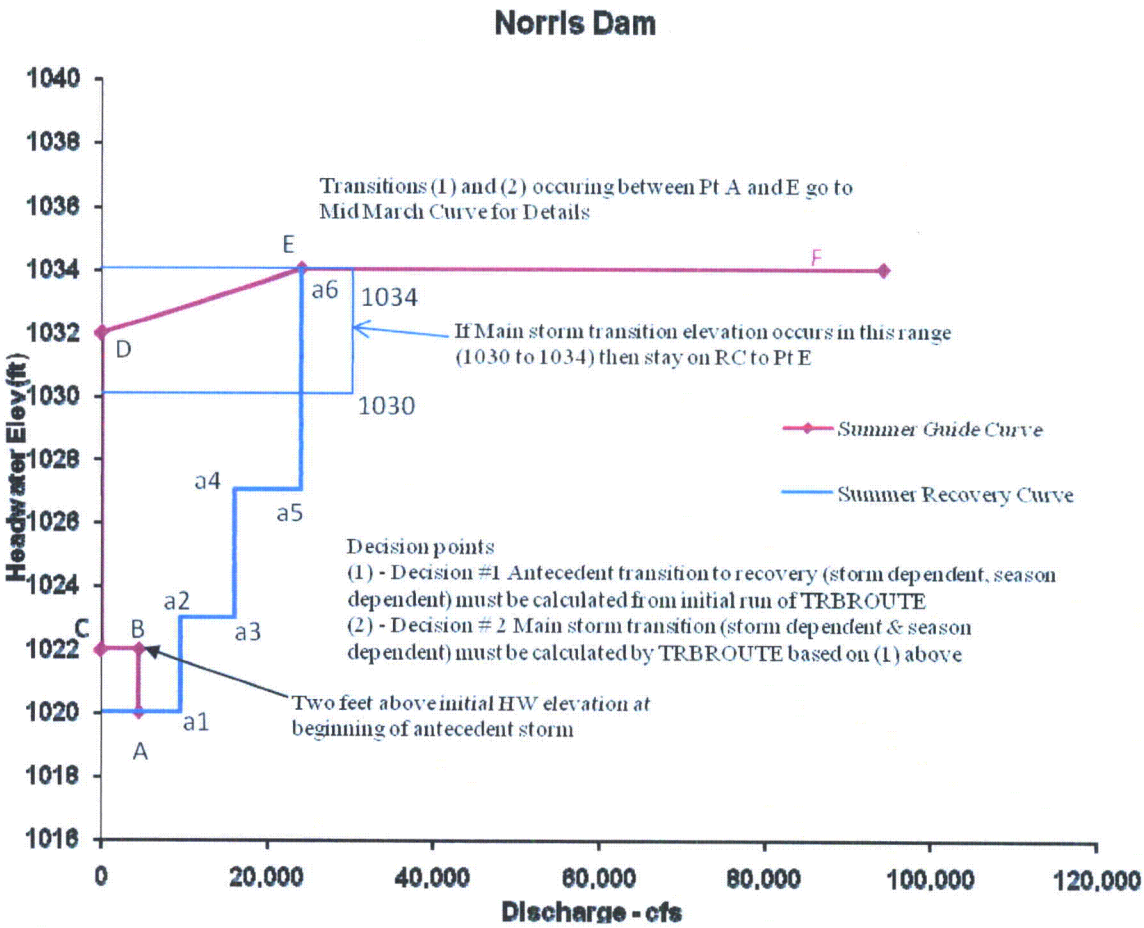
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1001	1004	1004	1032	1034	1034	1004	1006	1006	1015	1015	1034
Discharge (cfs)	4,500	4,500	0	0	24,000	*	9,000	9,000	16,000	16,000	24,000	24,000

* - See Reference 20 for elevation/discharge at point F.

