Chapter 2

The Water Control System

Tennessee Valley Authority
Reservoir Operations Study – Final Programmatic EIS

2.1 Background and Water Control System Overview

This chapter describes the seasonal patterns of rainfall and runoff in the Tennessee Valley watershed and the specific components of the TVA water control system.

2.1.1 Rainfall and Runoff

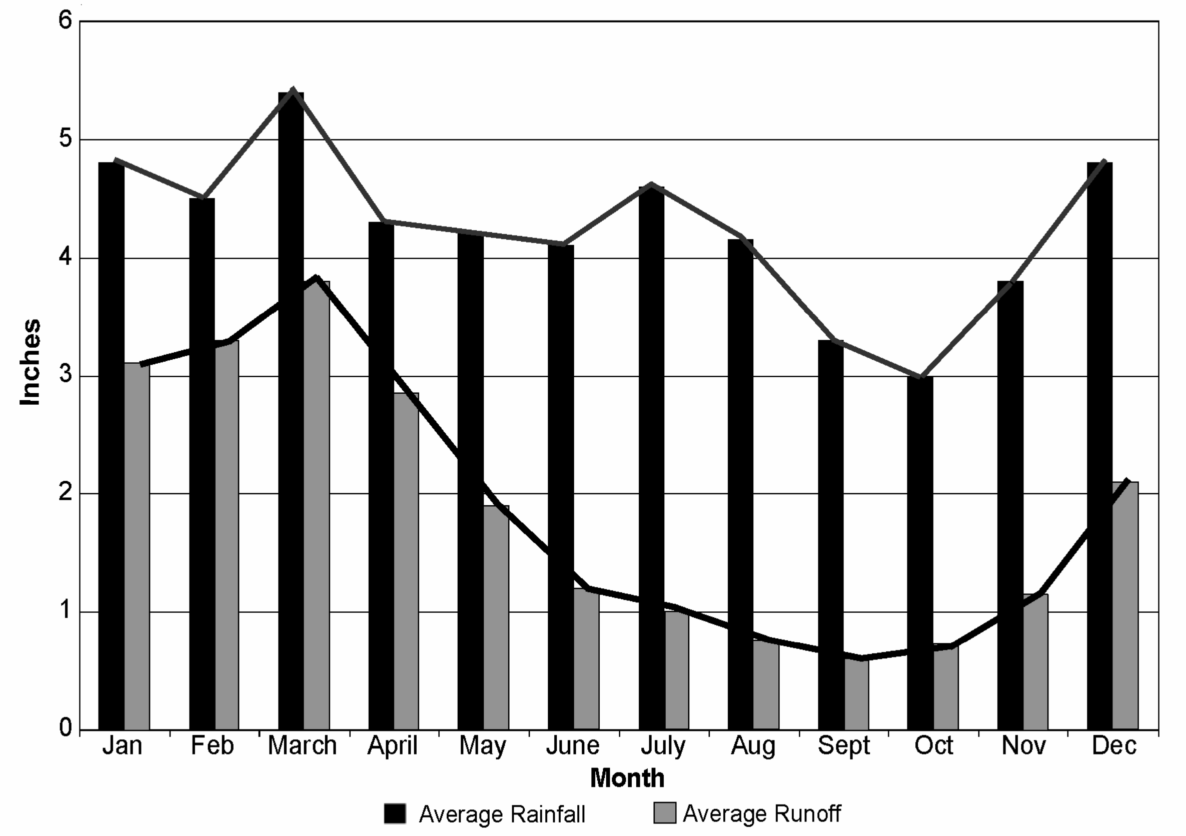
Rainfall, runoff, and topography in the Tennessee Valley watershed strongly influenced the original location, design, and operating characteristics of TVA reservoirs and the water control system. The locations and storage volumes of reservoirs reflect the variation in rainfall and runoff in the region. Rainfall and runoff continue to control when and where water flows into the reservoirs; and runoff exerts a strong influence on the annual, seasonal, and weekly patterns of reservoir operations.

Mean total annual rainfall is 52 inches per year throughout the TVA system, but rainfall varies considerably from year to year and at different locations in the system. During the past 100 years, mean annual rainfall has varied between a low of 36 inches in 1985 and a high of 65 inches in 1973. Rainfall is greatest in certain mountainous regions of the watershed—where rainfall totals over 90 inches per year. In contrast, mean annual rainfall in some portions of the Valley is as low as 40 inches. Although the months with the highest or lowest rainfall may differ each year, rainfall is typically highest from December through March and lowest from September through November (Figure 2.1-01).

More important to reservoir operations than rainfall is the seasonal variation in runoff. Runoff is rainfall that flows into streams and reservoirs. About 40 percent of rainfall in the drainage area of the Tennessee River system becomes runoff; the remainder evaporates, is used by plants, or drains into the soil and becomes part of the groundwater.

Although average rainfall varies somewhat, runoff patterns vary considerably more through the seasons due to changes in ground conditions, plant growth and cover, and storm and rainfall patterns (Figure 2.1-01). During late spring, summer, and fall, soils are generally drier, and dense ground cover helps to intercept and reduce rapid runoff from rainfall. In winter, as plants turn dormant and the ground becomes wetter, runoff increases. As shown in Figure 2.1-01, the greatest total runoff occurs from January through March, which is the major flood season in the Tennessee Valley. Storms tend to be larger during this period, and winter storms can cover the entire Valley for several days—sometimes with one storm followed by another storm 3 to 5 days later.

In contrast, runoff in summer and fall is much lower than in winter and spring. Summer storms generally affect only a portion of the basin. Although the total runoff in a summer storm is a fraction of that for a winter storm, flooding is still a concern—especially on a local scale—because reservoir levels are usually higher and less flood storage space is available.



Note: Rainfall amounts are monthly averages for the whole TVA Region. Runoff is rainfall that flows into streams and reservoirs.

Source: TVA data 2003.

Figure 2.1-01 Monthly Average Rainfall and Runoff (1903 to 2001)

Substantial variation in the annual amount of rainfall affects the degree to which objectives of the water control system can be achieved. For example, lack of rainfall and severe droughts in the 1980s and 1990s limited the amount of water in the system, which in turn reduced hydropower production, caused water quality problems, and reduced recreational use of reservoirs. During such low rainfall periods, achieving reservoir system objectives is difficult because of lower reservoir levels. At other times, excessive amounts of rainfall can rapidly exhaust flood storage space and necessitate frequent spills through sluiceways and spillways.

2.1.2 Structure of the Water Control System

The water control system is composed of dams and reservoirs, tailwaters, navigation locks, and hydropower generation facilities, as described in the following sections.

Dams and Reservoirs (Projects)

The 35 projects that comprise the water control system evaluated in the ROS include nine mainstem reservoirs and 26 tributary reservoirs (Table 2.1-01). Mainstem projects are those on the Tennessee River from Fort Loudoun Reservoir to Kentucky Reservoir (Figure 1.1-01).

Each TVA project typically falls into one of four general categories that are closely related to its characteristics (e.g., location and size), primary function (e.g., navigation, storage for flood control, or power generation), and operation. These categories include mainstem storage projects, mainstem run-of-river projects, tributary storage projects, and tributary run-of-river projects, as described below and listed in Table 2.1-01.

RESERVOIR CLASSIFICATION TERMS

Mainstem Projects—TVA mainstem projects are located on the Tennessee River as opposed to tributary streams and smaller rivers that feed into it.

Tributary Projects—TVA tributary projects are located on the smaller rivers and streams that feed into the mainstem.

Storage Projects—Storage projects have volume available for retaining floodwaters. These projects are operated on an annual fill and drawdown cycle. They are operated with higher pool levels during the summer recreation period and lower pool levels during the winter flood period.

Run-of-River Projects—Run-of-river projects have limited storage volume and generally release the same amount of water that flows into the reservoir on an hourly, daily, or weekly basis; therefore, these projects are operated based on streamflow, with limited seasonal change in storage.

- **Mainstem Storage Projects.** Projects located on the mainstem of the Tennessee River, the lowest part of the TVA water control system (Figure 1.1-01), are managed for navigation, flood control, power production, recreation, and other uses. Seven mainstem storage projects and their associated locks comprise the majority of the 800-mile Tennessee River commercial navigation channel. Their pool elevations (or reservoir levels) and flow releases are essential to maintaining a viable commercial waterway. Mainstem storage projects are operated on a seasonal basis for flood control. Mainstem project pool elevations typically fluctuate from approximately 2 to 6 feet on an annual basis—much less than tributary projects.

- **Mainstem Run-of-River Projects.** The two mainstem run-of-river projects serve the same general functions as the mainstem storage projects. Because they have limited storage volume, these projects generally release water on an inflow-equals-outflow basis (reflecting operations of the larger upstream projects). Run-of-river projects provide navigation, hydropower production, recreation, and a range of other benefits.

