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TVA/RDG/EQS-91/1

Final Environmental Impact Statement

Tennessee River and Reservoir System Operation and Planning Review

Tennessee Valley Authority

December 1990

TENNESSEE RIVER AND RESERVOIR SYSTEM
OPERATION AND PLANNING REVIEW

( ) Draft   (X) Final Environmental Impact Statement

Responsible Federal Agency: Tennessee Valley Authority (TVA)

Proposed Action: Changes in TVA reservoir operations are proposed to maintain minimum flows below dams at critical times and locations, to increase dissolved oxygen below 16 dams by aerating releases, and to delay unrestricted summer drawdown until August 1 on ten tributary reservoirs.

Proposed minimum flows and aeration of releases would recover over 170 miles of aquatic habitat lost from intermittent drying of the river bed below TVA tributary dams and improve levels of dissolved oxygen in over 300 miles of river where water quality is now impaired in the late summer and fall by releases through TVA dams. The annual value of lost hydropower for minimum flows is $50,000. Aeration equipment costs would be about $44 million; yearly operating and maintenance costs would be about $4 million.

Proposed summer lake levels in tributary reservoirs would increase lake recreation, improve scenic views, and provide opportunities for tourism and second home development on lakes where summer drawdown has been a constraint to economic growth. Reservoir fisheries would be improved through increased survival of young fish. Water depth for commercial navigation on the lower Ohio and Mississippi rivers would be increased during the months of lowest flow. Hydropower generation would be shifted from the spring and early summer to the late summer and fall. Annual hydropower energy losses would vary with rainfall, averaging about $2 million (including the $50,000 energy loss for minimum flows). The proposed implementation strategy would assure that hydropower is available to respond to critical power system needs without significantly affecting lake levels or requiring the addition of replacement capacity.

Power revenues are recommended to fund release improvements and Congressional appropriations are recommended to fund lake level improvements. Funding sources that allocate costs directly to beneficiaries are not recommended because they would not be adequate to cover the costs and would be difficult to administer.

Jurisdictions Affected by Action: See accompanying table.

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State	Counties Affected by the Alternatives		Other Counties in the Tennessee River Valley		Other Counties or Cities* Supplied with TVA Power	
Alabama	Colbert Jackson Lauderdale Lawrence	Limestone Madison Marshall Morgan	Blount Cullman DeKalb Etowah	Franklin Marion Winston	Bessemer* Cherokee	Tarrant City*
Georgia	Fannin Towns	Union	Catoosa Dade Gilmer	Walker Whitfield	Chatooga Gordon Murray	Lumpkin Rabun
Kentucky	Calloway Livingston Lyon	Marshall Trigg	Graves	McCracken	Allen Butler Carlisle Christian Cumberland Edmonson Fulton Glasgow* Grayson	Hickman Logan Monroe Monticello* Paducah* Princeton* Simpson Todd Warren
Mississippi	Tishomingo		Alcorn	Prentiss	Attala Benton Calhoun Chickasaw Choctaw Clay Itawamba Kemper Lafayette Leake Lee Lowndes Marshall Monroe	Neshoba Noxubee Okuibbeha Panola Pontotoc Scott Tallahatchie Tate Tippah Union Webster Winston Yalobusha
North Carolina	Cherokee Clay	Graham Swain	Avery Buncombe Haywood Henderson Jackson Macon	Madison Mitchell Transylvania Watauga Yancey		
Tennessee	Anderson Benton Blount Bradley Campbell Carter Claiborne Cocke Decatur Franklin Giles Grainger Hamblen Hamilton Hardin Hawkins Henry Houston Humphreys	Jefferson Johnson Knox Lincoln Loudon Marion McMinn Meigs Monroe Moore Perry Polk Rhea Roane Sevier Stewart Sullivan Union Washington	Bledsoe Carroll Chester Coffee Cumberland Dickson Greene Grundy Hancock Henderson Hickman	Lawrence Lewis Marshall Maury McNairy Morgan Rutherford Sequatchie Unicoi Wayne Williamson	Bedford Cannon Cheatham Clay Crockett Davidson De Kalb Dyer Fayette Fentress Gibson Hardeman Haywood Jackson Lake Lauderdale Macon Madison	Montgomery Obion Overton Pickett Putnam Robertson Scott Shelby Smith Sumner Tipton Trousdale Vanburen Warren Weakley White Wilson
Virginia	Washington		Bland Dickenson Grayson Lee Russell	Scott Smyth Tazewell Wise Wythe		

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SUMMARY

This study responds to the growing number of requests from people in the Tennessee Valley for major adjustments in TVA's reservoir management policy. Two principal changes are evaluated: (1) improving water quality and aquatic habitat by increasing minimum flow rates and aerating releases from TVA dams to raise dissolved oxygen levels and (2) extending the recreation season on TVA lakes by delaying drawdown for other reservoir operating purposes, primarily hydropower generation.

Reservoir Release Alternatives

Certain minimum flows exist along the Tennessee River and its tributaries as a result of operating the reservoir system for the purposes of navigation, flood control, and power production. TVA has agreed to work cooperatively with the state of Tennessee to improve the flow, depth, and dissolved oxygen content of reservoir releases at certain locations. However, progress under the current cooperative effort with Tennessee is expected to be slow and similar arrangements are not in effect with other Valley states.

Changes in TVA's current reservoir release policies *(the "no action" alternative)* are proposed to expand and accelerate current efforts to address the water quality effects of reservoir design, impoundment, and operation. Dissolved oxygen (DO) levels in the bottom portion of TVA reservoirs--especially deeper tributary reservoirs--are depleted in the summer as a result of unavoidable physical and biological processes. Pollution from both point and nonpoint sources contributes to the problem. Hydroturbines at TVA's dams withdraw water from this lower layer to help meet summer power demands, releasing water low in DO during the late summer and fall. This stresses aquatic life in tailwaters and reduces the quality of the water available for other uses (e.g., assimilation of wastes).

Aquatic communities in tailwater areas below TVA dams also are affected by variations in flow, depth, and temperature resulting from reservoir operations. Under current policies, over 200 miles of tailwater regions consist of a series of shallow pools and exposed riffle areas when hydroturbines are not operating. This has far-reaching effects on the health, number, and diversity of aquatic life, including some species now listed as endangered. It also reduces the quality of fishing activities in reservoir tailwaters and detracts from the scenic beauty of these areas.

These impacts led to consideration of three alternatives to TVA's current reservoir release policies.

> *Alternative A: Providing higher minimum flows from TVA dams, plus increasing DO levels in tailwater areas to a target of 4 milligrams per liter (mg/l) by aerating releases through TVA dams.*

> *Alternative B: Providing higher minimum flows, plus increasing DO levels in tailwater areas to a target of 5 or 6 mg/l, depending on the fishery, through a combination of aeration at TVA dams and state action to control pollution.*

Alternative C: Providing higher minimum flows, plus increasing DO levels in tailwater areas to 5 or 6 mg/l, depending on the fishery, solely through aeration at TVA dams.

Alternative B is recommended because it would provide significantly more water quality benefits in proportion to the added costs, while recognizing the responsibility of polluters to rectify the effects of their operations on downstream DO levels. These benefits include:

- o recovery of over 180 miles of aquatic habitat in areas below TVA tributary dams that now have little or no flow when hydroturbines are not operating;
- o dissolved oxygen improvements sufficient to promote the growth and diversity of aquatic communities, possibly including reestablishment of some species now listed as endangered;
- o improved recreational opportunities, both for people who like to fish and for people who value the scenic beauty of the region's lakes and rivers; and
- o increased potential for economic development in riverfront communities that rely on scenic values and water quality to attract new jobs.

About $44 million would be required under alternative B to purchase and install aeration equipment at 16 TVA dams. An additional $4 million a year would be required to operate and maintain this equipment. Providing minimum flows would reduce the value of the power produced at TVA dams by about $50,000 a year.

Although the capital cost of alternative A would be about $11 million less than alternative B, it is not recommended because the benefits to aquatic life would be much less. Raising DO levels to 4 mg/l would help some aquatic species survive, but growth, health, and species diversity would still be impaired.

Alternative C is not recommended because the cost of rectifying the effects of upstream pollution would be paid by TVA instead of by those responsible for the pollution source. This would increase the capital cost of achieving the 5 or 6 mg/l DO target by $10 million and the annual operating cost by $1.5 million.

Five recommendations are made in support of the preferred reservoir release alternative. TVA should:

1. *Take steps to inform tailwater users of the hazards associated with providing minimum flows by turbine pulsing.** These include assessing the adequacy of existing warning signs, given the new operation, and conducting a public education effort to inform tailwater users about the danger of rapidly rising waters resulting from turbine discharges.

2. *Monitor the effects of the proposed biweekly average summer flow requirements at mainstream dams on water quality and aquatic life.** This would help identify unforeseen effects on assimilative capacity at key locations affected by pollution sources.

*These recommendations are proposed as environmental commitments under the National Environmental Policy Act.

3. *Work with the states to implement release improvements within a five-year period.* This recommendation also calls for implementing minimum flows and DO improvements in close cooperation with state agencies, based on a joint assessment of the conditions and needs of individual tailwaters.

4. *Accelerate the development of autoventing turbine technology.* TVA reaeration research has already shown the potential of autoventing turbines to minimize problems associated with aeration of turbine discharges. This research should be accelerated so that the technology is available when TVA's existing hydroturbines are replaced.

5. *Work with interested local areas to find ways to finance tailwater releases for whitewater recreation.* To be responsive to requests from whitewater outfitters and to support local economic development, TVA should provide releases for recreational floating where ways can be found to compensate TVA's power system and its customers for the lost value of hydropower. The agreement with the state of Tennessee to provide releases from the Ocoee No. 2 Dam provides one model.

Lake Level Alternatives

Under TVA's current policy *(the "no action" alternative)*, lake levels normally reach their peak around Memorial Day and are drawn down thereafter as needed to meet peak summer power demands. Changes in this policy are proposed in response to growing public pressure for increased recreation benefits from reservoir operations. Providing higher lake levels for recreation uses, a long-standing issue in the Tennessee Valley, surfaced repeatedly in comments received during the scoping process at the beginning of this study and during public review of the Draft EIS. Residents and community leaders want high quality recreation on the region's lakes. In tributary counties plagued by low income and high unemployment levels, many see tourism and second-home development based on high lake levels for a longer recreation season as their economic salvation.

To accommodate these needs, seven alternatives to TVA's current policy were evaluated for extending recreation pool levels on ten tributary lakes--Norris, Cherokee, South Holston, Watauga, Douglas, Fontana, Blue Ridge, Hiwassee, Nottely, and Chatuge.

All would involve filling these lakes more aggressively in the spring, and all would include a flexible implementation strategy to avoid any waste of water power and to assure that hydropower is still available as a resource to meet critical power system needs. This strategy would limit hydrogeneration to that needed to meet minimum flow requirements, when lack of rainfall results in unsatisfactory lake levels. Generation above this level would be permitted only to prevent running combustion turbines or dropping interruptible loads, and to provide frequency regulation and transmission reliability. Before extra hydrogeneration could be committed, TVA's Raccoon Mountain Pumped storage plant and all available thermal generating units would be fully committed, and all equivalently priced interchange power would be purchased.

What would vary under the seven alternatives is the timing of unrestricted drawdown to January 1 flood control levels. Under three of these alternatives, tributary reservoirs would continue to be treated uniformly:

Alternative 1: Unrestricted drawdown would be delayed until August 1.

Alternative 2: Unrestricted drawdown would be delayed until Labor Day.

Alternative 3: Unrestricted drawdown would be delayed until October 31.

Under the other four alternatives, unrestricted drawdown would begin on August 1 on most reservoirs, but would be delayed until October 1 on others.

Alternative 1A: August 1 drawdown on South Holston, Watauga, Fontana, Blue Ridge, Hiwassee, Nottely, and Chatuge; October 1 drawdown on Norris, Cherokee, and Douglas.

Alternative 1B: August 1 drawdown on Norris, Cherokee, Douglas, Fontana, Blue Ridge, Hiwassee, Nottely, and Chatuge; October 1 drawdown on South Holston and Watauga.

Alternative 1C: August 1 drawdown on South Holston, Watauga, Norris, Cherokee, Douglas, Blue Ridge, Hiwassee, Nottely, and Chatuge; October 1 drawdown on Fontana.

Alternative 1D: August 1 drawdown on South Holston, Watauga, Norris, Cherokee, Douglas, and Fontana; October 1 drawdown on Blue Ridge, Hiwassee, Nottely, and Chatuge.

Alternative 1 is recommended because it would produce the most recreation and economic development benefits without significantly reducing other reservoir system benefits. Implementation of this alternative is expected to:

- increase recreation visitation by about 21 percent;

- improve the scenic beauty of affected reservoirs, making them more attractive for residential development;

- increase the survival rate of young fish by keeping shallow spawning areas and shoreline vegetation submerged for a longer period; and

- improve navigation on the lower Ohio and Mississippi rivers by increasing flows during September and October (typically low flow months).

Impacts on flood control and navigation on the lower Ohio and Mississippi rivers preclude the choice of alternative 3. If TVA delayed unrestricted drawdown until October 31, stored flood water could reach or even exceed TVA's easement levels on Kentucky Lake; this might increase flooding on the lower Ohio and Mississippi rivers during flood control operations by the U.S. Army Corps of Engineers. Also, under alternative 3, flow from the Tennessee and Cumberland rivers would be decreased during September and October before tributary lake levels are lowered; this would reduce water depths for commercial navigation on the lower Ohio and Mississippi rivers when low flow conditions are most likely.

Power costs and environmental considerations preclude the choice of either alternative 2 or 3. Delaying unrestricted drawdown of all ten lakes until Labor Day or beyond would involve the eventual addition of 750 megawatts of capacity (requiring a capital expenditure of about $560 million) to assure the reliability of the power system during the summer peak season. Over 1.3 billion kilowatthours of generation would be shifted from the spring and summer into the post-Labor Day period. This would reduce the value of hydropower energy by $16 million under alternative 2 and by $25 million under alternative 3.

To make up for displaced hydroelectric power, TVA would have to increase the use of coal-fired facilities during June and July. Assuming that TVA uses existing facilities, air emissions in the summer would increase by an average of six percent under alternatives 2 and 3. This could have an adverse impact on air quality because dispersion conditions are worse in the summer.

Alternatives 2 and 3 also would reduce the temperature of releases from tributary dams and increase temperature fluctuations in the tailwaters from year to year. This could add to the decline of warm water fisheries where conditions are currently marginal and, depending upon whether temperatures are already at or above the range for optimal growth, reduce or increase growth rates of cold water fisheries.

Power costs also weigh against the choice of alternatives 1A, 1B, and 1C. Alternative 1A would require a 100-megawatt capacity addition and involve annual losses in energy value of about $6 million. Alternative 1B would require 10 megawatts of replacement capacity and involve annual costs of $9 million. Alternative 1C would require 30 megawatts in new capacity and cost $3 million a year in lost energy value.

By comparison, no additional capacity would be required under alternatives 1 and 1D. About $2 to 3 million a year would be required for lost value of hydropower energy, including $50,000 per year in hydropower losses to provide minimum flows. The effects of these alternatives on air quality would be much less than the other alternatives because of greater hydropower generation in late summer. The effects on water temperatures in tailwater areas would not be significant.

Alternative 1 is preferred because it would cost less and would benefit all tributary areas equally. Alternative 1D would delay unrestricted drawdown on one group of reservoirs two months longer than on other tributary reservoirs. This could be viewed by some as preferential treatment and could result in strong opposition from people living around reservoirs subject to earlier drawdown.

Although the effect of extended lake levels on shoreline development is difficult to determine, protecting reservoir land will become more important. Public comments and available data on shoreline structures and population growth confirm that shoreline development around TVA reservoirs already is increasing. A commitment to monitoring the cumulative impact of shoreline development trends and improvements in the management of TVA reservoir lands are proposed in conjunction with the preferred lake level alternative for this reason. Specifically, TVA should:

6. *Monitor shoreline development.** If TVA implements the proposed lake level alternative, it should commit to monitoring shoreline development trends so that problems can be identified in time to implement effective remedial action. This would help ensure a future balance between protecting environmentally important uses of the shoreline and development to promote economic growth.

7. *Promote the balanced use of reservoir shorelines through TVA land management.* TVA should accelerate its tributary lands planning effort, completing plans for Melton Hill, Norris, Cherokee, Chatuge, and Tellico reservoirs by 1996. TVA also should improve the data base for reservoir lands management, extend the reservoir lands planning process to include "marginal strip" land, and place higher management and budget priority on implementing reservoir land management plans. These actions are intended to establish TVA as a model land manager and increase TVA's effectiveness in influencing the management of non-TVA reservoir lands.

Additional Recommendations

Three additional recommendations are made in response to concerns identified in the course of this study.

8. *Improving communication with lake users.* To ensure that TVA's lake and river operations respond to the needs and desires of lake users, TVA should take steps to improve communication regarding routine reservoir operations, increase public understanding of reservoir operating policies, provide opportunities for public input to system planning and management, and work more closely with Valley states to address water resource issues of mutual concern.

9. *Reasserting leadership in navigation development.* TVA should seek adequate funding from Congress to maintain and improve existing navigation facilities and for feasibility studies for new projects.

10. *Monitoring and planning for the effects of climate change on reservoir operations.* To improve its flexibility to deal with any future changes in temperature and rainfall, TVA should increase its research on the system impacts of potential changes in climate, including improvements in the collection and analysis of weather-related data, and develop contingency plans as needed to adapt to departures from the historical climatic record.

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*This recommendation is proposed as an environmental commitment under the National Environmental Policy Act.

Funding Options

There are three principal options for funding release and lake level improvements. Federal taxpayers could bear the costs through the use of Congressional appropriations, Valley power consumers could bear the costs through the use of power revenues, or both groups could share the costs through the use of a combination of appropriated and power funding. Based on consideration of these options, power revenues are recommended to pay for release improvements, and appropriated funds are recommended to pay for lake level improvements.

Power funds should be used pay for release improvements because low flows and low DO releases result from the design and operation of TVA dams for hydropower purposes. Hydroturbines at TVA dams were designed with low level intakes to permit operation during the winter season when lake levels are kept low to provide flood storage capacity. The cost of mitigating the resulting adverse environmental effects can appropriately be viewed as an ordinary business expense of the power system. In addition, improvements in water quality and aquatic habitat would benefit the region's economy by improving the overall quality of life and the attractiveness of the Valley. Any improvements in the region's economy are good for TVA and its power program.

The costs of lake level improvements should be paid out of Congressional appropriations because the primary purpose served by the improvements is recreation and associated economic development in tributary lake areas. Congressional appropriations should be used to cover these costs, as they are for other TVA economic development programs. Many of the counties around TVA tributary reservoirs are among the poorest in the Tennessee Valley region and, thus, are appropriate candidates for such assistance. User fees for lake level improvements are not recommended because they would be difficult to administer, given the diversity and geographical dispersion of beneficiaries, and because they probably would not be adequate to cover the full cost of the improvements.

INTRODUCTION

This Final Environmental Impact Statement (EIS) presents the results of the Tennessee River and Reservoir System Operation and Planning Review, a study authorized by the TVA Board in September 1987.

Purpose and Need for Action

The TVA Board called for the study to determine whether the operating priorities for TVA dams and reservoirs, set out in the TVA Act over 50 years ago, still make sense given the changes that have occurred in the Tennessee Valley since the 1930s. In their words:

> "Today...neither TVA nor the region can take the river for granted if we expect to have the best river system in America--in terms of water quality and supply as well as usefulness to the regional economy. To ensure that TVA is meeting the more complex needs of today, we have called for the broadest reassessment in 50 years of the operating priorities for TVA dams and reservoirs."

The TVA Act directs TVA to manage the reservoir system primarily for navigation and flood control, and (consistent with those purposes) for power generation. However, other benefits of reservoir operations have become increasingly important to the people of this region. Today, public demand for abundant supplies of clean water and for high quality recreation on the region's lakes and streams competes with the demand for the rate benefits afforded by the continued production of low-cost TVA hydroelectricity. Many people now take flood control and navigable waterways for granted, perhaps because few have experienced the floods that once devastated cities and towns along streams, or the shoals and rapids that plagued Tennessee River navigation before TVA.

In response to these changes, TVA has made many modifications in how it operates the reservoir system. In 1971, for example, TVA established higher normal minimum operating levels for its principal tributary storage reservoirs to increase the probability of more favorable lake conditions for recreation. Other adjustments have been made to improve fisheries, water quality, recreational floating, and other uses. In fact, while the study was being conducted, work continued on numerous projects and studies to improve the reservoir system, such as TVA's Reservoir Resources Reevaluation (RRR) and Reservoir Releases Improvements (RRI) programs. These efforts, however, only consider changes that fit within the framework of existing statutes and established policies.

This study, in contrast, was not limited to established policies or to options that fit within the operating priorities laid out in the TVA Act or other legislative authority. The objective was to identify a long-term operating strategy for the Tennessee River and reservoir system that would fit the needs and values of the region and its people into the next century. It was recognized that the study might produce recommendations that TVA could not implement without Congressional action. Because this was a policy and environmental study aimed at helping the Board evaluate alternatives, implementation of some of the recommendations also may require additional technical and engineering analysis. Further environmental review may be appropriate if some of the recommendations are implemented and result in proposed actions with potential adverse environmental effects which are outside the scope of effects identified in this EIS.

The extreme weather conditions of the last several years have challenged TVA's reservoir managers. Lack of rainfall first forced TVA to limit hydroelectric power production, caused serious water quality problems, and reduced the recreation and economic development value of tributary area lakes. Then, in June 1989, there was so much rain that flood storage space was rapidly taken up and TVA had to spill water as a flood control measure. The effects of actions taken in response to these extreme conditions, and information obtained about water quality problems on the Tennessee River, were of value to this study. But recent weather patterns were not a factor in TVA's decision to review its reservoir operating policies. The focus was on the long-term policies that will guide future TVA reservoir operations, recognizing the invariable need for flexibility to respond to unusual rainfall amounts.

The EIS and Public Review Process

The National Environmental Policy Act charges Federal agencies to prepare a detailed statement on the environmental impact of proposed actions that could significantly affect the quality of the human environment. TVA developed an Environmental Impact Statement (EIS) in conjunction with its review of reservoir operating policies to comply with this charge.

By preparing an EIS, TVA sought to ensure that the environmental effects of reservoir operating alternatives were thoroughly investigated and that ample opportunities for public review and comment were provided. Broad public participation was essential given the fundamental purpose of the study--to ensure that TVA's operation of the system is responsive to the needs and desires of the region's people.

TVA published notice in the Federal Register on November 25, 1987, of its intent to prepare an EIS and requested comments on the proposed scope or contents. Scoping--the first step in the process of preparing an EIS--included these major activities:

- Written comments. TVA received letters about how it operates the reservoir system from over 100 individuals and groups.

- Public information sessions. Over 800 people took the opportunity to express their thoughts and ideas at eleven information sessions held across the Tennessee Valley in November and December 1987. Table 1 shows the location and number of people attending each meeting. Participants were able to discuss their concerns informally with TVA staff who took notes on their comments. They were also asked to fill out a comment card, indicating their primary interest in TVA's reservoir operation.

- QUEST sessions. About 60 individuals were involved, along with TVA staff, in two intensive planning meetings on the future of the reservoir system. These meetings were part of a two-step process known as QUEST (Quick

Environmental Scanning Technique) developed by Burt Nanus, a professor at the University of Southern California. Participants, called "stakeholders," met in small groups structured to represent a broad range of interests in the reservoir system. They had two primary tasks: to identify trends and issues that are critical to the future management of the reservoir system and to develop responsive operating alternatives.

Taking part in the process were State and local officials, representatives of other Federal resource agencies, navigation interests, distributors of TVA power, environmental group representatives, and tourism and other economic development interests. TVA staff representing the areas of reservoir operations, power, water quality, agriculture, land management and recreation, economic development, and aquatic biology also participated.

Table 1
Public Information Meetings

Location	Date	No. Registered
Blountville, TN	11/24/87	48
Blue Ridge, GA	11/30/87	141
Murphy, NC	12/1/87	64
Chattanooga, TN	12/2/87	20
Knoxville, TN	12/3/87	423
Huntsville, AL	12/8/87	21
Tupelo, MS	12/9/87	5
Memphis, TN	12/10/87	10
Paris, TN	12/15/87	25
Benton, KY	12/16/87	28
Nashville, TN	12/17/87	19

The results of the scoping process are presented in detail in four documents prepared by TVA staff: "Summary of Public Information Meetings, November-December 1987," February 1988; "Written Comments and Suggestions, Tennessee River and Reservoir System Operation and Planning Review," March 1988; "Results of First QUEST Sessions with Internal and External Participants," March 1988; and "Results of Follow-up QUEST Sessions with Internal and External Participants," May 1988. Copies of these documents can be obtained by writing to TVA.