Figure 29 – Norris Mid-March Flood Operational Guide

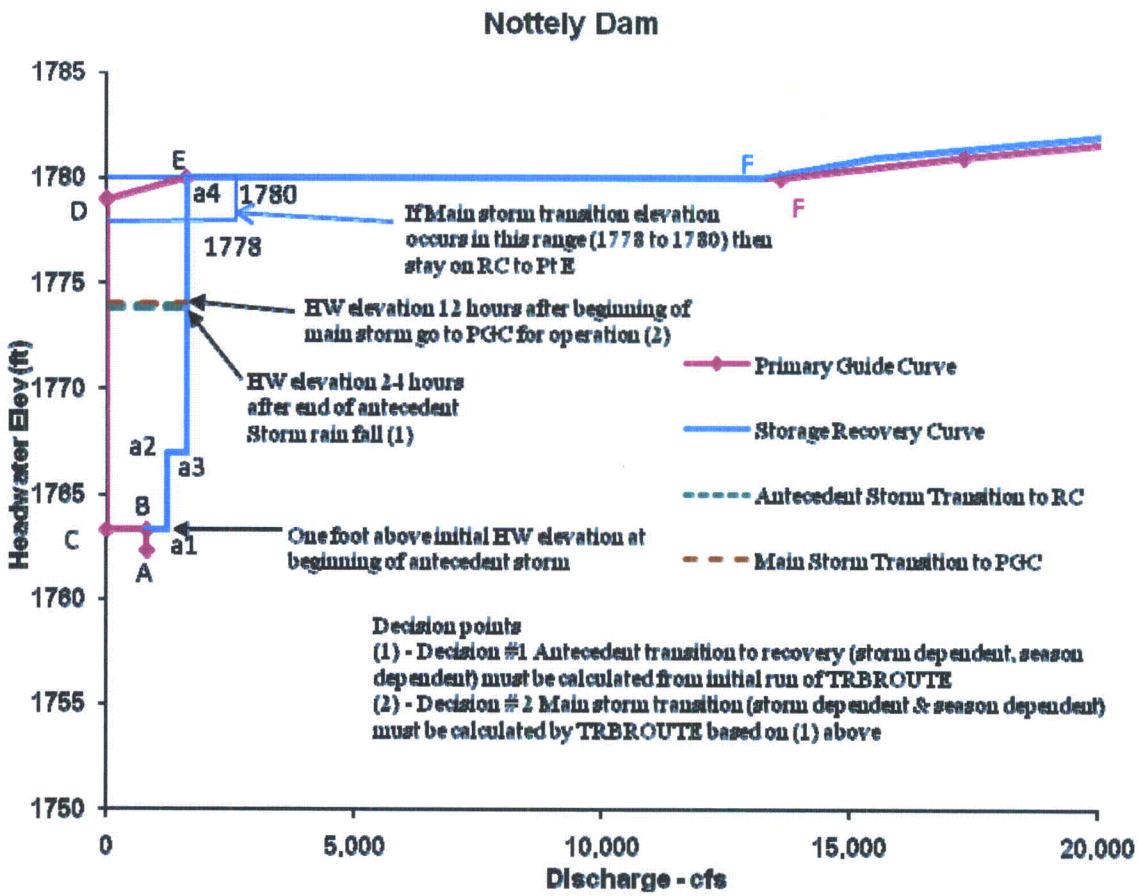


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1020	1022	1022	1032	1034	1034	1020	1023	1023	1027	1027	1034
Discharge (cfs)	4,500	4,500	0	0	24,000	*	9,500	9,500	16,000	16,000	24,000	24,000

* - See Reference 20 for elevation/discharge at point F.

Figure 30 – Norris June 1 Flood Operational Guide



Notes:

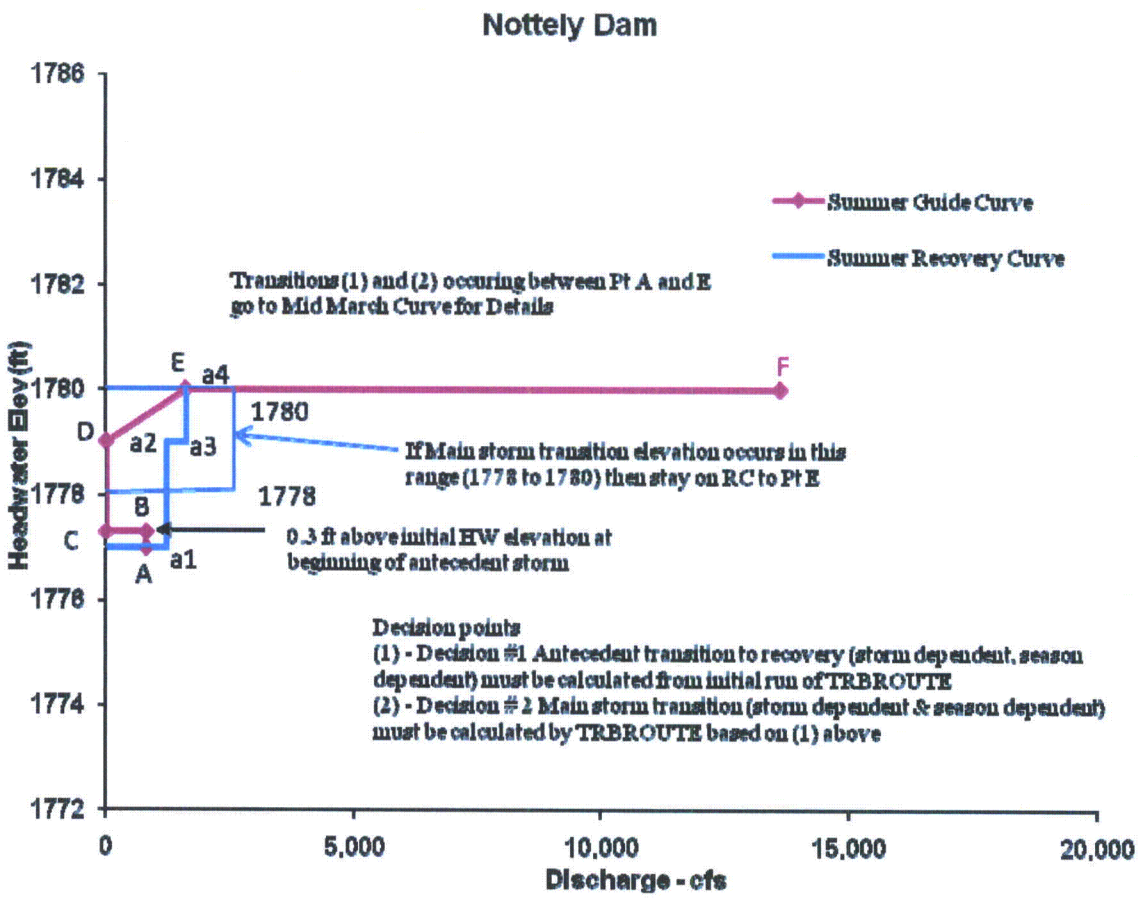
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1762.3	1763.3	1763.3	1779	1780	1780	1763.3	1767	1767	1780	N/A	N/A
Discharge (cfs)	800	800	0	0	1,600	*	1,200	1,200	1,600	1,600	N/A	N/A

* - See Reference 21 for elevation/discharge at point F.