Table 2.1-01 Characteristics of TVA Reservoirs

Project and Location	Operating Mode	Length of Reservoir (miles)[1]	Navigation Facilities	Flood Storage (1,000 acre-feet)[5]	Turbine Units and Generating Capacity (MW)[7]
Mainstem Projects					
Kentucky, KY	Storage	184.3	2 Locks, canal[2]	4,008	5 (223)
Pickwick, TN	Storage	52.7	2 Locks, canal[3]	493 [6]	6 (240)
Wilson, AL	Run-of-river	15.5	2 Locks	0	21 (675)
Wheeler, AL	Storage	74.1	2 Locks	349	11 (412)
Guntersville, AL	Storage	75.7	2 Locks	162	4 (135)
Nickajack, TN	Run-of-river	46.3	Lock	0	4 (104)
Chickamauga, TN	Storage	58.9	Lock	345	4 (160)
Watts Bar, TN	Storage	95.5*	Lock	379	5 (192)
Fort Loudoun, TN	Storage	60.8*	Lock	111	4 (155)
Total mainstem		**663.8**	**14 Locks**	**5,847**	**64 (2,296)**
Tributary Projects					
Norris, TN	Storage	129.0	-	1,473	2 (131)
Melton Hill, TN	Run-of-river	44.0	Lock	0	2 (72)
Douglas, TN	Storage	43.1	–	1,251	4 (156)
South Holston, TN	Storage	23.7	–	290	1 (39)
Boone, TN	Storage	32.7*	–	92	3 (92)
Fort Patrick Henry, TN	Run-of-river	10.4	–	0	2 (59)
Cherokee, TN	Storage	54.0	–	1,012	4 (160)
Watauga, TN	Storage	16.3	–	223	2 (58)
Wilbur, TN	Run-of-river	1.8	–	0	4 (11)
Fontana, NC	Storage	29.0	–	580	3 (294)
Tellico, TN	Storage	33.2	Canal[4]	120	0 [8]
Chatuge, NC	Storage	13.0	–	93	1 (11)
Nottely, GA	Storage	20.2	–	100	1 (15)
Hiwassee, NC	Storage	22.2	–	270	2 (176)
Apalachia, NC	Run-of-river	9.8	–	0	2 (100)

Table 2.1-01 Characteristics of TVA Reservoirs (continued)

Project and Locations	Operating Mode	Length of Reservoir (miles)[1]	Navigation Facilities	Flood Storage (1,000 acre-feet)[5]	Turbine Units and Generating Capacity (MW)[7]
Tributary Projects (continued)					
Blue Ridge, GA	Storage	11.0	–	69	1 (22)
Ocoee #1, TN	Storage	7.5	–	0	5 (19)
Ocoee #2, TN	Run-of-river	–	–	0	2 (23)
Ocoee #3, TN	Run-of-river	7.0	–	0	1 (29)
Tims Ford, TN	Storage	34.2	–	220	1 (45)
Normandy, TN	Storage	17.0	–	48	0[8]
Great Falls, TN	Storage	22.0	–	0	2 (34)
Upper Bear Creek, AL	Run-of-river	14.0	–	0	0[8]
Bear Creek, AL	Storage	12.0	–	37	0[8]
Little Bear Creek, AL	Storage	6.0	–	25	0[8]
Cedar Creek, AL	Storage	9.0	–	76	0[8]
Total tributary		**622.1**	**1 Lock**	**5,979**	**45 (1,546)**
Total projects		**1,285.9**	**15 Locks**	**11,826**	**109 (3,842)**

Notes:

[1] Full summer pool. *Fort Loudoun—49.9 miles on the Tennessee River, 6.5 miles on the French Broad River and 4.4 miles on the Holston River; Watts Bar—72.4 miles on the Tennessee River and 23.1 miles on the Clinch River; Norris—73 miles on the Clinch River and 56 miles on the Powell River; Boone—17.4 miles on the South Fork Holston River and 15.3 miles on the Watauga River.

[2] Includes new main lock chamber (110 feet wide and 1,200 feet long) and the Barkley Canal.

[3] Tennessee–Tombigbee Waterway; Bay Springs Reservoir is connected to Pickwick Reservoir by a navigation canal.

[4] River diversion through a canal increases energy generation at Fort Loudoun.

[5] Numbers reflect allocated flood storage. The observed flood storage varies, depending on rainfall and runoff.

[6] Includes additional storage volume from Bay Springs Reservoir.

[7] Actual megawatt generating capacity at any time depends on several factors, including operating head, turbine capability, generator cooling, water temperature, and power factor. Generating capacities include rehabilitation and modernization of turbine units already performed, as well as those in the design, construction, or authorization phase.

[8] Project design does not include power generation capacity.

- **Tributary Storage Projects.** Eighteen tributary storage projects are located on the tributaries of the Tennessee River and one, Great Falls Reservoir, is located on a tributary of the Cumberland River (Figure 1.1-01). These projects store water to provide flood control, recreational benefits, and water supply. They release water over time to generate power and support downstream flows for navigation and power generation lower in the system—at downstream tributary and mainstem projects. Historically, water in tributary projects was held in storage and released to maximize hydropower production during summer. Presently, water is released not only to generate hydropower but also to provide minimum flows (water releases necessary to help maintain downstream water quality and protect aquatic habitat) and to maintain summer pool elevations longer into the summer. Reservoir levels for tributary storage projects fluctuate considerably on a seasonal basis; levels can fluctuate up to 90 feet.

- **Tributary Run-of-River Projects.** The seven tributary run-of-river projects are operated as part of the tributary project group. Because they are located between much larger reservoirs (Figure 1.1-01) and have limited storage volume, tributary run-of-river projects generally release water on an inflow-equals-outflow basis, reflecting operations of the larger upstream projects. Daily fluctuations in pool elevations are common but limited to a few feet. Although tributary run-of river projects are operated for similar objectives as tributary storage projects, they are generally operated as pass-through projects and provide little storage for flood reduction or minimum flows.

Tailwaters

Tailwater is a widely used term that generally refers to the portion of a river below a dam that extends downstream to the upper portion of the next reservoir pool in the system. The term tailwater can also refer to the upper portion of a reservoir pool immediately below an upstream dam with river-like characteristics, but which is also influenced at times by the elevation of the downstream pool. In these tailwater areas, the water is nearly always moving but the rate of flow, temperature, and other water quality characteristics are controlled or at least strongly affected by releases from the upstream dam.

In this EIS, several resource areas define or identify various lengths of tailwaters. These differences reflect the many types of tailwater characteristics and uses that occur in the study area and demonstrate that there is no single, well-defined definition of tailwater or, in many cases, a clearly defined transition point between a tailwater and the downstream reservoir pool. Section 4.1 provides further information on waterbody types in the TVA reservoir system.

Navigation Locks

The TVA reservoir system also includes 15 navigation locks located at 10 dams. Operated by the USACE, the locks provide an 800-mile commercial navigation channel from the mouth of the Tennessee River at Paducah, Kentucky; upstream past Knoxville, Tennessee; and into parts of the Hiwassee, Clinch, and Little Tennessee Rivers. TVA operates the reservoir system to maintain a minimum 11-foot depth in the navigation channel along this navigable waterway.

Hydropower Generation Facilities

Hydropower generation facilities are incorporated into 29 of the project dams. Although these facilities initially provided base load power (operating almost continuously), they now generate electricity primarily during periods of peak power demand. Fossil and nuclear power generation facilities with much greater generation capacities have been added to the TVA power system to provide base load power. Operation of the reservoir system has changed over time to meet peak power demands, improve overall power system reliability, and to ensure that an adequate supply of cooling water is made available to the coal and nuclear power plants. Depending on annual runoff, the hydropower facilities provide from 10 to 15 percent of TVA’s average power requirements.

TVA is in the midst of an Hydro Automation Program, which will automate the control of TVA's hydro generating units. When completed in 2004, the Hydro Automation Program will greatly improve TVA's flexibility to control its conventional hydro generating units (turbines). This flexibility will enable TVA to reduce overall operating expenses and to increase operating efficiencies. TVA will be able to produce the maximum amount of power with the available minimum amount of water and to provide rapid, automatic, real-time dispatching of the generating units.