Based on the comments received during the scoping process, a Draft Environmental Impact Statement (EIS) was prepared and distributed for broad public review beginning in January 1990. A notice was published in the Federal Register and copies of the Draft EIS, and/or a newspaper summary, were sent to approximately 2500 individuals, organizations, and agencies on the study's mailing list (identified in Section 4 of this report.)

The public was invited to submit written comments on the Draft EIS or attend one of the twelve public meetings, listed in table 2, which were held across the Tennessee Valley in February and March 1990. Over 820 people responded, including 627 who wrote letters and 196 who spoke at a public meeting (out of nearly 1200 registrants). These comments, summarized in Appendix C to this report, were used in revising the Draft EIS.

Additional information on the results of the public review process can be obtained by writing for the following reports: "Transcripts of Public Meetings, Draft Environmental Impact Statement, Tennessee River and Reservoir System Operation and Planning Review," February-March 1990; "Results of Public Meeting Opinion Survey, Draft Environmental Impact Statement, Tennessee River and Reservoir System Operation and Planning Review," February-March 1990; and "Written Comments, Draft Environmental Impact Statement, Tennessee River and Reservoir System Operation and Planning Review," December 1990.

Table 2
Public Meetings on the Draft EIS

Location	Date	No. Registered	No. of Speakers
Blountville, TN	2/12/90	91	16
Knoxville, TN	2/13/90	112	15
Bryson City, NC	2/14/90	163	37
Jefferson City, TN	2/15/90	227	25
Blairsville, GA	2/19/90	323	30
Scottsboro, AL	2/27/90	15	4
Florence, AL	2/28/90	55	10
Chattanooga, TN	3/1/90	42	11
Murray, KY	3/5/90	55	11
Lexington, TN	3/6/90	50	13
Memphis, TN	3/7/90	15	10
Nashville, TN	3/9/90	35	14

About the Study

The study was conducted in four phases to permit review of the results at key points. The first phase helped clarify the major issues to be addressed in the study. The second phase focused on the development of alternative reservoir operating strategies. The third phase involved the evaluation of these alternatives in terms of risk and return. The fourth phase aimed at resolving differences of opinion and identifying preferred alternatives. Each phase concluded with presentations to TVA management and outside groups on preliminary results. This approach allowed for mid-course corrections as the study progressed and helped keep the focus on the issues of greatest concern to decisionmakers and affected constituency groups.

The study staff consisted of one full-time project manager and two part-time analysts. Staff from throughout TVA contributed to the effort, providing information and conducting numerous technical analyses and special studies as assigned. The project manager was advised by an internal steering committee, composed of a cross-section of mid- and upper-level TVA managers, who provided guidance on the direction of the study. Nine expert reviewers from outside TVA also were consulted periodically to help ensure that the work performed was conceptually and methodologically sound. External reviewers were drawn from research organizations, universities, public agencies, and other organizations without a direct stake in the Tennessee River and reservoir system. Other outside consultants were used in decision analysis and when TVA expertise was unavailable.

EIS Format

This EIS is composed of four sections and seven chapters, supported by this introduction, a summary, and three appendices.

The first section sets the stage for the evaluation of alternative operating policies by describing current conditions and operations. Chapter 1 provides some background information on the topography and hydrology of the Tennessee Valley and on the dams and reservoirs that make up the Tennessee River water control system. Chapter 2 describes TVA's current reservoir operations and land management policies. Chapter 3 describes the current state of the river and reservoir system, including those aspects of both the natural and socioeconomic environments that could be affected by any change in TVA reservoir operations.

The second section outlines alternatives and summarizes evaluation results. Chapter 4 describes the alternatives that were evaluated, as well as the alternatives that were considered but not evaluated in detail. Chapter 5 presents the evaluation results. Major reservoir operating alternatives are compared in terms of their environmental consequences and their effects on hydropower production, flood control, navigation, recreation, and other uses.

The third section presents a recommended plan of action. Chapter 6 describes the preferred alternatives and summarizes the analysis leading to their selection. It also presents seven recommendations developed during the course of the study that complement the preferred alternatives. Chapter 7 discusses funding for the preferred alternatives.

Section 4 contains supporting information, including an index and a glossary of some of the technical terms used in the report. Also presented is a list of the individuals principally responsible for preparing this report; a list of agencies, organizations, and persons to whom copies of this report have been sent; and a list of working papers and references that may be of interest to some readers. Copies of these papers can be obtained by writing to TVA.

There are three appendices to the report. The first presents a description of the land, water, and aquatic resources of each major TVA reservoir discussed in the report. The second presents additional information describing the effect of the alternatives on lake levels for each of the major tributary reservoirs considered in the report. The third summarizes public comments received on the Draft EIS and provides TVA's response.

SECTION ONE: THE TENNESSEE RIVER AND RESERVOIR SYSTEM TODAY

Chapter 1

Background

Topography and Rainfall

The Tennessee River system (figure 1) has its headwaters in the mountains of western Virginia and North Carolina, eastern Tennessee, and northern Georgia. Two rivers, the Holston and the French Broad, join at Knoxville to form the Tennessee. Below this point, the river flows southwest through the state of Tennessee, gaining water from three other principal tributaries--the Little Tennessee, the Clinch, and the Hiwassee rivers, in that order. The Tennessee continues flowing southwest into Alabama as far south as Guntersville and then westward, picking up water from another large tributary, the Elk River, in its course through the Muscle Shoals area in northern Alabama. At the northeast corner of Mississippi the river turns north, recrosses the state of Tennessee, and continues to Paducah, Kentucky, where it enters the Ohio River. During the river's second passage through Tennessee, it is joined by another large tributary, the Duck River.

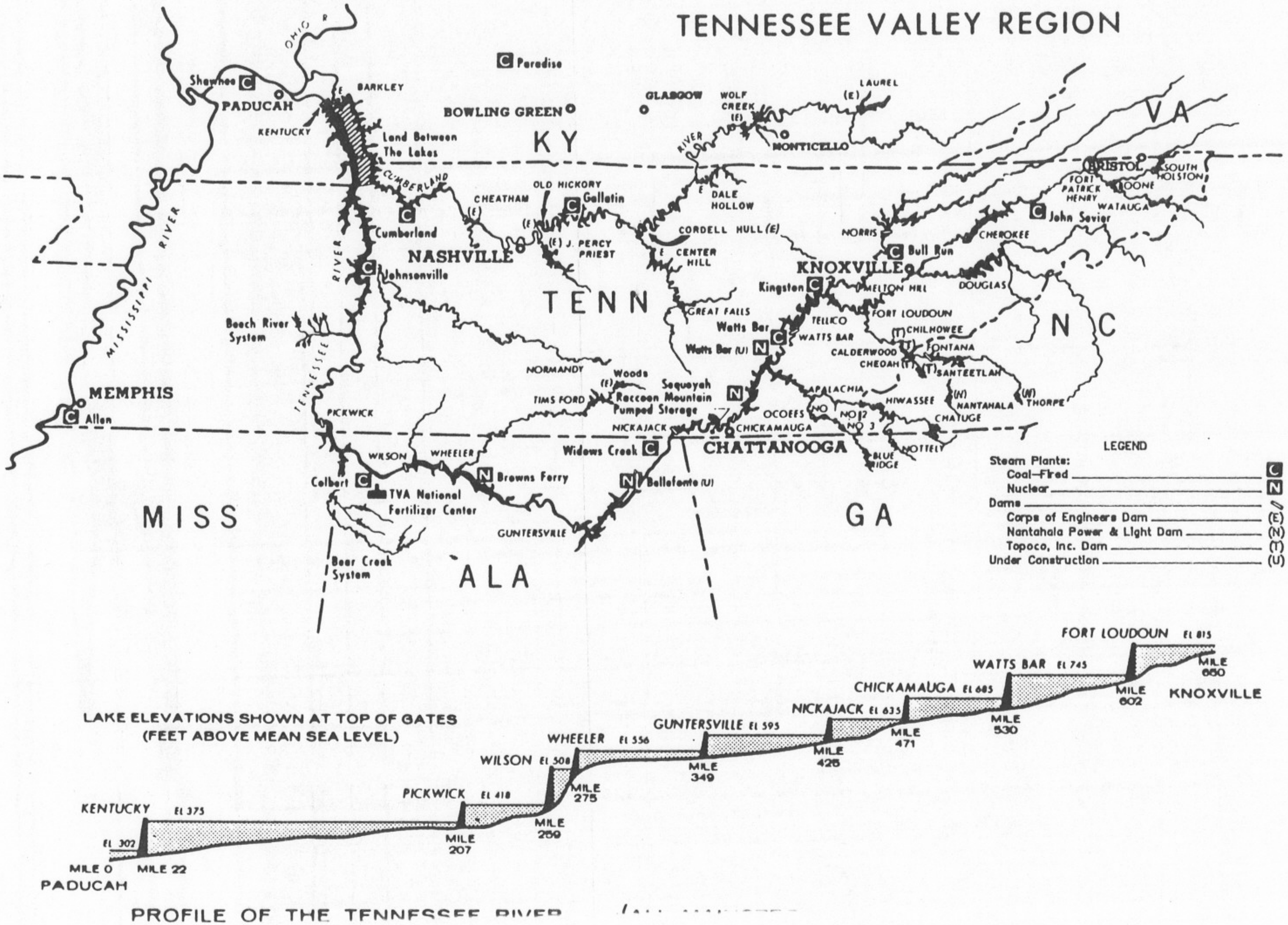
The Tennessee River system drainage area covers 40,910 square miles. It is divided into two distinct regions--approximately 21,400 square miles upstream of Chattanooga, Tennessee, east of the Cumberland Mountains; and about 19,500 square miles west of Chattanooga. The drainage area lies mostly in the state of Tennessee with parts in six other states--Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi.

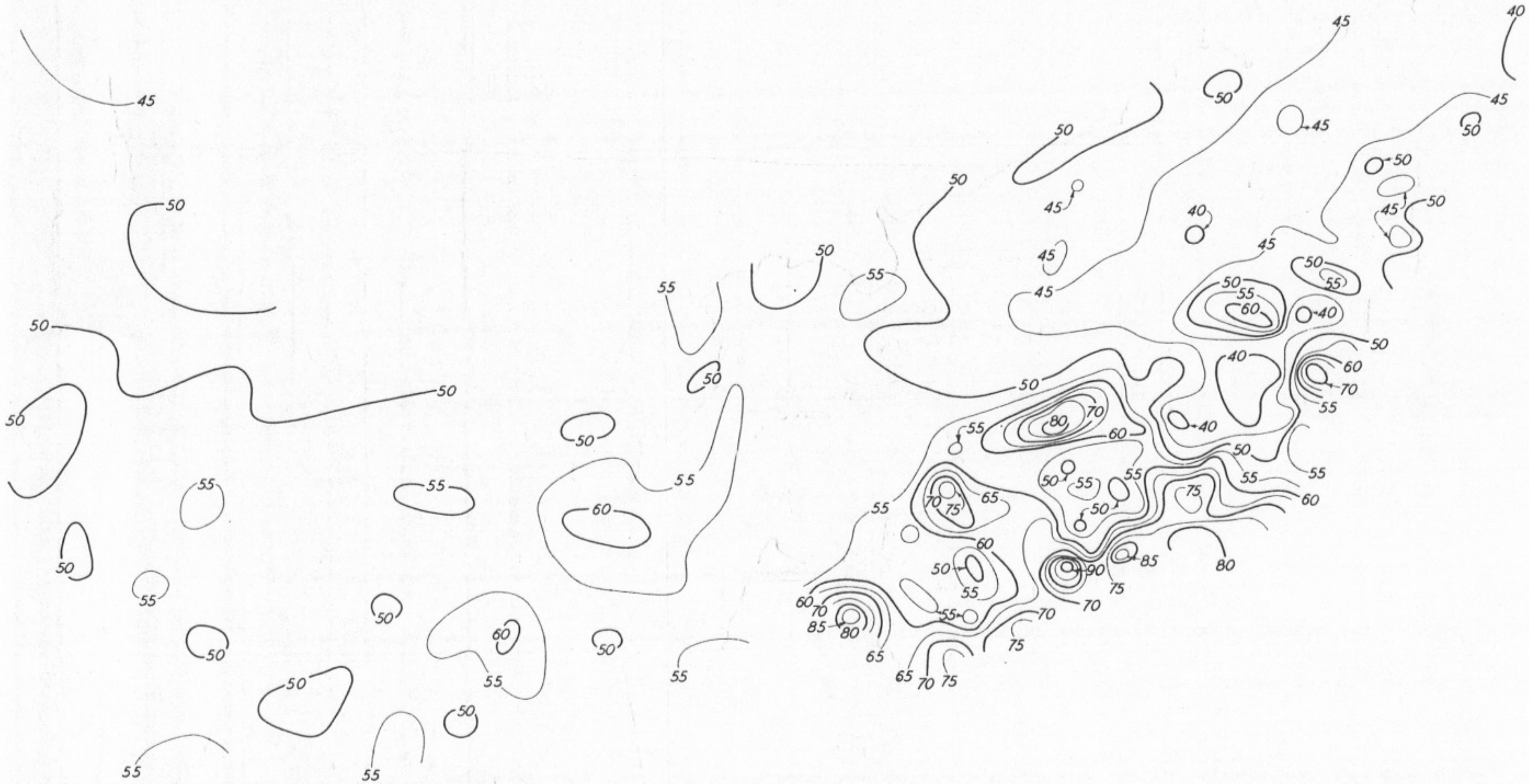
The eastern half of the Valley includes the slopes of the Blue Ridge and Great Smoky Mountains, where an abundant growth of timber covers the ground. The western half of the Valley is less rugged, with substantial areas of flat or rolling land occurring in middle Tennessee and along the western edge.

Total river fall from the maximum reservoir surface at Watauga Dam (highest elevation on the system) to the minimum tailwater surface at Kentucky Dam (lowest elevation on the system) is 1,675 feet in 828.6 river miles. The Tennessee, the main river, has a fall of 515 feet in 579.9 river miles from the top of the Fort Loudoun Dam gates to the minimum tailwater elevation at Kentucky Dam. The mainstream fall is gradual except in the Muscle Shoals area of Alabama, where a drop of 100 feet is found in a stretch of less than 20 miles.

Mean annual rainfall over the drainage area amounts to about 52 inches, varying during the past 100 years of record-keeping between a low of 36 inches in 1985 and a high of 65 inches in 1973. As shown in figure 2, the heaviest concentrations occur in certain mountainous areas along the headwaters of the tributaries where mean annual rainfall reaches over 90 inches. In portions of the French Broad, Clinch, and Holston Valleys, the mean annual rainfall is as low as 40 inches.

Figure 1


TENNESSEE VALLEY REGION
OHIO R
Paradise
Shawnee
PADUCAH
BARKLEY
KENTUCKY
BOWLING GREEN
GLASGOW
WOLF CREEK
LAUREL
MONTICELLO
Land Between The Lakes
KY
VA
CUMBERLAND
RIVER
BRISTOL
SOUTH HOLSTON
FORT PATRICK HENRY
BOONE
WATAUGA
John Sevier
CHEROKEE
OLD HICKORY
Gallatin
CHEATHAM
DALE HOLLOW
CORDELL HULL (E)
NORRIS
Bull Run
Cumberland
J. PERCY PRIEST
CENTER HILL
NASHVILLE
KNOXVILLE
Johnsonville
MISSISSIPPI RIVER
TENN
Kingston
MELTON HILL
DOUGLAS
GREAT FALLS
TELLICO
FORT LOUDOUN
Beech River System
Watts Bar
WATTS BAR
CHILHOWEE
N C
Watts Bar (U)
CALDERWOOD
FONTANA
CHEOAH
SANTEETLAH
NORMANDY
Woods
Sequoyah
Raccoon Mountain Pumped Storage
APALACHIA
HIWASSEE
NANTAHALA
THORPE
MEMPHIS
TIMS FORD
OCOEES
NO 1
NO 2
NO 3
Allen
PICKWICK
NICKAJACK
CHICKAMAUGA
CHATUGE
TENNESSEE
CHATTANOOGA
NOTTELY
BLUE RIDGE
WILSON
WHEELER
Widows Creek
Colbert
Browns Ferry
Bellefonte (U)
TVA National Fertilizer Center
MISS
GA
GUNTERSVILLE
Bear Creek System
ALA
LEGEND
Steam Plants:
Coal-Fired
Nuclear
Dams
Corps of Engineers Dam (E)
Nantahala Power & Light Dam (N)
Topoco, Inc. Dam (T)
Under Construction (U)
LAKE ELEVATIONS SHOWN AT TOP OF GATES
(FEET ABOVE MEAN SEA LEVEL)
KENTUCKY EL 375
EL 302
MILE 0
PADUCAH
MILE 22
PICKWICK EL 418
MILE 207
WILSON EL 508
MILE 259
MILE 275
WHEELER EL 556
GUNTERSVILLE EL 595
MILE 349
NICKAJACK EL 635
MILE 425
CHICKAMAUGA EL 685
MILE 471
WATTS BAR EL 745
MILE 530
FORT LOUDOUN EL 815
MILE 602
MILE 650
KNOXVILLE
PROFILE OF THE TENNESSEE RIVER



SYMBOLS:

- 50 — Rainfall in Inches
- State Lines
- Dams

TENNESSEE VALLEY AUTHORITY

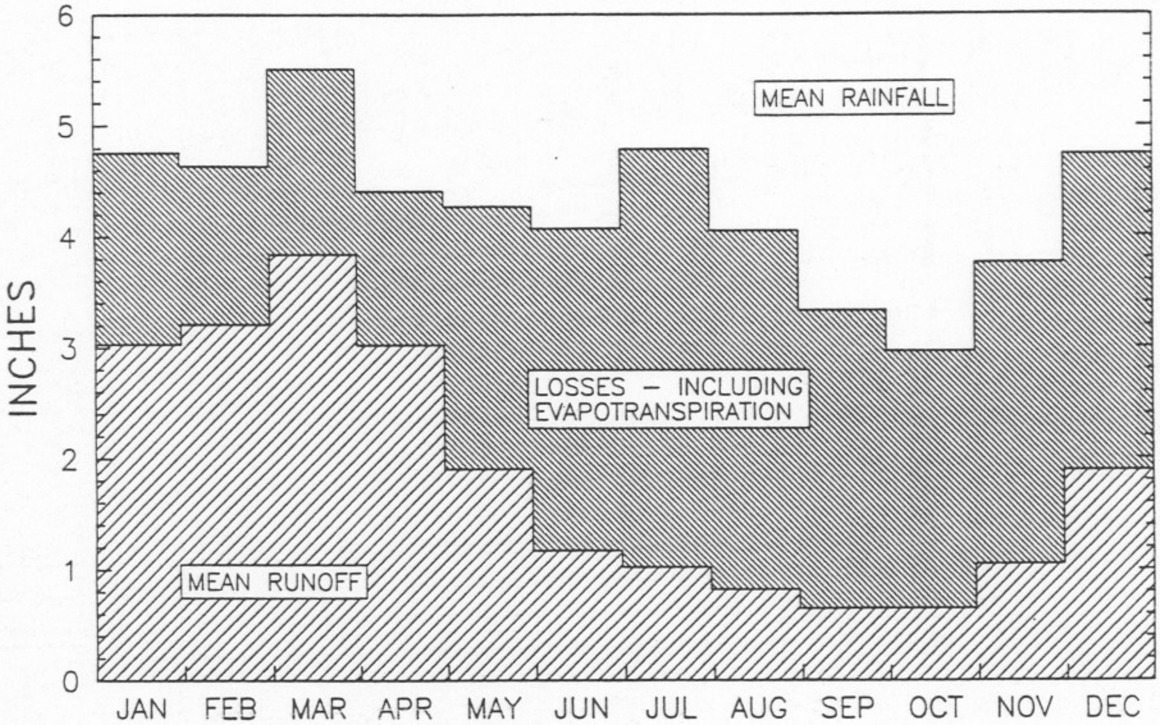
TENNESSEE RIVER BASIN

MEAN ANNUAL PRECIPITATION

35-YEAR PERIOD 1935-1969

SCALE 0 10 20 30 40 50 MILES

Figure 3
Tennessee Valley
Monthly Rainfall and Runoff



Monthly average rainfall ranges between 3 and 5.5 inches, as shown in figure 3. March and July are typically the highest rainfall months and September through November are usually the lowest rainfall months. Of course, in any year the highest and lowest months may be different.

Figure 3 also shows the monthly variation in runoff, the amount of rainfall that flows into streams, rivers, and reservoirs. The average annual runoff is about 22 inches, roughly 40 percent of the average annual rainfall over the drainage area. Considerable natural storage, afforded by the deep soils and extensive underground storage in many of the tributary areas, tends to stabilize runoff to some extent. During most of the year, dense ground cover on the steep slopes also helps to check rapid runoff from heavy rainfall. In the winter, however, runoff increases as plants turn dormant and the ground becomes wetter. As a result, heavy storms moving across the Tennessee Valley between December and April become potential causes of widespread major floods.

December through mid-April is the major flood season in the Tennessee Valley because runoff is higher, and because storms tend to be larger during this period. The worst winter storms can cover the entire Valley for several days, with one storm followed by another, even larger, storm three to five days later. The worst case flood, known as the probable maximum flood or PMF, is used in studies to determine the flood safety of main river dams and nuclear power plants.

In contrast, the worst case summer storm affects only a portion of the Valley, typically producing heavy rains over an area of 3000 square miles or less. The total rainfall involved is less than for the worst case winter storm, but flooding is still a concern because summer lake levels are almost always higher than winter levels. Consequently, less storage space is available to catch and hold the runoff from the storm. However, flooding during such a storm would normally be greatest in the local basin affected, and would be less severe further downstream. Although relatively rare, a summer storm like the one that occurred in June 1989 can cover the entire Valley, causing concerns Valley-wide when pools are at or near their maximum levels.

The city of Chattanooga sits at the juncture between the eastern and western parts of the Tennessee Valley at a point just before the Tennessee River passes through the Cumberland Mountains. This location explains why Chattanooga was subject to devastating floods before the construction of the TVA reservoir system. The Tennessee River, swollen by major Valley-wide storms, would attempt to carry more flow through the Cumberland Mountain passes below the city than the river channel would allow. The excess water that could not flow immediately through the mountains would naturally back up to the city, flooding it. Reducing this flood damage by storing the water from such storms in reservoirs upstream of Chattanooga was a principal purpose of TVA's dam building and continues to be a major factor in reservoir operations in the eastern half of the Valley.

The upper graph in figure 4 shows that floods with the potential to inflict damage at Chattanooga have occurred regularly since 1874 when the first reliable flood information was recorded. The lower graph in figure 4 shows the same information by month of the year, indicating that such floods are most likely to occur from mid-December through March.

Tennessee River Water Control System

Thirty-four major dams make up the Tennessee River water control system (figure 5). TVA built 25 of these dams and acquired five others. Four belong to Tapoco, Inc., a subsidiary of the Aluminum Company of America, but are operated by agreement as part of the regional system. In addition, TVA has acquired two smaller dams and built a pumped storage project; a system of four smaller dams and a floodway for local flood relief, water supply, water quality, and recreation in the Bear Creek watershed of northwest Alabama; a similar system of eight dams on west Tennessee's Beech River; and a small two-dam flood protection project in the eastern end of the Valley above Bristol, Tennessee. TVA has deferred construction of one project. This adds up to a total of 52 dams under TVA control.

The major TVA reservoirs may be considered in three main groupings that govern the way they are operated--as multiple-purpose reservoirs on the main Tennessee river, as multiple-purpose reservoirs on tributaries, or as single-purpose power projects.* (Basic information about these projects is provided in table 3.)