Figure 31 – Nottely Mid-March Flood Operational Guide

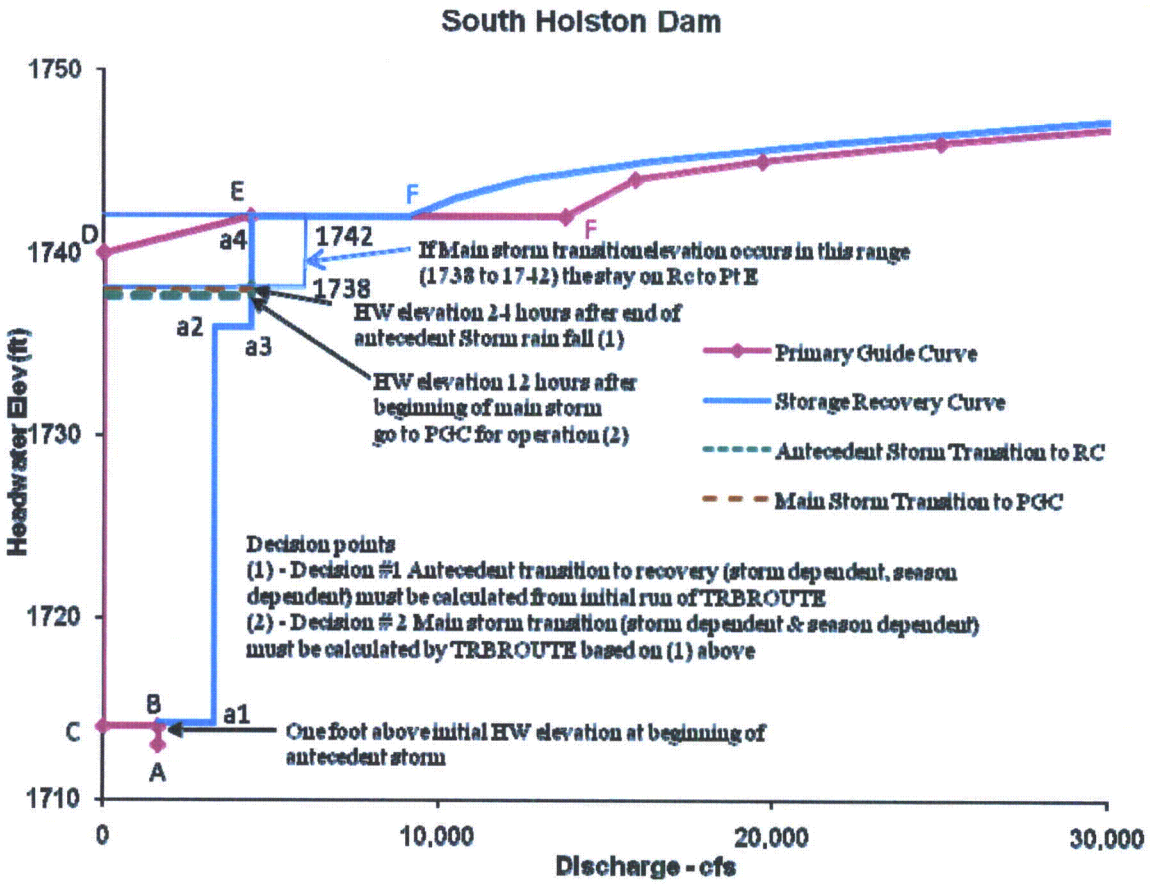


June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1777	1777.3	1777.3	1779	1780	1780	1777	1779	1779	1780	N/A	N/A
Discharge (cfs)	800	800	0	0	1,600	*	1,200	1,200	1,600	1,600	N/A	N/A

* - See Reference 21 for elevation/discharge at point F.

Figure 32– Nottely June 1 Flood Operational Guide



Notes:

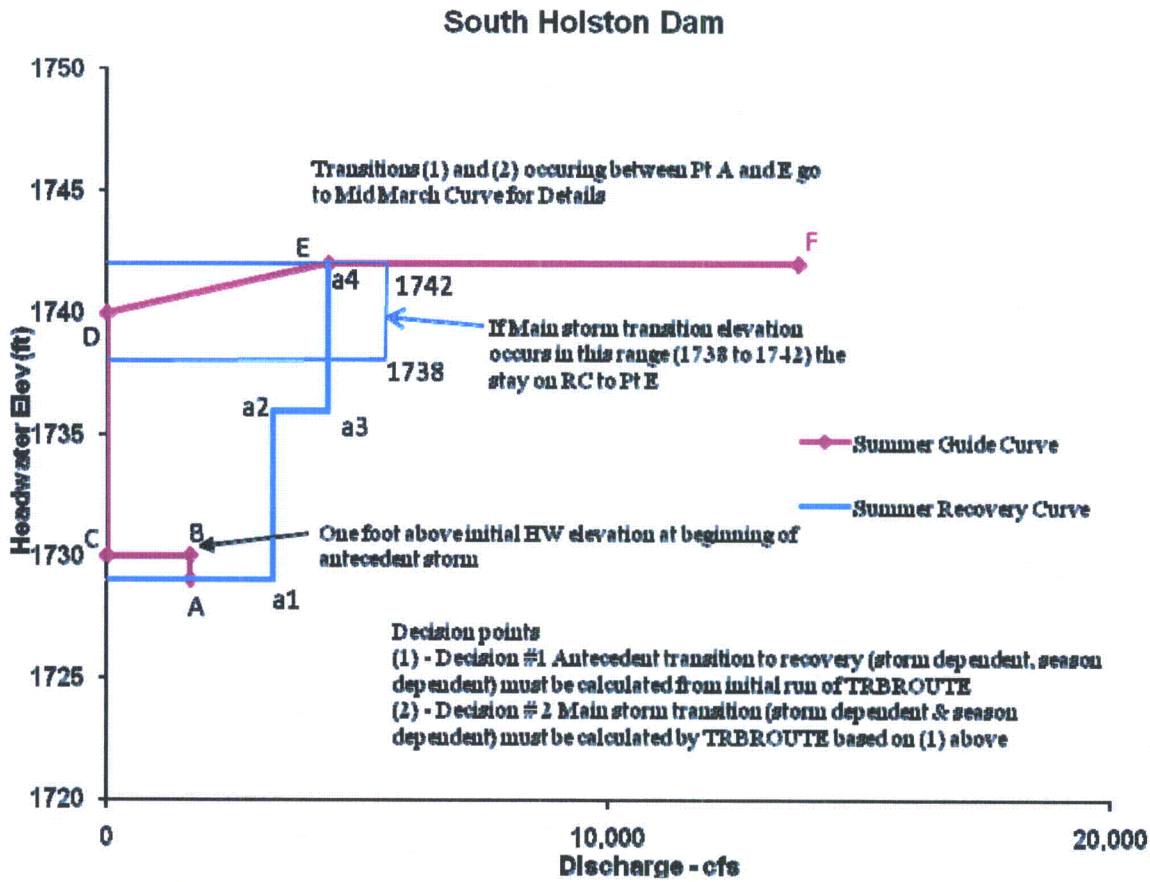
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1713.2	1714.2	1714.2	1740	1742	1742	1714.2	1736	1736	1742	N/A	N/A
Discharge (cfs)	1,650	1,650	0	0	4,400	*	3,300	3,300	4,400	4,400	N/A	N/A