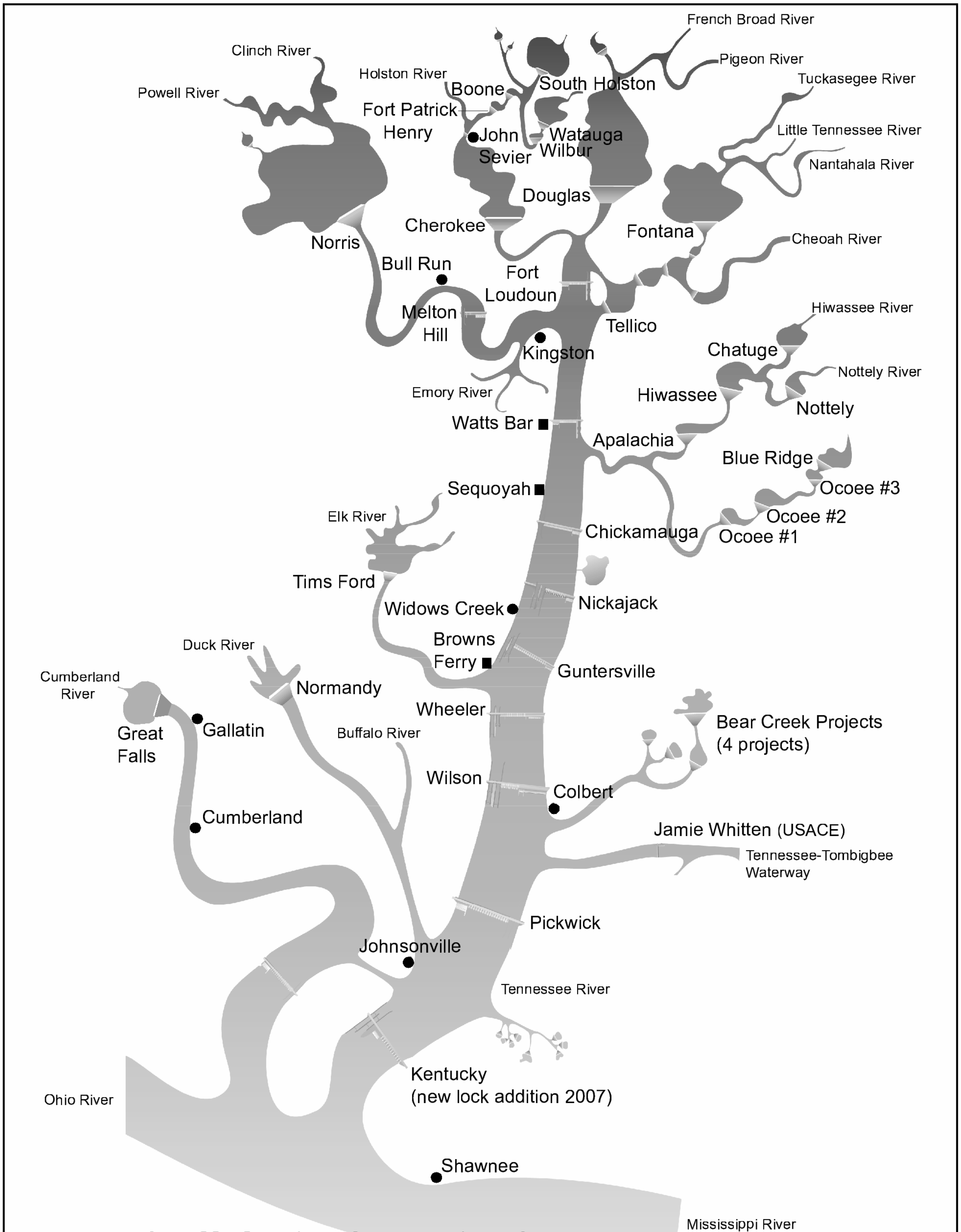
In addition, TVA began to rehabilitate and upgrade its aging hydropower generation facilities in 1991. Eventually, as many as 92 hydro turbine units at 26 plant sites (including Raccoon Mountain Pumped Storage Project) may be rehabilitated and modernized. The goal of TVA's HMOD projects is to provide for a safer and more reliable hydropower system, improved operational efficiency, and increases in system capacity at an acceptable economical cost and return to TVA. HMOD projects that were designed and funded, implemented, or completed on or before October 2001 are considered in this EIS as part of the Base Case (see Appendix A, Table A-09). The projects yet to be designed or implemented as of October 2001 are considered in the cumulative impacts analysis.

2.2 Water Control System

This section describes how the water control system is operated to optimize public benefits while observing physical, operational, and other constraints.

2.2.1 Flows through the Water Control System

Figure 2.2-01 depicts a schematic of the water control system. Water stored in the tributary reservoirs is released downstream to the larger Tennessee River mainstem projects (shown on the center of the schematic) and eventually flows into the Ohio River. Water is released from the projects to provide flows to maintain minimum navigational depth, reestablish flood storage volume in the reservoirs, generate power as it passes through the system, supply cooling water to the coal and nuclear power plants, and maintain water quality and aquatic habitat.



Note: The scope of the ROS EIS includes the 35 projects and power facilities shown here. (Paradise and Allen Fossil plants are outside the bounds of this schematic. See Figure 1.1-02 for their locations. The other 14 TVA projects not labeled on this figure are outside the scope of this study.)

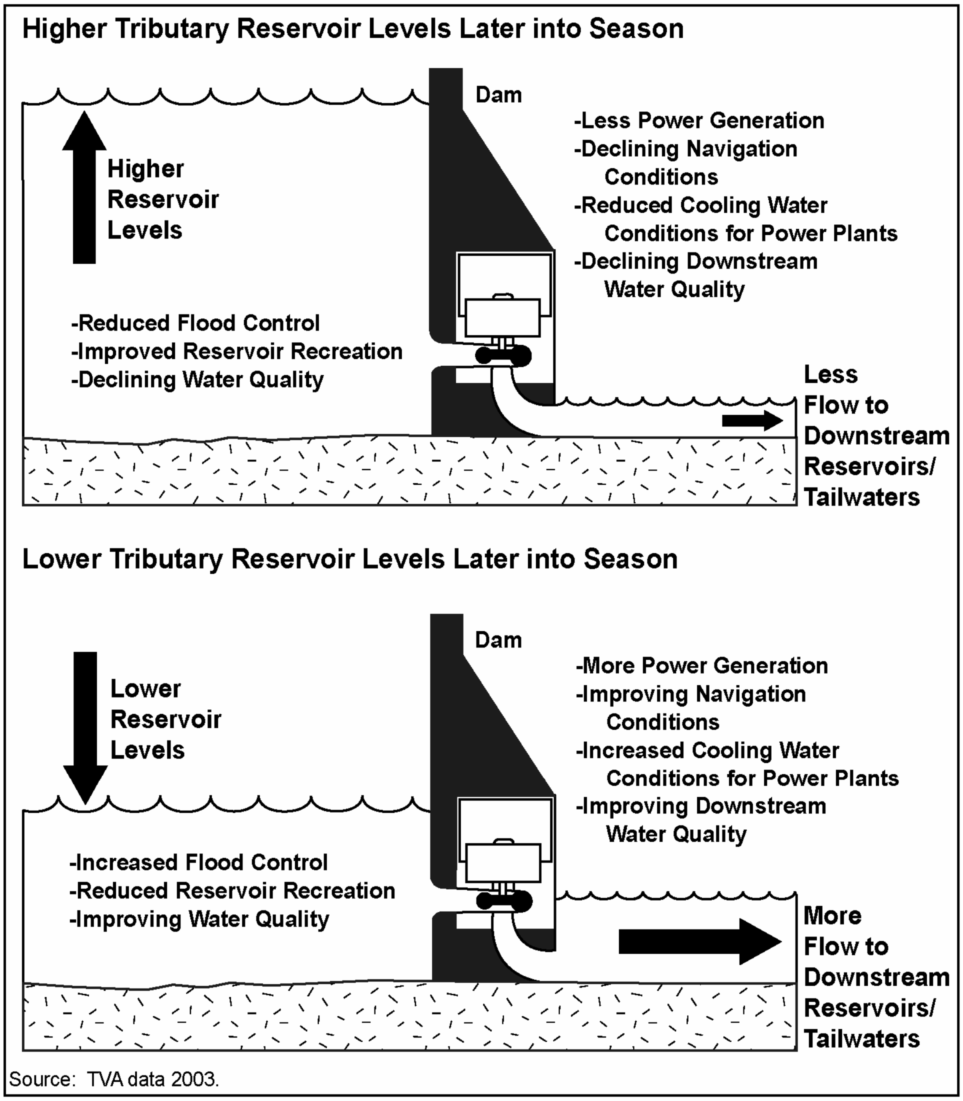
Source: TVA data 2003.

Figure 2.2-01 Schematic Diagram of the TVA Water Control System

Throughout the year, TVA manages the distribution of flows through the system in response to changing rainfall and runoff levels and other operating factors. Higher reservoir levels during some months of the year increase recreational opportunities and other benefits. During other months of the year, lower reservoir levels (especially at storage projects) provide flood storage volume during high-runoff periods.

2.2.2 Balancing Operating Objectives

The TVA reservoir system is not operated to maximize a single benefit to the exclusion of others. The system is operated to achieve a number of objectives and to provide multiple public benefits. Some operating objectives are complementary; others require trade-offs, especially in periods of limited water (Figure 2.2 -02).


Higher Tributary Reservoir Levels Later into Season

Lower Tributary Reservoir Levels Later into Season

Source: TVA data 2003.

Figure 2.2-02 Achieving a Balance of Reservoir System Operating Objectives (Summer/Fall)

During the late summer and fall drawdown period, water released to increase winter flood storage also supports navigation, power production, water quality, and tailwater recreation, creating complementary benefits.

A clear example of a trade-off during operation of the reservoir system is the lower reservoir levels needed for flood control and the higher reservoir levels desired for recreation. To manage flood risk, TVA lowers reservoir levels before the high runoff period, thus providing storage volume. Lowering reservoir levels affects the amount of water surface available for reservoir recreational activities and detracts from the recreational experience. In certain seasons, there is an unavoidable trade-off between flood control and reservoir recreational opportunities. Just as the trade-offs affect the benefits created, they often involve different beneficiaries.