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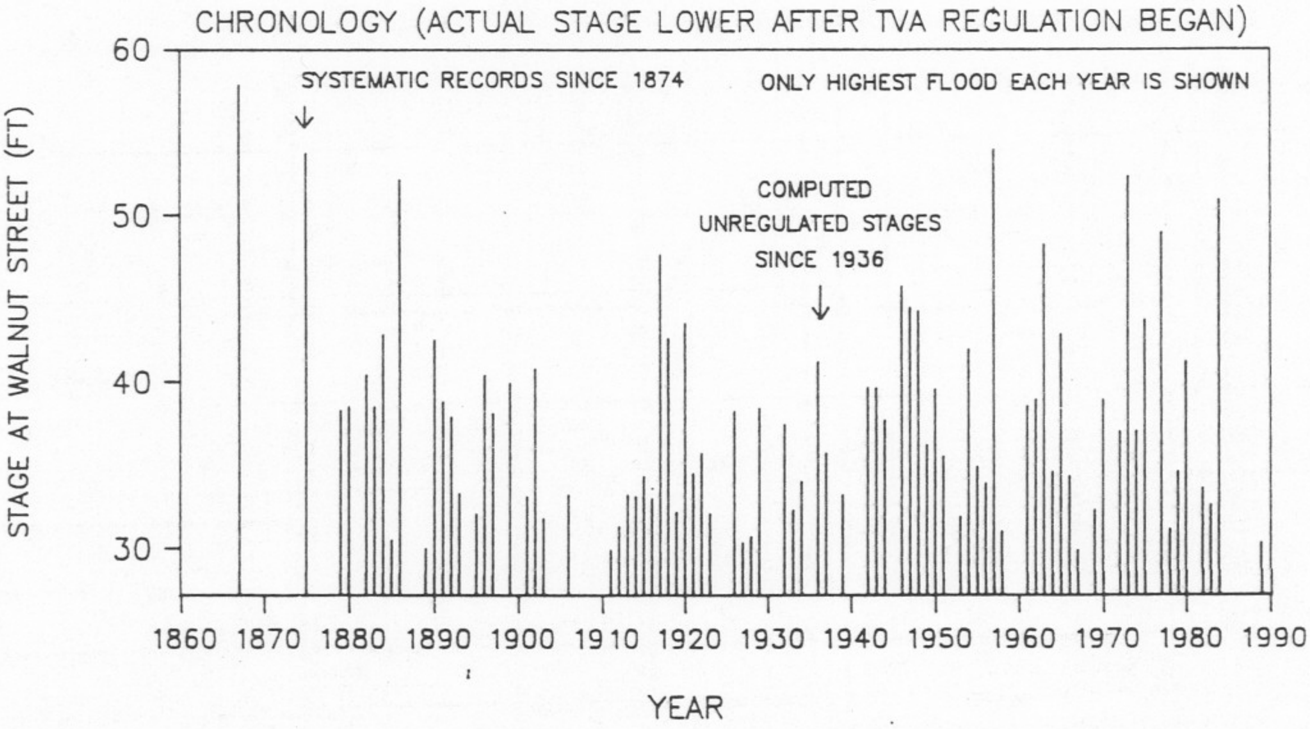
*References in this document to "reservoirs" generally include all of these groupings, references to "mainstream" reservoirs mean the reservoirs on the Tennessee River, and references to "tributary" reservoirs mean the reservoirs on the tributary streams or rivers feeding into the Tennessee River.

Figure 4

HISTORY OF FLOOD FLOWS AT CHATTANOOGA



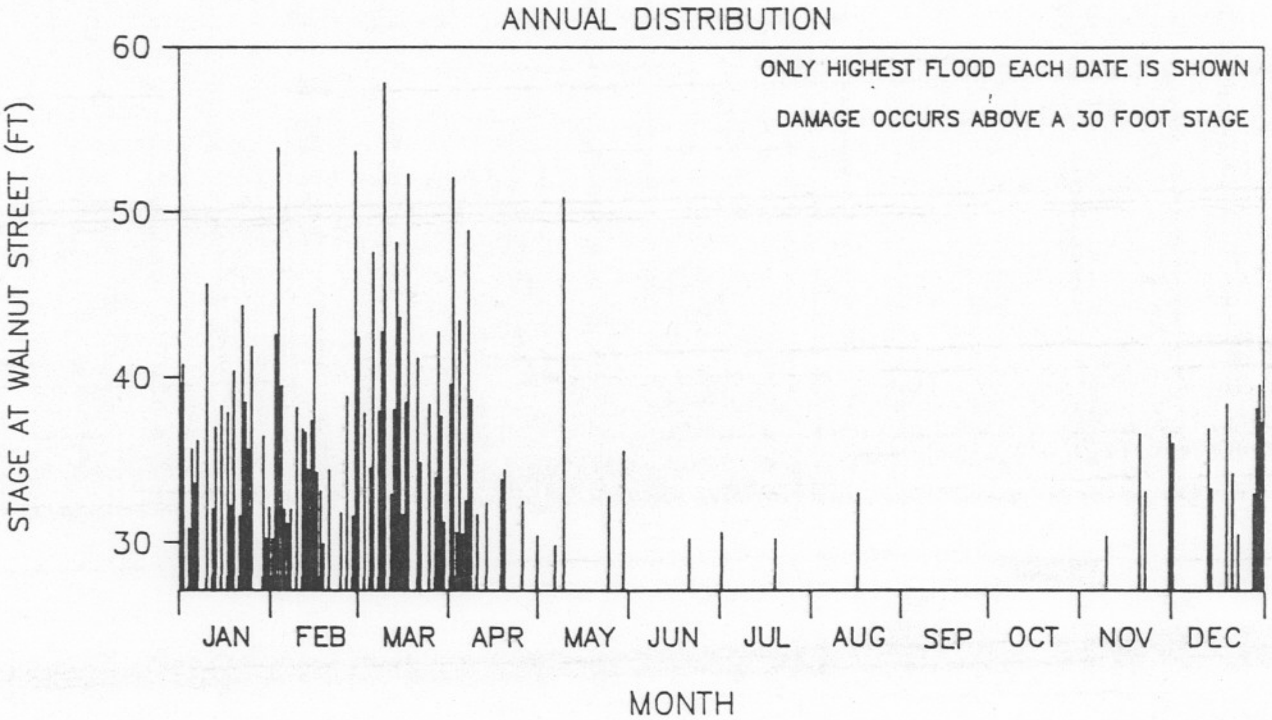


Figure 5

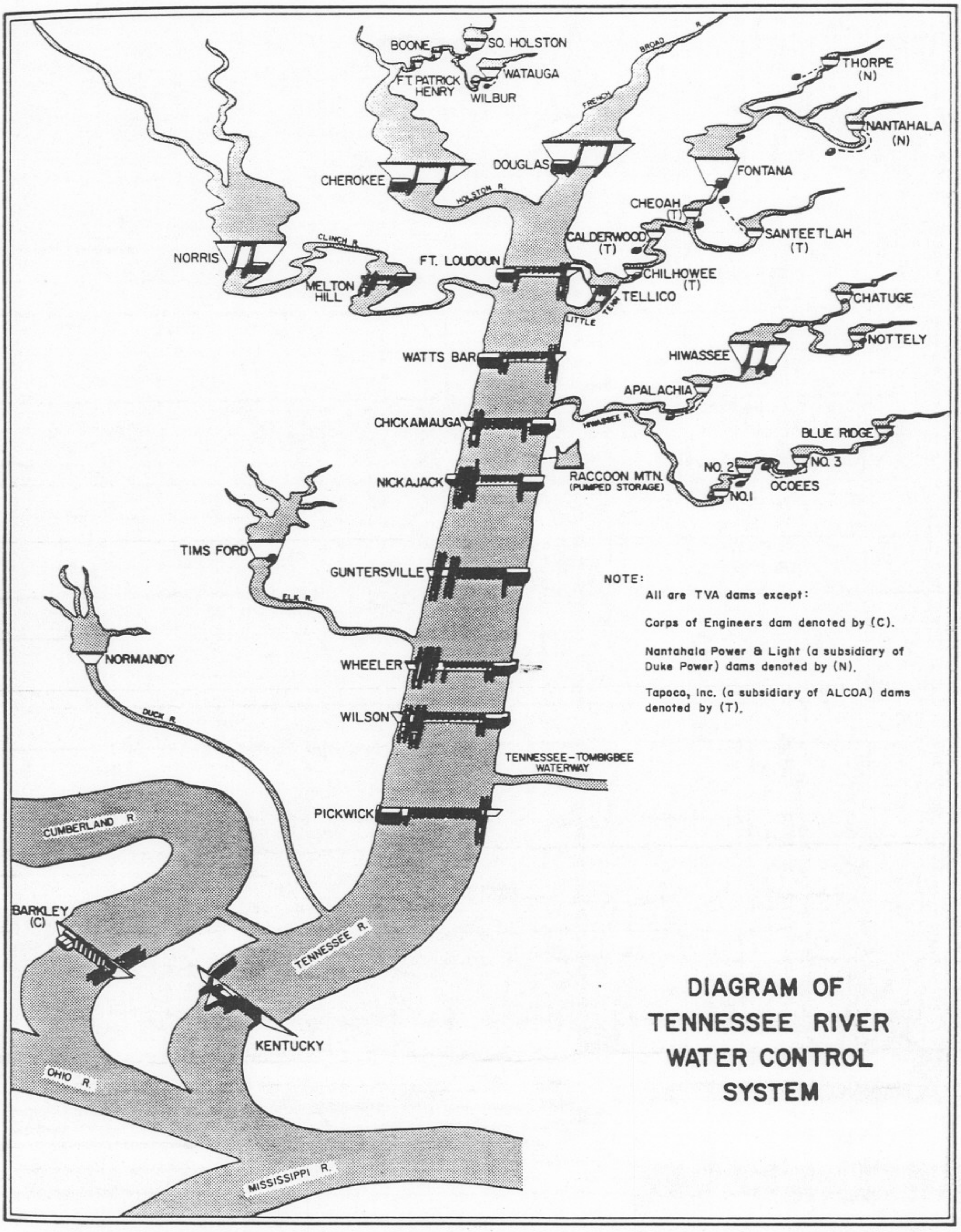

BOONE
SO. HOLSTON
FT. PATRICK HENRY
WATAUGA
WILBUR
THORPE (N)
NANTAHALA (N)
CHEROKEE
DOUGLAS
FONTANA
HOLSTON R.
FRENCH BROAD R.
CHEOAH (T)
SANTEETLAH (T)
NORRIS
CLINCH R.
CALDERWOOD (T)
FT. LOUDOUN
CHILHOWEE (T)
MELTON HILL
TELLICO
LITTLE TENN.
CHATUGE
NOTTELY
WATTS BAR
HIWASSEE
APALACHIA
HIWASSEE R.
CHICKAMAUGA
BLUE RIDGE
NO. 2
NO. 3
NICKAJACK
RACCOON MTN. (PUMPED STORAGE)
OCOEES
NO.1
TIMS FORD
GUNTERSVILLE
NOTE:
All are TVA dams except:
Corps of Engineers dam denoted by (C).
Nantahala Power & Light (a subsidiary of Duke Power) dams denoted by (N).
Tapoco, Inc. (a subsidiary of ALCOA) dams denoted by (T).
ELK R.
NORMANDY
WHEELER
DUCK R.
WILSON
TENNESSEE-TOMBIGBEE WATERWAY
PICKWICK
CUMBERLAND R.
BARKLEY (C)
TENNESSEE R.
KENTUCKY
OHIO R.
MISSISSIPPI R.
DIAGRAM OF TENNESSEE RIVER WATER CONTROL SYSTEM

Table 3
Major Dams Under TVA Control[1]

Dams	Year Dam was Closed	Power Capacity (mw)	Navigation Facilities	Lake Length[2] (miles)	Flood Storage[3] (1000 ac-ft)
Mainstream Multipurpose					
Kentucky	1944	175	Lock, Canal	184	4,008
Pickwick Landing	1938	236	Locks	53	418
Wilson	1924[4]	630	Locks	15	54
Wheeler	1936	378	Locks	74	349
Guntersville	1939	115	Locks	76	162
Nickajack	1967	104	Lock	46	–
Chickamauga	1940	120	Lock	59	345
Watts Bar	1942	166	Lock	72	379
Fort Loudoun	1943	139	Lock	56	111
Tributary Multipurpose					
Normandy	1973	–	–	17	61
Tims Ford	1970	45	–	34	220
Melton Hill	1963	72	Lock	44	–
Norris	1936	101	–	73	1,473
Cherokee	1941	135	–	54	1,012
Boone	1952	76	–	17	92
South Holston	1950	38	–	24	290
Watauga	1948	58	–	16	223
Douglas	1943	121	–	43	1,251
Tellico	1979	–[5]	Canal	33	120
Fontana	1944	238	–	29	580
Hiwassee	1940	117	–	22	270
Nottely	1942	15	–	20	100
Chatuge	1942	10	–	13	93
Single-Purpose Power					
Ft. Patrick Henry	1953	36	–	10	–
Wilbur	1912[4]	11	–	2	–
Ocoee No. 1	1911[4]	18	–	7	–
Ocoee No. 2	1913[4]	21	–	–	–
Ocoee No. 3	1942	28	–	7	–
Blue Ridge	1930[4]	20	–	11	–
Apalachia	1943	83	–	10	–

Notes:

1. Not shown: Raccoon Mountain Pumped Storage Project (not part of river control system); Columbia (construction deferred); Great Falls (in Cumberland Valley); 4 dams in Bear Creek Water Control System; 8 dams in Beech River Project; 2 dams at Bristol Project; Nolichucky dam; and 4 dams owned by the Aluminum Company of America. See table 13 for lake area and drawdown statistics.
2. At normal maximum level.
3. From December 31 flood control levels to top of gates.
4. Existing dam acquired from others.
5. River diversion through canal increases energy generation at Fort Loudoun.

Multiple-Purpose Mainstream Reservoirs. Nine dams control the main Tennessee River and provide a chain of navigable lakes from Knoxville to Paducah. This channel is 650 miles long and has a nine-foot navigational depth. The Fort Loudoun project forms the uppermost step of the stairway, bringing navigation to the Knoxville waterfront. Moving downstream, there is Watts Bar, then Chickamauga, near the midpoint of the Tennessee Valley. Below Chattanooga, the channel is created by the Nickajack, Guntersville, Wheeler, Wilson, Pickwick, and Kentucky dams.

Each of these dams has installations for power generation and navigation locks that raise and lower vessels from one lake to the next. They were designed so that, even at the lowest operating pool level, the water behind one dam backed up to the downstream side of the next dam, meeting the requirement to provide a nine-foot navigational depth. This limits the annual drawdown from summer "full pool" to winter flood season levels to less than seven feet (in contrast to the much steeper drawdowns at tributary storage reservoirs to flood control levels). This drawdown, even though only a few feet, represents important capacity for regulating the passage of floodwaters down the main river during the winter when the risk of major Valley-wide storms is the highest.

At winter pool levels, the eight mainstream reservoirs upstream of Kentucky Dam provide storage space for about two inches of runoff in their respective watersheds. Kentucky Reservoir, extending some 184 miles across the states of Tennessee and Kentucky, provides more storage capacity than any other TVA reservoir--a total of four million acre-feet. This helps protect the Mississippi River levee system, guarding six million acres of land in Kentucky, Illinois, Missouri, Mississippi, Arkansas, and Louisiana, and helps reduce the frequency of flooding on four million acres of land not protected by the levee system. Flood control operation of Kentucky Reservoir can reduce the flood crest by a few feet, reducing the probability of overtopping levees along the lower Ohio and Mississippi rivers. This operation also can reduce the frequency of flooding in the Birds Point-New Madrid floodway area, containing 130,000 acres of arable land in Missouri. The purpose of this floodway, which has been used only once, is to prevent overtopping levees and floodwalls along the Mississippi and lower Ohio rivers within the immediate area and upstream.

Two other reservoirs extend commercial navigation from mainstream reservoirs to industrial sites on tributary rivers. These are Melton Hill on the Clinch River (with a lock) and Tellico Reservoir on the Little Tennessee River (with an open canal linking Tellico Lake to Fort Loudoun Lake on the main river). Two interconnections with other river systems also have been constructed. A canal from Kentucky Lake near Kentucky Dam connects the Tennessee River navigation channel with Lake Barkley on the Cumberland River in western Kentucky. A system of dams and locks connects the Yellow Creek embayment of Pickwick Reservoir with the Tombigbee River in western Alabama. The latter interconnection uses a small amount of water from the Tennessee River to increase flow on the Tennessee-Tombigbee Waterway, while flow between Kentucky and Barkley Lakes can be in either direction depending on river flows and water releases at the two dams.

In addition to navigation, flood control, and hydroelectric power production, mainstream reservoirs have a variety of other functions--recreation, fishery and wildlife management, water supply, wastewater disposal, and commercial development of various kinds.

Multiple-Purpose Tributary Reservoirs. On the major tributary rivers, storage reservoirs provide seasonal streamflow regulation for flood control (primarily to protect Chattanooga from winter floods), power plant cooling, and power generation. In the eastern half of the Valley these include Norris and Melton Hill on the Clinch River; Cherokee, Boone, South Holston, and Watauga in the Holston River basin; Douglas on the French Broad River; Fontana and Tellico on the Little Tennessee River; and Hiwassee, Nottely, and Chatuge in the Hiwassee River basin. In the western half of the Valley are Tims Ford on the Elk River and Normandy on the Duck River. Normandy has no hydroelectric capacity.

The tributary reservoirs range in size from 3,800 to 1,920,000 acre-feet of useful storage and from 620 to 34,200 acres of surface area when at full levels. Collectively, they furnish more than 7,500,000 acre-feet of storage capacity for flood control and power generation, and their total surface area amounts to some 200,000 acres.

It is important to note that the flood control storage built on both the main river and tributary dams upstream of Chattanooga is not sufficient to eliminate flooding in that city. The original design of the flood control system for the eastern half of the Valley called for the city of Chattanooga to construct a system of levees to provide the additional protection to prevent extreme floods from damaging the city. Only one of these levees, along South Chickamauga Creek, has been built; it affords protection principally from local flooding rather than from Tennessee River flooding. Storage capacity in TVA reservoirs completely protects Chattanooga during most floods, but only reduces the damages experienced by the city in larger floods.

Water stored in tributary reservoirs is also released to help maintain navigation on the Tennessee River, particularly in dry years, and is used to provide such benefits as recreation, fishery and wildlife development, water supply, aesthetics, and economic development. On Tims Ford, minimum lake levels for recreation during the summer months are specifically required as part of the project's authorization.

Single Purpose Power Reservoirs. Seven reservoirs, most of them relatively small, were either built or acquired by TVA for the single purpose of power production. Five of these seven are on the Hiwassee River or its main tributary, the Ocoee River (known as the Toccoa River in Georgia). These include Apalachia, Ocoee No. 1, Ocoee No. 2, Ocoee No. 3, and Blue Ridge. The other two are Fort Patrick Henry and Wilbur, both in the Holston River basin.

Although all costs associated with these projects are charged to the power program, and power production has first priority in their operating patterns, these reservoirs also provide other public benefits--habitat for wildlife, fish and other aquatic animals and minor amounts of storage for flood protection, for example. These reservoirs also serve other incidental functions such as water supply, tourism development, and recreation. Power production, however, is the dominant consideration in their operating strategy.

Ocoee No. 2 presents an unusual exception in TVA's single-purpose projects. On selected days, primarily weekends and holidays, power production is stopped to provide for whitewater recreation. The TVA power system was reimbursed for the value of the lost power during these periods by funds appropriated by Congress (now being repaid to the U.S. Treasury from user fees).

Chapter 2

Current Reservoir Operating Policies

In operating the reservoir system, TVA managers face three decisions:

- o How much water should be released from each reservoir?
- o When should that water be released?
- o How should the water be released--through the dam's hydroelectric facilities, or through spillways or sluiceways? (See figure 6.)

In making these decisions, they are guided, first, by the operating priorities laid out in the TVA Act and, second, by specific lake level and reservoir release policies. Of course, each of these decisions are constrained by the design characteristics of TVA's dams.

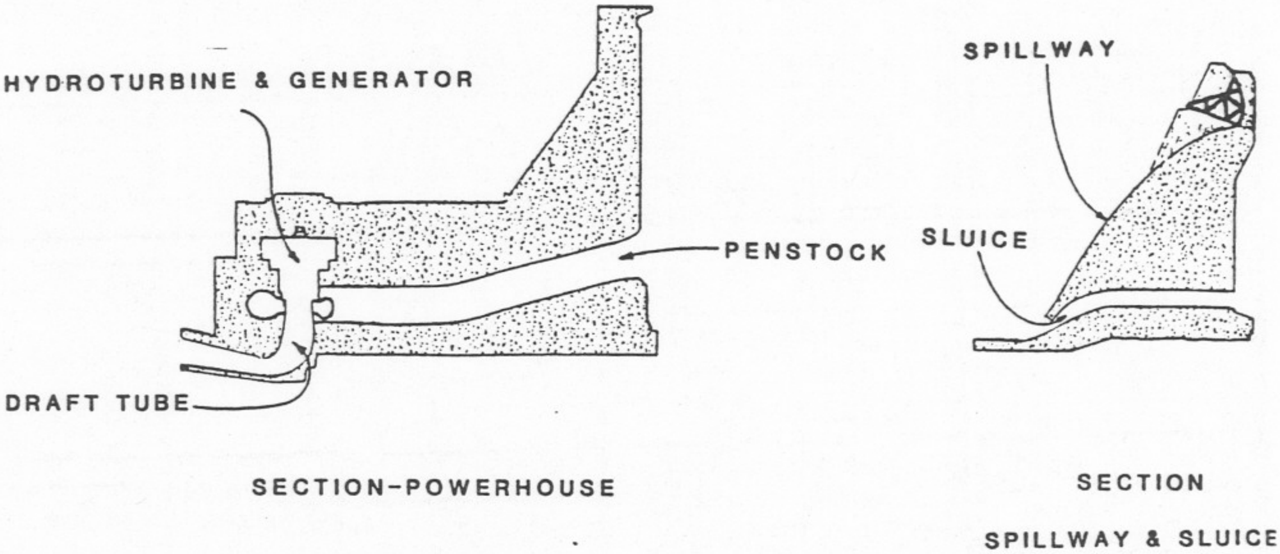
Section 9a of the TVA Act

Section 9a of the TVA Act creating TVA provides the historical and legal context for the policies that guide the operation of TVA's dams and reservoirs today. Added by Congress as an amendment in 1935, Section 9a requires that the reservoir system be operated primarily to promote navigation and flood control and, to the extent consistent with these purposes, for power production:

> "The Board is hereby directed in the operation of any dam or reservoir in its possession and control to regulate the stream flow *primarily for the purposes of promoting navigation and controlling floods. So far as may be consistent with such purposes, the board is authorized to provide and operate facilities for the generation of electric energy at any such dam* for the use of the Corporation and for the use of the United States or any agency thereof, and the board is further authorized, whenever an opportunity is afforded, to provide and operate facilities for the generation of electric energy in order to avoid the waste of water power, to transmit and market such power as in this act provided, and thereby, so far as may be practicable, to assist in liquidating the cost or aid in the maintenance of the projects of the Authority." (Emphasis added.)

From its inception to the present time, TVA has construed Section 9a to permit regulation of water levels and streamflows for other objectives--recreation and water quality, for example--only if consistent with the three primary objectives of navigation, flood control, and power. As a result, TVA has consistently taken the position that its power program must be compensated if water is released downstream without producing power for any purpose other than flood control or navigation.

Figure 6
Dam Release Options



Current Lake Level and Reservoir Release Policies

Within the framework provided by Section 9a, TVA reservoir managers are guided by two broad types of reservoir operating policies:

- Lake level policies prescribe a maximum, minimum, or range of lake levels that must be maintained at a given time of year. Releases from the dam must be made so that these prescribed lake level criteria are met.

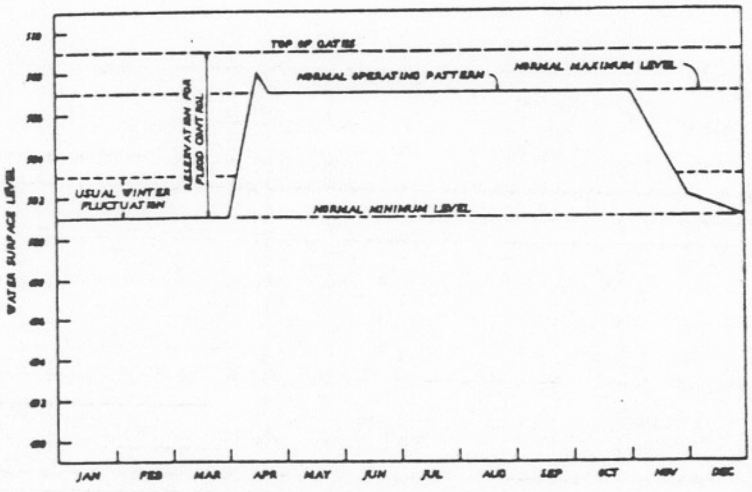
- Reservoir release policies prescribe a maximum or a minimum flow that must be maintained from the dam over an hourly, daily, or weekly period.