* - See Reference 22 for elevation/discharge at point F.

Figure 33 – South Holston Mid-March Flood Operational Guide



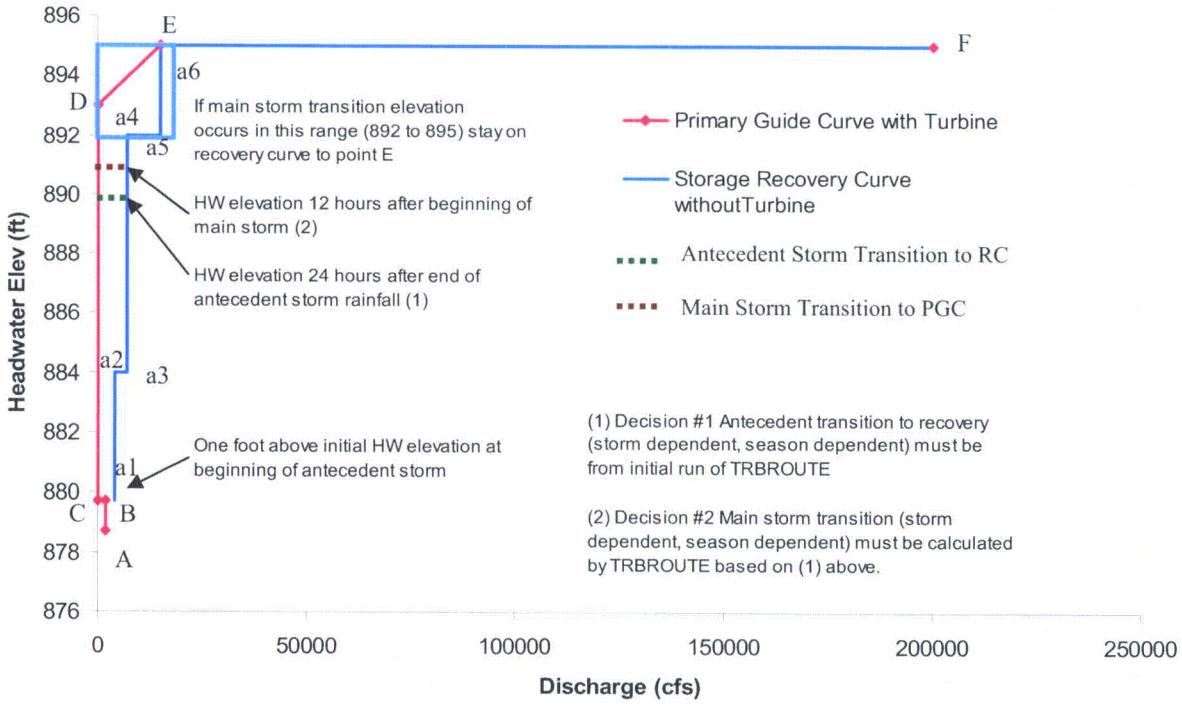
June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1729	1730	1730	1740	1742	1742	1729	1736	1736	1742	N/A	NA
Discharge (cfs)	1,650	1,650	0	0	4,400	*	3,300	3,300	4,400	4,400	N/A	NA

* - See Reference 22 for elevation/discharge at point F.