2.2.3 Reservoir Operations Policy

TVA's reservoir operations policy establishes a balance of operating objectives. It guides system-wide decisions about how much water is stored in specific reservoirs, how the water is released, and the timing of those releases. The policy helps TVA in managing its reservoir system to fulfill its statutorily prescribed operating objectives (navigation, flood control, and power production) and to provide other benefits to the region—such as recreational opportunities and improved water quality.

The reservoir operations policy is composed of guidelines that describe how the reservoirs should be operated given the rainfall and runoff and the operating objectives. To be effective over the wide range of rainfall and runoff patterns within the 40,000-square-mile watershed, these guidelines must be flexible. This flexibility also allows the water control system to provide multiple uses of the water.

Reservoir operating guidelines establish pool level parameters for daily operations. One of the most important factors that determines where the actual pool levels are relative to these guidelines is the year-to-year variation in rainfall and runoff. Reservoir operations may temporarily deviate from normal operating guidelines to meet critical power system situations and meet other reservoir system needs to the extent practicable. Temporary deviations above and below these guidelines occur frequently due to floods and droughts.

Elements of TVA's reservoir operations policy include:

- **Reservoir Operating Guidelines—**control the amount of water in each reservoir, the reservoir pool elevations, and the flow of water from one reservoir to another; these guidelines are implemented through guide curves for each reservoir.
- **Water Release Guidelines—**control the release of water needed for reservoir system and project minimum flows, including flows for special operations.
- **Other Guidelines and Operational Constraints—**include procedures and limitations set for hydropower generation, response to drought conditions, scheduled maintenance

for power generation facilities, power system alerts, dam safety, security threats, and environmental emergencies (e.g., spills).

The manner in which these guidelines are implemented under the present reservoir operations policy is described in the following section and in Section 2.3, Existing Water Control System Operations.

Reservoir Operating Guidelines

Reservoir operating guidelines are implemented as planned operating ranges of reservoir levels throughout the year. TVA represents these guidelines in graphs called guide curves, which show the planned 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.

RESERVOIR GUIDE CURVES

Guide curves are line graphs showing the planned reservoir levels throughout the year. They also depict the storage allocated for flood control, operating zones and, in some reservoirs, the volume of water available for discretionary uses.

(See Figures 2.2-03 and 2.2-04.)

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 and usually include a discretionary operating zone (the area between the flood guide and Minimum Operations Guide [MOG]). Because guide curves specify certain periods for raising or lowering the reservoirs, they substantially affect seasonal releases in project tailwaters. 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 per 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.

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

RESERVOIR OPERATING PERIODS

Winter Flood Control Period—Reservoir elevations are held at lower levels during periods of higher runoff to provide more flood storage.

Fill Period—During the spring period of diminishing runoff, reservoirs are filled at a rate designed to maintain flood storage and reach summer pool elevations.

Recreation/Summer Pool Period—Reservoir levels are maintained at or above minimum operations guide levels to the extent possible during this time of lower flood risk. Drawdown rates are restricted during this period in tributary reservoirs.

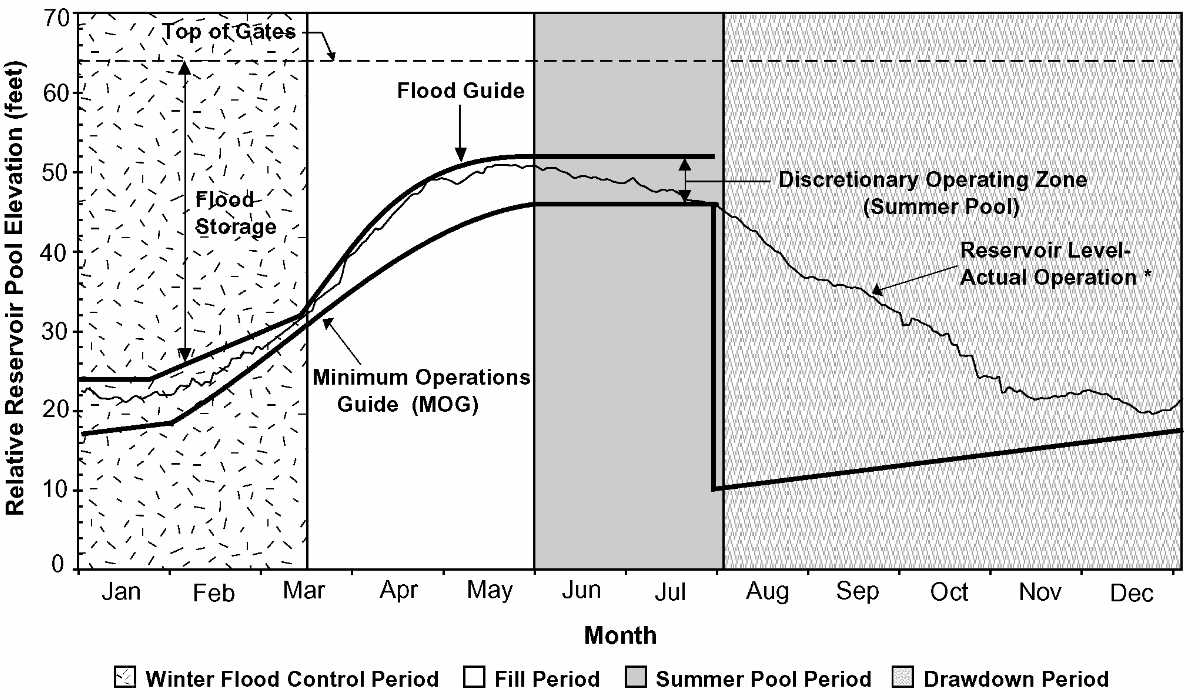
Drawdown Period—Reservoirs are drawn down to or below winter flood guide levels (for tributary reservoirs) or within operating zone levels (for mainstem reservoirs) in anticipation of higher runoff; this is the unrestricted drawdown period.

(See Figures 2.2-03 and 2.2-04.)

(droughts) or high inflow conditions (floods) that substantially increase the difficulty in meeting the multiple needs of the system. Other extreme circumstances include extreme temperatures and sudden loss of generating units, requiring a quick response that may be available only from TVA's hydropower electric units.

Tributary Reservoir Guide Curves

Figure 2.2-03 shows a generic guide curve for a tributary storage reservoir. Because tributary reservoirs provide a significant portion of the system's flood storage, their reservoir pool may vary substantially over the annual cycle.



* Varies from year to year

Source: TVA data 2003

Figure 2.2-03 Generic Tributary Reservoir Guide Curve

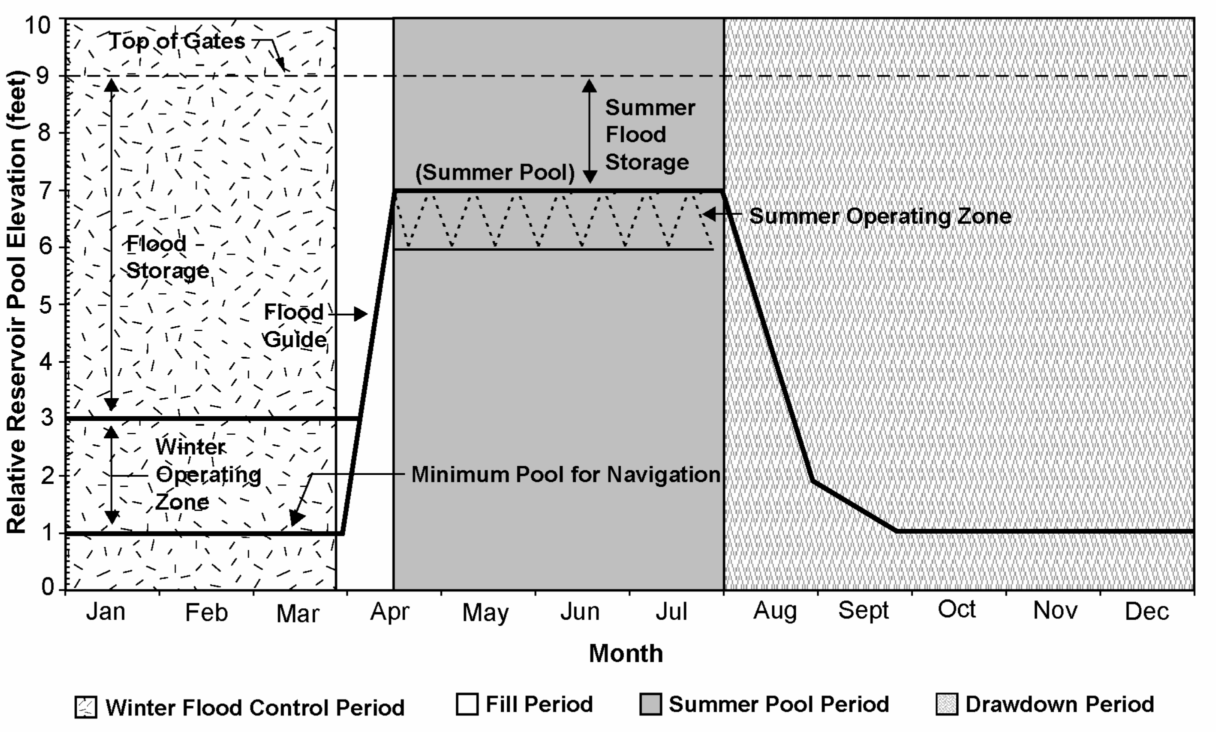
To achieve multiple reservoir system elevations, the guide curve must include operational flexibility. Managing the tributary reservoir levels within a discretionary operating zone creates this flexibility. The lower limit of this zone is the MOG. When a reservoir is at or below its MOG, only minimum flows are released.