After prescribed lake level and flow criteria are met, reservoirs are operated to meet power system needs as economically as possible and, when possible, to enhance other uses--level manipulation for fisheries management and mosquito control, for example.

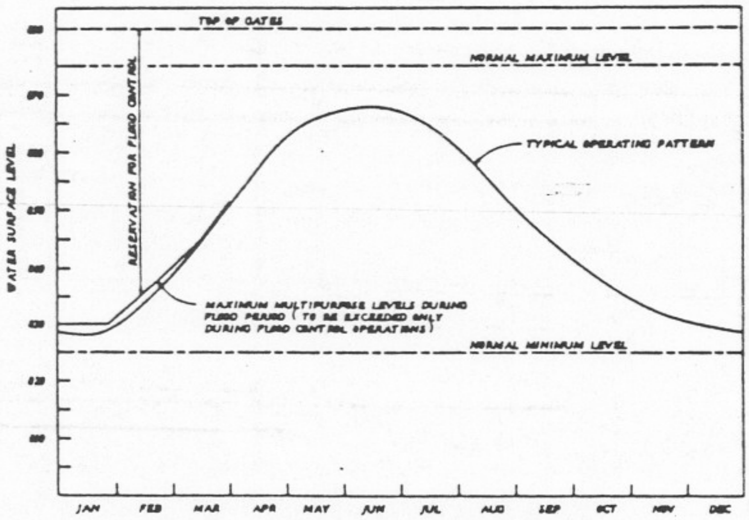
It should be emphasized that these policies are guidelines--not hard and fast operating rules. Some exceptions occur in actual practice to accommodate unusual circumstances--an extended drought, for example. These exceptions may be based on the judgment of reservoir operators or at the discretion of the TVA Board of Directors.

Specific lake level and reservoir release policies are described below in terms of different reservoir operating purposes. Reference should be made to figure 7, showing typical mainstream and tributary reservoir operating levels.

Figure 7
Typical Reservoir Operating Levels



TYPICAL MAINSTREAM RESERVOIR OPERATING LEVELS



TYPICAL TRIBUTARY RESERVOIR OPERATING LEVELS

Water levels on mainstream reservoirs can fall only a few feet for winter flood control, because adequate water depths must be maintained in the navigation channel to the next dam upstream.

On tributary reservoirs, low lake levels provide storage capacity for the winter flood season, then normally rise to high levels by the end of spring. The stored water is gradually released to augment the smaller river flows of summer and fall for power production, water supply, and other needs.

Normal maximum level is almost always achieved on mainstream reservoirs for navigation, but is achieved in only 10-20 percent of the years on multipurpose tributary reservoirs if rainfall is high. Levels are reduced below normal minimum level infrequently during periods of unusual drought and high power demand, or for maintenance purposes.

Reservoir Operation for Navigation. On mainstream reservoirs, lake level policy prescribes a normal minimum level that provides a channel at least 11-feet deep, thus guaranteeing a navigable depth of nine feet. At two of these dams (Pickwick and Kentucky), reservoir release policy sets a minimum flow when necessary to provide adequate depth in the tailwater near the dam.

Tributary reservoirs also provide conservation storage for navigation. Under normal weather conditions, the operation of the tributary reservoirs for flood control and power generation also provides enough reliable streamflow to maintain navigation depths on the Tennessee River barge waterway. However, in a dry year, special releases may be needed from some tributary reservoirs to meet navigation requirements.

Reservoir Operation for Flood Control. As discussed previously, in designing and developing the plan of operation of the TVA reservoir system, the seasonal occurrence of floods was an important factor. Although large storms at any time of year can flood small streams, the major regional floods on the Tennessee River normally occur between December and April.

To fit this streamflow cycle, TVA reservoirs are lowered to flood control levels by January 1 each year to provide storage for the heavy flows of winter and early spring. On mainstream reservoirs, navigation requirements limit drawdown for winter flood control to only a few feet. Therefore, tributary lakes must absorb the majority of the winter rainfall to reduce the flood risk. Consequently, on tributary reservoirs the drawdown between summer "full pool" and winter flood season levels can range from 11 feet on Normandy Reservoir to 128 feet on Fontana.

TVA's lake level policy prescribes winter flood guide levels that are to be exceeded only during flood control operations. Even if there are large storms and excessive runoff during the winter months, these flood guide levels are not exceeded more than temporarily to reserve flood storage space for future storms.

When heavy runoff occurs during the flood season, discharge from tributary dams can be reduced or shut off, and the reservoirs may be temporarily filled above the operating guide curves, thus storing floodwaters and reducing downstream flood crests. When flood danger has passed, reservoir release policy prescribes the magnitude and method of releasing water until the reservoirs are returned to the prescribed seasonal levels. Sometimes this drawdown can be accomplished by operating the hydroelectric plants at turbine capacity until the necessary quantity of water has been discharged from the reservoirs. However, it is often necessary to release additional water through sluiceways or spillways to lower the reservoir levels more quickly and regain the detention space needed for future rains.

Tributary reservoirs are allowed to begin filling to summer levels after March 15 when the chances of flood-producing storms, prolonged wet periods, and multi-storm sequences decline. Mainstream reservoirs are kept at lower levels until near the end of the flood season--late April or early May--because flood storage space in these reservoirs is so limited. For this same reason, however, mainstream lakes fill more quickly than tributary reservoirs. A small amount of flood detention capacity is reserved in all reservoirs through the summer months as a protection against flood-producing storms over limited areas.

As discussed earlier, a primary purpose of Kentucky Reservoir is to reduce flooding on the lower Ohio and Mississippi rivers. When these rivers reach critical flood stages at specified locations, TVA operates Kentucky Dam in cooperation with the U.S. Army Corps of Engineers under a joint memorandum of understanding.

Reservoir Operation for Hydroelectric Power. On all TVA reservoirs, there is an upper limit to lake levels (determined by flood storage requirements) and a lower limit (set to meet navigation requirements on mainstream reservoirs and to ensure a reasonable chance of spring filling on tributary reservoirs).

When reservoir levels are below flood guide levels and above normal minimum levels, TVA dams are operated to maximize the production value of hydroelectric power. The objective is to produce as much electric energy as possible from the water nature provides, at the times when it is most useful.

TVA operates the reservoir system for maximum hydroelectric benefit for several reasons. Hydroelectric power is by far the most economical form of electricity available in the TVA system because incremental costs for hydropower (the costs that vary with production levels) are very low. By comparison, incremental costs for nuclear units are about 16 times higher, coal-fired units about 30 times higher, and gas and oil-fired combustion turbines about 75 to 100 times higher.

Hydropower also offers versatility and dependability that cannot be equaled by any other type of capacity. It can be started and brought to full load much more quickly and reliably than other sources of generation. It is ideal for peaking power--supplying additional power quickly for those times when daily power demands are the highest--and can be made available almost instantaneously to cope with system emergencies or to provide system voltage regulation. Hydroelectric generation equipment is more reliable and equipment problems are more predictable than with other types of generation, primarily because hydro equipment does not operate at high speeds or high temperatures.

In terms of conservation, hydroelectricity is a renewable energy source, which originates with energy from the sun. Hydroelectric generation is the most efficient method of power generation thus far demonstrated. Hydroplant efficiencies in excess of 90 percent are not uncommon (i.e., 90 percent of the water's energy potential is turned into electricity). In comparison, TVA's thermal plants are 30 to 40 percent efficient and combustion turbines are 25 to 30 percent efficient.

Because the supply of hydropower depends upon rainfall, use of this valuable resource must be carefully allocated. Under normal streamflow conditions, the water releases from upstream dams are scheduled so as to avoid producing more streamflow in the Tennessee River than the main river hydro plants can convert to hydroelectric power--particularly at Chickamauga, Nickajack, and Guntersville dams. Spillways or sluiceways must be used to pass excess water during high flow periods, but their use is minimized in favor of releasing water through hydroturbines to produce power.

Hydropower production is also scheduled when seasonal, weekly, or daily power demands are the greatest to avoid using other, more costly generating sources. Because the peak seasons of power demand are summer (June, July, and August) and winter (December, January, and February), hydropower is used most economically if it is used primarily during those months. Reservoir operators store late winter and spring rains in the reservoirs to meet summer power demands.

Tributary drawdown during the summer usually begins in June at a significant rate, determined by power demands and summer rainfall and runoff. Drawdown rates vary widely among reservoirs, depending on their annual operating cycle. Typically, daily drawdown varies from 0.15 feet at Chatuge to 0.50 feet at Fontana. In extreme years, drawdown rates have been as high as 1.5 feet per day.

As runoff decreases, the stored water is needed to supplement releases for power production and navigation. Throughout the fall months, reservoirs continue to recede gradually toward the flood control levels of January 1, with releases made through the hydroturbines to capitalize on the water's energy potential.

In the winter, tributary reservoir levels may approach the normal minimum, well below the flood guide levels, especially if rainfall is low and power supply is tight because of high demand for heating. Continued low rainfall and heavy demands for hydroelectric power production during the normal filling period (April 1 to June 1) would prevent filling of tributary reservoirs, which then could remain substantially below normal maximum levels through the summer. The reservoir levels ultimately reached at the end of the spring season depend on the levels at the beginning of the season and, to a greater extent, on the rainfall and runoff during the season.

Daily and weekly hydroturbine operations also are scheduled when power demand is greatest. Most operation occurs during the peak demand hours of each day, and on weekdays rather than on the weekend. Sometimes hydroturbines are operated 24 hours a day to provide water for other purposes or to recover storage space in the reservoir.

Power system operating needs affect reservoir operations in other ways. For example, flows may be provided from one or more dams to assure a certain minimum flow past a TVA coal-fired or nuclear generating plant. An example is the minimum flow requirement imposed by the state of Tennessee past the John Sevier Fossil Plant on the Holston River just upstream of Cherokee Reservoir. Minimum flow requirements to provide cooling water for the plant and to meet environmental requirements vary from a minimum of 1400 cubic feet per second (cfs) in the winter to a maximum of 1867 cfs in the spring, summer, and fall. This requires greater releases from Fort Patrick Henry Dam and the upstream reservoirs (Boone, South Holston, Wilbur, and Watauga) about 20 percent of the time, causing lower lake levels than would otherwise occur.

Flow requirements past other TVA plants (Bull Run Fossil Plant on Melton Hill Reservoir; Kingston Fossil Plant on Watts Bar Reservoir; Sequoyah Nuclear Plant on Chickamauga Reservoir; Widows Creek Fossil Plant on Guntersville Reservoir; Browns Ferry Nuclear Plant on Wheeler Reservoir; and Colbert Fossil Plant on Pickwick Reservoir) do not have a noticeable effect on reservoir operations except in extreme circumstances. The most recent exception was the withdrawal of about two to three feet of cold water from Norris Reservoir during 1988 to assure that Sequoyah Nuclear Plant had an adequate supply of cooling water for safe shutdown of its nuclear reactors in an emergency. Higher than normal water temperature and lower than normal river flows past Sequoyah because of the drought were the cause of this extraordinary action; in most years, such an action is not necessary.

Reservoir Operation for Secondary Purposes. When it is consistent with the three primary objectives of flood control, navigation, and power production, water levels and streamflows can be regulated to achieve secondary objectives.

Water quality: Water quality benefits, for example, are often provided as a by-product of operations to meet the primary purposes. Certain minimum flows exist along the Tennessee River and its tributaries as a consequence of operating the reservoir system for the statutory purposes of navigation, flood control, and hydropower production. These flows are important to aquatic life in tributary tailwater areas and to waste water dischargers downstream.

However, with a few exceptions, TVA has no policies which assure these flows and is not externally required to maintain them. The exceptions are minimum flow requirements associated with some TVA power plant discharge permits, Congressional project authorizations for Normandy and Bear Creek dams, and water supply uses established before certain dams were constructed.* Otherwise, reservoir releases may be shut off for power or flood control operations, for example. Because the tailwater area is left dry except for small pools of water for certain periods, the effects on the health, number, and diversity of aquatic life can be severe.

Similarly, some of these minimum flows can significantly affect water quality at certain locations, such as Kingsport, Elizabethton, Knoxville, Charleston, and Chattanooga, Tennessee, and Calvert City, Kentucky. TVA has provided historical flow data for these and other locations to help the appropriate state pollution control agencies evaluate discharge permit applications and set appropriate permit limits for municipal and industrial effluents. If these flows cannot be provided for any reason, TVA has agreed to inform the appropriate state pollution control agency as soon as possible so appropriate measures can be taken.

If a waste water discharger desires additional flow for assimilation of its effluent beyond what is provided as a consequence of normal reservoir operations, it must obtain approval from the state pollution control agency and reimburse TVA for the costs TVA incurs in providing these flows. The costs result from operating at times when hydropower would not normally be generated. Currently, the only discharger that pays for additional flow is the Tennessee Eastman Company in Kingsport, Tennessee. Tennessee Eastman uses the water primarily for industrial water supply, with a secondary benefit being increased assimilative capacity.

When needed, TVA may also provide a minimum flow past one of its coal-fired or nuclear generating plants to meet the water temperature requirements of the plant's discharge permit. The added cost of such flows is borne by TVA power consumers.

Tributary minimum flows that are as high as the seven-day, ten-year recurrence interval flow can be met easily as a result of normal reservoir operations. Such minimum flows normally do not affect lake levels in tributary reservoirs beyond the effects experienced due to the amount of rainfall received, and due to operations for navigation, flood control, and hydropower production. In a drought situation, such as occurred from 1985 to 1988, providing minimum flows to prevent severe impacts to water supply and water quality can affect tributary lake levels. However, this effect is small compared to the effects of the drought itself, which significantly reduced hydropower generation as well as levels in tributary lakes.

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*South Holston, Boone, and Fort Patrick Henry dams, for example.

Reservoir operation also affects the dissolved oxygen (DO) content of the water, a key indicator of water quality. These effects are discussed in detail in the next chapter. Low DO levels in the bottom portion of TVA tributary reservoirs in the summer and fall are the result of temperature stratification and oxygen demands in the water column and sediments--a common consequence of impoundment. Because most hydroturbines withdraw water from this lower layer, hydropower production contributes to downstream DO problems, particularly below tributary dams. From June through November, hydroturbine releases from deeper reservoirs can be low or completely devoid of DO. This stresses the aquatic life in the tailwater area, and limits the ability of the water to assimilate wastes that flow into tailwater areas.

State and federal law do not require a minimum amount of DO in releases from dams. However, under the TVA Reservoir Releases Improvements program begun in 1981, DO improvements have been implemented at the Norris, Tims Ford, Upper Bear Creek, and South Holston projects, and multiyear tests are being conducted at Cherokee and Douglas.

As part of this program, TVA has agreed to work cooperatively with the state of Tennessee to improve the flow, depth, and water quality of reservoir releases. The goal of this cooperative effort is to achieve a minimum DO level of 4 milligrams per liter (mg/l) in releases all the time, and to work toward a DO level of 5 or 6 mg/l depending on the fisheries present. Because over half the funding for this program is appropriated by Congress on an annual basis (power funds are used for the rest), budget constraints and uncertainties require improvement schemes to be phased in slowly.

Recreation: Depending on the availability of water, reservoir operations are also regulated to enhance recreational use of the water consistent with other operating priorities. Reservoir releases for whitewater recreation have already been mentioned. Congress provided an appropriation to reimburse the TVA power system for the value of lost power during those periods when TVA spills water at the Ocoee No. 2 project for river recreation. These funds are being repaid to the U.S. Treasury from whitewater user fees. Many other special reservoir operations are performed in response to requests connected with river festivals, boat races, raft trips, and fishing contests.

Mosquito control: Mosquito control is another secondary purpose accommodated under current operating policies if flows permit. Weekly, one-foot fluctuations during the summer and early fall months disrupt mosquito habitat on mainstream reservoirs, thereby reducing the number of mosquito larvae during the height of the mosquito breeding season. Hydropower production is not affected, because the direction of the change in reservoir levels is alternated in adjacent reservoirs. For example, on weekdays, Guntersville and Wilson are lowered, filling Wheeler and Pickwick, respectively; on the weekend, Wheeler and Pickwick are lowered, and Guntersville and Wilson are filled. This operation is not necessary on tributary lakes because of the fluctuations in their normal course of operation.

Other secondary purposes: Other special operations serve secondary objectives such as controlling the growth of aquatic plants; stabilizing reservoir levels during the fish spawning season; providing a water supply for domestic, industrial, and agricultural use; assisting individual navigators, farmers, and others who experience emergency needs; minimizing the effects of accidental spills; and expediting construction, repair, and maintenance activities in or adjacent to reservoirs or regulated streams.

Other operations--like holding lake levels higher in the winter and summer for recreation--are not performed either because they conflict with lake level and reservoir release policies for navigation and flood control, or because they would result in significant losses in hydropower production or value. If a proposed operation is consistent with navigation and flood control operations but would result in significant hydropower losses, the proposal may be initiated if power losses are reimbursed.

Land Management Policies

To meet the navigation, flood control, and power generation mandates of the TVA Act, TVA has acquired, as an agent of the United States, land and landrights for the operation of its reservoir system. TVA has in its custody over 700,000 acres of reservoir property, about 80 percent of which is under water or can be flooded during reservoir operations. TVA also has obtained flowage easements over an additional 324,000 acres of publicly or privately owned reservoir land subject to flooding during TVA reservoir operations. Land above the easement level may still experience flooding, but no more than would occur naturally. TVA also has responsibility under Section 26a of the TVA Act to review and approve construction of structures that could affect navigation, flood control, or public lands along the Tennessee River and its tributaries.

TVA manages its property interests to promote recreational use, protect water quality, and meet other agency goals. Plans for activities that require Section 26a approval are reviewed by TVA pursuant to the requirements of the National Environmental Policy Act (NEPA) and other federal environmental legislation. For example, if a proposed discharge may affect navigable waters, the Clean Water Act requires the applicant to submit to TVA a certification from the appropriate regulatory authority that the discharge will not violate water quality standards.

As shown in table 4, about 250,000 acres of TVA reservoir land is located above summer pool (including about 2750 miles of shoreline). Over 70 percent of this acreage is located on six reservoirs (Kentucky, Guntersville, Norris, Tellico, Pickwick, and Wheeler), an historical artifact of past TVA land-buying policies. Land management plans are complete for 140,000 acres on four of the nine mainstream reservoirs, underway for those remaining, and planned for tributary reservoirs. These plans allocate tracts for specific uses--such as recreation, wildlife, agriculture, and industrial development--based on extensive public input and a thorough staff analysis of the capability and suitability of the land. More than 100,000 acres of agency-held land are under active forest management and 11,000 acres are licensed for agricultural use. On reservoirs without land management plans, allocation decisions are handled on a case-by-case basis, using TVA's forecasting system.

TVA's policy for controlling the marginal strip of shoreland between the water surface and certain adjoining property (usually owned previously by TVA) permits a wide range of alterations by the adjacent property owner. These landowners usually possess deeded or implied landrights to cross TVA land. Upon receipt of TVA's written permission, landowners may build boat docks and other water use facilities and remove small trees and other vegetation.

Table 4
Ownership Pattern of the Shoreline Around TVA Reservoirs[1]

	Shoreline Miles					
	Total Shoreline Miles	Private[2]	Public Non-Recreation	Commercial, Industrial, Public Recreation	TVA	TVA-owned Fee Acres Above Summer Pool
Navigation and W. Tributary Reservoirs						
Kentucky	2380	913				66,944
Normandy	73	0			73	4,798
Pickwick	496	132				17,372
Wilson	154	143.5				548
Wheeler	1063	115				27,717
Tims Ford	246	33.5				4,051
Guntersville	949	114				35,865
Nickajack	192	160		2	30	3,144
Chickamauga	810	286	201	108	215	15,375
Watts Bar	783	395				13,455
Melton Hill	173	102	3	17	50	2,852
Ft. Loudoun	311	251	1	33	26	1,601
Tellico	373	65				12,879
	8,003	2,710 (34%)				206,651
E. Tributary Reservoirs						
Norris	661	251	79	81	251	26,815
Cherokee	386	214	3	27	142	8,065
Ft. Patrick	28	15	0	8	4	246
Boone	118	101	1	2	14	899
South Holston	152	43	91	9	9	1,584
Wilbur	4	0	2	0	2	133
Watauga	97	48	45	0	4	719
Douglas	500	470	0	8	22	1,969
Nolichucky						
Fontana	248	21	0	223	4	783
Ocoee No. 1	47	0[3]	47[3]	0	0	86
Ocoee No. 2	0	0	0	0	0	86
Ocoee No. 3	24	4	18	0	2	246
Blue Ridge	65	16	47	0	3	313
Apalachia	31	0	30	0	1	988
Hiwassee	163	10	144	6	3	777
Nottely	106	46	57	0	3	815
Chatuge	132	76	26	5	25	1,527
	2,762	1,315 (48%)	590 (21%)	369 (13%)	489 (18%)	46,051

Notes:
1. Data not shown is unavailable.
2. This includes both private property over which TVA has flowage easements and the narrow strip of TVA-owned land, the "marginal strip" at the water's edge, which the adjoining private property owner has the right to cross.
3. The U.S. Forest Service has issued permits for vacation cabin sites on 4 miles of Ocoee No. 1 shoreline.

Chapter 3

Affected Environment

The development of the Tennessee River system had an impact on the Tennessee Valley's environment that would be difficult to overstate. Intensive development and use of the region's water resources to satisfy a wide variety of beneficial purposes drastically modified and continues to modify the entire river community and adjoining lands.

This chapter summarizes current conditions as a base line for assessing possible changes in the way TVA manages its reservoirs. Only those aspects of the environment that may actually be affected by one or more of the alternatives are addressed. Aspects that will not be affected, such as climate, are not discussed.* Key issues and concerns about the Tennessee River system identified during the scoping process for this study also are discussed. This process included the general public, lake users of all types, government agencies and officials, and TVA staff.

Natural Environment

Water Quality. Overall, the Tennessee River is generally considered to be a clean river. Two major water quality problems exist, however. First, point and nonpoint sources of pollution degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. Toxic substances also have been found in sediments and fish in reservoirs which otherwise have good water quality. Second, occurrences of low dissolved oxygen (DO) levels stress aquatic life and limit the ability of the water to assimilate wastes in the tailwater areas below many TVA dams.

Discharges of pollutants from point sources are regulated to achieve a certain level of water quality as defined by the U.S. Environmental Protection Agency and state governments. Environmental regulations recognize that it is not practical to remove all pollutants from these discharges, so discharges are permitted to have lower quality than the water originally withdrawn. Natural processes in rivers and reservoirs decompose these wastes further. The capability of the receiving water to accomplish this task is often referred to as its "assimilative capacity." The decomposition process uses DO in the water, so a useful measure of assimilative capacity is the DO content. Discharge of wastes that do not decompose also is limited by environmental regulations to prevent violation of instream water quality criteria.

Nonpoint sources of pollution, which have not been subjected to government regulations or control in most cases, contribute as much as five times more DO-consuming wastes than point sources. Principal causes of nonpoint source pollution, depending on the location, are agriculture, including runoff from

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*Climate, however, does have a significant effect on the ability of the TVA reservoir system to meet its various purposes. See Chapter 6 for a discussion of the potential effects of long-term changes in Tennessee Valley weather patterns on reservoir system operations.

fertilizer and pesticide applications, erosion, and animal wastes; mining, including sedimentation and acidification from tailings; mountain land development, including erosion and nutrient releases; and urban runoff, including storm sewers, combined storm and sanitary sewer overflows, and septic systems. The sedimentation and introduction of nutrients and organics into rivers as a result of floods also is a large source of nonpoint pollution, although TVA flood control operations now prevent the dramatic changes in channel depth and location that once occurred. Atmospheric deposition is another likely nonpoint source.

Tables 5 and 6 summarize the principal water quality concerns in TVA reservoirs and in Tennessee Valley watersheds, respectively. This summary reflects the best available data and the current understanding of the causes and effects of point and nonpoint sources of pollution on water quality.

Table 5 shows that there is no one pervasive water quality concern in TVA reservoirs, but a collection of concerns affecting various uses. As shown in the table, more major water quality concerns have been found on navigation and western tributary reservoirs than on eastern tributary reservoirs, and these concerns are more often caused by nonpoint sources of pollution than point sources. The specific concerns include PCB contamination of fish in the navigation reservoirs in the eastern half of the Valley; aquatic plants from Chickamauga to Wheeler; pollution from major population centers affecting Boone and Fort Loudoun; pulp and paper mills affecting Douglas and Chickamauga; past DDT production near Huntsville, Alabama, affecting Wheeler; past mining activities affecting Nolichucky and the Ocoee reservoirs; and other nonpoint sources affecting Normandy, South Holston, Cherokee, Douglas, Watts Bar, Chickamauga, Guntersville, and Kentucky.