Figure 34 – South Holston June 1 Flood Operational Guide

Tim's Ford Dam



Notes:

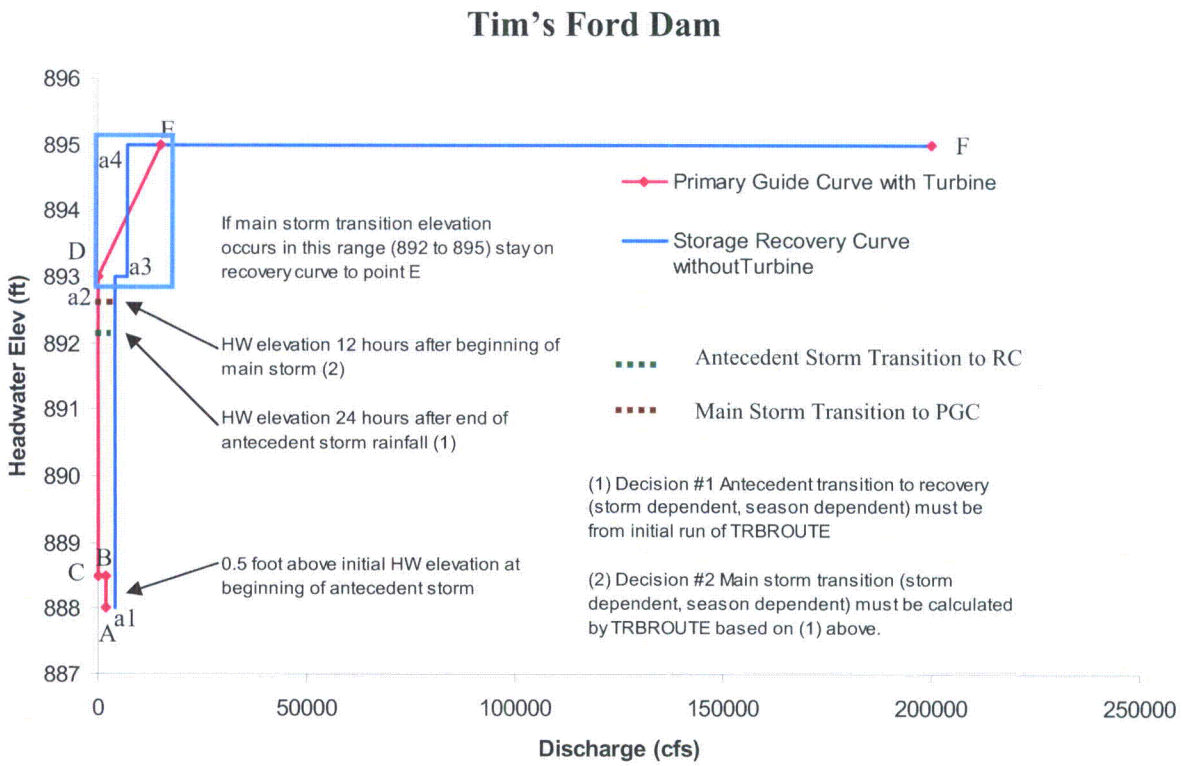
1. All transition points (dashed lines) are shown for illustration purposes only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	878.7	879.7	879.7	893	895	895	879.7	884	884	892	892	895
Discharge (cfs)	2000	2000	0	0	15000	*	3900	3900	7000	7000	15000	15000

*See Reference 28 for elevation/discharge at point F.