The upper limit of the discretionary operating zone is the flood guide. Reservoir levels generally are not allowed to exceed this limit because the flood guide controls the minimum amount of flood storage available in a reservoir. 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. Occasionally, temporary fills to higher levels occur when high flows are regulated, and lower levels may occur for power generation emergencies.

Under typical conditions, the water level in a tributary storage reservoir fluctuates within its discretionary operating zone. The reservoir can be drawn down to generate hydropower and to meet downstream water requirements, such as providing cooling water for nuclear and coal power plants, process water for industry, or flow for navigation.

Mainstem Reservoir Guide Curves

The generic guide curve for a mainstem reservoir (Figure 2.2-04) shows that the schedules for drawdown and fill are somewhat similar to those for a tributary reservoir, but the drawdown is generally much smaller than for a tributary reservoir because of the difference in reservoir characteristics. All mainstem projects have a seasonal fluctuation zone, which is followed to the extent practicable (Appendix A, Table A–02).



Source: TVA data 2003.

Figure 2.2-04 Generic Mainstem Reservoir Guide Curve

- **January–March.** Reservoir elevations are lowest from January to March, the period of highest runoff and flood risk, as shown in Figure 2.2-04. Pools are maintained within a 1- to 2-foot winter operating zone to the extent possible, except when regulating high flows. The bottom of this winter regulating zone is the lowest elevation to which the reservoir is drawn while still meeting minimum navigation depth requirements.

- **April.** From late March through the middle of April, reservoir elevations are raised to the summer pool level as runoff and system demands allow.
- **Mid-April through Late Summer.** Reservoirs are maintained at summer operating levels until seasonal drawdown begins. Normal operation includes a band of reservoir fluctuations, called the summer operating zone. Fluctuations of reservoir levels in this zone are used for power generation; and for mosquito control operations at Chickamauga, Guntersville, Wheeler, and Pickwick Reservoirs.

  Occasionally, temporary fills to higher levels occur when high flows are regulated, and lower levels may occur for power generation emergencies.

RESERVOIR POOL LEVELS AND OPERATING ZONES

Top of Gates—Top of Gates represents the maximum controlled elevation at a project; typically, the top of a spillway gate in a closed position or crest elevation of an uncontrolled outlet structure.

Flood Guide*—This seasonal elevation guide depicts the amount of storage allocated in a reservoir for flood reduction.

Flood Storage—Flood storage is the volume of runoff that can be stored in a reservoir to reduce downstream flooding.

Minimum Operations Guide (MOG)*—This seasonal guideline for reservoir elevation for some tributary projects depicts the elevation below which only minimum flows are usually released, except during emergencies.

Minimum Flow—A minimum flow is a release from one or more dams to meet downstream water needs (e.g., navigation, water supply, aquatic habitat, and waste assimilation). A minimum flow does not represent the lowest flow rate that TVA can pass from a dam or dams.

Discretionary Operating Zone*—This range of reservoir elevations between the MOG and the flood guide enables flexible operation of the system to achieve multiple benefits.

Summer Pool*—The range between the flood guide and the MOG during June and July. Full summer pool is the targeted reservoir elevation to be achieved by the beginning of the summer recreation season, and is also the summer flood guide. Minimum summer pool is the level for tributary storage projects equal to the MOG for June and July.

Restricted Drawdown*—This allowable lowering of tributary storage pool levels from June 1 to July 31 is limited to maintaining at least minimum summer pools, if possible.

Unrestricted Drawdown*—Reservoir pool elevations are lowered in late summer (usually August 1) to meet the January 1 flood guide. The release rate depends on the economical use of hydropower and design considerations, and is not restricted to maintaining minimum reservoir levels.

Summer Operating Zone—**This zone allows for fluctuations in reservoir levels for power production, flood control, and mosquito control.

Winter Operating Zone—**This zone includes fluctuations in reservoir levels between the winter flood guide and the minimum pool for navigation.

* Applies only to some tributary reservoirs.

** Applies only to mainstem reservoirs.

(See Figures 2.2-03 and 2.2-04.)

- **Fall Drawdown.** Reservoir elevations are lowered to the winter operating level beginning at various dates through summer and fall (Appendix A, Table A–08).

Water Release Guidelines

TVA manages the rate of flow and water levels through the system by selective releases from the dams. These releases affect water quality conditions in the tailwaters and reservoirs, water supply to the lower reservoirs, and the temperature of cooling water for coal and nuclear power plants located on mainstem reservoirs. TVA also manages flows in the tailwaters to maintain water quality and aquatic habitat. At times, TVA releases water to provide flows for special operations, as described in a following section.

To meet flow needs in the tailwaters and flow-through needs in the downstream reservoirs, TVA has adopted two broadly defined reservoir release policy elements: project minimum flows and system minimum flows. A minimum flow is a release from one or more dams to meet downstream water needs (e.g., navigation, water supply, aquatic habitat, and waste assimilation); a minimum flow does not represent the lowest flow rate that TVA can pass from a dam or dams.

Project Minimum Flows

Project minimum flows are flows released at a specific reservoir (Appendix A, Table A–03). TVA implements project minimum flows to achieve specific operating objectives, including water supply and water quality improvements, and benefits for aquatic habitat and fisheries. Project minimum flows are provided below seven mainstem (these are also the system minimum flows discussed below) and 20 tributary reservoirs in a variety of ways, including instantaneous flows (continuous via small turbine operation or sluice outlet setting), pulsing flows (use of a generating unit at various hourly intervals), and daily average releases.

Minimum flows at 10 tributary projects were developed on the basis of techniques used by the USFWS to enhance aquatic life in streams in other regions of the country (see discussion of the Lake Improvement Plan in Chapter 1). These minimum flows are intended to afford greater protection for aquatic life from environmental stresses than would occur under average dry conditions.

System Minimum Flows

System minimum flows are indicators of total flow to meet requirements for navigation, water supply, cooling water for coal and nuclear plants, water quality, and aquatic habitat. System minimum flows are measured at the Chickamauga, Kentucky, and Pickwick Dams and other locations (Appendix A, Table A–03). These flows include a bi-weekly average minimum flow in summer and a daily average minimum flow in winter. If the total of the project minimum flows discussed above plus any natural runoff from the watershed is insufficient to meet these system minimum flows, additional water must be released from upstream reservoirs to supply the difference.

TVA uses a number of guidelines for system minimum flows as described in Section 2.3, Existing Water Control System Operations. These system minimum flows include:

- **Flows for Navigation—**to maintain minimum channel depths in the Tennessee River navigation channel.
- **Flows for Water Quality—**to minimize the water residence time (the amount of time it takes for water to pass through the reservoir) in mainstem reservoirs, thereby limiting periods of low DO in mainstem dam releases and reducing water quality degradation.
- **Flows for Cooling Water—**to meet the water temperature requirements of the cooling system discharges for TVA's nuclear and coal power plants.

Flows for Special Operations

Flows for special operations occur when reservoir levels are held steady or release schedules are modified to accommodate specific requests. In 2002, TVA responded to over 200 requests to support special events and activities across the Valley. Special operations have included boat parades, regattas, rowing competitions, and fishing tournaments throughout the Valley. Special operations have been scheduled to assist clean-ups, aid in stocking trout, free stranded barges, dilute runoff from fire-fighting, and recover drowning victims. They have also been used to support surveys of endangered plants, help control mosquito populations, and conduct fisheries research. Special operations may also be scheduled to facilitate boat ramp and pier construction, installation of water intake pipes, and shoreline stabilization projects.

Other Guidelines and Operational Constraints

Ramping Rates

Reservoir releases are normally made through a project's hydropower turbines, and these releases determine the rate of flow and depth in the project tailwater. The number of turbines in use and their size control the rate of flow. Project design features (e.g., the types and sizes of turbines) and the rate at which turbines are turned on and off—or ramped up or down—also govern the rate of flow. For purposes of this EIS, ramping rates refer to how many hydro turbine units are simultaneously brought online or taken offline at a hydropower plant. The term ramping rate can also indicate an increase or decrease in generation by an individual hydro turbine unit.

Restrictions are placed on ramping rates for environmental or safety concerns, or to limit upstream generation to balance a downstream project's storage volume. Existing ramping restrictions for TVA dams are outlined in Appendix A, Table A–04.

Response to Drought Conditions

Based on the 100 years of water flow data compiled by TVA, severe system-wide drought conditions are rare. When drought conditions occur, it becomes more difficult to meet competing demands for the use of water.