Table 6 shows that nonpoint sources are the cause of most principal water quality concerns affecting Tennessee Valley watersheds. Agricultural and mining activities cause siltation and bacterial contamination that affects aquatic life and recreational uses of streams in the region. Most of the other principal water quality concerns are caused by present and past point sources of pollution affecting specific reaches of rivers in the Holston, French Broad, and Little Tennessee River watersheds.

Support for improved water quality is widespread in the Tennessee Valley, as evidenced by comments received at public meetings and QUEST sessions. In addition to environmental groups and recreation users, economic development interests stressed the importance of good water quality to economic growth.

Nevertheless, significant reductions in the pollution load on the TVA reservoir system are not expected in the near term. Point source pollution in the Tennessee Valley has been reduced considerably, but little progress has been made in controlling the nonpoint source pollution which represents most of the remaining pollutant load. Significant reductions can be achieved, but are expected to take many years to accomplish.

Preventing pollutants from entering the water depends primarily on the actions of state and federal regulatory agencies. Through technical assistance, demonstration projects, and other program activities, TVA can influence the actions of others to improve water quality. For example, cooperation among

Table 5
Principal Water Quality Concerns in TVA Reservoirs

Navigation & W. Tributary Reservoirs	Uses Affected: Aquatic Life	Fish Consumption	Recreation	Water Supply	Future Development	Source: Point	Nonpoint
Kentucky	DO						X
Normandy	DO			taste, odor, Fe, Mn			X
Pickwick							
Wilson				taste, odor			X
Wheeler		DDT	aq. plants			X	X
Tims Ford							
Guntersville			bacteria, aq. plants				X
Nickajack		PCBs					
Chickamauga	DO		aq. plants color			X	X
Watts Bar	DO	PCBs				X	X
Melton Hill		PCBs					X
Ft. Loudoun	DO	PCBs	bacteria			X	X
Tellico		PCBs					

E. Tributary Reservoirs	Aquatic Life	Fish Consumption	Recreation	Water Supply	Future Development	Point	Nonpoint
Norris							
Cherokee	DO					X	X
Ft Patrick							
Boone	DO	metals, toxics	bacteria			X	X
South Holston			bacteria				X
Wilbur							
Watauga							
Douglas	DO			color		X	X
Nolichucky	siltation		siltation	siltation			X
Fontana							
Ocoee 1-3	metals, siltation		siltation			X	X
Blue Ridge							
Apalachia							
Hiwassee							
Nottely							
Chatuge							

Table 6
Principal Water Quality Concerns in Tennessee Valley Watersheds

Watershed	Uses Affected[1]: Aquatic Life	Fish Consumption	Recreation	Water Supply	Future Development	Source: Point	Non-Point
Tennessee							
Pickwick	toxics		bacteria				X
Watts Bar	siltation		bacteria				X
Duck	siltation		bacteria				X
Sequatchie	siltation		bacteria				X
Clinch/Powell	siltation		bacteria				X
Holston							
North Fork		mercury	bacteria			X	X
South Fork	siltation	metals, toxics	bacteria		limited assimilative capacity	X	X
French Broad	siltation	dioxin	bacteria			X	X
Little Tennessee	siltation	PCBs				X	X
Hiwassee	metals, siltation		bacteria	bacteria		X	X

Notes
1. Uses are affected by the problem noted on at least one stream in the watershed.

TVA, states, and farmers have helped to control soil erosion and its attendant impacts over the years. But TVA has little direct control in this area, except for providing flows to reduce the impact of pollutants that are spilled or discharged into the reservoir system. Some water quality proponents urged TVA to regulate both point and nonpoint sources of pollution into rivers and reservoirs. (See Chapter 4 for a discussion of this proposal.)

Point and nonpoint pollution is one of the major water quality problems affecting the Tennessee River system. The other is low DO levels in stream reaches below TVA dams. The principal cause of this problem is reservoir impoundment (to be explained subsequently), although pollutants use oxygen as they decompose, contributing to low DO levels in turbine releases during periods of reservoir stratification. Low DO levels in the water released when turbines are operating are largely responsible for the DO level in the stream reaches below the dams, although these, too, can be affected by pollution sources.

Table 7 shows the average and maximum number of days DO is below various concentrations in the releases from 22 TVA dams where low DO levels are observed. Because natural reaeration occurs as the water flows downstream, DO is usually lowest immediately below the dam. Long stretches of river can be affected, however, especially in areas where nonpoint source pollution uses up

Table 7
Dissolved Oxygen Concentration in Releases from TVA Dams, 1966 to 1988

DAM	AVERAGE NUMBER OF DAYS BELOW 6 mg/l	5 mg/l	4 mg/l	3 mg/l	2 mg/l	1 mg/l
Kentucky	14	0	0	0	0	0
Pickwick	88	23	0	0	0	0
Wheeler	10	0	0	0	0	0
Guntersville	10	0	0	0	0	0
Tims Ford[1,2]	183	130	35	0	0	0
Nickajack	91	0	0	0	0	0
Chickamauga	67	0	0	0	0	0
Watts Bar	129	74	5	0	0	0
Fort Loudoun	153	112	45	5	0	0
Norris[1]	55	29	4	0	0	0
Cherokee	167	148	124	107	79	55
Ft. Patrick Henry	174	131	70	0	0	0
Boone	157	79	12	0	0	0
Watauga	88	36	0	0	0	0
South Holston[1,2]	47	36	8	1	0	0
Douglas	165	138	107	93	57	0
Fontana	105	81	62	12	0	0
Apalachia	57	0	0	0	0	0
Blue Ridge	86	50	26	12	0	0
Hiwassee	83	31	0	0	0	0
Nottely	143	121	86	67	33	0
Chatuge	143	117	93	57	38	0

	MAXIMUM NUMBER OF DAYS BELOW 6 mg/l	5 mg/l	4 mg/l	3 mg/l	2 mg/l	1 mg/l	MILES AFFECTED 5 mg/l	4 mg/l
Kentucky	105	38	6	2	0	0	N/A	N/A
Pickwick	90	45	15	0	0	0	N/A	N/A
Wheeler	150	135	10	0	0	0	N/A	N/A
Guntersville	128	10	0	0	0	0	N/A	N/A
Tims Ford[1,2]	183	130	35	0	0	0	42.0	35.0
Nickajack	150	50	1	0	0	0	N/A	N/A
Chickamauga	150	120	45	7	0	0	8.0	N/A
Watts Bar	165	120	105	52	0	0	30.0	30.0
Fort Loudoun	202	172	150	113	26	0	42.0	42.0
Norris[1]	55	29	4	0	0	0	13.6	13.6
Cherokee	365	171	150	122	112	95	50.0	50.0
Ft. Patrick Henry	202	180	160	108	20	2	10.0	5.0
Boone	365	172	132	110	14	0	9.6	9.6
Watauga	98	84	69	11	0	0	1.8	1.8
South Holston[1,2]	47	36	8	1	0	0	7.5	5.0
Douglas	365	165	128	98	90	60	80.0	80.0
Fontana	143	104	74	60	50	2	N/A	N/A
Apalachia	102	42	15	0	0	0	1.8	N/A
Blue Ridge	120	110	60	37	14	0	15.1	5.0
Hiwassee	117	62	23	10	0	0	3.0	N/A
Nottely	165	135	108	96	78	28	2.3	1.5
Chatuge	165	146	126	105	90	42	6.5	4.0
							323.0	283.0

Notes:
1. With turbine baffles, compressors, or other aeration device.
2. Average and maximum days are identical due to relatively short-term experience (5 years or less).

the DO restored through natural reaeration. The longest continuous stretch of river with DO concentrations affected by the water released through TVA dams (in addition to nonpoint source pollution) is the 200 river miles from Cherokee and Douglas dams on the Holston and French Broad rivers, respectively, through Fort Loudoun and Watts Bar reservoirs to the upper reaches of Chickamauga Reservoir.

The data in table 7 has important implications for fish and other aquatic life. At least 3 or 4 milligrams per liter (mg/l) of DO is necessary for most fish species to survive. To avoid growth impacts, longer-term exposures (1 to 4 weeks) of about 5 mg/l are recommended for warm water fisheries and about 6 mg/l for cold water fisheries. Higher DO levels are required during spawning and the first 30 days of juvenile life. Improvements in benthic community diversity (in the kinds of animals that live on the bottom of streams and lakes) require concentrations of 5 mg/l or higher. Reference data suggests that mussels typically require 5 mg/l for survival and 6 mg/l for growth. However, recent TVA data suggest that mussels survive at DO levels below 5 mg/l, but do not address the requirement for growth.

To understand the causes of low DO levels in water released through TVA dams, it is necessary to understand the changes in temperature and DO content that occur in deep tributary reservoirs during a typical year. In short, tributary reservoirs begin to stratify during the spring as a result of surface heating and reduced streamflows. The DO content of the upper 10 to 20 feet usually remains at an acceptable level due to surface reaeration and exposure to the atmosphere and to light, the latter resulting in the production of oxygen in the water through photosynthesis by algae. However, oxygen levels in the lower portion decline because there is no photosynthesis in the bottom waters and they are isolated from reaeration. What oxygen exists is used by decaying algae and other organic matter as it settles in the water column.

Hydroturbines at TVA dams were designed to withdraw water from this lower layer. Low level intakes maximize generating potential, and allow the hydroturbines to operate during the winter season when reservoir levels are kept low to provide flood storage capacity, or during other times of the year under drought conditions. The result is low or zero DO in the water released through TVA dams in the process of hydrogeneration from mid-summer to early fall.

One way to address the DO problem would be to release the water through spillways which draw from the upper layer of the reservoir where DO content is higher. However, the cost in terms of lost power generation would be high and there are other potential adverse effects to this type of release (e.g., gas bubble disease in fish; detrimental effects on cold water fisheries below some TVA dams; increased wear of the spillway gates and operating equipment; increased operation and maintenance costs; and, possibly, increased risk to boaters below the dams). Moreover, there are less expensive methods available to release high DO water into the tailwater. TVA is investigating these through its Reservoir Releases Improvements program, discussed earlier.

In some reservoirs, discharge of the deep water layer also contributes to the release of sulfides, iron, and manganese in the tailwater. These elements dissolve in the bottom water, affecting water supplies and aquatic life. The presence of sulfides has been documented in the tailwaters of Upper Bear Creek and Douglas reservoirs, and is suspected at Cherokee, Chatuge, Normandy, and Tims Ford. The presence of iron and manganese has been documented at these and other projects.

The temperature and DO cycles that give rise to these effects are described in detail below.

Water temperature: Temperatures in deep tributary impoundments follow an annual cycle that begins with large amounts of cold, well-mixed water in storage at the beginning of spring. During the spring, surface water in the reservoir is heated while deeper water remains at a relatively constant winter temperature. A highly stable situation results with the lighter surface water remaining on top. Very little mixing occurs between the warm, lighter surface water and the cold, deeper water. As spring and summer progress, inflows warm and enter the reservoir as interflows, forming three layers: the warm, stagnant surface layer, the cold winter layer on the bottom, and the spring and summer interflow layers.

Turbine operation during the summer gradually draws off the cold water at the bottom of the reservoir. At some point in late summer or early fall, withdrawal of the colder water and gradual reduction in air temperature act in concert to again initiate mixing of surface and bottom water. Completely mixed conditions persist through the winter while the temperature of the reservoir is gradually lowered. The annual cycle then begins to repeat during the next spring fill season.

Gradual elimination of the cold water deep in the reservoir during the summer produces a steady rise in release temperature and in reservoir temperatures below the surface. The amount of cold water available to begin the summer season and the rate of turbine withdrawal during the summer are the key variables that determine reservoir temperature profiles and release temperatures during the late summer and early fall months.

With the exception of Cherokee and Douglas which are cool/warm water fisheries, and Chatuge which supports a self-sustaining wild trout population, TVA tributary reservoir releases support healthy "put, grow, and take" cold water salmonid fisheries, primarily rainbow and brown trout. The ability to support these kinds of fisheries is one of the positive effects of TVA reservoir system construction. However, during a typical annual cycle, these "put, grow, and take" fisheries are exposed to water temperatures that range from a minimum of 5 or 6^{o}C (41 or 43^{o}F) in the winter to a maximum of about 20^{o}C (68^{o}F) in early fall. Some tailwaters such as Tims Ford remain very cold throughout the year with temperatures never rising above 13 or 14^{o}C (55 or 57^{o}F). Such low temperatures result in an extensive length of tailwater supporting cold water fish, but also significantly reduce the growth rate in tailwater reaches nearest the dam.

Daily variations of 5 to 9^{o}C (9 to 16^{o}F) are common in tributary tailwaters on days when turbine use is intermittent. This variation can affect warm water fish growth, particularly if fish are exposed to lower temperatures for an extended period. However, lethal responses resulting from thermal shock generally are associated with rapid temperature changes exceeding 13 to 14°C (23 to 25°F). Thermal shock potential exists whenever turbine use begins after a period of tailwater warming, but is not considered to be a major problem. Reservoir temperatures generally remain adequate to support healthy sport fisheries that have adapted to existing conditions.

Dissolved oxygen: Dissolved oxygen in deep tributary impoundments follows an annual cycle similar to that of temperature. Sediments deposited in the upstream portion of the reservoir are a major source of oxygen demand. Beginning with the spring filling season, pool levels rise over the sediments and inflows are warmed and reduced in velocity. As a result, retention times are increased over the sediments, atmospheric reaeration is reduced, and sediment oxygen demand on bottom waters begins to dominate. Dissolved oxygen decreases due to additional oxygen demand from decaying algae that settles from the water surface to the bottom.

This body of water with its depleted oxygen concentrations remains as an isolated thermal layer in the reservoir, moving slowly toward the dam. The rate of movement depends on the magnitude of inflows and turbine releases during the summer, with oxygen-depleted waters reaching the outlets only after all of the cold winter and early spring water is released downstream. When these waters reach the outlets, oxygen levels in turbine releases drop, and remain low until mixing of the reservoir begins. Higher oxygen levels are then maintained in the pool and the tailwater until the following summer.

Mainstream reservoirs are characterized by shorter retention times due to inflows that are higher relative to their storage volumes. Cold water in storage is normally depleted very early in the summer. Warm inflows then occupy the lower portion of the reservoir for the remainder of the summer period. Vertical stratification is relatively weak and intermittent in some reservoirs and strong and more stable in others.

Dissolved oxygen concentrations in mainstream reservoirs depend to some extent on the amount of flow through the reservoir. In high flow periods, DO levels in the reservoir are similar to those in the inflow. During droughts, DO demands from sediments and pollution loads can cause DO in the reservoir and turbine releases to drop below 4 mg/l. Total depletion has never occurred in turbine releases because significant amounts of near-surface waters, high in DO, are withdrawn by the turbines.

Land Resources. The land adjacent to rivers, streams, and lakes in the Tennessee Valley serves multiple purposes. It is critical to the life cycle of fish and wildlife and to the plants and organisms on which they depend for food and cover. It is also important for residential and industrial development, agriculture, mining, recreation, tourism, and other uses.

Before TVA's reservoir system was constructed, major floods could cause severe streambank erosion. Sediments would be deposited at other locations, resulting in dramatic changes in the depth and location of the river channel and costly damages. Today, major flooding is controlled by TVA's system of dams. Because sediments generally are deposited in the bottom of the reservoir, the changes in the river are not as dramatic and the damages are not as severe.

Shoreline and streambank erosion continues to occur, however, as a result of many factors--wave action due to wind, pleasure boats, and navigation traffic; changes in the rate of streamflow; mismanagement of agricultural, forest, and urban lands; destruction or removal of shoreline vegetation; and poor mining practices. Damages include the loss of valuable agricultural land and sedimentation which can adversely affect flood storage capacity, hydroelectric generation, water supply, recreation, navigation, aquatic life, and water quality.

Erosion is most serious on the prime farmland in the western part of the region where the rich soil erodes easily. Erosion of prime farmland also is a concern below some dams in the eastern part of the region (Nottely, for example). Also in the eastern area, extensive sedimentation from uncontrolled upstream mining operations caused TVA's Nolichucky project to be retired from commercial operation in 1972. Decades of copper smelting operations near Copperhill, Tennessee, on the Ocoee River destroyed all vegetation in the area and has caused severe siltation and reservoir filling in the Ocoee reservoirs. TVA carries out cooperative reclamation projects to address many of these mining related concerns. In the Copper Basin, over 2400 acres have been treated since 1984, reducing siltation into the Ocoee River by nearly 431,000 tons per year.

In addition to revegetation and reclamation efforts in selected areas, TVA has worked cooperatively, in the past, with the U.S. Department of Agriculture and local farmers to demonstrate low-cost erosion control methods. Because of limited funds, these demonstration projects were small in size and short in duration. TVA presently offers technical assistance and aid in obtaining the necessary permits for streambank erosion control projects.

Shoreline development, a potentially significant contributor to shoreline erosion and reservoir sedimentation, is discussed in detail in the next section on the socioeconomic environment. It is important to note here, however, that shoreline development can have serious implications for the natural environment. As noted above, soil erosion and runoff as a result of residential, industrial, and recreation development increases nonpoint source pollution. In addition, such land use activities conflict with the preservation of the shoreline for scenic and aquatic resources, wildlife, and wetlands to the degree that natural shoreline habitat is removed or significantly altered. These effects are discussed below, along with land management concerns raised by various interest groups.

<u>Scenic Resources.</u> TVA tributary reservoirs are located in areas of eastern Tennessee, southwestern Virginia, western North Carolina, and northern Georgia known for mountain vistas and seasonal colors. TVA reservoirs and tailwater areas contribute to this landscape when lakes are full and streams are flowing; they detract when lake levels are low and streambeds are shallow or dry.

There are approximately 2100 miles of rivers and large streams in the Tennessee Valley. About two-thirds of this is impounded; one-third is free-flowing. Of the 740 miles of unimpounded large river habitat, nearly 30 percent (210 miles) is exposed when hydroturbines are not operating. An average of about 25,000 acres of land is exposed by drawdown of tributary reservoirs during the summer months. Mainstream reservoirs detract less from the landscape because the drawdown is 7.5 feet or less and tailwater areas are always covered.

Aquatic Resources. The construction of the TVA reservoir system fundamentally changed and continues to change the character of the Tennessee River and its tributaries. Impoundments promoted navigation, flood control, and power benefits by decreasing the magnitude of flow extremes throughout the year--moderating the flow effects of flood and drought events--but totally disrupted the daily, seasonal, and annual patterns that are characteristic of a river. The movements of water, sediments, nutrients, and organic material changed drastically as a result, with far-reaching effects on the health, number, and diversity of aquatic life.

Today, mainstream and tributary reservoirs support over 200 species of fish that attract people from across the Nation. Large populations of native species (such as largemouth bass, crappie, buffalo, and catfish) have developed in many reservoirs and support important sport and commercial fisheries. Other species have been introduced (such as striped bass, lake trout, and northern pike). These species, which support unique trophy fisheries, take advantage of particular habitat conditions resulting from reservoir construction.

In addition, the creation of artificial cold water habitats has provided an opportunity for fishing enthusiasts which would not otherwise exist in this area. Table 8 shows that most tailwaters of tributary dams support cold water habitats and are stocked with rainbow and/or brown trout, species which did not exist in the Tennessee Valley prior to construction of the dams. In contrast, most tailwaters of mainstream reservoirs support resident or seasonal populations of several warm water species, including smallmouth and white bass, sunfish, buffalo, sauger, and catfish.

While there have been many benefits to aquatic resources due to impoundment, there also have been negative effects. Unlike a river, a reservoir is relatively deep and stagnant and therefore subject to the effects of stratification. Nutrients and organic materials that flow into a reservoir have time to settle into the sediments or be used in internal reservoir processes. About 50 to 75 percent of the organics are trapped in a reservoir, contributing to higher productivity (more biomass or pounds of living matter per mile) in a reservoir than in an unimpounded river. Tailwater areas, in contrast, are deprived of nutrients and organics and often are less productive than before the reservoir was built.

The effects of stratification on DO in the lower layer of a reservoir and in tailwater releases were discussed earlier in this chapter. Prior to impoundment, low DO concentrations--less than 4 or 5 milligrams per liter (mg/l)--were relatively rare occurrences caused mostly by pollution. Now, they are commonplace in the late summer and early fall. Releases from tributary reservoirs also are generally colder during the summer months and have higher concentrations of dissolved metals compared to conditions before impoundment. Flows downstream of hydropower plants vary depending on power conditions, rather than following natural patterns. While the occurrence of extreme flooding events has been greatly reduced by TVA's system of dams, wide swings in flow, depth, and temperature in the tailwater still occur as a result of reservoir operations.

Table 8
Characteristics of Tailwater Fisheries

Reservoir Tailwater	Fishery Class. C	L	W	Fishery Type T	S	R	Trout: Rainbow	Trout: Brown	Bass: Smallmouth	Bass: White	Sunfish	Buffalo	Sauger	Catfish	Other
Navigation and W. Tributary															
Kentucky			X		X	X							X	X	
Pickwick Lndg			X		X	X			X			X	X	X	
Wilson			X		X	X			X	X	X		X	X	
Wheeler			X		X	X			X	X	X		X	X	
Tims Ford	X			X			X								
Guntersville			X		X	X				X			X	X	
Nickajack			X		X	X				X		X	X	X	c
Chickamauga			X		X	X				X	X			X	a
Watts Bar			X		X	X					X	X	X	X	b
Melton Hill		X	X		X					X		X	X		
Ft. Loudoun			X		X	X						X	X	X	b
E. Tributary															
Norris	X			X			X	X							
Cherokee		X	X		X	X			X	X	X	X	X		
Ft Pat. Henry	X			X			X								
Boone	X			X			X								
South Holston	X	X		X			X	X							
Wilbur	X	X		X		X	X	X			X				
Watauga	X			X			X								
Douglas		X	X		X	X				X	X	X	X		
Chilhowee	X	X		X	X		X	X				X			
Fontana	X			X			X	X							
Ocoee 1	X	X			N										
Ocoee 2	X	X			N										
Ocoee 3	X	X			X										
Blue Ridge	X	X		X		X	X								a
Apalachia	X			X			X								
Hiwassee	X	X			U										
Nottely	X	X			X		X			X					d
Chatuge	X	X			X		X	X	X	X					d

Classification
C = cold water
L = cool water
W = warm water

Type
T = stocked trout
S = seasonal runs
R = resident
N = no known fishery
U = unknown fishery characteristics

Other Species
a = black bass
b = crappie
c = paddlefish
d = walleye

These changes have had the greatest effect on benthic invertebrates and on the habitat and species of fish. Benthos refers to the wide variety of animals that live in or on the first few inches of the mud, sand, gravel, or other material that makes up the bottom of streams and lakes. Benthic animals include worms, snails, and crayfish, which spend their entire lives in or on the substrate, and aquatic insects, mussels, and clams, which live there during part of their life cycle.

Benthic organisms are a vital part of the food chain of aquatic systems; they transform nutrients and organic materials into biomass and provide a food base for fish and other vertebrate predators. Most benthic organisms have specific habitat requirements in terms of physical, chemical, or biological factors; alterations of these factors cause changes in both the composition and productivity of the benthic community. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters.

Benthic organisms have virtually disappeared from the deep portions of reservoirs because of the lack of flow and DO, and from the upstream reaches of tributary reservoirs because of drawdown. In the tailwater area immediately below the dam, only those species that can survive low DO conditions, highly turbulent waters, and colder temperatures have survived, although the standing crop has increased because of the lack of competition. Further downstream, the number of species of benthic organisms increases as natural reaeration occurs and DO levels climb.

The effect of impoundment on the species diversity of benthic organisms is most readily apparent in mussels. Because of their long lives, sedentary nature, and tendency to occur clumped in areas of suitable habitat, mussels are highly vulnerable to disruptions of habitat or changes in environmental factors. Prior to impoundment, the Tennessee River and its tributaries supported a large and diverse mussel fauna. Impoundment significantly reduced the amount of suitable habitat (shallow, flowing water over stable gravel or cobble substrates). Today, there are only about 175 miles of suitable mussel habitat in the Tennessee River, about 27 percent of what once existed. Pollution, sedimentation, and commercial overharvesting have adversely affected those mussel stocks which survived the destruction of habitat from impoundment. Recent investigations indicate that mussel stocks in the main river and most tributaries are continuing to decline. Mussel species dominate the list of threatened and endangered species in the Tennessee Valley, as discussed below.