Figure 35—Tim's Ford Mid-March Operational Guide



Notes:

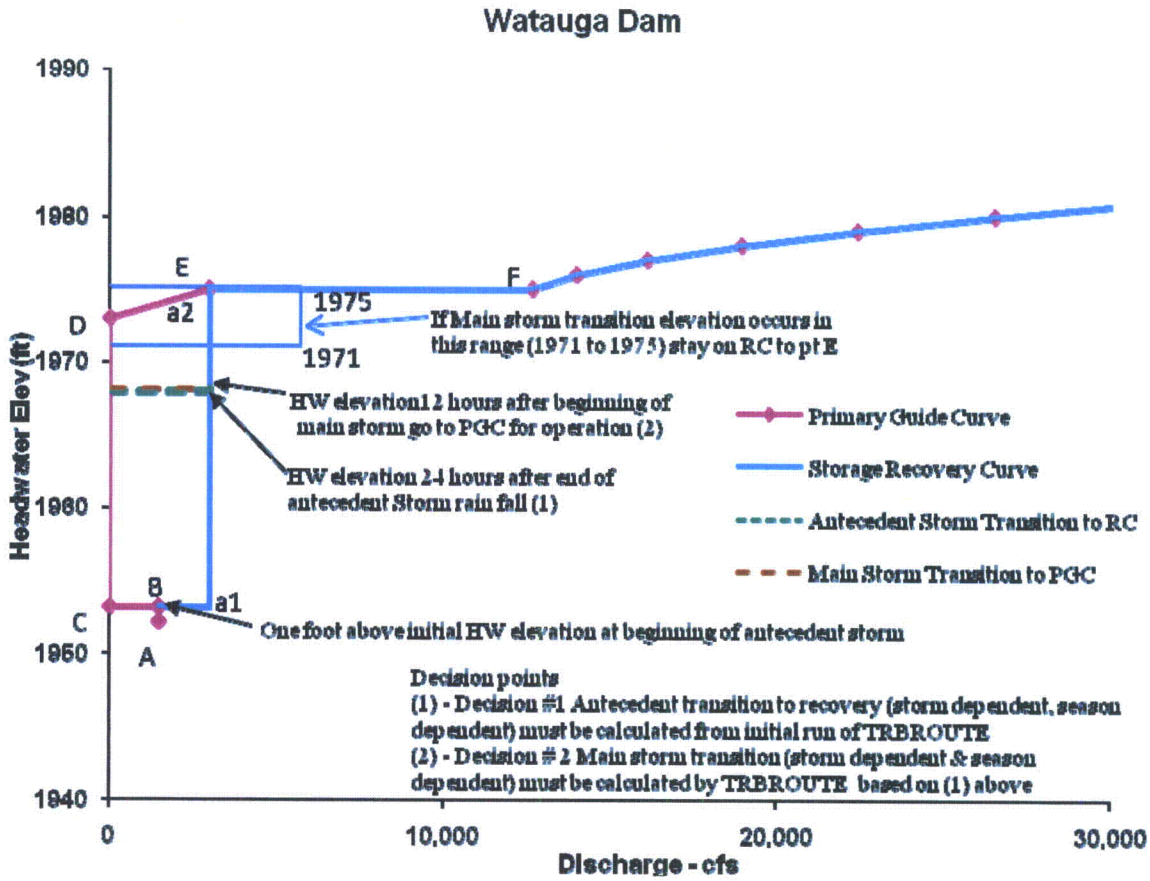
1. All transition points (dashed lines) are shown for illustration purposes only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	888	888.5	888.5	893	895	895	888	893	893	895	N/A	N/A
Discharge (cfs)	2000	2000	0	0	15000	*	3900	3900	7000	7000	N/A	N/A

*See Reference 28 for elevation/discharge at point F.

Figure 36—Tim's Ford June 1 Operational Guide



Notes:

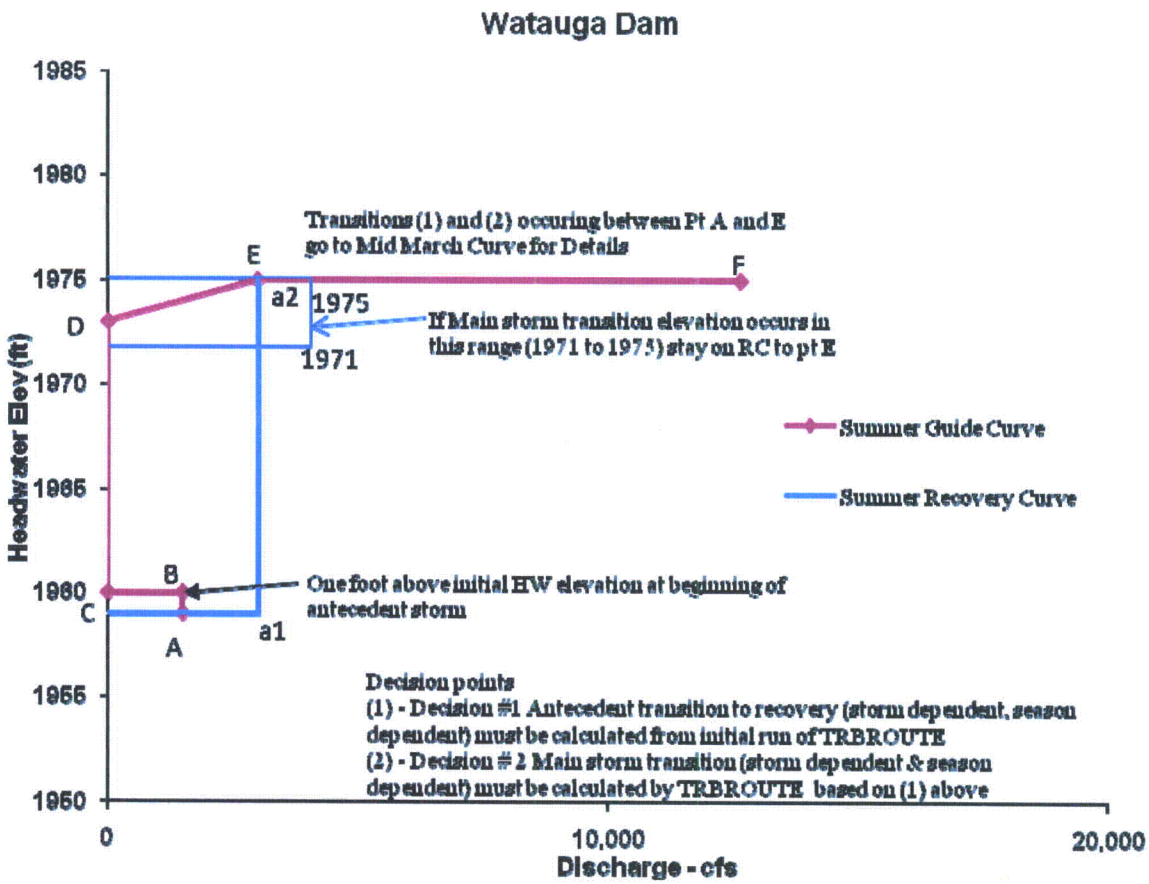
1. All transition points (dashed lines) are shown for illustration purpose only. Transitions are storm dependent.
2. The possibility exists that the antecedent storm exceeds point E elevation prior to transition.

Mid-March

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1952.2	1953.2	1953.2	1973	1975	1975	1953.2	1975	N/A	N/A	N/A	N/A
Discharge (cfs)	1,500	1,500	0	0	3,000	*	3,000	3,000	N/A	N/A	N/A	N/A

* - See Reference 24 for elevation/discharge at point F.

Figure 37 – Watauga Mid-March Flood Operational Guide



June 1

Pt	A	B	C	D	E	F	a1	a2	a3	a4	a5	a6
Elevation (ft)	1959	1960	1960	1973	1975	1975	1959	1975	NA	NA	NA	NA
Discharge (cfs)	1,500	1,500	0	0	3,000	*	3,000	3,000	NA	NA	NA	NA

* - See Reference 24 for elevation/discharge at point F.

Figure 38 – Watauga June 1 Flood Operational Guide

Table 1 – Initial Reservoir Starting Levels

Reservoir	Mid-March Elevation	June 1 Elevation
Fort Loudoun	808	812.75
Tellico	808	808
Melton Hill	795	795
Watts Bar	736	740.75
Chickamauga	676	682.5
Nickajack	632.5	632.5
Guntersville	593.3	595
Wheeler	551	555.75
Apalachia	1276	1276
Blue Ridge	1676.6	1687
Boone	1369.1	1382
Chatuge	1918.2	1926
Cherokee	1045.6	1071
Douglas	958.6	994
Fontana	1654.2	1703
Fort Patrick Henry	1263	1263
Hiwassee	1488.5	1521
Norris	1001	1020
Nottely	1762.3	1777
South Holston	1713.2	1729
Tim's Ford	878.7	888
Watauga	1952.2	1959

* See Reference 26 in Section 2 as the source of the median levels.