The system operating guidelines for the larger tributary storage projects include some measures that respond to drought conditions. For example, releasing only minimum flows when reservoirs are below their MOGs helps conserve water while still protecting aquatic life. When drought conditions persist for an extended period of time, operating decisions must be made based on the best available information. For example, during the hot, dry summer of 1999, operations at Normandy Reservoir were adjusted to enhance municipal water supply and Tims Ford Reservoir was operated to alleviate problems with inadequate water depth at the intake for a downstream public utility.

Scheduled Maintenance Periods for Hydropower Generation Facilities and Power Plants

TVA must plan and conduct periodic shutdowns of its hydropower facilities for maintenance activities. Special operations for this purpose usually require restrictions on reservoir levels or releases. These restrictions sometimes extend to upstream hydropower plants, because their flows can affect the special operations or maintenance outages at downstream projects. When hydropower units are out of service, they are unavailable for reservoir releases; therefore, such shutdowns are scheduled in consideration of projected release schedules.

TVA also schedules and performs periodic maintenance on its nuclear and fossil power plants. Scheduling of these outages may influence the timing of reservoir level changes or downstream flows.

Critical Power System Situations

During critical power system situations, including but not limited to Power System Alerts or implementation of the Emergency Load Curtailment Plan (ELCP), reservoir operations may temporarily deviate from normal system operating guidelines to meet power system needs. In such situations, water stored in the reservoirs may be used to the extent practicable to preserve the reliability of the TVA power system. Power system alerts are issued when situations such as an unexpected shutdown of a large generating unit, extreme temperatures, or an interchange curtailment (which limits TVA's ability to import power due to overloads on the bulk transmission grid) would reduce power supply reserves below TVA/North American Electric Reliability Council requirements.

The ELCP was developed to provide arrangements and contingency plans to meet power system emergencies. Emergency situations involving a sudden loss in power generation do not always allow a sequential implementation of the steps contained in the power system alert and ELCP processes. Further, issuance of a power system alert or ELCP does not necessarily mean that MOGs are no longer followed. The specific type of power emergency determines the type of operational responses required.

Dam Safety

TVA follows federal regulatory guidelines to ensure that operation of its reservoir system does not jeopardize the structural integrity of the dams. Dams and adjacent features, such as embankments and shoreline structures, are designed to be stable under a set of operating conditions, both normal and unusual, that might occur during the life of the structure. Drawdown limits for dam safety (Appendix A, Table A–07) ensure that the structures and systems are not exposed to conditions that are outside those design or safety limits. Relative to the reservoir operations policy, the pertinent limits include a maximum allowable reservoir elevation and a maximum rate of reservoir drawdown. The maximum allowable reservoir elevation is an unusual condition that would occur during a major flood. Reservoir drawdown occurs as a part of normal operations, and TVA must limit the rate of drawdown to maintain structural stability.

2.3 Existing Water Control System Operations

The previous section described the reservoir guide curves and other operational guidelines that are used to manage day-to-day operation of the water control system. The guide curves and guidelines were developed to achieve, to the extent possible, public benefits from the operating objectives established for the water control system. The following sections discuss how the system is operated to meet these objectives.

The operating objectives include:

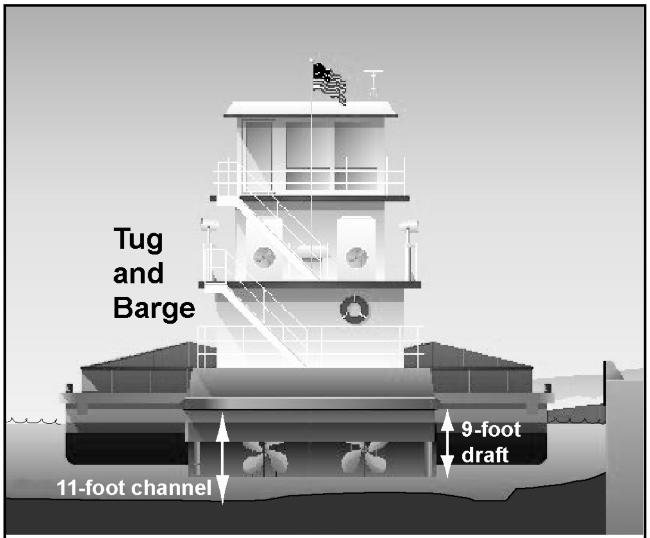
- Navigation
- Flood control
- Power production
- Water supply
- Water quality
- Recreation
- Other objectives

2.3.1 Operations for Navigation

Navigation is one of TVA's primary objectives. The Tennessee River is a key element of regional commerce because it provides a waterborne transportation route for movement of bulk commodities and materials into and out of the region. Commodities transported by barge include coal, aggregates, grains, and chemicals. Because most bulk commodities are needed on a year-round basis, maintaining navigation on the reservoir system is an important operating objective. This objective is met by maintaining adequate river depths, rate of flow, and controlling flood flows during times of high runoff.

Maintaining Adequate River Depths for Navigation

The existing reservoir operations policy prescribes that the reservoir system be operated to provide a minimum depth of 11 feet in the navigation channel within the reservoirs on the mainstem between Paducah, Kentucky (where the Tennessee River joins the Ohio River), and Knoxville, Tennessee. The 11-foot channel allows for passage of commercial barges with a 9-foot draft (the depth below the water surface that a towboat and barge extend when fully loaded). The additional 2 feet of channel depth allow for such operational factors as squat, trim, and wave action (factors that affect the draft of the boat), as well as sufficient channel width for safe navigation (Figure 2.3-01).



Note: A minimum channel depth of 11 feet allows standard commercial barge traffic to move through the system with a 2-foot overdraft (extra space between bottom of boat and river bottom).

Source: TVA data 2003.

Figure 2.3-01 Illustration of Minimum Channel Depth for Navigation

During normal flow conditions, operation of the reservoir system for flood control and power generation provides adequate water flow through the system to maintain minimum channel depths, making these operating objectives complementary uses of the water. To maintain adequate river depths for navigation, TVA must:

- Hold pool levels at all nine mainstem reservoirs high enough to provide an 11-foot depth at the shallowest points along the channel; and,
- Release enough water to create a depth of flow sufficient to provide an 11-foot channel at Kentucky and Pickwick tailwaters.

At times during summer and fall, when runoff is lowest, flows may be insufficient to maintain an 11-foot depth for the entire navigation channel. The channel depth at shoals, sandbars, and other shallows may cease to meet the 11-foot minimum and may impede navigation operations. During these periods, barge operators may reduce barge loads (and the draft needed for passage) or cease operations altogether. In response to low flows and shallow navigation channels, TVA may release water from storage in the tributary reservoirs to increase flows in the mainstem reservoirs and tailwaters in order to maintain the 11-foot minimum channel depth for navigation.

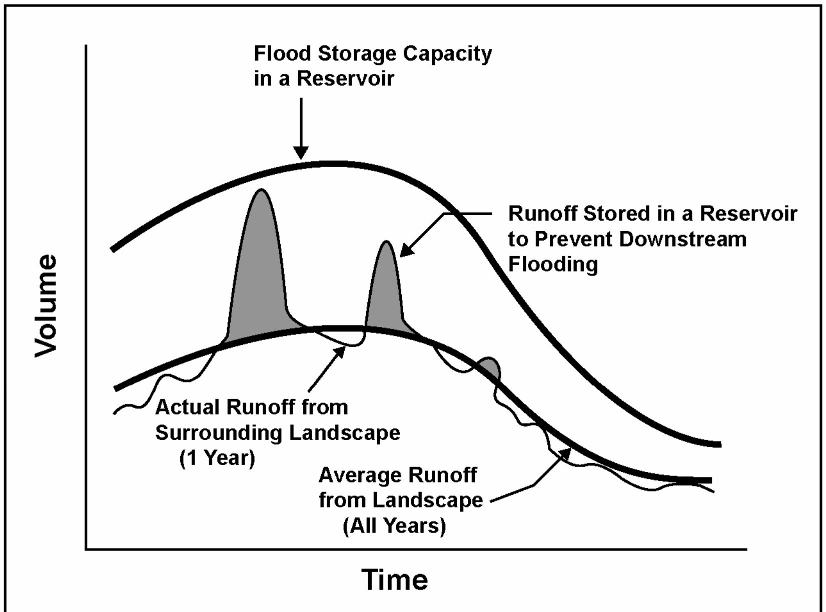
Controlling Flood Flows for Navigation

During periods of high flow (during and after major storms and high runoff), flow velocity and turbulence in the navigation channel, especially at the entrance and exit of locks and in shoal areas, may become dangerous to barge operations. For safety in these circumstances, navigation is suspended and barge movement is stopped until flows are reduced to a safe level and navigation can be resumed. When the reservoir system stores flood flows, disruption of navigation from dangerous high flows is minimized. To the extent that navigational operations are not interrupted by insufficient water depths or high river flows, the reliability and cost effectiveness of river transportation are achieved by operation of the reservoir system.

2.3.2 Operations for Flood Control

Reducing flood damage at critical locations is the second primary objective of the reservoir system. The greatest potential for flood damage is in and around Chattanooga, which is located just upstream from the point where the Tennessee River passes through the Cumberland Mountains. This mountain pass constricts higher river flows, backing water up onto adjacent floodplains.