Like benthic organisms, fish populations and communities also have been profoundly affected by the construction of the TVA reservoir system. The impoundment of the main Tennessee River and its tributaries dramatically altered the river-stream habitat and the resulting food chain. Changes in the species composition of the fish community and in the number of surviving species occurred rapidly. Those species whose annual migration cycles were interrupted by dams, and those species whose requirements for temperature, spawning habitat, or food were closely associated with riverine conditions rapidly declined in numbers or were eliminated. Lake sturgeon, blue sucker, sauger, walleye, paddlefish and other stream-spawning species were significantly reduced, as were the number of smaller fish, such as darters and minnows.

Those fish species that have survived or have been introduced into the reservoirs and rivers of the Tennessee Valley do not have optimal conditions for reproduction and growth. In tributary tailwater areas, lack of minimum flows in the first few miles below the dam severely limits the habitat available to fish, and restricts their movement, migration, reproduction, and available food supply. Daily temperature variations of 5 to 9^{o}C (9 to 16^{o}F) are common in tributary tailwaters on days when turbine use is intermittent, and can stress some species. DO levels less than about 5 or 6 mg/l affect growth, and levels less than about 3 or 4 mg/l lead to decreased survival and poor reproduction.

TVA attempts to enhance fish spawning by providing stable pool levels in reservoirs for a two-week period during the peak of the spring spawning season. However, throughout the rest of the year, current operating procedures for tributary reservoirs are detrimental to fish populations and angler use. The most productive region of a reservoir is the shoreline because of submerged vegetation for cover and organics, nutrients and aquatic invertebrates (benthos) for food. Operations that alter this reservoir margin have a variety of negative effects. Water level drawdowns for hydropower production destroy cover and reduce the food supply for young-of-year fish. Drastic changes in levels due to flood control can discourage spawning, strand fish eggs on the shoreline, and strand fish in isolated pools.

In mainstream reservoirs, lack of minimum flows during drought periods can reduce DO levels, leading to effects like those experienced in tributary tailwaters, though less severe. On some mainstream reservoirs, most notably Guntersville, aquatic plants (macrophytes) grow excessively, uninhibited by the steep drawdowns that limit their growth in tributary reservoirs. This benefits fisheries, but creates extensive mosquito breeding habitat and has led to conflicts between fishing enthusiasts and boaters and shoreline landowners whose access to the water is limited by thick vegetation.

In addition, on both tributary and mainstream reservoirs, shoreline development operates to modify fish habitat and other environmental factors which shape the fish community. Removal of vegetation in and near the water as a result of agricultural, industrial, residential, and urban development subjects the area to more nonpoint source pollution from runoff on nearby lands. Mining, deforestation, domestic and industrial effluents, erosion, agricultural practices, and urbanization have affected nearly all of the fish habitat in the Tennessee River watershed.

Fishing enthusiasts and state agencies that manage fisheries want to improve the fisheries of the Tennessee Valley. They desire improved flow and DO in tailwaters, and stable spring levels and higher summer levels in tributary reservoirs. They want more aquatic vegetation and fish attractors (man-made habitat which fish can use for cover). Like other lake and stream recreators, they also want improved access facilities and less pollution.

Wetlands. Wetlands are transitional ecosystems between terrestrial and aquatic communities where the land is saturated with water or covered by shallow water during at least part of the growing season. Wetlands become established and continue to exist in areas where frequent flooding occurs, nutrients are abundant, water flows are of low velocity, and soils allow the development of vegetation. Wetlands are highly productive systems, owing to the combination of abundant water and nutrients that allows wetlands to develop.

Wetlands on federally owned land are given special consideration under federal laws and regulations because of their importance to aquatic life and because they provide habitat for certain wildlife species. Wetlands also have been shown to be important for erosion control, flood and storm damage prevention, water quality improvement, and groundwater recharge. Wetlands on private land normally are not as well protected.

Because wetlands change from year to year, and even from season to season, they are difficult to map and measure. The U.S. Fish and Wildlife Service is in the process of inventorying national wetlands on a regional basis. TVA is acquiring better data on wetlands from aerial surveys of aquatic plants and as part of its reservoir lands planning process. However, detailed information about wetlands in the Tennessee Valley is lacking at this time.

Based on the field experience of TVA staff, it is estimated that over 90 percent of the wetlands on TVA reservoirs are located on mainstream reservoirs. Tributary reservoirs have few wetlands because of the steeper slope of their shorelines, and the steeper drawdown for flood control. The topography around mainstream lakes is flatter, lending itself to the establishment of wetlands, and there is much less drawdown from summer to winter on mainstream lakes (see table 13 for drawdown statistics). In addition, there are about three times as many shoreline miles on mainstream lakes (see table 4).

Wildlife. The groups of wildlife most closely associated with streams and reservoirs are the waterfowl--ducks, geese, and swans; waterbirds--loons, herons, and cormorants; and wetland furbearers--muskrats, beavers, mink, and raccoons. The animals within these groups are dependent to varying degrees upon streams, reservoirs, and the lands bordering them for feeding, nesting sites, and shelter.

Most waterfowl in the Tennessee Valley are migratory and usually are observed in the fall and winter. Migratory waterfowl numbers generally peak in the Tennessee Valley during the month of January, although this can vary from year to year depending on weather conditions, flyway populations, and other factors. A large variety of migratory ducks use flooded overbank and shoreline habitat in the Tennessee Valley in their flyway to the north and south. The most common migratory ducks observed on tributary reservoirs include mallards, American black duck, blue-winged teal, bufflehead, ring-necked duck, scaup, common goldeneye, common merganser, and hooded merganser. Nesting waterfowl observed in the Valley include wood ducks and resident (nonmigratory) Canada geese, which breed on select areas of mainstream and tributary reservoirs.

Three waterfowl management subimpoundments--two on Chickamauga Reservoir and one on Tellico Reservoir--have been constructed through the joint effort of TVA and the Tennessee Wildlife Resources Agency (TWRA) to provide water surface and feeding areas in the late fall and winter for waterfowl. TVA's power program is reimbursed for the cost of lost storage capacity. In addition, in cooperation with the U.S. Fish and Wildlife Service, TWRA, and the Alabama Department of Conservation and Natural Resources, TVA operates several dewatering projects on Kentucky and Wheeler reservoirs which provide shallow flooded food for ducks. On Guntersville Reservoir, the Alabama Department of Conservation and Natural Resources operates three dewatering projects. A total of more than 15,000 acres is involved in these projects.

Waterbirds in the Tennessee Valley include a diverse representation of bird families--some migratory, some observed year round. These include the common loon, double-crested cormorant, various wading birds, and other chiefly fish-eating species. Like waterfowl, some waterbirds use the shoreline for nesting while others forage for food in the drawdown zone, shallowly flooded overbank and dewatering areas. Numerous shorebird species also migrate through the Valley region, using available habitats.

Ospreys, also fish-eating birds, occur throughout the Tennessee Valley region along lakes and larger streams during their spring and fall migrations. This regionally rare species has been afforded some level of protected status in all of the Valley states. The control of pesticides and success of management efforts have combined to yield an increase in nesting populations of osprey, especially in the eastern Valley area.

Wetland furbearers, such as muskrat, mink, beaver, and raccoon, and some species of upland wildlife, including white-tailed deer, eastern cottontail rabbit, northern bobwhite, mourning dove, and various songbird species also use the shoreline for food and cover.

These wildlife species have adapted to the dynamic conditions of TVA's present lake level operating pattern, using habitat as it is available. Continued shoreline development, however, is gradually limiting this habitat, adversely impacting these birds and animals. State wildlife management agencies and environmental groups are advocating preservation of vegetation and trees along the strip of land at the water's edge to preserve as much natural habitat as possible in important locations for wildlife and wetlands resources.

Endangered and threatened terrestrial species are discussed below.

Endangered and Threatened Species. The Endangered Species Act of 1973, as amended, establishes procedures for identifying animal and plant species in need of protection; requires all federal agencies to determine if their activities are likely to jeopardize the continued existence of listed species; requires federal agencies to cooperate in programs for the conservation of listed species; and sets penalties for illegal taking, possession, or sale of listed species, their parts, or products.

Aquatic endangered species: At the present time, 30 aquatic species that occur in the Tennessee River watershed are listed by the U.S. Fish and Wildlife Service as either endangered or threatened, as shown in table 9. Of these, 17 occur in the impounded mainstream Tennessee River or in tributary stream reaches affected by dam releases; the remaining 13 live only in underground aquifers or in free-flowing streams within the watershed.

These 17 species fall into three groups based on apparent population trends. Eight of these species (two fish, six mussels) each occur at several sites throughout the watershed and appear to be maintaining themselves, if only at low population levels. Six species (all mussels) have been virtually or actually destroyed. Of these, two are presumed to be extinct--no live specimens have been seen in over 50 years. The remaining four have been found recently in the main Tennessee River; however, these animals were old and do not appear to be reproducing. These four species also occur in free-flowing reaches of other streams, but only two appear to be reproducing. The remaining three species (all mussels) no longer occur in the Tennessee River but persist downstream from two tributary dams--Normandy on the Duck River and Tims Ford on the Elk River--and in a few free-flowing stream reaches. The Duck River supports the largest known population of one of these; the remaining two species occur only in very low numbers. All three species are represented by a few specimens in the Elk River.

Table 9
Aquatic Species Found in the Tennessee River Watershed
Listed as Either Endangered (E) or Threatened (T)
By the U.S. Fish and Wildlife Service

Common Name	Federal Status	Areas of Occurrence: Free-flowing Streams	Regulated Streams	Main Tennessee River
Fish				
Alabama cavefish	E	(underground aquifer)		
Boulder darter	E	X	X	
Slackwater darter	T	X		
Slender chub	T	X		
Smoky madtom	E	X		
Snail darter	T	X	X	X
Spotfin chub	T	X		
Yellowfin madtom	T	X		
Freshwater Mussels				
Alabama lamp pearly mussel	E	X		
Appalachian monkeyface mussel	E	X		
Birdwing pearly mussel	E	X	X	
Cracking pearly mussel	E	X	X	X
Cumberland monkeyface mussel	E	X	X	
Dromedary pearly mussel	E	X		X
Fanshell	E	X		X
Fine-rayed pigtoe	E	X	X	
Green-blossom pearly mussel	E	X		
Little-wing pearly mussel	E	X		
Orange-footed pearly mussel	E			X
Pale lilliput pearly mussel	E	X		
Pink mucket pearly mussel	E	X	X	X
Ring pink mussel	E	X		X
Rough pigtoe	E	X		X
Shiny pigtoe	E	X	X	
Tan riffle shell	E	X	X	
Tuberculed-blossom pearly mussel	E			X
Turgid-blossom pearly mussel	E	X		
White wartyback pearly mussel	E			X
Yellow-blossom pearly mussel	E		X	X
Crustacean				
Alabama cave shrimp	E	(underground aquifer)		

Terrestrial animal and plant endangered species: Of the terrestrial animal and plant species currently listed as endangered or threatened, there are four which, owing to their habitat or life-cycle requirements, are closely associated with the main Tennessee River or tributary streams and reservoirs.

Bald eagles, which feed primarily on fish and secondarily (especially in winter) on waterfowl, occur in the region throughout the year and are most numerous in the winter.

Gray bats roost in caves throughout the year and forage over water for their insect food. Caves supporting summer populations of gray bats occur along or near all main river and six tributary reservoirs, as well as along the unimpounded sections of several tributary rivers. Increased protection of roosting and hibernation caves from human disturbance has led to a general population increase.

The green pitcher plant is limited to bogs and wet areas adjacent to creeks. In one known site near Chatuge Reservoir, it occurs within 100 feet of the summer pool level. The principal threat to its continued existence appears to be human disturbance (i.e., removal by collectors and increased residential, agricultural, and forestry development).

Ruth's Golden Aster is located in the riverine sections of the Hiwassee and Ocoee rivers. It chiefly occurs in full sun on rock outcrops in and adjacent to the river channel. TVA is conducting a multiyear monitoring program to establish baseline population information and to determine trends.

Air Quality. Overall, the Tennessee Valley and the southeastern U.S. have reasonably good air quality, although problems exist. In terms of traditional measures of air pollution--the National Ambient Air Quality Standards (NAAQS)--the Tennessee Valley in general, and some of its major metropolitan areas in particular, have shown marked improvement during the past two decades for sulfur dioxide, particulate matter, carbon monoxide, and lead as the direct consequence of air pollution control programs. Ozone, however, has either generally not improved or, in some instances, actually become worse. As for much of the country, ozone pollution is the most critical NAAQS issue. Various non-traditional regional air quality issues--such as climate change, visibility, acid rain, indoor air pollution, and toxic air pollution--are beginning to receive attention and may be important to the Tennessee Valley and its inhabitants.

Air pollution control programs have done a good job in controlling localized, source-specific pollution problems. Nashville and Chattanooga are good examples of urban air pollution control. Once listed as among the most polluted cities in the country, they now are among the best. Another improvement is the control of sulfur dioxide pollution from coal-burning power plants, ore processing facilities, and industrial boilers. Exceedances of sulfur dioxide standards and the associated adverse environmental effects which used to be commonplace near these facilities are now almost nonexistent. For TVA coal-burning power plants, total sulfur dioxide emissions decreased from about 2.2 million tons per year in the early 1970s to about 1.1 million tons per year in the late 1980s. Nitrogen oxides emissions averaged about 370,000 tons per year during this period.

Regional air pollution problems have proven more difficult to control because of their scale and complexity. Ozone is a good example of an important regional pollution problem. Ozone, a secondary pollutant--contributed not by direct emission but rather formed from a complex series of atmospheric chemical reactions involving both manmade and naturally emitted compounds--has been associated with respiratory health effects and damage to crops, forests, and many manmade materials. On a national scale, annual ozone damage is estimated in the billions of dollars. As more is learned about ozone, it is clear that resolution of this problem will not be quick or easy.

Other air quality issues of major interest include: (1) climate change--with potential long-term effects on the entire world, (2) visibility--with aesthetic implications for national parks and wilderness areas, (3) acidic deposition--with potential long-term effects on the poorly-buffered natural ecosystems of the eastern Tennessee Valley, (4) indoor air quality--potentially affecting Valley residents from exposure to radon, combustion by-products, bioaerosols, and toxic air pollutants in their homes, schools, and workplaces, and (5) air toxics--potentially affecting some Valley residents via outdoor sources of toxic chemicals including waste disposal facilities, agricultural application of herbicides and pesticides, and resulting effects on water quality.

Socioeconomic Environment

Commercial Navigation. Before TVA's nine mainstream dams were built, shoals and other navigation hazards limited the use of the Tennessee River by modern commercial vessels. Barge traffic was mostly local and was a small fraction of the more than 40 million tons a year now transported on the river.

Today the 650-mile navigable channel that extends from Knoxville, Tennessee, to Paducah, Kentucky, links the Tennessee Valley with an inland waterway system connecting ports in 21 states. More than 80 percent of the traffic on the Tennessee River waterway is interregional. Table 10 shows the principal commodities moved along the Tennessee River system in 1987. Coal accounted for almost half of the tonnage, with over half of all coal shipments going to TVA coal-fired power plants at Widows Creek and Colbert, Alabama, and New Johnsonville, Tennessee. Stone, sand, and gravel accounted for about 20 percent of the total tonnage that moved on the waterway in that year. There are currently eight companies that dredge sand and gravel from the Tennessee River and its tributaries. Five of these companies operate on the lower end of the system in Kentucky Lake; the other three are located on the French Broad River. Their dredging activities are regulated by the U.S. Army Corps of Engineers through issuance of a five-year permit. The other principal industries served by the waterway are pulp and paper manufacturing, chemical production, grain processing, and construction.

Most of these are bulk commodities used in the production and manufacture of other products. Transporting bulk commodities by barge is advantageous because of its lower energy and cost requirements. Barge transport is slower, but long travel time is not a problem because these commodities do not deteriorate during transport. The savings to shippers by using barge over other modes of transportation is estimated at about $190 million per year.

Table 10
Tennessee River System
Commodity Traffic by Group, 1987

Commodity	Traffic (1000 Tons)	Percent of total
Coal and coke	20694.2	50
Stone, sand, gravel	8190.4	20
Grains and products	3970.9	10
Petroleum products	2385.1	6
Chemicals	2223.4	5
Iron and steel	1285.1	3
Forest products	593.9	1
All other	2436.1	6
	41779.1	100

Source: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, April 1989.

Shippers, however, are not the only ones to benefit from the development of the waterway. Originally justified for national defense, the waterway has strategic value to the Nation, providing inland water transportation during times of war. In addition, development of the Tennessee River system helped make the region's natural resources available to the Nation by lowering the cost of their transportation. Also, the availability of water-based transportation has been a major factor in the economic development of the Tennessee Valley. It has helped to attract industry to the region and continues to provide new jobs in communities along the waterway.

Other regions have benefited as well. For example, the Tennessee River system permitted water-based transportation to ports on the Gulf of Mexico to continue during the 1988 drought. When barge transport on the lower Mississippi River was disrupted by lack of river flow, barge traffic was rerouted down the Tennessee River to its interconnection with the Tennessee-Tombigbee Waterway to the port of Mobile, Alabama. Approximately 5.5 million tons of commodities were rerouted which otherwise would have moved by more costly transport modes or would have been delayed. The U.S. Army Corps of Engineers attributes about 60 percent of the benefits of low flow augmentation on the lower Mississippi River that comes from the Ohio River basin to the operation of TVA dams on the Tennessee River.

Several problems limit the further development of water-based industries along the Tennessee River. Traffic bottlenecks add significantly to travel times through certain points in the system. Because of the poor navigability of the Cumberland River below Barkley Dam, traffic through the lock at Kentucky Dam is so great that significant delays in locking through are often experienced. The small size of the upper Tennessee River locks prevents a modern eight-barge tow from passing Chattanooga without significant delays and costs. Modern size barges must be passed through the locks at Chickamauga, Watts Bar, and Fort Loudoun one at a time.

Adding to traffic congestion during certain times of the year is the increasing number of recreational boats using the locks for passage all along the Tennessee River. This reflects the growing importance of water-based recreation to the economy of the eastern half of the Valley.

Maintenance is also a problem. Because of single lock facilities, maintenance requirements at upper river locks can close the river to traffic until problems are corrected. At Chickamauga Dam, the concrete that was used to build the dam is slowly swelling, causing problems with the operation of the navigation lock and other structures. This problem eventually will require replacement of portions of the dam, including the navigation lock.

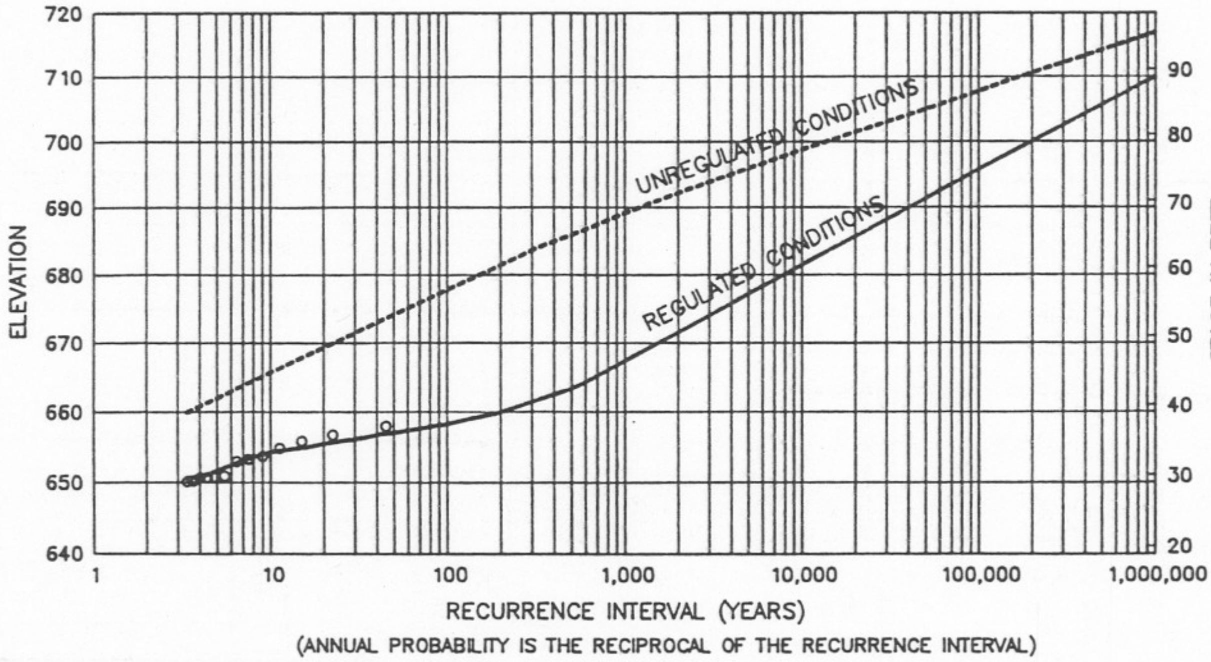
Finally, winter minimum pool levels on mainstream reservoirs are a major concern of shippers along the waterway. As discussed in Chapter 2, reservoir levels are lower during the winter months to provide storage capacity for floods. Heavily laden barges are more likely to run aground during the winter months if they stray outside the navigation channel, resulting in delays and damages to equipment. Cargo also could be lost, resulting in economic loss and potential environmental damage. Six ports on the river are of particular concern: Florence and Decatur, Alabama, and Charleston, Knoxville, New Johnsonville, and Chattanooga, Tennessee. Some areas of these ports are shallower than the navigation channel, and entry to some docks is prohibited until reservoir levels rise. This causes delays to shippers, tying up their equipment so that it cannot be put to productive use.

Flood Protection. On the main river, the operation of the TVA reservoir system reduces flood damages primarily at Knoxville, Lenoir City, and Chattanooga, and in the vicinity of Savannah, Tennessee; at Decatur and Florence, Alabama; and at Paducah, Kentucky. Flood control operations at Kentucky Reservoir also help reduce flooding near Cairo, Illinois, and in the Birds Point-New Madrid floodway area. In tributary areas, damages are reduced principally at Clinton, Tennessee, in the Clinch River basin; Elizabethton and Kingsport, Tennessee, in the Holston River basin; Murphy, North Carolina, McCaysville, Georgia, and Copperhill and Charleston-Calhoun, Tennessee in the Hiwassee River basin; Fayetteville, Tennessee, in the Elk River basin; agricultural areas in the Bear Creek basin in Alabama; and Shelbyville, Tennessee, in the Duck River basin.

The cumulative value of flood damages prevented by the operation of the TVA reservoir system since 1936 is estimated at about $3 billion. This estimate does not include the value of reduced risk of loss of human life or of reduced disruption of transportation, communication, or business resulting from reduced flood damages. These indirect losses are difficult to quantify; some researchers estimate their value to range from 100 to 150 percent of the value of direct flood damages.

Approximately 85 percent of the value of reduced flood damages has accrued to the city of Chattanooga, Tennessee. Figure 8 shows how the frequency of floods at Chattanooga has been reduced by operation of the reservoir system.

Figure 8
Probability of Flooding at Chattanooga



Although the storage capacity in TVA reservoirs protects Chattanooga during most floods, major storms that occur less frequently can still cause extensive damage.

About 10 percent of the value of prevented flood damages has accrued to other flood-prone areas in the Valley, and five percent to flood-prone areas near the lower Ohio and Mississippi rivers. The Corps of Engineers attributes approximately half of the flood protection benefits provided by the Ohio River basin on the lower Mississippi River to TVA's operation of the Tennessee River system.

To assure the safety of its dams and the continued provision of benefits, TVA is reevaluating the design, operation, and maintenance practices at its dams. Twenty-one dams have been or are being evaluated to safely pass the probable maximum flood, safely withstand the maximum credible earthquake, and assure structural soundness. Modifications to the dams are being undertaken as needed, and emergency action plans and operations and maintenance manuals prepared.

Residential development sometimes occurs in areas prone to flooding downstream of TVA dams because residents believe they are protected from flooding by the presence of the dam. In such cases, there are no local floodplain regulations (or floodplain regulations are poorly enforced) to assure that areas downstream of TVA dams are developed in a manner consistent with actual flood risk. TVA flood protection programs provide information on flood risks and advise communities on appropriate steps to take to control development in flood-prone areas.

Safety at dams is an important consideration not only to flood control beneficiaries and to those living immediately downstream, but also to the safe operation of TVA nuclear plants. Licenses to operate nuclear power plants are awarded to TVA by the Nuclear Regulatory Commission only after TVA demonstrates that they are designed to be operated safely, or can be shut down, during a probable maximum flood.

Flood protection beneficiaries strongly support the continued operation of the reservoir system for this purpose. On Kentucky Reservoir, farmers want increased flood protection from operation of the system. They object to flooding of their land and the associated shoreline erosion. Flood easements purchased by TVA cover only those lands which are subject to more frequent flooding by TVA operations than occurred before the construction of Kentucky and upstream dams. In place of increased flood protection, these farmers want TVA to purchase additional flood easements. (See Chapter 4 for a discussion of this proposal.)

<u>Hydroelectric Power.</u> The average annual generation from TVA hydroelectric plants is about 14 billion kilowatthours. This figure can vary considerably, however, depending on the annual rainfall and runoff into the rivers and reservoirs of the region. In a dry year, hydrogeneration can be as low as 8 billion kilowatthours; in a wet year, hydrogeneration can be as high as 18 billion kilowatthours.

Section 11 of the TVA Act provides that power projects "shall be considered primarily as for the benefit of the people of the section as a whole and particularly the domestic and rural consumers to whom the power can economically be made available, and accordingly that sale to and use by industry shall be a secondary purpose." Consistent with this, since 1952, residential consumers have been provided tangible price benefits. TVA rates have been designed to preserve the benefits of the low-cost hydroelectric system for the residential class. Rates for commercial and industrial consumers do not include hydro benefits but only reflect the higher costs of thermal power plants (coal, oil, and nuclear fueled).

This has saved the region's residential customers an average of about $300 to $350 million a year on electric bills (about $10 per month per customer) compared to the cost if this power had to come from other sources. Residential consumers are assumed to receive all the hydro output (which displaces TVA's average thermal generation costs). They are charged at its production and investment cost, which is considerably lower than the cost of other forms of generation or the average production cost of the TVA power system. While the residential consumer is allocated the annual average hydropower savings, the value of hydropower generation varies from $170 million to $450 million depending on rainfall and runoff in any given year.

If TVA were to replace the hydro system with other capacity, it would cost much more than the $350 million in hydropower benefits allocated to residential consumers. Alternate generating sources would be extremely expensive to install, more expensive to operate, and less dependable and versatile than hydroelectric capacity. Most important, TVA's hydro capacity does not require a high reserve margin (back-up capacity) as do other generating sources because it is composed of many small units with high availability.

As described in Chapter 2, hydropower production is maximized during the summer and winter seasons when electricity demand is highest. In an average year, about 57 percent of the annual hydrogeneration is typically produced during these peak seasons. The percentage is lower in a dry year (about 50 percent) and higher in a wet year (about 66 percent). Off-season generation cannot be avoided because there is not enough storage capacity in all the reservoirs to store water from one peak season to another and other uses require the passage of water downstream. In addition, generation capacity limitations at many hydroplants prevent more water from being used during the peak season.

Similarly, TVA tries--but is not always able--to schedule hydroturbine operations during the 60 hours of the week (or 12 hours of each weekday) when power demand is highest. During the summer peak season, about 60 percent of weekly hydropower generation typically occurs during these peak hours. This varies from about 50 percent in wet summers to about 70 percent in dry summers. During the drought of 1988, 90 percent was generated on peak because river flows were so low.

Like flood control, the beneficiaries of low cost hydropower strongly support the continued operation of the reservoir system for power production purposes. Residential consumers and the distributors of TVA power that serve them generally believe that the costs of any decrease in hydropower generation for purposes other than navigation and flood control should be borne by the beneficiaries of such actions. TVA's industrial customers and some distributors believe that the rate benefits of low cost hydropower should be shared by industrial and commercial users of electricity. Other distributors want the hydropower benefits shifted to winter months to help electricity compete with gas in the residential heating market.

An important factor affecting the future availability and cost of hydropower generation is the age of most TVA hydroplants and facilities. The average age of TVA's 107 hydropower units is 42 years. Maintenance of these units has kept their availability rate very high. Some major overhauls have been completed, are underway, or planned. Over the next two decades, major components of a number of units may require replacement. TVA's hydroplant controls were designed and installed before the days of computers and thus do not use currently available technology. Replacement hydroturbines can often achieve greater efficiencies than the turbines in current use. For these reasons, capital investments in hydroplant modernizations have the potential for a good return to TVA's power customers.

Population and Income. The watershed drained by the Tennessee River includes all or parts of 125 counties in the seven states of Kentucky, Tennessee, Mississippi, Alabama, Georgia, North Carolina, and Virginia. The population of these counties in 1987 was 5.1 million. Of this number, about 52 percent (2.7 million people) reside in the 57 counties that encompass the shoreline of the TVA reservoir system.

Table 11 presents population and income data for each of these counties for 1980 and 1987, summarized by reservoir. During this seven-year period, population in these 57 counties has been growing as the rate of 0.7 percent per year and per capita income has been growing at the rate of two percent per

Table 11-A: Population and Income Statistics
Navigation and Western Tributary Reservoirs

RESERVOIR	RESERVOIR COUNTIES	POPULATION 1980	POPULATION 1987	POPULATION 7-YEAR CHANGE	POPULATION ANNUAL GROWTH		PER CAPITA INCOME 1980	PER CAPITA INCOME 1980 (1987$'S)	PER CAPITA INCOME 1987	PER CAPITA INCOME 7-YEAR CHANGE	PER CAPITA INCOME ANNUAL GROWTH
KENTUCKY	HARDIN, TN	22280	22100	-0.8	-0.1		6451	8896	10057	13.1	1.8
	PERRY, TN	6111	6400	4.7	0.7		6316	8710	10039	15.3	2.0
	DECATUR, TN	10857	11000	1.3	0.2		6294	8679	9148	5.4	0.8
	HUMPHREYS, TN	15957	16000	0.3	.0		7750	10687	10811	1.2	0.2
	BENTON, TN	14901	15000	0.7	0.1		7152	9863	10336	4.8	0.7
	HOUSTON, TN	6871	7100	3.3	0.5		6478	8933	10195	14.1	1.9
	HENRY, TN	28656	29300	2.2	0.3		7695	10611	10486	-1.2	-0.2
	STEWART, TN	8665	9400	8.5	1.2		6133	8457	11063	30.8	3.9
	CALLOWAY, KY	30031	30300	0.9	0.1		7621	10509	11612	10.5	1.4
	TRIGG, KY	9384	9500	1.2	0.2		8243	11367	12184	7.2	1.0
	MARSHALL, KY	25637	26700	4.1	0.6		8381	11557	12109	4.8	0.7
	LYON, KY	6490	6300	-2.9	-0.4		6635	9150	10026	9.6	1.3
	LIVINGSTON, KY	9219	8900	-3.5	-0.5		7826	10792	11522	6.8	0.9
TOTAL		195059	198000	1.5	0.2	AVERAGE	7359	10147	10886	7.3	1.0
NORMANDY	COFFEE, TN	38311	41700	8.8	1.2		8064	11120	12746	14.6	2.0
TOTAL		38311	41700	8.8	1.2	AVERAGE	8064	11120	12746	14.6	2.0
PICKWICK	HARDIN, TN	22280	22100	-0.8	-0.1		6451	8896	10057	13.1	1.8
	TISHOMINGO, MS	18434	18100	-1.8	-0.3		7248	9995	9252	-7.4	-1.1
	COLBERT, AL	54519	53600	-1.7	-0.2		7793	10747	11012	2.5	0.3
	LAUDERDALE, AL	80546	82400	2.3	0.3		7470	10301	11257	9.3	1.3
TOTAL		175779	176200	0.2	.0	AVERAGE	7418	10229	10826	5.8	0.8
WILSON	COLBERT, AL	54519	53600	-1.7	-0.2		7793	10747	11012	2.5	0.3
	LAUDERDALE, AL	80546	82400	2.3	0.3		7470	10301	11257	9.3	1.3
TOTAL		135065	136000	0.7	0.1	AVERAGE	7600	10481	11160	6.5	0.9
WHEELER	MARSHALL, AL	65622	72100	9.9	1.4		7423	10236	11744	14.7	2.0
	MORGAN, AL	90231	99900	10.7	1.5		7979	11003	12991	18.1	2.4
	MADISON, AL	196966	231500	17.5	2.3		8848	12201	15082	23.6	3.1
	LIMESTONE, AL	46005	51700	12.4	1.7		7185	9908	11940	20.5	2.7
	LAWRENCE, AL	30170	31400	4.1	0.6		6274	8652	9984	15.4	2.1
	LAUDERDALE, AL	80546	82400	2.3	0.3		7470	10301	11257	9.3	1.3
TOTAL		509540	569000	11.7	1.6	AVERAGE	7990	11018	13171	19.5	2.6
TIMS FORD	FRANKLIN, TN	31983	34200	6.9	1.0		6610	9115	10175	11.6	1.6
	MOORE, TN	4510	4800	6.4	0.9		6931	9558	9401	-1.6	-0.2
TOTAL		36493	39000	6.9	1.0	AVERAGE	6650	9170	10080	9.9	1.4
GUNTERSVILLE	JACKSON, AL	51407	50200	-2.3	-0.3		6830	9419	10164	7.9	1.1
	MARSHALL, AL	65622	72100	9.9	1.4		7423	10236	11744	14.7	2.0
TOTAL		117029	122300	4.5	0.6	AVERAGE	7163	9877	11095	12.3	1.7
NICKAJACK	MARION, TN	24416	25400	4.0	0.6		6754	9314	9607	3.1	0.4
	HAMILTON, TN	287643	287300	-0.1	.0		9010	12425	14807	19.2	2.5
TOTAL		312059	312700	0.2	.0	AVERAGE	8833	12181	14385	18.1	2.4
CHICKAMAUGA	MEIGS, TN	7431	8100	9.0	1.2		6447	8890	9776	10.0	1.4
	RHEA, TN	24235	25300	4.4	0.6		7118	9816	11293	15.1	2.0
	HAMILTON, TN	287643	287300	-0.1	.0		9010	12425	14807	19.2	2.5
TOTAL		319309	320700	0.4	0.1	AVERAGE	8807	12145	14403	18.6	2.5
WATTS BAR	ROANE, TN	48425	49600	2.4	0.3		8156	11247	12086	7.5	1.0
	RHEA, TN	24235	25300	4.4	0.6		7118	9816	11293	15.1	2.0
	MEIGS, TN	7431	8100	9.0	1.2		6447	8890	9776	10.0	1.4
TOTAL		80091	83000	3.6	0.5	AVERAGE	7683	10595	11619	9.7	1.3
MELTON HILL	ANDERSON, TN	67346	69800	3.6	0.5		8684	11975	13105	9.4	1.3
	ROANE, TN	48425	49600	2.4	0.3		8156	11247	12806	13.9	1.9
TOTAL		115771	119400	3.1	0.4	AVERAGE	8463	11671	12981	11.2	1.5
FT. LOUDOUN	KNOX, TN	319694	329400	3.0	0.4		8695	11990	14292	19.2	2.5
	BLOUNT, TN	77770	83800	7.8	1.1		8197	11304	12819	13.4	1.8
	LOUDON, TN	28553	30800	7.9	1.1		7624	10513	10958	4.2	0.6
TOTAL		426017	444000	4.2	0.6	AVERAGE	8532	11766	10783	17.1	2.3
TELLICO	BLOUNT, TN	77770	83800	7.8	1.1		8197	11304	12819	13.4	1.8
	LOUDON, TN	28553	30800	7.9	1.1		7624	10513	10958	4.2	0.6
	MONROE, TN	28700	30600	6.6	0.9		5849	8066	9407	16.6	2.2
TOTAL		135023	145200	7.5	1.0	AVERAGE	7577	10448	11705	12.0	1.6

Table 11-B: Population and Income Statistics
Eastern Tributary Reservoirs

RESERVOIR	RESERVOIR COUNTIES	POPULATION 1980	POPULATION 1987	POPULATION 7-YEAR CHANGE	POPULATION ANNUAL GROWTH		PER CAPITA INCOME 1980	PER CAPITA INCOME 1980 (1987$'S)	PER CAPITA INCOME 1987	PER CAPITA INCOME 7-YEAR CHANGE	PER CAPITA INCOME ANNUAL GROWTH
NORRIS	ANDERSON, TN	67346	69800	3.6	0.5		8684	11975	13105	9.4	1.3
	CAMPBELL, TN	34923	35400	1.4	0.2		6227	8587	8845	3.0	0.4
	CLAIBORNE, TN	24595	26600	8.2	1.1		6465	8915	9947	11.6	1.6
	UNION, TN	11707	12300	5.1	0.7		5504	7590	8454	11.4	1.6
TOTAL		138571	144100	4.0	0.6	AVERAGE	7402	10208	11079	8.5	1.2
CHEROKEE	GRAINGER, TN	16751	17400	3.9	0.5		5144	7094	7974	12.4	1.7
	HAMBLEN, TN	49300	52500	6.5	0.9		6732	9283	10429	12.3	1.7
	HAWKINS, TN	43751	45100	3.1	0.4		6001	8275	9476	14.5	2.0
	JEFFERSON, TN	31284	33500	7.1	1.0		6522	8994	10035	11.6	1.6
TOTAL		141086	148500	5.3	0.7	AVERAGE	6270	8647	9763	12.9	1.7
FT. PATRICK HENRY	WASHINGTON, TN	88755	91500	3.1	0.4		8075	11135	12700	14.1	1.9
TOTAL		88755	91500	3.1	0.4	AVERAGE	8075	11135	12700	14.1	1.9
BOONE	SULLIVAN, TN	143968	147300	2.3	0.3		8144	11231	12512	11.4	1.6
	WASHINGTON, TN	88755	91500	3.1	0.4		8075	11135	12700	14.1	1.9
TOTAL		232723	238800	2.6	0.4	AVERAGE	8118	11194	12584	12.4	1.7
SOUTH HOLSTON	SULLIVAN, TN	143968	147300	2.3	0.3		8144	11231	12512	11.4	1.6
	WASHINGTON, VA	65529	65400	-0.2	.0		7458	10285	12031	17.0	2.3
TOTAL		209497	212700	1.5	0.2	AVERAGE	7929	10935	12364	13.1	1.8
WATAUGA	CARTER, TN	50205	51400	2.4	0.3		6216	8572	9508	10.9	1.5
	JOHNSON, TN	13745	14100	2.6	0.4		5611	7738	7742	0.1	.0
TOTAL		63950	65500	2.4	0.3	AVERAGE	6086	8393	9128	8.8	1.2
DOUGLAS	COCKE, TN	28792	29400	2.1	0.3		5829	8038	8431	4.9	0.7
	HAMBLEN, TN	49300	52500	6.5	0.9		6732	9283	10429	12.3	1.7
	JEFFERSON, TN	31284	33500	7.1	1.0		6522	8994	10035	11.6	1.6
	SEVIER, TN	41418	47800	15.4	2.1		7278	10036	11126	10.9	1.5
TOTAL		150794	163200	8.2	1.1	AVERAGE	6666	9192	10192	10.9	1.5
FONTANA	GRAHAM, NC	10283	10700	4.1	0.6		6257	8628	9097	5.4	0.8
	SWAIN, NC	7217	7100	-1.6	-0.2		5616	7744	8127	4.9	0.7
TOTAL		17500	17800	1.7	0.2	AVERAGE	5993	8264	8710	5.4	0.8
OCOEES	POLK, TN	13602	13700	0.7	0.1		6428	8864	10120	14.2	1.9
TOTAL		13602	13700	0.7	0.1	AVERAGE	6428	8864	10120	14.2	1.9
BLUE RIDGE	FANNIN, GA	14748	16100	9.2	1.3		6076	8379	9906	18.2	2.4
TOTAL		14748	16100	9.2	1.3	AVERAGE	6076	8379	9906	18.2	2.4
APALACHIA	CHEROKEE, NC	18933	20900	10.4	1.4		5711	7875	9659	22.6	3.0
TOTAL		18933	20900	10.4	1.4	AVERAGE	5711	7875	9659	22.6	3.0
HIWASSEE	CHEROKEE, NC	18933	20900	10.4	1.4		5711	7875	9659	22.6	3.0
TOTAL		18933	20900	10.4	1.4	AVERAGE	5711	7875	9659	22.6	3.0
NOTTELY	UNION, GA	9390	11000	17.1	2.3		5099	7032	10006	42.3	5.2
TOTAL		9390	11000	17.1	2.3	AVERAGE	5099	7032	10006	42.3	5.2
CHATUGE	TOWNS, GA	5638	6600	17.1	2.3		5125	7067	9776	38.3	4.7
	CLAY, NC	6619	7200	8.8	1.2		5654	7797	8833	13.3	1.8
TOTAL		12257	13800	12.6	1.7	AVERAGE	5411	7461	9284	24.4	3.2
EASTERN TRIBUTARY TOTAL		798499	832800	4.3	0.6						
COUNTY AVERAGE		34717	36209	4.3	0.6		6699	9239	10299	11.5	1.6
OVERALL TOTAL		2549129	2672700	4.8	0.7						
OVERALL COUNTY AVERAGE		44722	46889	4.8	0.7	AVERAGE	7647	10545	12094	14.7	2.0

year. Reservoir county per capita income is about $12,100, which is higher than non-reservoir county per capita income ($10,900) and Valley-wide per capita income ($11,600). Tributary county per capita income (about $10,300), however, is lower than either per capita income in mainstream counties or non-reservoir counties. Eleven of the 21 counties near eastern tributary lakes have been designated by TVA as Special Opportunities Counties (SOC). This designation, given to 50 of the 201 counties in the Tennessee Valley, is based on per capita income and percentage of population below the poverty level. SOC counties are targeted by TVA for special economic development assistance.

Table 11-A shows that the areas with the highest population and per capita income in counties along navigable and western tributary reservoirs are near the three largest cities along mainstream reservoirs: Knoxville, Chattanooga, and Huntsville. The counties with highest population and income growth also are associated with these urban areas and nearby residential communities. Eight counties either had lower population or lower per capita incomes in 1987 compared to 1980; these were primarily in rural areas near Kentucky and Pickwick reservoirs.

Table 11-B shows that the tributary reservoir areas in the eastern half of the Valley with highest population and highest per capita income were also near the largest cities in the region--the tri-cities area of Kingsport, Johnson City, and Bristol. Counties with the highest population and income growth from 1980 to 1987, however, were principally associated with reservoirs experiencing significant growth due to recreation, tourism, and second home development. The reservoirs near these counties are Nottely, Chatuge, Douglas, Hiwassee, Blue Ridge, Norris, and Cherokee. Residents from these counties accounted for about 60 percent of the attendance both at the public meetings conducted at the beginning of this study and at the public meetings held to receive comments on the Draft EIS (see tables 1 and 2).

Only two counties in the tributary areas near Fontana and South Holston reservoirs lost population during the seven-year period; in the latter case, Washington County, Virginia, experienced high growth in per capita income. No counties among the 21 counties near eastern tributary lakes lost per capita income during the period, but per capita income for the tributaries grew at a slower rate than for mainstream reservoir counties.

Land and Shoreline Development. As the population and economy of the Tennessee Valley have grown, so have the pressures for the use and development of shorelands on TVA reservoirs. These pressures include the expanding need for public recreation facilities; commercial tourism development; residential development (including primary residences, second homes, and weekend cabins); and industrial development on the commercial navigation channel. Recreation, wildlife, and commercial and industrial development interests want TVA to allocate--or, in some cases, purchase--additional land for their use, reflecting the competition for shorelands.

There are several variables that can be used to describe the current extent and growth rate of shoreland development. Two have already been mentioned: population growth in counties around each reservoir (see table 11), and the ownership pattern of the reservoir shoreline (see table 4). In addition, the number of miles of privately owned shorelands that have been developed and the number of shoreline structures approved by TVA under its Section 26a authority are good indicators of the extent of shoreland development.

The ownership pattern of the reservoir shoreline is important because privately owned shorelands are more likely to be developed than publicly-owned shorelands. Table 4 shows the ownership pattern around TVA reservoirs. Half of the shoreline of tributary reservoirs in the eastern half of the Valley is privately owned* compared to about 35 percent of the shoreline of navigation and western tributary reservoirs. However, there are twice as many miles of privately owned shoreline on navigation and western tributary reservoirs because the reservoirs are larger. Private ownership of the shoreline on individual reservoirs varies greatly, from over 90 percent on Douglas Reservoir to limited private ownership on Fontana and none on Ocoee No. 1 or Ocoee No. 2. Over half of the shoreline on South Holston, Watauga, Fontana, Hiwassee, and Blue Ridge reservoirs in the eastern half of the Valley is owned by the U.S. Forest Service and the National Park Service.

Table 12 provides additional information on the privately owned shorelands around TVA reservoirs. Approximately 40 percent of the 2710 miles of privately owned shoreline on navigation and western tributary reservoirs is developed, compared to about 22 percent of the 1315 miles of privately owned shoreline on eastern tributary reservoirs. The amount of development on individual reservoirs varies considerably, ranging from 10 percent or less developed on four reservoirs to 90 percent or more developed on two reservoirs. Table 12 also shows the rate of development of privately owned shorelands on each reservoir expected in the 1990s, based on the judgment of TVA staff. High growth is expected on five navigation and western tributary reservoirs, compared to only two relatively small eastern tributary reservoirs. Appendix A to this report contains a description of each of the reservoirs listed in table 12 and provides the rationale for the estimated growth rate.

Lower levels of development and lower expected growth rates on the shorelands around eastern tributary reservoirs, compared to navigation and western tributary reservoirs, is explained partially by the difference in summer and annual drawdown rates. As shown in table 13, the navigation and western tributary reservoirs are drawn down an average of six feet annually, and only one foot during the summer, while eastern tributary reservoirs are drawn down much more steeply--an average of 32 feet annually and 15 feet during the summer. The actual shoreline of a reservoir can be several hundred feet to a mile or more removed from shoreline property when reservoirs levels are low. This can significantly affect the desirability of the land for development.

The number of structures approved by TVA under its Section 26a authority (discussed in Chapter 2) provides additional information on shoreline development trends in the Valley. In the five-year period from 1984 to 1988, TVA approved over 9200 shoreline structures. Of these, about 600 were

*Shoreline miles in "private ownership" include both private land over which TVA has flowage easements and narrow strips of land owned by TVA--marginal strip lands--at the water's edge on which the adjacent private property owner may construct piers, docks, and related private water use facilities upon approval of plans by TVA.

Table 12
Development of Private Shorelands Around TVA Reservoirs

	Total Private Shoreline Miles	Private Shoreline Miles Developed	% of Private Shoreline Miles Developed	Expected Rate of Development in 1990s
Navigation and W. Tributary Reservoirs				
Kentucky	913	274	30	Medium
Normandy	0	0	0	Low
Pickwick	132	62	47	High
Wilson	143.5	112.5	78	Medium
Wheeler	115	43	37	Medium
Tims Ford	33.5	30	90	High
Guntersville	114	89	78	Medium
Nickajack	160	24	15	Low
Chickamauga	286	143	50	Medium
Watts Bar	395	198	50	Medium
Melton Hill	102	19	19	High
Fort Loudoun	251	85	34	High
Tellico	65	11	17	High
	2,710	1,090.5	39	
E. Tributary Reservoirs				
Norris	251	60	24	Medium
Cherokee	214	43	20	Medium
Ft. Patrick	15	7	47	Low
Boone	101	46	46	Medium
South Holston	43	8	19	Medium
Wilbur	0	0	0	---
Watauga	48	7	15	Medium
Douglas	470	59	13	Medium
Nolichucky		----Data Not Available----		
Fontana	21	0.5	2	Low
Ocoee No. 1[1]	0	0	0	---
Ocoee No. 2	0	0	0	---
Ocoee No. 3	4	0	0	Low
Blue Ridge	16	8	50	Medium
Apalachia	0	0	0	---
Hiwassee	10	5	50	Medium
Nottely	46	18	39	High
Chatuge	76	34	45	High
	1,315	295.5	22	

Note:
1. The U.S. Forest Service has issued permits for vacation cabin sites along four miles of Ocoee No. 1 shoreline.