During periods of high flow, flood risk can be significantly reduced by storing runoff in both tributary and mainstem storage reservoirs (Figure 2.3-02).



Note: On average, there is more storage capacity than is needed. However, the full capacity is needed during high runoff years.
Source: TVA data 2003.

Figure 2.3-02 Storage of Increased Runoff to Prevent Flooding

To reduce the risk of flooding, TVA implements the following actions:

- A portion of each reservoir's storage volume is set aside specifically for floodwater storage (Table 2.1-01). This storage is reserved so that it is available when increased runoff occurs.

- During a flood event, the reservoir operations policy permits storage reservoirs to rise above their flood guides, storing the excess runoff and reducing downstream flood crests that may otherwise inundate flood-prone areas.

- After the peak flow of the storm has passed, the stored floodwaters are released at a controlled rate to recover flood storage. This controlled release protects against downstream flooding and reclaims the reservoir's flood storage volume in preparation for the next storm.

Each reservoir's flood guide curve reflects the amount of storage reserved for flood control and how it varies by season of the year. These allocations were determined in the original project design, and some have been modified based on subsequent analysis of rainfall and runoff characteristics of the drainage basin and the physical limitations of the reservoir system. As noted in the discussion of reservoir guide curves (Section 2.2, Water Control System), the amount of flood storage for most tributary storage reservoirs is greatest in winter and early spring. As runoff volumes decline in late spring or summer, reservoir levels are allowed to increase, thus reducing flood storage volume (Figures 2.2-03 and 2.2-04).

Water releases during flood control operations may differ from normal releases. Most often, water is released through the hydro turbines. The flood control reservoir operations policy prescribes the amount of water to be released and the method of its release to reestablish flood storage. This drawdown is usually accomplished by operating the hydro turbines at maximum capacity until the necessary quantity of water has been discharged from the reservoirs. At other times, additional water must be released through sluiceways or spillways to lower the reservoir levels more quickly and regain the storage space needed for future storms.

Although the general flood protection procedure is the same for all storms, which reservoirs are filled and the timing of the store-and-release operation varies from storm to storm depending on where and how much rainfall occurs, and how much flood storage is allocated. System operations in response to an isolated thunderstorm might involve store and release at a single reservoir. In contrast, flood control operations for a major storm that spans the majority of the Tennessee Valley would necessitate the integrated operation of all the reservoirs in the system and may require coordination with the USACE on the lower Ohio and Mississippi Rivers.

2.3.3 Operations for Power Production

A third primary objective of the TVA water control system is the production of power for energy users in the TVA Power Service Area (Figure 1.1-02). TVA's power system includes 3,842 megawatts (MW) of conventional hydropower generating capacity, 1,645 MW of pumped storage capacity, and over 25,000 MW of fossil and nuclear generation facilities.

Most of TVA's fossil and nuclear generation plants are located along the reservoir system. Thus, the reservoir system is used directly to generate electrical energy (hydropower) and supports energy generation by providing cooling water to coal and nuclear plants, and transport of coal to its power plants. TVA operates all of its power plants together to meet regional power demands at the lowest possible cost to consumers.

Hydropower Generation

Energy generation from TVA's hydropower facilities is an important component of TVA's power supply system. Hydropower facilities provide reliable, low-cost energy. In the TVA system, these facilities primarily provide peaking power (power needed during periods of highest energy demand). The TVA Power Service Area typically has one period of high demand in summer and a second high-demand period in winter; the summer peak period is longer than the winter peak period. In an average year, more than 55 percent of the annual hydropower generation occurs during these two peak periods.

Hydropower is generally produced whenever reservoir releases are made, regardless of the purpose of the release. When a reservoir is within its discretionary operating zone (Section 2.2, Water Control System), additional water may be released for the sole purpose of generating hydropower. Releases are scheduled so that hydropower turbines are operated to maximize their value to the power supply system—by operating during the peak demand hours of each day and typically more on weekdays than on weekends.

The primary limit on generation of hydropower within the reservoir system is the availability of water, which may be constrained by low rainfall or other system operating priorities. For example, when TVA maintains higher summer pool levels by restricting drawdown, less water is available for hydropower generation.

Under normal streamflow conditions, releases from upstream reservoirs are scheduled to avoid releasing more flow into the mainstem reservoirs than TVA's hydropower units can use. During high-flow periods, excess water must be discharged through spillways or sluiceways, but using this option means losing the opportunity to use the water to generate electricity and diminishing the potential energy value of the water.

Coal and Nuclear Power Generation

Operation of the reservoir system also provides cooling water for TVA's coal and nuclear power plants. TVA coal and nuclear plants provide 80 percent of the energy needed for the TVA Power Service Area and depend on reservoir operations. Because their availability is essential to TVA's ability to provide reliable, affordable electricity, support of coal and nuclear plant operations by the reservoir system is an important operating objective.

The coal and nuclear plants require large quantities of cooling water to operate. Return of the cooling water to the reservoir system is regulated (by permit) and includes limitations on the increase in reservoir water temperatures that can result from the power plant discharge. These limitations are established to maintain water quality and protect aquatic life. System minimum flows in the Tennessee River are governed in part by the cooling water needs of these plants.

If cooling water discharges from any of TVA's power plants are predicted to exceed permit limits, power plant operations must be curtailed or river flows must be modified. The options available to TVA include reducing generation output (referred to as derating a power plant), which reduces the amount of discharged heat; or, at some facilities, switching to more expensive backup cooling systems (cooling towers). Both options increase TVA's cost of power generation. TVA may also modify reservoir releases to provide more flow or create steady flow. When possible, TVA selects the option that minimizes power costs.

Reductions in coal and nuclear power generation (derates) typically occur during summer months. When flows in the reservoir system are reduced, reservoir water temperatures increase—providing less power plant cooling capacity. If the river flow is too low to provide adequate cooling water, flows may be supplemented by releases from tributary storage reservoirs. Historically, modification of some plant operations for some portion of the summer period has been necessary to maintain thermal limit compliance.

Any reduction in energy output from the coal and nuclear plants typically must be replaced by obtaining the electricity from other generating sources. Because generation output reductions due to thermal limits generally occur on hot summer days when the demands on TVA's generating resources are the greatest and when all of TVA's plants are already operating, replacement energy often must be obtained from non-TVA energy resources at higher costs. Although replacement energy may be available from outside sources, overloading can occur on the bulk transmission grid, resulting in insufficient transmission capacity to bring it into TVA's Power Service Area. Recently, circumstances have occurred when energy was available only from other sources and the costs of the available energy were very high compared to TVA's power system costs.

2.3.4 Operations for Water Supply

The TVA reservoir system supports a variety of instream and offstream water uses, including power production (cooling water for coal and nuclear power plants), industrial production, public supply, and irrigation. Water is withdrawn at over 700 points along the Tennessee River and its tributaries to benefit approximately 4 million citizens. According to the U.S. Geological Survey, about 12 billion gallons of water are withdrawn from the river system each day (Hutson et al. 2003). TVA's reservoir operations provide the reservoir levels and system flows necessary to support water supply withdrawals and allow pumping mechanisms to function properly.

Water in the TVA system is some of the most intensively used in the United States as measured by water use per area or population (Hutson et al. 2003). At the same time, the basin has one of the lowest rates of consumptive use. Basin-wide consumptive use is presently about 5 percent of the water withdrawn; 95 percent of the water withdrawn is returned to surface water or groundwater for reuse. Increase in consumptive uses through 2030 is not expected to exceed 14 percent of the total water withdrawn (Hutson et al. 2003).