Table 13
Lake Area and Drawdown Statistics of TVA Reservoirs

	Average Drawdown		Avg Summer Lake Area	
	Ann (ft)	Summer (ft)	Mem. Day (1000 (acres)	Labor Day (1000 (acres)
Navigation & W. Tributary Reservoirs				
Kentucky	5	3	147.0	133.4
Normandy	11	2	3.2	3.1
Pickwick	6	2	43.1	40.7
Wilson	3	0	15.6	15.6
Wheeler	6	2	61.2	55.7
Tims Ford	12	2	10.3	9.9
Guntersville	2	1	67.9	65.0
Nickajack[1]	0	0	10.4	10.4
Chickamauga	7	2	36.1	33.7
Watts Bar	6	0	39.0	39.0
Melton Hill[1]	0	0	5.7	5.7
Ft Loudoun	6	0	14.6	14.6
Tellico	6	0	15.9	15.9
Total	6 (avg)	1 (avg)	470	443
E. Tributary Reservoirs				
Norris	32	22	31.6	23.5
Cherokee	28	16	24.6	19.1
Fort Pat[1]	0	0	0.9	0.9
Boone	25	1	4.2	4.1
So. Holston	33	17	7.4	6.4
Wilbur[1]	0	0	0.1	0.1
Watauga	26	18	6.2	5.5
Douglas	48	23	27.6	19.5
Nolichucky[1]	0	0	0.4	0.4
Fontana	64	31	9.6	8.0
Ocoee No. 1	7	0	1.9	1.9
Ocoee No. 2[1]	0	0	–	–
Ocoee No. 3[1]	0	0	–	–
Blue Ridge	36	15	3.3	2.8
Apalachia[1]	0	0	1.1	1.1
Hiwassee	45	13	5.7	4.9
Nottely	24	11	3.5	2.6
Chatuge	10	7	6.7	5.2
Total	32 (avg)	15 (avg)	135	106

Note:

1. No scheduled annual or summer drawdown, but fluctuations do occur throughout the year; not included in computed average annual or summer drawdown.

industrial, public, and commercial shoreline structures, and certain privately owned structures (see table 14). These facilities are high in investment value and are being constructed at a stable growth rate.

The remaining 8600 structures were associated with private uses of the shoreline, principally for residences. These include retaining walls, bank stabilizations, launching ramps, docks, boat slips, boathouses, associated channel excavations, and other miscellaneous structures. As figure 9 shows, not only do these private structures far outnumber the public, commercial, and industrial structures approved each year, but they are increasing at a more rapid rate (over 300 per year from 1984 to 1988).

Many more such structures are being built without TVA's prior knowledge or approval. Although about 400 encroachments and violations of TVA's property rights and Section 26a regulations are resolved annually, at last report, the backlog of over 2000 cases is growing by over 150 new cases each year.

The number of private shoreline structures being built can vary from reservoir to reservoir depending on population growth, the amount of privately owned shoreland, and the type of development. Table 15 shows the number of such structures for selected mainstream and tributary reservoirs in the southeastern part of the Tennessee Valley. Chatuge Reservoir shows a much larger number of structures approved per shoreline mile than any of the other reservoirs listed. To varying degrees, Chatuge and the other reservoirs shown are experiencing, and will continue to experience, localized negative effects of shoreline development, including nonpoint sources of pollution from user activities on developed lands, and loss of aquatic habitat for fish and wildlife. However, the cumulative impact of this development has yet to cause any major water quality concerns in the Tennessee Valley (see table 5). Aquatic resource problems in the region are caused principally by nonpoint sources of pollution from activities like farming and mining and low DO releases and lack of minimum flows from TVA dams (see also table 6).

It is difficult to estimate when the increased shoreline development on reservoirs where high growth is projected will cause sufficient localized problems such that the cumulative impact will be significant. Staff judgment is that these effects could become significant in the next decade if enough shoreline is developed without adequate controls to protect water quality and aquatic resources from nonpoint source pollution and loss of habitat. Controls on the types, extent, and quality of shoreline development, if implemented by local governments or the landowners themselves, could significantly reduce these local problems.

State wildlife management agencies and environmental groups want as much natural habitat preserved as possible in important locations for wildlife and wetlands resources. As noted earlier, some of those interested in improved water quality want TVA to limit nonpoint source pollution from the development of shoreland due to soil erosion and runoff from land use activities.

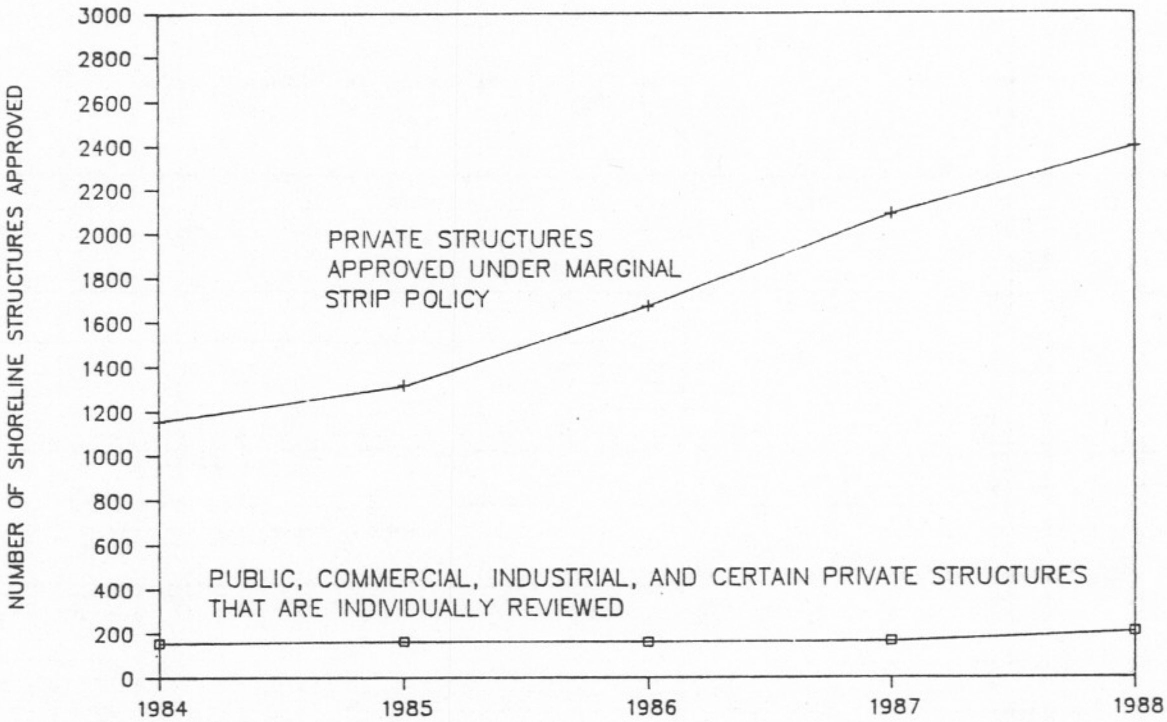
The effects of shoreline development on reservoirs with medium to low expected growth will be much smaller. Reservoirs in the low category likely will not experience any negative effects of shoreline development. Stability and protection for many reservoir riparian habitats also is provided on reservoirs

Table 14
Individually Reviewed Section 26a Approvals On TVA Reservoirs*
1984 - 1988

	Type of Structure				
	Industrial	Public	Commercial	Private	Total
Navigation and W. Tributary Reservoirs					
Kentucky	8	6	22	0	36
Normandy	0	0	0	0	0
Pickwick	3	8	18	1	30
Wilson	1	3	15	9	28
Wheeler	5	19	9	10	43
Tims Ford	0	3	3	0	6
Guntersville	5	19	17	0	41
Nickajack	4	6	2	26	38
Chickamauga	2	11	21	3	37
Watts Bar	0	7	16	2	25
Melton Hill	1	17	2	16	36
Ft. Loudoun	2	13	22	7	44
Tellico	1	4	2	17	24
Subtotal	32	116	149	91	388
E. Tributary Reservoirs					
Norris	0	2	31	0	33
Cherokee	0	7	19	1	31
Ft. Patrick	0	5	0	0	5
Boone	0	8	16	2	26
South Holston	0	3	11	0	14
Wilbur	0	1	0	0	1
Watauga	0	1	11	1	13
Douglas	0	7	14	11	32
Nolichucky	0	0	0	0	0
Fontana	0	5	6	0	11
Ocoee No. 1	0	0	0	0	0
Ocoee No. 2	0	1	0	0	1
Ocoee No. 3	0	0	0	0	0
Blue Ridge	0	1	1	1	3
Apalachia	0	0	0	0	0
Hiwassee	1	1	2	0	4
Nottely	0	2	2	1	5
Chatuge	0	8	10	4	22
Subtotal	1	52	123	21	201
Total	33	168	272	112	589

*All industrial, public, commercial, and privately owned shoreline structures require Section 26a approval. Only those that are individually reviewed are shown in this table; structures approved under TVA's marginal strip policy are not included.

Figure 9
Private Shoreline Structures in the Marginal Strip
All Reservoirs, 1984 - 1988



where over half of the shoreline is in public ownership. However, development that could potentially affect wildlife and wetlands also can occur on publicly owned shoreline, depending on individual agency shoreline management policies.

Cultural Resources. Numerous recorded and unrecorded prehistoric and historic archaeological sites are found on the shoreline of TVA reservoirs, in their drawdown zone, on islands in the reservoirs, and along the banks of rivers in tailwater areas. All standing historic structures have previously been removed from these areas up to the high-water marks of TVA lakes.

Federal laws and regulations are designed to preserve and protect these cultural resources from shoreline development on public land. With mitigation of adverse impacts, however, some loss is permitted. Cultural resources also are threatened by wave wash due to wind and water craft on navigable portions of the reservoirs and rivers. Changes in the rate of streamflow and reservoir pool level fluctuations may contribute to erosion of the shoreline, which can cause further loss of sites as a result of bank slumping and exposure to vandalism and looting.

Water Supply. The streams, rivers and reservoirs of the Tennessee Valley are a source of water supply for municipalities and utility districts. Over 500 public water systems supply water for drinking and other domestic uses to about 80 percent of the Valley's residents; the other 20 percent are on private wells. Total withdrawal by public water systems is about 450 to 550 million gallons per day (mgd), about half of which comes from the ground, and the other half from surface sources.

Table 15
Section 26a Approvals On Selected TVA Reservoirs, 1984 - 1988[1,2]

	Industrial	Commercial	Private: Individually Reviewed	Private: Marginal Strip Policy	Total	Total Per Developed Private Shoreline Mile
Navigation and and W. Tributary Reservoirs						
Nickajack	4	2	26	36	68	2.8
Chickamauga	2	21	3	659	685	4.8
Watts Bar	0	16	2	713	731	3.7
E. Tributary Reservoirs						
Blue Ridge	0	1	1	29	31	3.9
Hiwassee	1	2	0	8	11	2.2
Nottely	0	2	1	54	57	3.2
Chatuge	0	10	4	340	354	10.4

Notes:
1. All industrial, public, commercial, and private shoreline structures require Section 26a approval. Any private shoreline structures that have possible conflicts with navigation, flood control, or hydropower purposes are individually reviewed, while most residential shoreline structures are approved under TVA's marginal strip policy.
2. Data for other reservoirs not available.

Over 300 industrial water systems withdraw water for industrial processes and cooling. Industrial water systems withdraw about six times as much water per day as municipal systems from surface water sources (not including water withdrawn for power plant cooling). The total amount of water withdrawn from surface waters by municipal and industrial water systems is roughly equivalent to the average amount of water that evaporates each year from TVA lakes, or about two to three percent of the annual average flow of 64,000 cubic feet per second (cfs) at the mouth of the Tennessee River.

While the amount of water withdrawn for municipal and industrial water supply from surface sources is small, the consumptive use of water for this purpose is even smaller. This is because over 75 percent of the water withdrawn is returned to a river, stream, or reservoir after use. Other categories of consumptive water use in the Tennessee Valley are even smaller. Irrigation demand in the Valley is very small and is not projected to grow. Most interbasin transfers are from relatively small utility systems which are located near the perimeter of the Tennessee Valley and which are not expected to increase greatly. The transfer of water between Barkley and Kentucky reservoirs on the Cumberland and Tennessee rivers, respectively, only affects the short reaches of these rivers from the canal to their mouths.

The largest transfer of water from the Tennessee Valley to other watersheds is from Pickwick Reservoir to the Tennessee-Tombigbee Waterway. About 235 mgd (364 cfs) is used for this purpose at present, which is about equal to what is withdrawn by Valley municipal water systems from surface waters. Transfer of water for this purpose could grow to as much as 800 mgd (1200 cfs) as traffic on the waterway increases.

The average production cost of potable water in the Tennessee Valley is about $1 per 1000 gallons, ranging from about $0.50 per 1000 gallons for groundwater sources to about $1.50 per 1000 gallons for surface water sources. Production costs include pumping, treatment, and storage costs. Municipalities spend about $150 to $200 million on potable water supply each year. Groundwater sources are cheaper because they are usually higher quality and often more accessible, thus reducing pumping costs.

The quality of surface water in the Tennessee Valley has not had a significant effect on municipal and industrial water supplies except in a few areas. The most significant of these is the Duck River in central Tennessee. In Normandy Reservoir, the level of organics and nutrients is high and contributes to the consumption of DO, leading to algae growths and high iron and manganese which have affected drinking water. Nonpoint pollution sources from agriculture contribute to the problem. The assimilative capacity of the Duck River below Normandy Dam also is reduced by these conditions.

Lake Recreation. Reservoirs in the Valley region are used for a variety of water-oriented recreation activities. Swimming, fishing, water skiing, and boating are enjoyed on the lake, and camping, hiking, picnicking, sightseeing, nature-watching, and fishing are enjoyed from the shoreline. A variety of factors affect the type and amount of recreation activities that occur on any given lake. Among the most important are lake surface area (including miles of shoreline), annual and summer drawdown, access, location (including proximity to population centers), water quality, and reservoir aesthetics.

Table 16 summarizes some statistics related to lake recreation in the Tennessee Valley. Visitation to mainstream reservoirs is about three times higher than visitation to tributary reservoirs.* Investment in recreation facilities and homes also is about three times higher on mainstream versus tributary reservoirs.

Higher recreation visitation and facilities investment on mainstream lakes is explained, in part, by their location. There are more population centers near mainstream reservoirs than there are near tributary reservoirs. However,

*The visitation estimates shown in table 16 are based on an inventory of access facilities and staff judgment. A "visitor-day" constitutes a recreation trip. That is, a person is counted as making one trip to the reservoir during a 24-hour period, regardless of how many different areas are visited. This estimate does not include recreation visits from lakefront homeowners, but does include informal use of undeveloped public lands.

Table 16
Recreation Visits and Facilities on TVA Reservoirs

	Annual Visitor Days (mill)	Rec Facil. Invest. ($m)	Number of Facilities: State Parks	City, County Parks	Camps, Clubs	Comm. Rec. Areas	Public Access Facil.	Wildlife Mgt. Areas	Other Nat. Areas
Navigation & W. Tributary Reservoirs									
Kentucky	4.9	180.0	4	6	10	92	38	3	31
Normandy	N/A	N/A					6		
Pickwick	1.9	62.0	2	5	2	11	14	4	8
Wilson	1.2	43.0		1	2	8	4		
Wheeler	1.0	42.0	1	6	2	9	12	3	1
Tims Ford	0.2	8.3	1	2	1	3	7		
Guntersville	2.2	130.0	2	11	7	28	30	4	3
Nickajack	0.2	6.8		2		6	7		2
Chickamauga	2.0	140.0	2	6	9	15	82	2	
Watts Bar	1.0	71.0		7	6	31	77	2	4
Melton Hill	0.2	9.0		6	2	6	5		
Ft Loudoun	0.6	70.0		12	2	13	37		
Tellico	N/A	N/A		1			12		
Total	15	762	12	65	47	222	335	18	49
E. Tributary Reservoirs									
Norris	1.4	77.0	3	6	5	28	64	2	11
Cherokee	0.6	26.0	1	6		15	29	1	0
Fort Pat	0.5	12.0	1	1			3		
Boone	0.3	34.0		1	2	8	14		
So. Holston	0.5	13.0		2	1	7	3	1	
Wilbur	0.01	0.01							
Watauga	0.3	9.7				6	4		
Douglas	0.5	18.0		2		10	9	2	
Nolichucky	0.01	0.5		1					2
Fontana	0.2	8.7		2	2	8	1		
Ocoee No. 1	0.1	3.3			5	1	4	1	
Ocoee No. 2	-	-							
Ocoee No. 3	-	-			1				
Blue Ridge	0.1	5.3		1	2	1			
Apalachia	-	0.1							
Hiwassee	0.1	10.0		2		3			
Nottely	0.1	4.8		1		7	2		
Chatuge	0.5	17.0		3	1	15	3		
Total	5.2	240	5	29	18	109	138	7	13

physical characteristics (summer surface area and annual and summer drawdown) also are important, as table 13 shows. Mainstream reservoirs (including tributaries in the western half of the Valley and reservoirs with commercial navigation channels) have a total of 470,000 acres of surface area during the summer recreation season. They are drawn down an average of six feet annually, and only one foot during the summer. By comparison, tributary reservoirs in the eastern half of the Valley have about 135,000 acres of surface area during the summer recreation season--less than 30 percent of that in mainstream reservoirs. Moreover, the size of tributary area lakes can vary considerably because their drawdown is much steeper--an average of 32 feet annually and 15 feet during the summer.

TVA lake levels are often compared to the levels of surrounding reservoirs operated by the U.S. Army Corps of Engineers, Duke Power, Georgia Power, and Alabama Power. As shown in table 17, these reservoirs are generally operated

Table 17
Drawdown at Reservoirs
On the Perimeter of the Tennessee Valley

Reservoir Owner/Operator Reservoir	Drawdown* Annual (ft)	 Summer (ft)
Georgia Power		
Burton	7	0
Jackson	6	0
Duke Power		
James	6	0
Keowee	3	0
Jocasee	3.5	0
Corps of Engineers (Nashville)		
Center Hill	16	6
Wolf Creek	23	9
Dale Hollow	10	5
Barkley	5	3
Cheatham	3	0
Cordell Hull	5.5	0
J. Percy Priest	10	0
Old Hickory	3	0
Corps of Engineers (Mobile)		
Lanier	6	0
John Hollis Bankhead	1	0
Alabama Power		
Lewis Smith	14	6
Weiss	6	0

*Determined by rule curves.

with smaller annual and summer drawdowns similar to those of TVA's mainstream projects. There are several reasons for this. Because of their lower topography, it is generally not possible to construct reservoirs with large drawdowns in the regions surrounding the Tennessee Valley. Also, Corps and power company reservoirs are never allowed to fill to the degree that TVA reservoirs are because flood storage space is usually reserved year round. (TVA reserves flood storage space primarily during the winter). In addition, because of their proximity to major population centers such as Nashville, Birmingham, Atlanta, and Charlotte, there is more recreation visitation and associated shoreline development around reservoirs on the perimeter of the Tennessee Valley--hence more pressure for stable lake levels.

Many of the people who attended the public meetings held as part of this study commented on the magnitude of the drawdown on tributary lakes and its effect on recreation and associated economic development. This factor alone probably was responsible for the fact that about 80 percent of the public meeting attendance occurred in the tributary areas. Significant drawdown often makes access points on the reservoir unusable and requires boat dock and marina operators to expend considerable resources in moving their floating facilities several times a year. Drawdown also mars the scenic views on these lakes by leaving a brown ring of unvegetated or sparsely vegetated land along the shoreline. In addition, the number of submerged hazards increases as reservoir levels recede, restricting the lake surface area available for boating. Effects of drawdown on fisheries and wildlife, discussed earlier, also were mentioned by public meeting participants.

Representatives of chambers of commerce, development councils, and tourism promotion groups, elected officials, and others from the eastern half of the Tennessee Valley point to tributary lake drawdown as a significant constraint to future economic growth in tributary lake areas. Many communities in these areas see recreation and tourism, based on the natural beauty of their mountains and lakes, as the best--if not the only--solution to problems of high unemployment, low per capita income, and outmigration of young people.

State and local officials in North Georgia, for example, look to growth in recreation and tourism to increase incomes and employment opportunities. This area, in which Blue Ridge, Nottely, and Chatuge reservoirs are located, has become a significant tourism destination point during the summer and fall and a popular location for vacation and retirement home development.

Lake users also mentioned other concerns about recreation on TVA lakes. Boaters and lakefront homeowners on Guntersville and other mainstream reservoirs complained about the excessive growth of submerged aquatic plants, which makes access to some lake areas extremely difficult. In other areas, congestion during periods of peak reservoir usage brings conflicts between activities such as fishing and water skiing. Some lake users also desire water safety programs and increased regulation and enforcement related to boating speed limits, drunk driving, noise, hunting from boats, and dumping of trash and houseboat waste. These requests are evidence that lake use conflicts will intensify with increases in recreational use of TVA lakes.

Stream Recreation. Fishing, canoeing, and rafting are the primary recreation activities on major streams and unimpounded rivers in the Tennessee Valley, along with related shoreline activities such as picnicking, camping, hiking, sightseeing, and nature-watching. Recreational use of streams and rivers, although small in comparison to lake recreation, is increasing in popularity. Public investment in stream access facilities has historically been much lower than on reservoirs, although TVA has initiated a project to acquire and develop public access in cooperation with local governments. With few exceptions (e.g., the Hiwassee, Nantahala, Ocoee, and Norris tailwaters), most stream use is low density informal use. This is largely due to the character of the resource and the lack of formal access points on many streams.

Because about two-thirds of the miles of rivers and large streams in the Tennessee Valley have been impounded, many of the remaining river reaches downstream of TVA tributary dams have the best stream recreation potential. Their potential, however, is constrained by the lack of minimum flows from these dams and limited public access. When hydropower turbines are off, the depth of water in these rivers decreases, often until only shallow pools are left. While this can result in good fishing opportunities, it makes it impossible to float downstream, affects the area's scenic beauty, and stresses fish and other aquatic life in the stream, as discussed earlier. As part of a multiyear test beginning in 1990, TVA is providing releases for recreational floating on three weekend days below five projects (Chatuge, South Holston, Tims Ford, Norris, and Wilbur).

Recreational floating using rafts, canoes, and kayaks is increasing on whitewater streams. Table 18 shows visitation estimates for major whitewater rivers of the eastern U.S. Four of the eighteen rivers are in east Tennessee

Table 18
Major Adventure Class Whitewater Rivers in the Eastern United States and Canada[1,2]
Use Data, 1987

River	State	Number of visits	Source
Ocoee	TN	136,000	State
Youghiogheny	PA	132,749	State Parks
Nantahala	NC	130,000	USFS
Lehigh	PA	112,383	State Parks
New	WV	85,000	NPS
Ottawa	Canada	65,000	Outfitters
Rouge	Canada	65,000	Outfitters
Chattanooga	GA, SC	55,000	USFS
Cheat	WV	40,000	outfitters
Gauley	WV	34,000	Corps
Kennebec	ME	29,724	State I&F
Shenandoah	WV	24,000	Outfitters
Hudson	NY	20,000	Outfitters
Penobscot	ME	19,000	State I&F
Black	NY	9,000	Outfitters
Nolichucky	TN	9,000	Outfitters
French Broad	NC	8,000	Outfitters
Dead	ME	3,587	State I&F
Total		977,443	

Source: Eastern Professional River Outfitters Association

Notes:
1. Adventure class rivers include some class III whitewater and, for the purposes of this listing, are widely available to the general public through professional outfitters. Several of the rivers are borderline adventure class (predominantly class II rapids), but guided trips are commonly available.
2. Some rivers are not listed due to uncertainty about use levels or because use is sporadic due to uncertainty of flows (e.g., Sacandaga, North Branch of the Potomac, Hiwassee, Pine Creek). Therefore, the total understates whitewater recreation in the Eastern U.S.

and western North Carolina; two of the three most visited rivers are the Ocoee River downstream of TVA's Ocoee No. 2 Dam, and the Nantahala River downstream of Nantahala Dam.

Nantahala Dam is owned by Nantahala Power and Light Company, a subsidiary of Duke Power. TVA provides releases from Ocoee No. 2 Dam as part of an agreement with the state of Tennessee (see Chapter 2). The U.S. Congress appropriated monies to TVA to compensate for water that is released from Ocoee No. 2 Dam without passing through the Ocoee No. 2 powerhouse. These monies are being repaid from user fees collected from floaters as part of the fee they pay to outfitters for each float trip.

Outfitters who take visitors on float trips on the Ocoee, Hiwassee and Watagua rivers would like guaranteed releases from Ocoee No. 3 dam and the Apalachia and Wilbur hydroplants, respectively. Local governments support their requests, viewing whitewater recreation as part of their economic future, like lake recreation and tourism.