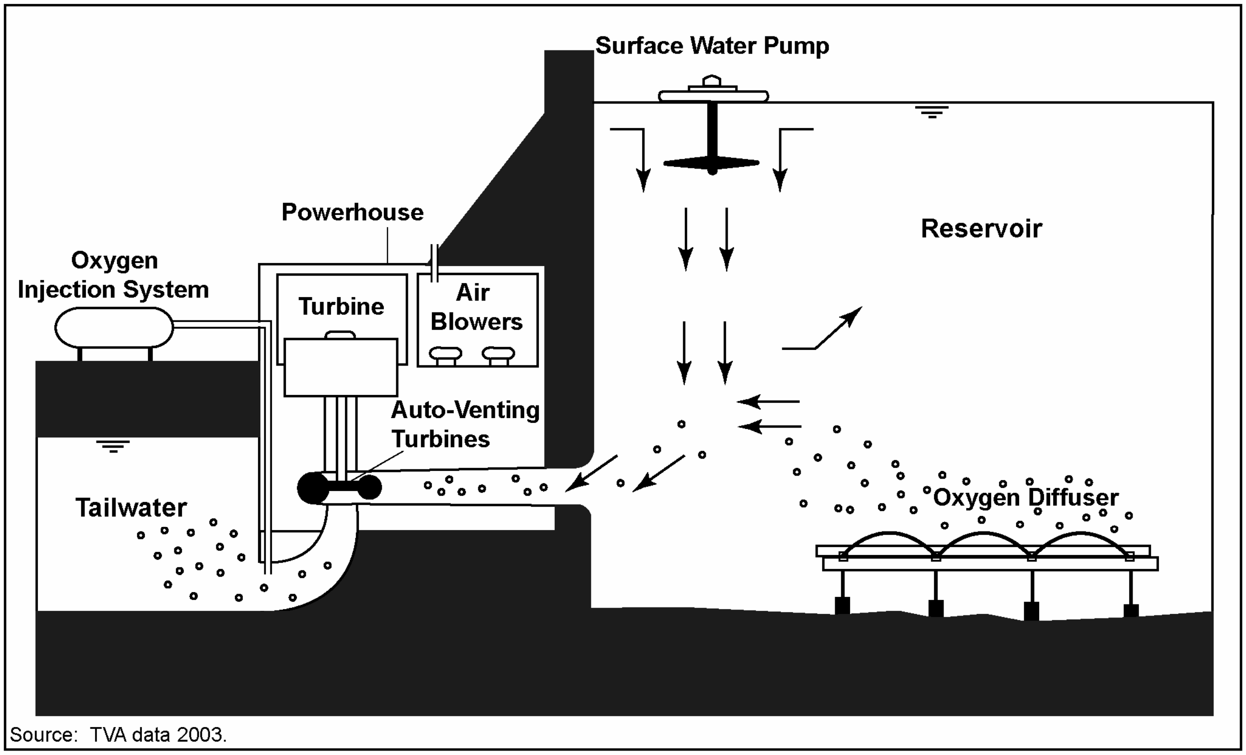
2.3.5 Operations for Water Quality

The public value placed on water quality has increased in recent years; TVA reservoir operations presently support a variety of water quality functions. These functions—previously outlined in Section 2.2.5, Water Release Guidelines, and more fully explained in the Water

Quality sections in Chapters 4 and 5—include maintaining water quality in project reservoirs and tailwaters, increasing the aeration of reservoir releases, diluting municipal and industrial waste, and ensuring adequate supplies of cooling waters for coal and nuclear power plants.

Reservoir operations and releases affect the concentration of DO in the water. Dissolved oxygen is an important water quality parameter, because insufficient DO concentration can be detrimental to the health and integrity of aquatic biota in reservoirs and tailwaters. As water is stored in reservoirs, physical and biological processes often depress the concentration of DO in the deeper waters of the reservoir. Depletion of DO concentrations is generally greater when the rate of water flow through a reservoir is less (water is held for longer periods). Higher DO concentrations accompany higher rates of flow through a reservoir. Because most hydropower turbines withdraw water from the deeper waters of the reservoir, the operation of hydropower facilities contributes to downstream DO problems, particularly below tributary dams. From June through November, hydropower releases from deeper reservoirs may contain little or no DO. This lower concentration of DO stresses aquatic life in tailwaters, cool-water species in reservoirs, and limits the water's capacity for assimilating waste.

Starting in the 1980s, under the Reservoir Release Improvement (RRI) Program, TVA developed methods to increase oxygen in the water below hydropower dams. These methods included auto-venting turbines, surface water pumps, oxygen injection systems, aerating weirs, and blowers (Figure 2.3-03). In 1991, under the Lake Improvement Plan, TVA adopted efforts to increase DO concentrations in the releases from 16 dams using these techniques (Appendix A, Table A–05) and to provide project minimum flows.



Source: TVA data 2003.

Figure 2.3-03 Aeration Methods to Increase Oxygen in Water below Hydropower Projects

A direct relationship exists between storage of water in the tributary reservoirs later into the summer and an increasing frequency of late summer water quality problems, especially DO. Increasing flow through the reservoirs in late summer, as is now accomplished by the late-summer/fall drawdown and system minimum flows, reduces DO problems. Higher DO concentrations often occur when water from the tributaries is moved through the reservoir system in late summer and early fall to meet certain other reservoir system operating priorities, such as hydropower production and system minimum flows for navigation and coal plant cooling water.

2.3.6 Operations for Recreation

Recreation on the reservoirs and tailwaters of TVA's system has grown in importance over the last 30 years. Reservoir operations presently include a variety of measures that provide recreational opportunities for residents and for visitors. Operations for recreation can be broadly divided into those for reservoir recreation and those for tailwater recreation.

Reservoir Recreation

TVA's present guidelines for reservoir levels were developed in part to improve recreational opportunities on tributary reservoirs during spring, summer, and fall. Beginning in mid-March, the 10 tributary reservoirs that are subject to substantial drawdown—Norris, Cherokee, South Holston, Watauga, Douglas, Fontana, Blue Ridge, Hiwassee, Nottely, and Chatuge—are filled to reach the target June 1 summer pool levels for recreation. The reservoirs are filled as quickly as possible, as long as reservoir levels do not exceed flood guide levels. Further, if low rainfall prevents reservoirs from filling at the desired rate, releases are limited to only those necessary for minimum flows.

Based on TVA's most recent evaluation in the Lake Improvement Plan, reservoir levels are maintained within the discretionary operating zone as much as practicable from June 1 to August 1. The rate of drawdown from June 1 to August 1, known as the period of restricted drawdown, is adjusted as necessary in an effort to generate hydropower while keeping reservoir levels above the MOG for recreation. If reservoir levels fall to the MOG due to low rainfall or high power demand, water levels are maintained as high as possible for recreation by restricting any further releases to minimum flows. On August 1, TVA begins the period of unrestricted drawdown on these reservoirs and is no longer restricted to maintaining minimum reservoir levels. Mainstem reservoirs fill earlier and drop only a few feet from summer pool to winter flood season levels.

Tailwater Recreation

There are 21 tailwaters on the reservoir system that may support recreational activities. In some tailwater reaches of the river, fishing, boating, and white-water activities (rafting and kayaking) are important. Providing recreational benefits may require managing reservoir releases for flows in tailwaters. Flows in the tailwaters should be sufficient to maintain fisheries and aquatic communities, and to support water-based recreation. Project minimum flow guidelines have been established at 20 tributary dams in the system; many of these have tailwaters that support recreational use. In addition, releases to meet system minimum flows support recreational use at various levels, depending on the specific conditions, access, accrual of flow from other tributaries, and a variety of other factors.

2.3.7 Operations for Other Objectives

TVA operates the reservoir system to achieve the primary operating objectives described earlier, but the system produces other important benefits in the watershed and Power Service Area. The following secondary benefits are generally available when they do not conflict with the reservoir system's primary objectives.

Mosquito Control

During late spring and summer, TVA fluctuates water levels every week on four mainstem reservoirs (Chickamauga, Guntersville, Wheeler, and Pickwick) by 1 foot, flow permitting. This temporary change in reservoir level disrupts mosquito habitat, reducing the number of mosquito larvae during the height of the mosquito breeding season.

Fish Spawning

In spring (generally the period of late-April to mid-May), the reservoir system is operated so that water levels in tributary reservoirs are relatively stable for a 2-week period when the water temperature at a 5-foot depth reaches 65 °Fahrenheit. At this water temperature, peak spawning occurs for several popular sport fish species (mainly largemouth bass and black crappie). If reservoir levels are reduced during the peak spawning period, fish nests and eggs may be stranded above the water line or fish may abandon nests if water becomes too shallow. Stabilizing reservoir levels aids fish spawning success for these species, ultimately improving recreational angling. During the peak spawning period, it is most beneficial to avoid more than a 1-foot-per-week change (either lowering or rising) in pool levels. Rising water levels affect fish spawning success less than falling levels.

The period to maintain constant tributary reservoirs levels for fish spawning coincides with the period for filling reservoirs to reach their target summer elevations, resulting in conflict. In addition, if the water level in a particular reservoir or group of reservoirs rises during this period due to heavy rains, it is often necessary to lower pool levels in order to recover flood storage volume.

2.3.8 System Monitoring and Decision Support

TVA's reservoir operations policy provides the framework for overall operation of the system. Day-to-day decisions on actual release schedules are based on existing and forecasted weather conditions, immediate and projected needs for river flows, and special operation requirements. To ensure the efficient operation of its complex reservoir system, TVA uses a variety of data collection, computerized reporting, and decision support systems.

TVA, in cooperation with the USGS and USACE, maintains a computerized hydrologic data network (rainfall and streamflow gauges) throughout the Tennessee Valley; these measurements are reported and used in real time, generally about every 2 hours. Forecasting of weather and scheduling of water releases are supported by an array of computerized data collection and decision support tools, allowing TVA to examine several operational options before making decisions.

TVA's operations are closely coordinated with those of other agencies, especially the Nashville District of the USACE, which operates projects in the Cumberland River Basin that can interact with TVA's operations and affect downstream conditions. During periods of flooding on the lower Ohio and Mississippi Rivers, releases from Kentucky Dam are coordinated with the USACE Great Lakes and Ohio River Division, to aid in reducing flooding on those rivers. The same is true during extreme low-flow periods, when minimum river depths for commercial navigation are not available. The interconnected Tennessee and Cumberland Rivers constitute only 6 percent of the total Mississippi River watershed area above Memphis. During low-flow periods, however, discharges from the storage dams on these rivers contribute up to 40 percent of the total flow.